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PRELIMINARY STUDIES OF SOIL EROSION IN A VALLEY BOTTOM IN IBADAN UNDER SOME TILLAGE PRACTICES

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ABSTRACT

The effects of soil type and tillage interaction on nutrient loss in surface runoff and eroded soil, soil physico-chemical properties and maize growth and yield was assessed at a valley bottom in the University of Ibadan. Ibadan extends from Latitude 7^0 24^1 N to Longitude 3^0 54 E. Field experiments were carried out for four months on 5% slope as a 2x3 factorial in a randomized complete block design involving two soil types (Apomu and Osun series) as factors, each at three levels of tillage practices; stubble mulch tillage (ST), Traditional tillage (TT), and Zero tillage (ZT). Each tillage method occupied 22 x 5 m size erosion plot, which was replicated three times on each soil type. Pre-and post study soil samples were analysed for physical and chemical properties. The plots were sown to maize at 90 cm between and 30 cm within rows spacing under which runoff and soil loss from each plot were determined using soil and water collecting devices at the end of each plot. Results showed that soil bulk density at 0-30cm soil depths was lower in ZT than ST and TT by 0.06 and 0.17g/cm^3 and 0.09 and 0.14g/cm^3 on Apomu and Osun series, respectively, after cropping cycle. Zero tillage was higher in moisture content than ST and TT on both Apomu and Osun series by (10.83:11.67)% and (4.05; 8.77)%, respectively. The interaction between soil type and tillage had no significant effect on soil physical properties while it had effect on some soil nutrients: org. C, Ca, Mg, K and Zn. Although soil nutrients declined in all plots after cropping cycle but lowest declines were in ZT plot on both Apomu and Osun Series: Soil loss was higher in ST and TT than ZT by (56.27, 79.46)%, (30.36; 56.52)% on Apomu and Osun series, respectively. Corresponding runoff were (36.50; 52.38)% and (22.58; 26.52)% respectively for the Apomu and Osun series. Maize height, stem girth and leaf area index were in the following order: TT>ST>ZT on Apomu and Osun series with significant interaction ($P<0.05$). Maize grain yield was higher on TT than ST and ZT by (14.98; 11.56)% and (5.62; 15.08)% on Apomu and Osun series, respectively. Eroded soils and runoff water obtained from ST and TT plots were consistently richer in nutrient contents than ZT plots on both soil types. ZT could be a better option for soil and water conservation on Apomu and Osun series, which dominate the valley bottoms in Ibadan.

KEYWORDS: Soil series, tillage, crop yield, soil loss and runoff.

INTRODUCTION

Nigerian soils, as any other tropical soil, are inherently infertile. This is largely because they are highly weathered. They contain low activity clay minerals, which make them behave like sieves retaining little water during rainfall and irrigation. Also, the organic matter content, the seat of plant food, is very low and this confers a weak structure on the soils. Thus, the soils are fragile and their aggregates collapse readily under the impact of raindrops making them highly susceptible to soil erosion. More than 90 percent of Nigerian soils have suffered from variable degree of degradation (Babalola and Zagal, 2000). Spectacular gullies are the exhibits of erosion in south – eastern Nigeria. Annual soil loss from bare soils as high as 200 tons/ha and runoff representing almost 50% of the annual rainfall have been reported in Western Nigeria (Osuji, 1984). These values are modified to varying degrees in cropped lands depending on slope, extent of soil cover and soil management practices (Babalola, *et al.*, 2007)

CTA (1995) estimates indicated that more than 200 million landless people have migrated into the tropical forests and that this number is increasing annually. No doubt, the farmers can no longer give the land the usual ample period to fully recover or regenerate as fallow periods are now shortened to less than two years in most communities (Ndaeyo *et al.*, 1998). Organic matter and other nutrients in the soil are depleted and crop yields are on the decrease. Besides, various natural as well as institutional constraints also mitigate against rapid growth in the food production sector. Notably among these are vagaries of weather, lack or little use of inputs, and in -appropriate technology transfer. The uses of incompatible land management techniques have not only resulted in the emergence of degraded and marginal lands but also accentuates its occurrence. The dire need for the development of compatible tillage practice(s) is further justified by the fact that, in most African countries, growth in population coupled with urbanization and industrialization has largely reduced the available land for agricultural purpose (Isokrari, 1995). Moreover, these same phenomena have also placed more demand on agriculture for more food and industrial raw materials.

