J. Agric. Food. Tech., 1(6) 94-100, 2011

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ISSN 2090 – 424X
Journal of Agriculture and Food Technology
www.textroad.com

Effect of Tillage Techniques on Soil Properties, Nutrient Uptake and Yield of Yam (*Dioscorea Rotundata*) on an Alfisol in Southwestern Nigeria

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ABSTRACT

Researches into optimum production of yam in Nigeria cannot be underestimated as a result of the significant roles it performs in solving the problems of hunger in the country. Field experiments were conducted to investigate the effect of five soil tillage techniques namely ploughing (P), ploughing plus harrowing (PH), manual ridging (MR), manual heaping (MH) and zero-tillage (ZT) on the soil properties and yam performance in Ondo, southwestern Nigeria for two farming seasons (2007 and 2008). Experimental design used was randomized complete block with each treatment replicated three times. Soil physical characteristics were measured at 4-weeekly intervals and for 20 weeks. Yam tuber yield parameters were measured at harvest. Post harvest soil chemical characteristics and leaf nutrients concentration were determined. Data obtained were subjected to analysis of variance using SAS Institute Package. Soil moisture content, bulk density and total porosity were significantly (P>0.05) influenced by soil tillage techniques. Zero tillage plots had the highest soil bulk density, moisture content and the least total porosity. Manually heaped and ridged plots had the lowest soil bulk density, moisture content and highest total porosity. Soil nutrients status were better enhanced in zero-tillage plots in terms of soil organic matter, available P, exchangeable Ca, exchange acidity, Mn and Zn. The soil total N, exchangeable Mg, K, base saturation and CEC were better enhanced in manually tilled plots. Soil nutrients status reduced at the end of the second cropping for all the tillage techniques investigated in the order of PH>P>MH>MR>ZT. Yam leaf nutrients concentration and tuber yield were better enhanced in tilled plots than zero-tillage plots. Yam tuber yield could not entirely be related to differences in soil chemical properties caused by the tillage techniques investigated. It is concluded that yam production on Alfisols in the southwestern Nigeria requires tillage and loose soil structure for tuber development.

Key words: ploughing, harrowing, manual, zero tillage, moisture, temperature.

INTRODUCTION

It is the goal of many Nigerian farmers to produce sustainable high yield of crop [1] among which include yam, cassava and maize. It is established fact that Nigeria produces over 70% of yam in the world [2]. Even with this large production, most of the produce is consumed locally while little quantity is left as export crop; showing its value for the country producing it. Inappropriate farm practices such as tillage are major constraints to yam production in Nigeria.

Many researches had been conducted on tillage technique of various crops [3], [4] and [5]. In Nigeria, researches on the response of yam to soil tillage techniques produced inconclusive and controversial results. For instance, Odjugo, [6] found that zero tillage reduced yield when compared with ploughing.. Onwueme, [7] found no significant difference in yam tuber yield between planting on mounds and ridges while Agbede and Ojeniyi [8] reported that mounding produced higher tuber weight and tuber length compared with ridging. Conservation tillage is better than mould board plough[9]. Vine et al, [10] reported that mounding or ridging delayed emergence and vine length and caused slumping and compaction of the soil after rain storms. Zero and manual tillage techniques are the commonest planting system among yam growers in Nigeria while ridge tillage techniques restricted to research stations [11].

With these controversial and conflicting research results, there is need to conduct research into the appropriate tillage technique that would result in optimum production of yam in southwestern Nigeria. Hence, the objective of this study was to determine the effect of tillage techniques on soil properties and yam performance on an Alfisol in southwestern Nigeria.

MATERIALS AND METHODS

Field Experiment

The investigation involved five soil tillage techniques namely plough alone (P), ploughing plus harrowing (PH), manual heaping (MH), manual ridging (MR) and Zero tillage (ZT). The experiments were located in Ondo, Southwestern Nigeria.

The experimental design used was randomized complete block. A total land area of 55m by 35m was marked out for the experiment and the land area was divided into three blocks; adjacent blocks were demarcated by 5 metre alley ways. Each block was further divided by into five plots of 5m by 5m and the plots were also demarcated by 5m alley ways. Each tillage technique was replicated three times, the field investigations were carried out in two farming seasons (2007 and 2008) using the same treated plots. Yam setts were cut and measured with weighing balance. The size of the yams were 300 g each and planted at a spacing of 1m by 90 cm. staking was done as the vines started to crawl on the land in order for the leaves to be adequately exposed to sunlight for photosynthesis. Manual

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weeding was used to control weed at 4, 8, 12, 20 and 24 weeks after planting (WAP).

Determination of Soil Properties
Soil bulk density, total porosity, temperature and moisture content were determined as described elsewhere by Adeleye and Ayeni, [12]. At harvest, surface soil samples (0 -15cm) were collected on treatment basis, air dried and chemically analyzed. The soil pH was determined in 1:2 soil - water ratio using glass electrode pH metre. Organic carbon, total N, available P, exchangeable cations (Ca, K, Mg, Na), exchangeable acidity and the micronutrients were determined following the procedures outlined by AOAC [13]. Cations were determined by the summation of NH_4-OAc-eaxtractable cations and KCl-exchange acidity.

Determination of yam leaf nutrient content
Mature leaves were collected on treatments basis after five months of planting, oven dried at 65°C for 48 hours. Leaf N, P. K, Ca and Mg were determined as described by AOAC[14] and read with Perkin Elmer Atomic Absorption Spectrophotometer.

Yam Tuber Yield Data

At harvest, ten yam stands were selected on treatment basis for the measurement of yam tuber yield parameters. Yam tuber weight was weighed using a weighing balance, yam tuber length and tuber girth with a measuring tape.

Data Analysis
Data on the soil physical, soil chemical, leaf nutrient contents and yam tuber yield were subjected to analysis of variance using statistical analysis system Institute Package (SAS) and the mean values were compared using Duncan's Multiple Range Test at 0.05% level of significance, where F-ratio was significant.

RESULTS

Table 1 shows the effect of tillage techniques on soil moisture content. The data in the table indicated that there were significant differences (p>0.05) in soil moisture content due to tillage techniques. The highest soil moisture content was obtained in zero tillage plots at both planting seasons while the least soil moisture content was obtained in manually ridged plots. The soil moisture content at first cropping (2007) was significantly higher than the second cropping season (2008) in all the tillage techniques in the study.

Table 1: Effect of Tillage Techniques on Soil Moisture Content (g kg-1)

Treatments	4 WAP		8 WAP		12 WAP		16 WAP		20 WAP	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT	72.35a	69.67a	79.51a	58.50a	116.60a	88.50a	120.51a	114.13a	97.24a	**60.51a**
P	60.74b	57.50b	58.55c	47.42b	78.50c	71.33b	108.40c	92.60b	62.93c	**51.23a**
PH	68.15b	61.67a	68.24b	56.41a	88.33b	81.50a	118.51b	99.73b	77.29b	**59.11a**
MR	50.20c	48.71c	48.45d	41.79b	69.20d	62.10c	81.24d	82.10c	56.80c	**48.12b**
MH	**52.45c**	**53.41b**	**55.21c**	**48.12b**	**76.37c**	**64.80c**	**83.76d**	**88.12c**	**61.63c**	**50.91b**

Means with the same letter in the same column are not significantly different at 5% level using DMRT
ZT = zero tillage. P = ploughing alone; PH = ploughing plus harrowing; MR = manual ridging; MH = manual heaping; WAP = week after planting

Table 2 shows tillage effect on soil temperature. Zero-tillage plots had the lowest soil temperature compared to other tillage techniques in the study at both cropping seasons. Manually heaped and ridged plots had higher soil temperature compared to zero-tillage and ploughed plus harrowed plots. At both cropping seasons, soil temperature decreased as from 12 weeks after planting in all the tillage techniques and this pattern was observed till week 20 after planting. There was no significant difference in soil temperature of ploughed, manually ridged and heaped plots.

Table 2: Effect of Tillage Techniques on Soil Temperature (^{0}C)

Treatment	4 WAP		8 WAP		12 WAP		16 WAP		20 WAP	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT	33.1a	33.7a	34.4a	32.9b	31.3b	29.9d	30.8c	30.2a	30.2b	**29.7a**
P	33.1a	34.1a	34.8a	33.3b	32.5a	30.3c	32.8b	30.8a	30.9a	**30.2a**
PH	33.2a	33.8a	34.6a	33.1b	31.8b	30.7c	32.5b	29.9a	30.0b	**30.2a**
MR	34.5a	34.8a	35.9a	34.1a	32.6a	31.6b	33.1a	31.4a	31.6a	**30.5a**
MH	**33.8a**	**34.3a**	**35.2a**	**34.6a**	**32.5a**	**32.2a**	**33.5a**	**30.0a**	**31.1**	**30.8a**

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 3 shows the effect of tillage techniques on soil bulk density. Tillage effect on soil bulk density was significant (p>0.05). Soil bulk density increased with increase in time after planting at both cropping seasons. This increase in bulk density was more pronounced in ploughed plus harrowed plots. The soil bulk densities of plots under the various tillage techniques at second cropping (2008) were relatively higher than the values obtained at the first cropping (2007). The soil bulk density at the second cropping (2008) increased by 11.56%, 13.24%, 15.10%, 8.85% and 7.56% over the first cropping (2007) soil bulk density values for zero-tillage, ploughed plus harrowed, manually heaped and ridged plots respectively. Zero-tillage plots for the two cropping had the highest mean soil bulk density value (1.55 g cm^{-3}) and the least mean value of soil bulk density (1.43 g cm^{-3}) was obtained in manually heaped plots and this was closely followed by manually ridged plots (1.45 g cm^{-3})
Table 4 shows the influence of tillage techniques on soil total porosity. Zero-tillage plots at both cropping seasons had the least soil total porosity while the highest soil total porosity was

obtained in manually heaped plots. Higher soil total porosity was obtained in the first cropping (2007) compared to the second cropping (2008), at both cropping seasons, soil total porosity decreased with increase in time after planting. There was no significant difference in soil total porosity between manually heaped and manually ridged plots.

Table 3: Effect of Tillage Techniques on Soil Bulk Density (g cm^{-3})

Treatment	4 WAP		8 WAP		12 WAP		16 WAP		20 WAP	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT	1.37a	1.52a	1.46a	1.65a	1.48a	1.65a	1.51a	1.67a	1.51a	1.70a
P	1.31c	1.46b	1.37c	1.63a	1.39b	1.62a	1.42b	1.61b	1.46b	1.68a
PH	1.35b	1.48b	1.40b	1.63a	1.42a	1.62a	1.47b	1.66a	1.51a	1.68a
MR	1.30c	1.43c	1.33d	1.55b	1.36b	1.57b	1.39c	1.57c	1.43b	1.60b
MH	1.31c	1.40c	1.34d	1.52b	1.34b	1.53b	1.36c	1.54c	1.40b	1.55c

Means with the same letter in the same column are not significantly different 5% level using DMRT

Table 4: Effect of Tillage Techniques on Soil Total Porosity (%)

Treatment	4 WAP		8 WAP		12 WAP		16 WAP		20 WAP	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT	48.30b	42.64c	44.91d	37.74c	44.15d	37.73d	43.01d	36.98c	43.02c	35.85c
P	50.57a	44.91b	48.30b	38.49b	47.55a	38.97c	46.42b	39.25b	44.91b	38.87b
PH	49.06b	44.15b	47.16c	38.49b	46.42c	38.87c	44.53c	37.36c	43.02c	36.60c
MR	50.94a	46.04a	49.81a	41.51a	48.68a	40.75b	47.55a	40.75a	46.04a	39.62a
MH	50.19a	47.17a	49.43a	42.64a	49.43a	42.26a	48.68a	41.89a	46.97a	41.51a

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 5 and 6 show effects of tillage techniques on soil chemical characteristics at the end of 2007 and 2008 cropping respectively. Tillage had significant different treatment effects on soil chemical characteristics determined. At the end of the first cropping, zero-tillage plots had the highest soil pH, organic matter content (OM), available P, exchangeable Ca. Ploughed plots had the highest exchangeable Mg and K. At the end of the second cropping (Table 6), zero-tillage plots had the highest soil pH, OM, total N, available P and percent base saturation. Ploughed combined with harrowed plots had the lowest total N, available P, percent base saturation; highest exchangeable K and exchange acidity. There were no significant differences in soil chemical characteristics of manually heaped and ridged plots in terms of soil pH, total N, available P, exchangeable Ca, K and exchange acidity. Soil fertility status as indicated by soil pH, organic matter, total N, available p, exchangeable Ca and K declined at the end of the second cropping (Table 6) in all the tillage techniques investigated, however, the decline was more pronounced in ploughed plus harrowed plots.

Tables 5: Effect of Tillage Techniques on Some Soil Chemical Properties at First Cropping (2007)

Treatments	PH	Org. M	TOT.N	AV.P	Ca	Mg	Na	K	Ex.Ac	CEC	Base sat.	Mn	Fe	Cu	Zn
	H2O	%	%	mg kg-1			c molkg-1				%		mg kg-1		
ZT	6.43a	3.50a	0.46a	71.60a	0.84b	1.28b	0.49b	0.18b	0.40	3.19b	87.4b	0.05a	6.70b	2.33c	8.50c
P	6.39a	3.`7b	0.49a	40.29b	1.09a	1.48a	0.55a	0.26a	0.35a	2.52c	86.02b	0.05a	6.55b	3.97a	9.35b
PH	6.35a	3.14b	0.44a	69.45a	0.81b	1.20b	0.59a	0.17b	0.35b	3.73a	90.62a	0.05a	6.46b	3.15b	10.10a
MR	6.07b	2.98c	0.43a	16.17c	0.89b	1.28b	0.57a	0.17b	0.38a	3.81a	90.03a	0.04a	6.85b	3.00b	7.96c
MH	6.27ab	3.01b	0.47a	68.81a	0.81b	1.11c	0.58a	0.17b	0.35b	3.01b	88.37b	0.06a	7.45a	3.15b	7.99c

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 6: Effect of Tillage Techniques on Some Soil Chemical Properties at Second Cropping (2008)

Treatments	PH	Org. M	TOT.N	AV.P	Ca	Mg	Na	K	Ex.Ac	CEC	Base sat.	Mn	Fe	Cu	Zn
	H2O	%	%	mg kg^{-1}	---------------------c molkg^{-1}-------------------------						%	------------mg kg^{-1}-------------			
ZT	6.50a	3.40a	0.46a	33.84a	0.75b	1.77a	0.68a	0.17b	0.35c	3.72b	90.59a	4.68a	5.53b	3.70a	9.48a
P	6.33a	2.79b	0.39b	37.40a	0.93a	1.55b	0.61bc	0.14b	0.65b	3.88b	83.24b	4.76a	5.80b	2.93c	8.71b
PH	5.81b	2.76b	0.39b	11.90b	0.98a	1.24c	0.68a	0.28a	1.05a	4.23a	75.17c	4.03b	6.80a	3.28b	9.33a
MR	5.96b	2.21c	0.43a	14.91b	0.83a	1.82a	0.58c	0.16b	0.60b	3.39c	82.30b	4.45b	7.38a	2.77c	8.62b
MH	5.80b	2.97b	0.42a	14.56b	0.99a	1.71a	0.64b	0.14b	0.52b	4.00a	87.00a	4.75a	6.00b	2.72c	7.68c

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 7 shows the effect of tillage techniques on leaf nutrients concentration of yam (*Dioscorea rotundata*). There were significant (P>0.05) differences in leaf nutrients concentration of yam due to tillage techniques at both cropping seasons. Tilled plots (i.e ploughed, ploughed plus harrowed, manually ridged and heaped plots) had higher leaf nutrients concentration compared with zero-tillage plots. Concentration of phosphorus was low in leaf tissue of yam compared to nitrogen concentration in yam leaf tissue. Yam leaf nutrients concentration at first cropping (2007) were relatively higher than the leaf nutrients concentration in the second cropping (2008). Manually heaped plots had the highest leaf N, P, K , Ca and Mg while the zero-tillage plots had the least leaf N, P, K, