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Assessment of the farmers' tillage practices for soil conservation in Mubi north local government area, Adamawa state

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Abstract
The major aim of this research was to assess farmers' tillage practices for conserving soil and to determine which of the practices minimize soil erosion and profitable for crop production. Five objectives were pursued using different tools to arrive at the result obtained. Laboratory analysis of four soil samples randomly but purposively selected from the study sites were analysed. And a total of four hundred and fifteen (415) questionnaires were administered to the target population. Descriptive statistics was used to analyse respondent's demographic characteristics; also, student's' test and ANOVA were used to determine respondents farming variables. The results on respondent's participation in farming revealed gender distribution of 51.0% male and 49.0% female, majority 68% are aged between 20 – 40 years. Likewise 60% of the farmers had basic education, 74% are majorly crop producers and 62% of farmers had between 11 – 15 people in their household. The results of analysis on respondents farming variable revealed that, most farmers (53%) acquired there farmlands by inheritance, only 20% of farmers practiced no-till while 63% and 11% practice ridge and mulching till respectively. Also, 64% of farmers use animal traction only 6% could afford tractors. Majority 73% had been practice tillage farming system between 6 – 15 years.

Keywords: farmers, tillage practice, soil conservation

Introduction

One of the main causes of soil degradation identified in various parts of Africa by the Food and Agriculture Organization of the United Nations (FAO, 2005) [30] is the practice of inappropriate method of soil preparation and tillage. Among different Operations, soil tillage is considered as one of the most important practice in agricultural production due to its influence on physical, chemical, and biological properties of the soil environment (Klute, 1982) [47].

Tillage however, include all operations of seedbed preparation that optimize soil and environmental conditions for seed germination, seedling establishment and crop growth (Dumanski *et al*, 2006: Sanginga and Woomer 2009) [25]. It is a soil related action necessary for crop production (Keshavarzpor and Rashidi, 2008). According to Jabro *et al* (2009) [40], the structure of the topmost part of soil is largely influenced by the soil tillage system and the implements used for tillage operations. Soil tillage has a major influence on the water intake, storage, evaporation and absorption of water from the soil by plant roots, biological activities, and organic matter break down, which influence the soil aeration, soil moisture and soil temperature (Kathirval *et al*…, 1992).

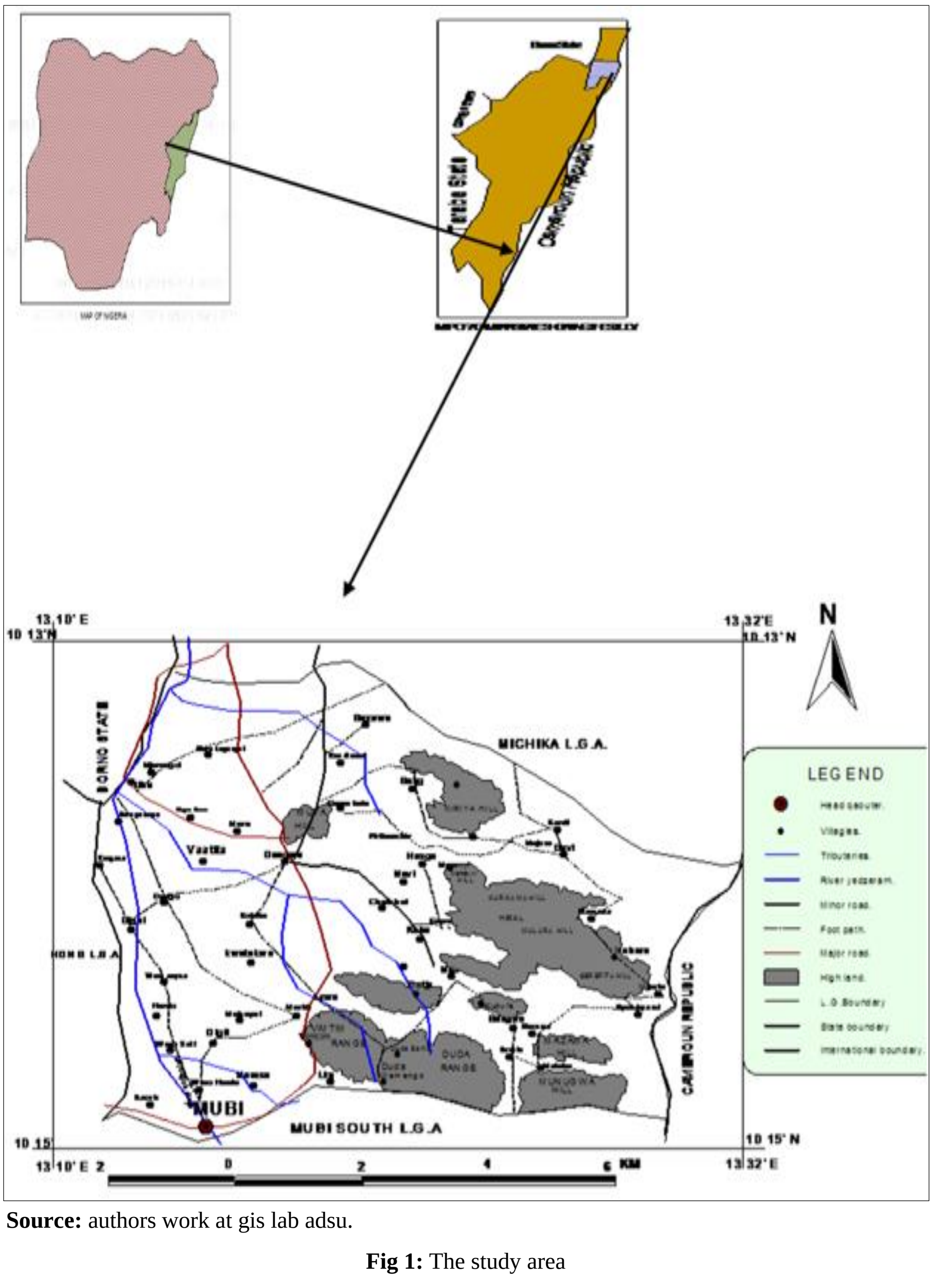
However, changes in soil physical properties are influence by different tillage treatments but the changes are small and insignificant (Morgan, 2005) [57]. According to (Jordhal and Karlen 1993; Mielke Wihelm, 1998) [42], tillage treatments affect soil physical properties, especially, when the same tillage system has been practiced for longer time. Proper use of tillage improves soil related constraints, while an improper tillage leads to destruction of soil structures, accelerated erosion, depletion of organic matter and fertility, and disruption in cycles of water, organic carbon and plant nutrients (Elder and Lal, 2008) [26]. Appropriate tillage practices are those that prevent the degradation of soil properties and maintain crop productivity as well as ecosystem stability (Lal, 1981b, c, 1982, 1984b, 1985a; Greenland, 1981) [50, 33].

However, conservation tillage is any tillage or planting system in which at least 30% of the soil surface is covered by plant residue after planting to reduce erosion by water (Conservation Technology Information Center in West Lafayette, Indiana USA, 2004). No- tillage, minimum tillage, reduced tillage and mulch tillage are terms synonymous with conservation tillage as observed by Atkinson *et al* (2007) [8]. In recent years, interest in conservation tillage system has increased in response to the need to limit erosion and promote water conservation (Mulumba and Lal, 2008) [59]. Conservation tillage provides the best opportunity for halting degradation, restoring and improving soil productivity (Lal, 1983; Parr *et al*.., 1990) [51, 64]. It has the potential to aggrades soil quality and reduce soil loss by providing protective crop residue on soil surface and improving water conservation by decreasing evaporation losses (Carter, 1991) [19]. Conservation tillage leads to positive changes in the physical, chemical and biological properties of a soil (Bescanca *et al*., 2006). The effect of conservation tillage is to reduce the volume fraction of large pores and to increase the volume fraction of small pores relative to conventional tillage (Bhattacharya *et al*, 2008).

Mubi is an area that is chiefly hilly and mountainous, with a large population which are dependent on agricultural production for their livelihood. Farmers in quest to cultivate their farmlands often disturb the soil to varying degrees. And conventional tillage are the most common practice in the area where the use of tractors and different types of ploughs cause severe soil loss. Generally speaking, the perception of local farmer in the area is that the more you till the more the yield. However, farming is a major source to the teeming population in the area to the point that marginal lands are cultivated, and most of these farmers are peasant farmer farming on a small pieces of land that are sometimes less than a hectare, and therefore using rudimentary implement such as hoes, machetes, and spears. In recent times, tractors and ploughs have been introduced in tillage; these practices are very much different from what were obtained in the past. And these may be unsuitable for the soil of the area as the use of tractors in which fields are plowed several times, leaves soil free of any cover for extensive periods, this result to soil erosion and decline fertility. Therefore, there are other types of tillage that assists in soil conservation which are most needed in areas of high soil degradation such as the study area. If these are incorporated in the land management system, there will be less soil erosion and other forms of degradation problems in the area.

Material and Methods

The study area is Mubi north and its environs. Mubi is a town in Adamawa north senatorial district Adamawa state, Nigeria located between latitude 9^0 30 and 11^0 north of the equator and longitude 13^0 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 below:



Source: authors work at gis lab adsu.

Fig 1: The study area

Table 1: Record of Rainfall in Mubi North Local Government Area, 2006 – 2020.

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean (mm)
2006	-	-	-	34.7	86.2	235.8	108.2	327.5	250.5	145	-	-	1187.9	99.9
2007	-	-	-	2.3	90.7	100.4	247.4	401.9	175.3	77.4	-	-	1095.4	91.2
2008	-	-	-	115	40.6	183.6	190.4	419.6	174.8	134.4	-	-	1258.4	104.8
2009	-	-	-	63.9	221	598	262.8	219.1	221.6	24.5	-	-	1610.9	134.2
2010	-	-	-	-	44.5	146.7	155.8	338.6	187.3	45.1	9.9	-	927.9	77.3
2011	-	-	-	-	92.7	123.6	189.7	242.4	187.8	69.1	5.1	-	910.4	75.9
2012	-	-	-	52.6	99.9	96.5	274.5	235.9	146.5	73.6	5.1	-	984.6	82.1
2013	-	-	-	47.2	75.3	154.7	207.3	329.5	254.7	41.9	-	-	1110.6	92.5
2014	-	-	48	2.5	102.7	95.6	229.6	216.8	244.2	52.5	-	-	991.9	82.6
2015	-	-	-	-	48.5	132.2	143	278.1	85.5	25.5	-	-	712.75	59.3
2016	-	-	-	6.7	74.5	148.2	211.3	286.2	103.7	18.7	-	-	849.3	70.7
2017	-	-	6.5	-	96.3	80.3	174.4	245.5	109	147	-	-	859	71.5
2018	-	-	-	71.5	141.4	124	125.3	61.2	249.6	-	-	-	776	64.6
2019	-	-	-	7.9	62	93.9	140	195	182.3	83.7	-	-	764.8	63.7
2020	-	-	-	65.4	133.7	187.2	201.8	333.5	314.5	109.7	-	-	1345.8	112.1

Station – Mubi met. station, latitude 10^0 15’ N longitude 13^0 16’, altitude- 579m-

Source: ADSU Mubi met. station, 2020.

Reconnaissance Survey

Before the commencement of the main research work, a familiarization visit was made to the study area by the researcher. The aim of the survey is to determine the limits of the study area and to get first-hand information from the target population.

The data for this research were obtained from both primary and secondary sources. Primary data were generated through direct field observation and Focus Group Discussion (FGD). A well-structured questionnaire was administered as a tool for obtaining primary data incorporating the set objectives of demographic and non-demographic characteristics. In addition, laboratory analysis of soil were carried out to determine whether there is a marked difference between the physical and chemical properties of tilled and untilled farmlands.

Sampling technique

Mubi North Local Government Area consists of eleven (11) wards which includes; Muchala, Mijilu, Bahuli, Vimtim, Sabonlayi, Yelwa, Mayobani, Kolere, Lokuwa, Betso, Digil. For the purpose of this research, the researcher use all the wards in the study area for which samples was drawn four (4) was purposively selected; Lokuwa, Digil, Vimtim, and Muchala. These were selected irrespective of their identities, names and dialectical differences. In selecting sample size, Taro Yammane sampling technique was used to randomly select 372 respondents from population of 5324 registered famers with ADP Mubi from the selected wards. Total of three hundred and seventy two questionnaires were administered. The formular for Taro Yamenne is given as

$$n = \frac{N}{(1+N(e^2))}$$

Where N= population

n = sample size

e = accepted sampling error (Yamane, 1967) [79]

Soil sampling procedure

The sampling procedure involve the use of simple random but purposive sampling, where a representation sample of four (4) wards was purposively selected from the eleven (11) wards in the study area. In this way, the researcher administers the research instrument to the respondents encountered

Field sampling technique

For the purpose of laboratory analysis, soil sample were taken at each farm sites of the purposively selected 2 tilled and 2 no-till, making then total of 4 farm lands. A hand driven soil auger were used to take sample at the depth of 0-20cm. The soil were placed in a polythene bags for easy convenience.

Soil analysis

For laboratory analysis, soil sample were taken each from the selected farm points to determine both physical and chemical properties of soil on the tilled and untilled farms. The physical properties that are of interest include; particle size, bulk density and porosity. While chemical properties to be considered are the soil pH, Organic Carbon (OC), Exchange Bases (EC), Base saturation (BS), Effective Cation Exchange Capacity (ECEC), Electrical Conductivity (EC), Exchange Acidity (EA), Total Nitrogen (TN), Available phosphorus (AVP).

Laboratory analysis

Soil analysis were carried out in the soil laboratory of the department of Soil Science, Modibbo Adama University of Technology, Yola. Adamawa State.

Determination of soil physical properties

Bulk density

Bulk density of a soil were determined using undisturbed core soil sampling as described by Blake and Hartage (1986) [13].

Particle size: the particle size analysis of the soil were determined using hydrometer method (IITA, 1979).

Soil porosity: the soil porosity was determined as described by (Brady and Well, 2002) [17]

Determination of soil chemical properties

Soil pH: the soil was measured in a 1:2, soil to water ratio using a glass electrode (H19017 microprocessor) pH mter (Jaiswal, 2003) [41].

Soil electrical conductivity: The soil EC were measured in a 1:2, soil to water ratio using a glass electrode (H19017 microprocessor) EC meter (Jaiswal, 2003) [41]

Total nitrogen (N): total nitrogen were determined by the macro Kjedahl digestion, distillation and titration procedure (Jaiswal, 2003) [41].

Available phosphorus (AVP): the available phosphorus was determined using Bray 1 method (Bray and Kurtz, 1945) [18].
Organic Carbon (OC): Organic Carbon was determined using Bray 1 method.

Effective Cation Exchange Capacity (ECEC): The ECFC were determined by using summation method (IITA, 1954).
Percentage Base Saturation (PBS): The PBS was determined by calculation.

Exchange acidity in soil: The soil was extracted with unbuffered 1.0 M KC l, and the sum of Al and H were titrated with 0.M NaOH in the presence of phenolphthalein indicator to a permanent pink color (Jaisawal, 2003) [41].

Exchange Base (EB): The exchange base were extracted with one normal (1N) ammonium acetate. Potassium and sodium were determined using flame photometer, while calcium and magnesium were determined by titration with 0.01N EDTA (ethylene di-aminotetra-acetic acid) as described by Jaiswal (2003) [41].

Data analysis

The method of data analysis adopted involve the application of descriptive statistics such as the use of percentages, distribution tables and graphical representations which were used to show variation in statistical data such as the different tillage practices in use, and population characteristics in the area. Analysis of Variance (ANOVA) were used to determine the Variation between the yield of maize of tilled and no-till farmlands in the study area.

Results and Discussion

Farm output per hectare

The results in Table 2, revealed the farm output in 15 of 100kg bag/hectare according to the Nigeria Cereal Yield Indicator of Food and Agriculture Organization, FAO, (2015). The table revealed the percentage distribution of sampled farmers with respect to their tillage practices and their farm output based on FAO cereal indicator. The table indicates that 52% of those that practicing no-tilling got farm output below FAO standard, while the remaining 48% have above FAO standard. In the category of those farmers practicing Ridge tillage, 49% farmers had output below FAO standard while 51% had above FAO standard. Likewise, 57% in the category of those practice mulching tillage got below FAO while 43% have farm output above FAO. Those farmer practices strip tillage had 65% output below FAO standard while 35% got above FAO standard. The overall results revealed that 52% of the sampled farmers irrespective of tillage practices had farm output less than FAO standard while the remaining 48% got above FAO standard.
The farmers' estimated farm output measure in 100kg per bag was divided by number of their estimated farm size (hectares) to determine those farmers that recorded farm output up to FAO standard and those recorded below.
Likewise, the table depicts farmers' farm output alongside their tillage system. Having most farmers in the study area have below 15 bags per hectare irrespective of the tillage practices used, indicates that choice of tillage alone may not determine the farm output other factors which include recommended farming practices such as planting date, seed rate, spacing, seed varieties, seed per hole, fertilizer rate, time of fertilizer application, weed control and harvesting may responsible for general drop in the farm output.
This finding reaffirmed that if farmers in the study area choose to practice conservational tillage system with the adoption of recommended practices, the chances of getting the expected farm output with little soil disturbance is high.
Above all, repeated farming on the same plot of land have affected the fertility of the land and reduced the annual farm yield below expectation.

Table 2: Distribution of respondents using FAO 2015 Nigeria cereal indicator

15 bag/hec*	No Tilling		Ridge		Mulching		Strip		Overall	
	Fx	%	Fx	%	Fx	%	Fx	%	Fx	%
Below FAO	40	52%	112	49%	24	57%	14	65%	190	52%
Above FAO	37	48%	117	51%	18	43%	7	35%	179	48%
Total	77	100%	229	100%	42	100%	21	100%	369	100%

* The FAO 2015, measures for 1,523 kg of maize per hectare, equivalent to 15.23 (100kg bag/hectare), Fx: frequency, %: percentage
Source: Field survey, 2020

Government's role in encouraging conservational tillage practices

Table 3, reveals the role plays by government in encouraging farmers' tillage practices in the study area. The result indicated that 75% of the famers had access to fertilizer and 63% to improved seeds while 70% of the respondents have no access to loan. In a similar manner, result has indicated that 72%, 75%, and 79% of the famers have not had access to farm implements, herbicides, and skilled man power respectively. This implied that, the sampled respondents irrespective of tillage system used have not benefitted from loan, farm implement, herbicides or skilled man power. The reasons for getting little from government may be attributed to many factors, namely; government interventions in agricultural practices which have been criticized by many people are below expectation, the corrupt practices by government official makes agricultural facility difficult to reach the local famers, and their inability to form a recognized group or association through which can easily be reached by the government, and other international donors. These among other factors might account for getting less from the government.
These results agreed with the findings made by Kumar and Kumar (2011) that high cost of farm implement, poor loan access for farmers, indiscriminately diversion of fertilizers and

herbicides to unknown location by government officials and shortage and unwillingness of skilled manpower to accept responsibility are indicators of government challenges to harness the opportunities in agricultural sectors.

Table 3: Government roles in encouraging tillage practices in the study area

Government support	Fx	%	Fx	%	Fx	%	Fx	%	Avg N=369
Loan	29	8%	41	11%	41	11%	258	70%	
Improved seed	41	11%	236	64%	59	16%	33	9%	
Fertilizer	262	71%	44	12%	41	11%	22	6%	
Implement	37	10%	37	10%	30	8%	265	72%	
Herbicides	18	5%	30	8%	44	12%	277	75%	
Skilled manpower	11	3%	18	5%	48	13%	292	79%	
Grand Average									

Fx: frequency, %: percentage, Avg: Average value
Source: Field survey, 2020

Table 4, revealed the coping strategies adopted by farmers in the study area to conserve their farmlands. The table shows that the most commonly practiced strategies are mixed cropping with 28%, followed by use of fertilizer (16%), the use of cover crop 15% and crop rotation 14%. Use of terraces, manure and bush fallow were 13%, 8% and 6% respectively. The results indicated that mixed farming has been the orthodox coping strategies used by farmers over the years. The farming system offers insurance against total crop failure, and helps to control soil erosion and weeds. Farmers resort to mixed cropping with the aim to conserve their soil for the fact that majority could not afford to switch from one farmland to another and allow the former to lay fallow in the face of land ownership problems. Fermont, *et al* (2009) reported that among the merits of mixed cropping system was a diverse crop species grown together to complement one another by using resources in different ways, scarce labour is efficiently utilized, weeds and insects are suppressed, erosion is controlled and there is sequential harvesting and the risk of total crop loss is averted.

Table 4: Strategies used by farmer to conserve their farmlands

Coping strategies	Frequency	Percentage
Mixed cropping	221	28%
Use of cover crop	119	15%
Bush fallow	45	6%
Use of fertilizer	127	16%
Crop rotation	106	14%
Terraces	98	13%
Manure	66	8%
Total	782*	100%

* Multiple responses
Source: Field survey, 2020

Farmers choice of tillage practices

The results on Table 5, revealed respondents choice of a particular tillage practice in the study area. The result shows that most farmers (54%) practiced tillage of their choice to get more farm output, 18% till due to farm size, and 11% of the respondents practice tillage type of their choice due to financial constraints and manpower. While only 6% of all the respondents till to conserve their farmlands. It is obvious from the observed result that local farmers were into particular farming practices only to get good farm output, as their role in environmental degradation remain unchecked.

According to Gianessi (2009), farmers are not aware of the necessity to conserve soil for generation to come but rather intensifying efforts to keep foods for the yet coming generation and putting more pressure on soil and other natural resources. Dethier and Effenberger (2011) found that the only condition forcing farmers to practice no till or zero tillage is when they perceived that their farmland is too big than what they can afford to cultivate base on their purse, while those with good manpower use available tillage practice in their farmland, others with small farm size do make ridges or animal traction all with the aim of getting more farm yield

Table 5: Farmer's choice of tillage practices

Reasons for practice	No tilling		Ridge		Mulching		Strip		Overall	
	Fx	%	Fx	%	Fx	%	Fx	%	Fx	%
Size of farmland	42	55%	18	8%	5	11%	0	0%	65	18%
Financial constraint	18	24%	16	7%	7	17%	0	0%	41	11%
Manpower	7	9%	25	11%	7	17%	0	0%	39	11%
Farm output	5	6%	156	68%	23	55%	17	83%	201	54%
To conserve the soil	5	6%	14	6%	0	0%	4	17%	23	6%
Total	77	100%	229	100%	42	100%	21	100%	369	100%

Fx: frequency, %: percentage
Source: Field survey, 2020

Impact of tillage practices on soil conservation

The results in Table 6, revealed the association between tillage practices and soil conservation, taken into consideration problems of erosion, observable drop in farm output which necessitate applying more than required input (fertilizer) to boost farm output. These variables were analyzed using categorical Chi-square to determine the respective impact of tillage practices on farmland with respect to the soil conservation. The results revealed that 62% of farmers practicing no tillage were not affected to 61.0% practicing ridge tillage, 55% Mulch-till and 52% for those practicing strip tillage. The critical value obtained (13.90) which is greater than calculated value (7.81) at the degree of freedom of 3, at p-value <0.005 is rejected, thus, the null hypothesis states that farmers tillage practices has no significant impact on soil conservation. This Implied that tillage practices impact significantly on soil conservation, however, the result reaffirmed that having 38% of those farmers practicing no tillage compared to 61% –ridge tillage, 55% –mulching tillage and 52% –strip tillage reported having some challenges could not be coincidental compared to 62% of those practicing no tillage reported having lesser challenges.

This finding collaborates to IITA (1990); Reeves (2004); Ibeawuchi (2007) and Meisinger, *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 expressed that no till or zero tillage is most efficient in terms of soil conservation techniques, followed by strip, mulching and ridge till. Ilona (2011) referred to the mechanized farmers as soil killers due to the heavy machines used on the farmland. He expressed that mechanization of soil tillage; allow higher working depths and speeds and the use of certain implements like ploughs, disk harrows and rotary cultivators have detrimental effects on soil structure. 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 mechanized tillage is constantly practiced. Farmers in the medium term of continuous tillage will experience soil erosion. Ajayi and Solomon (2010) reported that 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 6: Chi-square analysis on the impact of tillage practices on soil conservation

Tillage type	Impact on farmland						Chi-square	df	Table value	Sig. (2-sided)
	Not Affected		Affected		Total					
	Fx	%	Fx	%	fx	%				
No – Till	48	62%	29	38%	77	100%	13.90[a]	3	7.815	003
Ridge	89	39%	140	61%	229	100%				
Mulch	19	45%	23	55%	42	100%				
Strip	10	48%	11	52%	21	100%				
Total	166	45%	203	55%	369	100%				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.60.
Fx: frequency,
Source: Author data analysis, 2020

Impact of tillage practices on farm outputs

Table 7, presents the result of the differences between the average farm output of those farmers practicing no-till, ridge, mulching and strip tillage in their farmlands. However, farmers that practice no-till recorded an average farm output of 11.50 bag/hectare, those practices ridge tillage recorded average of 12.03 bag/hectare, those farmers practices mulching recorded 10.56 bag/hectare farm output, while those practicing strip tillage recorded an average farm output of 10.02 bag/hectare. The table revealed that the calculated F-value (1.108) which is less than the F-critical value (2.627) at the degree of freedom of 3 and 406, P-value =0.346. Since the calculated F-value is less than the F-critical value, this implied that there is no significant difference between an averages output per hectares of the categories of farmers irrespective of the tillage used. Furthermore, this result suggested that all things been equal, if farmers adopt conservational tillage system alongside recommended practices; such as using appropriate farm implement, sowing date, seed rate, appropriate and timely fertilizer application, proper weed control measures, controls of diseases and pests and recommended harvesting technology, the difference in the farm yields between those that tilled and those practicing no-tilled will be insignificant. This finding corroborates with Ogban *et al.* (2005), Senjobi *et al.* (2013) and Döring*et al.* (2013) who reported slight farm yield for those farmers tilling their lands than those practicing no-till. They expressed further that tillage practices turn-up the soil nutrients which support crop farming that take less than 3-months. However, they noted that other factors such as farmer's understanding about no-tillage practices, nature of land, seed rate and date of planting might also accounted for the slight disparities in farm output.

Table 7: Differences in farm outputs of different tillage practices using Chi Square analysis

Tillage practices	Count	Sum	Average	Variance	F-cal	p-value	F-crit
No till	77	882.4	10.30	39.28	1.108	0.346	2.627
Ridge	229	2754.8	10.85	46.03			
Mulch	42	443.2	9.44	40.16			
Strip	21	210.5	9.15	19.66			

df (3; 406), Sum of Square (157.04; 19188.99), mean square (52.35; 47.26)

The impact of tillage practices on soil physical properties

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

The results of soil physical properties obtained from the laboratory analysis presented in Table 8 revealed that the mean proportion of sand across the four practices indicated that sand is more 86.39 in no-till site than strip till site 78.4, while ridge and mulch till showed mean proportion of 78.4 each, which is slightly less than strip 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 till; 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. Tallman (2013) [76] 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 suggested the negative impact of tillage systems on soil over the no-till.

The results of soil analysis obtained on the proportion of silt across the four tillage presented in Table 8, revealed that no – till has a mean silt proportion of 9.30, 11.80 for ridge and strip till, with mulch till having a mean proportion of 12.5. These results indicated that mulch till has more presence of silt than the respective no-till, ridge and strip till sites. However, student t-test also revealed that there is a significant difference at (p-value <0.05). This result shows that most of the area under cultivation resulting from inappropriate tillage systems have lesser silt due to soil exposure and continues 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. Table 8, presents the mean percentage of clay in the four tillage practices in the study area. No – till has a mean clay of 4.2, ridge till 10.8 and 8.8, 10.7 for mulch and strip respectively. The t–test distribution revealed 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 the soil in the study area.

Table 8 presents an average bulk densities of the different tillage practices as follows: no-tillage 1.71 g/cm^3, ridge till 1.57 g/cm^3, mulch till 1.58 g/cm^3, and strip till1.58 g/cm^3. 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. However, the t-test further revealed that there were insignificant differences for all the recorded bulk density for the respective tillages in the study area at (P-value >0.05). The mean percentage of porosity recorded across the four tillage practices were presented in Table 8. The result reveals mean percentages of 67.55%, 59.74%, 61.3% and 59.24% for no-till, ridge, mulch and strip till respectively. The t-distribution revealed that there is significant differences between mean percentage of porosity recorded for no-till and the other three tillages at (P-values <0.05). This implies that no-till were more porous than the other practices. This may not be unconnected with the fact that in no till soils; organic matter was left undisturbed, thereby making the soil more porous. While in the other three practices, use of ploughs has affected organic matter content of the soils and hence less porous.

Table 8: The impact of tillage practices on soil physical properties

Soil 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	
Sand	86.39	2.83	0.03	78.4	2.83	0.04	79.9	0.71	0.01	78.4	2.83	0.04	0.11
Silt	9.3	2.12	0.23	11.8	0	0	12.25	0.71	0.06	11.8	0	0	0.03
Clay	4.25	0.71	0.17	10.8	1.41	0.13	8.8	0	0	10.7	2.83	0.24	0.04*
Bulk Density	1.71	0.01	0.01	1.57	0.05	0.03	1.62	0	0	1.58	0.06	0.04	0.13
Porosity	67.55	2.05	0.03	59.74	2.74	0.05	61.3	2.12	0.03	59.24	2.03	0.03	0.02*

Std. dev: standard deviation, C var: Coefficient of variation

Table 9

Location	Soil properties	No-till Site			Tilled site			P-value
		Mean	Std. dev	Covar	Mean	Std. dev	Covar	
Digil	Sand	86.39	2.83	0.03	78.4	2.83	0.04	0.11
	Silt	9.30	2.12	0.23	11.80	0.00	0.00	0.03
	Clay	4.25	0.71	0.17	10.8	1.41	0.13	0.04*
	Bulk density	1.71	0.01	0.01	1.57	0.05	0.03	0.13
	Porosity	67.55	2.05	0.03	59.74	2.74	0.05	0.02*
Lokuwa	Sand	85.4	1.41	0.02	79.9	0.71	0.01	0.07
	Silt	8.30	0.71	0.09	12.25	0.71	0.06	0.03*
	Clay	4.30	0.71	0.16	8.80	0.00	0.00	0.03*
	Bulk density	1.70	0.03	0.02	1.62	0.00	0.00	0.16
	Porosity	68.8	1.10	0.02	61.3	2.12	0.03	0.03*
Muchalla	Sand	86.4	2.83	0.03	78.4	2.83	0.04	0.11
	Silt	9.30	2.12	0.23	11.80	0.00	0.00	0.02*
	Clay	4.30	0.71	0.16	10.70	2.83	0.24	0.01*
	Bulk density	1.72	0.03	0.02	1.58	0.06	0.04	0.15
	Porosity	66.6	1.98	0.03	59.24	2.03	0.03	0.02*
Vitim	Sand	86.4	2.83	0.03	79.9	0.71	0.01	0.17
	Silt	9.30	2.12	0.23	12.3	0.71	0.06	0.02*
	Clay	4.30	0.71	0.16	16.80	0.00	0.00	0.03*
	Bulk density	1.72	0.03	0.02	1.62	0.00	0.00	0.13
	Porosity	68.8	1.13	0.02	63.8	1.41	0.02	0.03*

Source: Field survey, 2020

Impacts of tillage on soil chemical properties

Table 10; Presents the laboratory analysis of soil chemical properties in the study area. The result indicated that the soil pH across the four practices is slightly acidic as observed from the mean values; no-till 6.35, ridge till 5.4 and 6.5, 5.42 for mulch and strip till respectively. Using student t-test it was established that there is no significant difference at 0.05 level between no-till and the other three practices. The study showed that under no-tillage, soil pH tended to decrease, but this decrease was also not significant. 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 4.9 revealed the mean proportion of electrical conductivity in the study area. However, the mean values were (0.20, 0.14, 0.13 and 0.15) for no-till, ridge, mulch and strip till respectively. However, the result indicates that the soil is generally non-saline. This is 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. Similarly, 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. And using student‘t’ test it was established that there was no significant difference at 0.05 levels between no-till and the three tillage treatments. Table 9 shows the results of total carbon content for the different tillage treatments of the two sampling depths and sites. In general, the total carbon contents were 0.72g/kg, 0.78g/kg, 0.78g/kg, and 0.73g/kg for no-till, ridge till, mulch and strip respectively, which were very low for all the tillage treatments. From this study's results, showed that there was decrease in total carbon content of no-tillage and that of strip tillage treatments, which incorporates the 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. Therefore, using student t-test, it was confirmed that there was no significant difference at 0.05 levels in the organic carbon content of the soil across the four tillage practice treatments in the study area. The finding in table 9 reveals the percentage of total nitrogen across the four tillage practices. It was observed from the mean values 0.09g/kg, 0.08g/kg, 0.01g/kg and 0.08g/kg that the total nitrogen nearly the same. Using student t-test, at 0.05 levels, it was established that there was no significant differences in the practices at different depths. In a similar manner, table 10, revealed the mean values of available phosphorus of the soils obtained in the study area for the four different tillages 3.99, 3.58, 3.02, 3.63 for no-till, ridge till, mulch and strip respectively are generally low. The result indicated that the phosphorus levels are nearly the same except for the strip till that is slightly higher. This result is not in contrast with what was earlier expected. However, using student t-test, it was established that the difference in the phosphorus level of farmland in the study area are insignificant.

The result in table 10 also revealed the calcium content of soil in the study area. As observed from the mean values 4.7 Cmo1/kg, 2.15 Cmo1/kg, and 3.15 Cmol/kg for no-till, ridge till, and strip till, the available calcium are generally very low, with mulch having 5.3 Cmo1/kg showing medium calcium content. However, it can be deduced from the result that the calcium content of soils in the area are not fairly uniform, because different practices receive different treatment hence differences in calcium content of the soils. Using student‘t’ test it was established that there were significant differences in the soil calcium content across the four practices the study area.

Findings in Table 10 revealed that the magnesium content of soil across the four practices range from low to medium. The mean values are no-till 0.9 Cmo1/kg, ridge till 1.1 Cmo1/kg, mulch 0.85 Cmo1/kg, and strip till 1.05 Cmo1/kg respectively. It was observed that ridge and strip till have higher magnesium content than those of no-till and mulch farmlands. Therefore, using student t-test, there were significant differences in the magnesium content of the soil at various depths and sites. Table 9 revealed also that the sodium content across the four tillage is generally low. This was observed from the computed mean values that, the sodium content of all the sampled farmlands are nearly the same. However, using student‘t’ test it was established that the sodium content of soil at various depths and sites were not significantly different. Also, the finding in table 10 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. T-test distribution also confirmed that there were no significant differences in the potassium level of all the practices. Table 10 reveals that the Total Exchange Bases (TEB) and Total Exchange Acidity (TEA) were not statistically significant across the four practices, 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

Table 10: Tillage effects on soil chemical properties

Chemical properties	No-till			Ridge till			Mulch till			Strip till			P-value
	Mean	Std. dev	Covar	Mean	Std. dev	Cvar	Mean	Std. dev	Covar	Mean	Std. dev	Covar	
PH	6.35	0.22	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	0.02	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	0.04	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	0.01	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/kg)	4.7	0.14	0.03	2.15	0.07	0.02	5.3	0.71	0.13	3.15	0.07	0.02	0.02*
Mg (Coml/kg)	0.9	0.14	0.16	1.1	0.99	0.9	0.85	0.35	0.42	1.05	0.92	0.88	0.82
Na (Cmol/kg)	0.14	0.02	0.16	0.12	0.01	0.06	0.13	0.01	0.06	0.1	0	0	0.4
K (Cmol/kg)	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/kg)	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/kg)	1.25	0.07	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*

Source: Result of laboratory analysis calculated

Soil as natural resources must be utilized efficiently both in theshort and long-term to make agriculture more sustainable. The main aim of this study was to quantify and qualify the physical and chemical properties of soil through four different tillage applications on a research site. The secondary aim was to establish which of the tillage treatments were the most sustainable regarding the soil properties. However, prominent differences were observed between tillage treatments for most of the soil properties quantified. It was vivid from the study that, the total carbon content was generally very low in the 0 – 20cm soil depth and the decreased was in the order of no-till, strip, ridge and mulch till. This proves that tillage practices that caused little soil disturbance would cause increase in carbon content at the surface, although the extent to which it can increase is not significant.

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