The World Bank (1992) also projected that an average annual food production increase of about 4% is needed for food sufficiency to be achieved in the foreseeable future. This means that the ever-decreasing available farmlands must be rejuvenated to produce more food than before in order to meet the ever-increasing food requirement of the populace. To achieve this requires an understanding of the relationship between soil properties and soil management (tillage). This study was therefore focused on the following objectives:

1. Assessment of the effect of soil type and tillage interaction on nutrient loss in surface runoff and eroded soil.
2. Evaluation of the effect of soil type and tillage interaction on the soil physico-chemical properties.
3. Evaluation of the effect of soil type and tillage interaction on the growth and yield of maize.

MATERIALS AND METHODS

The study was conducted at the valley bottom bounding the Faculties of Education and Agriculture and Forestry; the Department of Nursing and Benue Road, University of Ibadan, Ibadan extends from latitude 7^0 24^1N to longitude 3^0 54^1E. Ibadan is characterized by a rainfall average of 1229 mm per annum, with a bimodal distribution that peaks in June and September, respectively. There are 175 total wet days. Annual temperature ranges between 21.3^{0}C and 31.2^{0}C. It has percentage sunshine of between 16% in August to 59% in February and December, respectively, with an average of

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44% (FAO, 1990). The soil of the area is Oxic Paleustaff in the class Alfisol, according to the USDA classification and by the local classification; the soil belongs to the Apomu and Osun series (Smyth and Montgomery, 1962). The soil classification and hydrological properties of the Inland valley soils, which had been under continuous cultivation for about five years, are presented in Table 1 according to Akinbola and Kutu (1999).

Table 1: Soil classification and hydrological properties of the inland valley soils.

Soil Type	Classification USDA	FAO/UNESCO	Series	Hydrological Properties
I	Typic Tropoquent	Eutric gleysol	Apomu	Moderately well drained with mottle and gleyic properties at depth
II	Typic Tropoquent	Eutric gleysol	Osun	Poorly drained with mottle and gleyic properties at depth

Source: Akinbola and Kutu (1999)

The field experiment which lasted for four months (July – October) had plot size of 22 m x 5 m with three replications on each soil type. Plots that received ZT treatment had no mechanical manipulation of the soil. The herbicides used were Gramozone and Premextra, applied at 2 and 1.5 litres per hectare, respectively. The TT involved manual clearing followed by mounding with the use of the native hoe to simulate farmers' practice while ST involved covering of the soil surface with plant residue as described by Odigboh (1991). Soil sampling was done prior to tillage imposition at 0 – 30 cm soil depth after plot demarcation. Subsequent soil sampling was done on plot basis at the end of the experiment. Twelve samples bulked into one were made per plot. The sieved soil samples were analysed for pH in a 1:1 soil: Water ratio using the Coleman's pH meter. Organic carbon was determined by the Walkley and Black procedure (Nelson and Sommers, 1982). While total N was determined by the Microkjeldahl method (Bremmer, 1965). Available P was extracted by Bray's P1 method (Bray and Kurtz, 1945) and read on the Spectrophotometer. The exchangeable cations (K, Na and Ca) were determined by the flame photometer while Mg was read from the atomic absorption spectrophotometer (AAS). Mn, Zn, Cu and Fe were extracted with sodium bicarbonate and their concentrations determined on the AAS. The plots were sown to maize at 90 cm between and 30 cm within rows spacing. Three seeds were planted and later thinned to two plants per spot after germination. Soil and water runoff collecting devices were installed at the bottom of each plot using a 20-cm diameter pipe to convey water and eroded soil to calibrated oil drums, 90 cm high and 58 cm diameter located in the bottom trench. At the lower end of each plot, a trench measuring 2.5 m x 1.2 m x 1.5 m was dug to accommodate two drums with one serving as a runoff tank and the other as an overflow tank. The drums were covered to prevent direct rain falling into them. Runoff and soil loss data were collected after every major storm that caused erosion during the cropping cycle. The volume of runoff was estimated from the height of water in each drum and later converted to mm of water for each plot. Soil losses were collected, weighed wet and converted to oven-dry weights. An aliquot of one litre of the soil suspension was collected for chemical analysis. The pH was determined by the electrometric methods using the Coleman's pH meter. K was determined with the atomic absorption spectrophotometer while NO_3 – N and PO_4 –P were determined colorimetrically by the ascorbic acid-molybdate blue method (Murphy and Riley, 1962). Soil loss was analyzed for organic C, Total N, P, K, Ca, Fe, Cu and pH using standard procedures as described earlier for the respective elements.
Maize growth parameters determined include:

Plant height: Twenty seven maize plants were randomly tagged per plot and their heights measured from soil surface level to the tip of the longest leaf using a measuring tape graduated in centimeters.

Stem girth: this was measured at 10cm above the soil surface level using a flexible tape.

Leaf area index (LAI): This was determined on intact leaves first by determining the maize leaf area using the length – width (widest position) method described by Saxena and Singh (1965), that is, using the formula: Leaf area = 0.75 (L x W) where L = length of leaf and W = width of leaf. LAI was then calculated by dividing the total leaf area by the land area of the crop.

$$LAI = \frac{\text{Total leaf area}}{\text{Land area (planting distance)}}$$

Maize plant height, stem girth and LAI on each plot were all determined at 2,4,6, and 8 weeks after planting, while yield and yield parameters were determined at harvest at 13% moisture content.

Statistical analysis was carried out using Analysis of Variance, ANOVA, and the means that showed significant differences were further separated using Duncan Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Soil physical properties:

Table 2 shows the effect of soil type and tillage interaction on soil physico-chemical properties. At the end of experiment, the value of soil bulk density on ST and TT plots were higher than ZT plot by (2.00; 5.32)% and (2.71; 4.16)% on Apomu and Osun series respectively. The observed trend could be ascribed to the effect of settling and consolidation of the soil particles with time due to the raindrop impact on tilled plots. This is contrary to the findings of Agboola (1981) in which there were no significant changes in the bulk density of the soil under the various tillage treatments [zero, minimum and conventional] at 0 – 30 cm depth in southwestern Nigeria. Soil total porosity values on ZT plots were higher than ST and TT treatments by (2.68; 8.05)% and (4.52; 7.21)% on Apomu and Osun series, respectively. (Table 2). The soil moisture content differed significantly ($p<0.05$) among tillage practices only on Apomu series after the cropping cycle. The value of moisture content obtained from ZT on Apomu series was higher than TT and ST by 11.68% and 10.83%, respectively. Similarly, moisture content value obtained from ZT on Osun series was higher than TT and ST by 10.13% and 4.06%, respectively. This could be ascribed to higher organic matter in ZT than ST and TT on Apomu and Osun series. Lal (1986) found that zero tillage had higher soil moisture content in the profile than ploughed plots and attributed this to the soil moisture reserve through a reduction in losses due to surface runoff and evaporation.

Table 2: Effect of soil type and tillage interaction on soil physical properties at the end of experiment.

Soil type	Tillage practice	Bulk density (g cm^{-3})	Total porosity (%)	Moisture content (%)
Apomu series	ST	1.57a	40.75a	11.20a
	TT	1.68a	36.60a	11.01a
	ZT	1.51a	43.01a	13.92b
	Mean	1.58	40.12	12.04
Osun series	ST	1.70a	35.84a	9.97a
	TT	1.75a	33.96a	8.82a
	ZT	1.61a	39.24a	10.81a
	Mean	1.68	36.34	9.86
Soil type (A)		1.65ns	4.32ns	2.54ns
Tillage (B)		2.14ns	3.87ns	27.42*
A x B		2.67ns	2.16ns	3.46ns
CV %		11.69	11.57	6.84

* = Significant, ns = not significant
Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range.

Soil Chemical Properties

Soil pH was only significantly affected by soil types at the end of maize growing season (Table 3). Although soil pH on all treatments on either Apomu or Osun series were not significantly difference but the lowest values of pH were obtained from TT plots on both soil series. This can be due to higher losses of surface runoff water and soil exchangeable cations on TT plots. This is contrary to Agboola (1981) that found a decrease in pH values generally among the tillage practices examined. The value of soil organic C was highest in ZT plot (30.80g/kg) and this value was higher than ST and TT by 4.22% and 4.05%, respectively on Apomu series. On Osun series, soil organic C value was also highest in ZT plot (17.20g/kg) and this value was higher than ST and TT plots by 7.50% and 8.16%, respectively. Relative to initial organic C status (31.30g/kg) at the beginning of experiment on Apomu series, the value of SOC decreased on ST, TT and ZT plots by 3.00%, 2.90% and 0.50%, respectively, while on Osun series which was initially untilled [17.50g/kg], SOC was reduced on ST, TT, and ZT plots by 2.70%, 2.90% and 0.30%, respectively.

The total N, P and Ca, were not significantly different among the treatments on either Apomu or Osun series, but Apomu series was significantly (p<0.05) higher in total N, P and Ca than Osun series by 23.95%, 68.09% and 36.53%, respectively (Table 4). The interactive effect of soil type and tillage practices was not significantly different (p<0.05) for N and P (Table 3). When total N contents from Apomu series at the end of growing season were compared with the base-line total N, TT, ST, and ZT plots decreased by 0.50, 0.40, and 0.10%, respectively. While on Osun series, total N contents decreased on TT, ST, and ZT plots by 0.25, 0.15 and 0.05%, respectively. The loss was accelerated in tilled plots than ZT plots due to impact of soil erosion and use which directly or indirectly influence SOC and total N in tropical areas. The concentration of K contents on ZT plots after the growing season was higher in value than on ST and TT plots by 15.07 and 22.58%, respectively on Apomu series, whereas ST had the highest value of K (0.09g/kg) and this was higher than the value obtained from ZT and TT by 5.88% and 12.50%, respectively on Osun series.

Relative to initial K at the beginning of the experiment on Apomu series, ST, TT and ZT plots decreased in K contents by 0.06%, 0.08% and 010%, respectively. Similarly, the value of K on Osun series decreased on ST, TT and ZT plots by 0.11%, 0.13% and 0.12%, respectively. The value of K dropped more in the tilled plots than ZT plots and this could be due to leaching from the upper soil horizon in the tilled soil. The values of Mg contents from ST and ZT plots were significantly (P<0.05) higher than ST plots by 79.76% and 81.89%, respectively on Apomu series while the reduction of Mg remained the same for all treatments at the end of experiment (Table 3). When Mg contents (1.00g/kg) from the soil at the beginning of experiment was compared with final values of Mg for all treatments, ST, TT and ZT plots decreased by 0.91%, 0.20% and 0.10%, respectively on Apomu series while a decrease of 0.10% occurred in all plots on Osun series (Table 4). The loss of Ca and Mg could be linked to leaching, uptake by the crop and loss in the eroded soil sediments and surface runoff water, which were more in tilled plots than ZT plot.

The micronutrients (Mn, Fe, Zn and Cu) varied in some plots but showed no definite trend (Table 2). The decline observed in some of the micronutrients was probably due to loss of soil organic matter particularly in the tilled treatments, as reported by Eneji *et al.*, (1997).

Table 3: Effects of soil type and tillage interaction on soil nutrient status at end of experiment

Soil type	Tillage	pH	Org.C (g/kg)	Total N (g/kg)	Avail.P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (g/kg)	K (g/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Apomu series	ST	6.00a	28.30a	2.30a	240.00a	2.80a	0.09a	0.60a	0 14a	749.00	282.40a	16.70a	202.10a
	TT	6.10a	28.40a	2.30a	240.00a	2.60a	0.80b	0.60a	0 12a	755 20	290.10a	15.40a	205.50a
	ZT	6.20a	30.80a	2.20a	240.00a	2.95a	0.90b	0.50a	0.19b	756.00	282.90a	16.60a	224.70b
Mean		6.10	29.16	2.20	240.00	2.78	0.59	0.56	0.15	753.40	285.13	16.23	210.76
Osun series	ST	4.00b	14.80b	1.35b	42.70b	1.60b	1.00b	0.52a	0.09c	102.02b	290.82a	17.20a	24.98c
	TT	4.00b	14.60b	1.25b	46.52b	1.20b	1.00b	0.65a	0.07c	112 31b	298.40a	19.45a	25.11c
	ZT	4.10b	17.20b	1.45b	47.50b	2.00b	1.00b	0.45a	0.08c	98.95b	293.22a	16.20a	26.21c
Mean		4.03	15.53	1.35	45.57	1.60	1.00	0.54	0.08	104.42	294.14	17.61	25.43
Soil type (A)		49.72*	95.48*	11.06*	342.14*	8.62*	1.23ns	1.11ns	3.55*	811.26*	46.24ns	9.42ns	6.49*
Tillage practice (B)		2.11ns	11.22ns	1.23ns	39.24ns	5.45*	2.89*	2.01ns	2.48*	69.42ns	31.22ns	6.31ns	89.02*
A x B		4.67ns	43.08*	1.37ns	21.43ns	7.11*	4.43*	1.72ns	2 91*	87.20ns	51.45ns	6.22ns	112.56*
CV%		13.48	15.67	10.49	9.45	6.72	14.14	18.07	6 71	15.01	19.11	13.4b	7.45

* = Significant (P<0.05), ns = not significant (P<0.05)
Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test.

Table 4: Magnitude of change *(%) in nutrient status as affected by tillage practices at end of cropping cycle at 0-30cm soil depth.

Soil type	Tillage practices	pH	Org. C	Total N	Av P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn
Apomu soil	ST	-0.20	-3.00	-0.40	-1 00	-0.06	-0.20	-0.91	+0.10	-7 90	-16.00	-0.80	-3.90
	TT	-0.10	-2.90	-0.50	-1.00	-0.08	-0.40	-0.20	+0.10	-1 80	+61 00	-1.10	-0.10
	ZT	0.00	-0.50	-0.10	-1 00	-0.01	-0.50	-0 10	+0.00	-1 00	-11 00	+0.10	+19.3
	Mean	-0.1	-1.23	-0.33	-1.00	-0.05	-0.21	-0.40	+0.06	-3.56	+11 33	-0.60	+5.10
Osun series	ST	-0.20	-2.70	-0.15	-6.20	-0.11	-0.40	-0.10	+0.12	+64 20	+28.50	+1.00	+35.3
	TT	-0.20	-2.90	-0.25	-2.38	-0.13	-0.80	-0.10	+0.25	+167.10	+14.30	+3.25	+36.6
	ZT	-0.10	-0.30	-0.05	-1.40	-0.12	0.00	-0.10	+0 05	+33.5	-37.50	0.00	+47.6
	Mean	-0.16	-1.96	-0.15	-3.32	-0.12	-0.40	-0.10	+0.14	+88.26	+1.76	+1.41	+39.83

(-) decrease
(+) increase
(*) changes are relative to pre-tillage imposition levels.

Runoff and Soil Loss

For four months rainfall events during which runoff and soil loss were measured before the rains ended, the beneficial effect of soil type and tillage interaction was clearly evident (Table 5). The mean runoff, as percentages of total rainfall were 11.02, 17.58, and 5.49% for ST, TT and ZT plots, respectively on Apomu series and 15.66, 17.03 and 9.89% for ST, TT and ZT plots, respectively on Osun series. However, runoff was significantly lower on ZT than ST and TT by (36.50; 52.38)% and (22.58; 26.52)% on Apomu and Osun series, respectively. Similar report was made by Lal (1986) where Zero tillage system used on structurally weak Alfisols was found to be a promising alternative to conventional tillage as it reduced erosion and improved water conservation.

The corresponding soil loss was significantly lower in ZT than in ST and TT by (56.27; 79.46)% and (30.36; 56.52)% on Apomu and Osun series, respectively (Table 5). This agrees with the finding of Lal (1982) that zero tillage, unlike conventional tillage prevents runoff and erosion, as well as maintains soil organic matter content. The mean concentration of NO_3 – N from runoff water was significantly (P<0.05) higher on TT plots than ST and ZT by 10.0% and 25%, respectively on Apomu series. On Osun series, average NO_3 – N concentration values were higher in runoff obtained from TT plots than ST and ZT plots by 33.32% and 50.00%, respectively. The mean concentration values of PO_4 – P obtained from runoff in TT plots were higher than ST and ZT plots by 33.33% and 14.29%, respectively on Apomu series. For Osun series, average PO_4 – P concentration obtained from ZT plot was lower than TT and ST by 77.79% and 50.00%, respectively. The mean K was also lower in runoff concentration on ZT plots than TT and ST plots on both soil series.

The chemical analysis of the eroded soils (Table 7) showed consistently higher macronutrient values (organic carbon, total nitrogen, phosphorus, potassium and calcium) in ST and TT plots than ZT plots on both soil series. The total nitrogen concentration in soil loss was significantly (P< 0.05) higher on TT plots than ST and ZT plots by 18.37% and 38.92%, respectively on Apomu series. On Osun series, the highest concentration (1.84kg/ha) obtained was from TT plot and this was higher than values obtained from both ST and ZT plots by 28.67% and 44.31%, respectively. Organic C from soil loss was higher on TT plot than ST and ZT plots by 17.15% and 32.89%, respectively on Apomu Series. Similar results were obtained on Osun series where the value of C from soil ion on TT (18.40kg/ha) was higher than in ST and ZT plots by 24.67% and 45.75%, respectively. The mean P obtained From soil loss was highest in TT (10.20kg/ha) and this Value was higher than ST and ZT by 9.39% and 27.39% respectively, on Apomu series The value of P from soil loss was significantly (P<0.05) higher on TT plot than ST and ZT by 11.67% and 9.29%, respectively on Osun series. The interactive effect of soil type and tillage was only significant (P<0.05) for N, C and P. The concentrations of N, C and P obtained from soil loss were significantly higher on TT than ST and ZT on both Apomu and Osun series because the ST surface was protected by mulch from direct impact of rain drops and ZT remained undisturbed. For micronutrients, no significant difference was observed among the treatments.

Table 5: Effects of interaction between soil type and tillage practices on soil loss (kg/ha) and run off (mm)

Soil type	Tillage practice	Rainfall (mm)	Soil loss**	Run off**	Run off tilled treatment as percentage of zero tillage
Apomu series	SM	364	390.00a	43.00a	215.00
	TT	364	954.00b	64.00b	320.00
	ZT	364	109.25c	20.00c	-
Osun series	SM	364	936.00b	57.00b	158.33
	TT	364	1,800.00d	62.00b	172.22
	ZT	364	500.00a	36.00ac	-
Soil type (A)			242.47*	435.75*	
Tillage practice (B)			960.20*	160.13*	
A x B			351.64*	250.36*	
CV %			10.11	8.56	

** Measurements commenced at 1 month after planting, * = Significant (P<0.05)
Within the same column, values followed by the same letters are not significantly (P<0.05) different using Duncan's Multiple Range Test.

Table 6: Effects of interaction between soil type and tillage practices on soil nutrient loss in runoff water (g/ha)

Soil type	Tillage practice	pH	NO_3-N	PO_4-P	K
Apomu series	ST	6.54a	0.11a	0.02a	0.04a
	TT	6.72a	0.15a	0.04a	0.05a
	ZT	6.30a	0.09b	0.03a	0.02a
Osun series	ST	5.20b	0.04bc	0.03a	0.03a
	TT	5.30b	0.06b	0.08b	0.05a
	ZT	5.25b	0.02c	0.01a	0.03a
Soil type (A)		6.72*	8.21*	7.35*	1.47ns
Tillage (B)		5.40ns	11.43*	9.08*	2.51ns
A x B		6.63*	6.47*	4.56*	1.88ns
CV%		6.65	12.20	9.47	17.28

* = Significant (P<0.05), ns = not significant (P<0.05)
Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test.

Table 7: Effects of soil type and tillage interaction on soil nutrient loss [kg/ha]

Soil type	Tillage practice	pH	Total Nitrogen	C	P	K	Ca	Fe	Cu
	ST	6.12a	1.60a	22.80a	8.45a	2.35a	2.17a	0.61a	0.05a
Apomu	TT	6.00a	2.32b	32.24b	10.20a	3.15a	2.29a	0.76a	0.05a
series	ZT	6.12a	1.02a	15.80c	5.815b	2.92a	1.64a	0.83a	0.04a
	ST	5.00a	1.02a	11.12a	11.12a	1.29a	1.26a	2.43b	0.51b
Osun	TT	5.00a	1.84ab	18.40ac	14.06c	2.05a	1.48a	2.00b	0.52b
series	ZT	5.00a	0.71a	6.85d	11.67a	1.03a	1.13a	2.11b	0.51b
Soil type (A)		3.25ns	15.61*	84.34*	48.63*	1.24ns	1.36ns	24.59*	14.34*
Tillage (B)		2.13ns	14.31*	52.00*	26.17*	3.11ns	2.64ns	4.12ns	2.47ns
AxB		4.70ns	14.69*	67.43	31.44*	2.73ns	2.01ns	16.73*	4.05ns
CV%		8.46	10.57	14.52	6.62	11.48	9.02	15.72	6.78

* = Significant, ns = not significant.
Means of the same letters are not significantly different from each other according to Duncan's Multiple Range Test at 5% probability level.

Maize Growth and Yield

The plant heights were consistently higher on TT plot than ST and ZT on Apomu and Osun series throughout the study period (Table 8). On the average, the highest plant height (89.44 cm) was obtained from TT on Apomu series and this value was significantly (p< 0.05) higher than the values obtained from both ST and ZT (Table 8) by 16.12% and 1692%, respectively. On Osun series, the highest plant height (58.08 cm) was obtained from TT plot and this value was also significantly (p<0.05) higher than the values obtained from both ST and ZT by 10.12% and 15.36%, respectively. Soil type and tillage method interaction on plant height was significant (p<0.05) at 4, 6 and 8 WAP (Table 8). Similarly, mean stem girth was significantly higher on TT plot than on ST and ZT plot on both Apomu and Osun series (Table 9). The interaction between soil type and tillage methods on stem girth was significant (p<0.05) at 4, 6 and 8 WAP. However, soil type and tillage interaction on leaf area index (LAI) did not show any significant difference except at 8WAP. On the average, the highest LAI of 0.33 obtained from TT plot was higher than ST and ZT on Apomu series by 18.18% and 20.36%, respectively, while on Osun series, LAI from TT (0.23) was higher than ST and ZT by 15.00% and 18.70%, respectively. The higher plant height, stem girth and leaf area index under TT management was the result of improved soil conditions (better water percolation and air circulation), which brought about quick seed emergence and root establishment.

The mean yield components (stovers, undehusked cob and dehusked cob yields) were consistently higher in TT than ST and ZT on both soil series. On the average, the highest grain yield (1.88t/ha) was obtained from TT on Apomu series and this value was higher than ST and ZT by 14.98% and 11.58%, respectively. However, on Osun series, the highest grain yield of 1.22t/ha was also obtained from TT, which was higher than ST and ZT by 5.62% and 15.08% respectively. This difference was attributed to a better soil condition for plant growth and development under traditional tillage systems. However, Aiyelari *et al.*. (1998) reported no significant differences among the tillage practices considered [zero, ridging, mounding, minimum and conventional tillage] in southwestern Nigeria. They attributed this to the availability of soil moisture throughout the study period.

Table 8: Effects of soil type and tillage interaction on maize height (cm)

Soil type	Tillage practice	Weeks After Planting [WAP] 2	4	6	8	Mean
Apomu series	ST	21.12a	51.32a	81.59a	104.36a	64.59
	TT	25.04a	81.12b	110.03b	141.57b	89.44
	ZT	23.55a	59.46a	78.52a	93.63a	40.38
	Mean	23.23	63.96	90.04	113.18	
Osun series	ST	21.10a	34.73c	60.37c	73.37c	47.39
	TT	25.89a	49.92a	68.53ac	88.01a	58.08
	ZT	21.08a	32.13c	48.53d	68.68c	42.06
	Mean	22.69	38.92	59.14	76.68	
Soil type (A)		3.97ns	531.50*	672.98*	724.73*	
Tillage (B)		2.31ns	205.88*	96.90*	80.50*	
AxB		2.36ns	423.08*	98.32*	451.30*	
CV%		10.46	7.20	13.92	5.32	

* = Significant (p<0.05), ns = not significant (p<0.05)

Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test.

Table 9: Effects of soil type and tillage interaction on maize stem girth (cm).

Soil type	Tillage practice	Weeks After Planting [WAP] 2	4	6	8	Mean
Apomu series	ST	1.42a	4.31a	5.94a	8.16a	4.95
	TT	1.58a	5.58b	6.02a	10.24b	5.85
	ZT	1.25a	4.17a	4.75b	7.39a	4.39
	Mean	1 42	4.68	5.57	8.59	
Osun series	ST	1.28a	4.22a	4.48b	6.26ab	4.06
	TT	1.05a	4.88b	5.25ab	7.32a	4.62
	ZT	0.95a	3 18c	4.13b	6 00ab	3.56
	Mean	1.09	4.09	4.62	6 53	
Soil type (A)		2.63ns	9,38*	31.40*	43 66*	
Tillage (B)		1.54ns	9.50*	9.87*	16.85*	
A x B		2.77ns	17.37*	8.52*	25.79*	
CV %		12.69	4.74	9.54	5.96	

Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test

* = Significant, ns = not significant

Table 10: Effects of soil type and tillage interaction on maize leaf area index

Soil type	Tillage practice	Weeks After Planting [WAP] 2	4	6	8	Mean
Apomu series	ST	0.01a	0 11a	0.33a	0.45a	0.225
	TT	0.02a	0.14a	0.46a	0.68b	0.325
	ZT	0.01a	0.14a	0.30a	0.41a	0.21520
	Mean	0-.01	0 13	0 36	0.51	
Osun series	ST	0.01a	0.11a	0.24a	0.32a	0 1715
	TT	0.01a	0.13a	0.32a	0 46a	0 23
	ZT	0.01a	0.11a	0 11a	0 30a	0.1575
	Mean	0.01	0.12	0.22	0.36	
Soil type (A)		1.08ns	1.91ns	2.12ns	027ns	
Tillage (B)		1.16ns	1.31ns	1.03ns	8.03*	
AxB		1.02ns	1.98ns	2.13ns	2.23ns	
CV %		13.20	3.88	9.16	3.95	

Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test.

* = Significant, ns = not significant

Table 11: Influence of interaction between soil type and tillage practices on maize yield parameters (t/ha)

Soil type	Tillage practice	Stover	Undehusked cob	Dehusked cob	Grain yield
Apomu series	ST	4.24a	2.79a	1.97a	1.39a
	TT	5.06a	3.59a	2.65b	1.88a
	ZT	4.36a	2.92a	2.24ab	1.49a
	Mean	4.55	3.10	2.28	1.58
Osun series	ST	3.65b	2.41b	1.12c	1.09b
	TT	3.89b	2.69ab	1.79ab	1.22ac
	ZT	3.35b	2.16b	1.09c	0.90b
	Mean	3.63	2.42	1.33	1.07
Soil type (A)		64.40*	115.29*	98.96*	78.67*
Tillage practice (B)		1.93ns	3.22ns	10.95*	4.10ns
A x B		10.57*	18.27*	15.46*	17.64*
CV %		4.86	13.50	16.04	6.55

Within the same column, values followed by the same letters are not significantly different at P<0.05 using Duncan's Multiple Range Test.
* = Significant, ns = not significant

SUMMARY AND CONCLUSION

Soil nutrients declined in all tillage treatments after cropping cycle but lowest declines were in ZT plot on both Apomu and Osun series. Tillage practices did not significantly affect physical properties such as bulk density, total porosity and moisture content after cropping cycle. However, higher bulk density was observed on ST and TT than ZT on both soil series, while moisture content was higher in ZT than ST and TT on Apomu and Osun series.

Mean runoff was significantly lower in ZT than ST and TT by (36.50; 52.30%) and (22.58; 26 .52%) on Apomu and Osun series, respectively. Corresponding soil losses were (56.27; 79.46%) and (30.36; 56.52%) respectively. The chemical analysis of the runoff and eroded soils showed consistently higher values of macronutrients in ST and TT plots than ZT plots on both soil series. However, crop yield increased in TT than ST and ZT by (14.98; 11.58%) and (5.62; 15.08%) on Apomu and Osun series, respectively.
In spite of this, TT was associated with higher runoff and soil loss and rapid deterioration of soil properties with soil exposure. Therefore, zero tillage could be a better option for soil and water conservation on both Apomu and Osun series.

There is however the need to develop tools and labour management techniques that will boost crop and soil productivity under zero tillage.

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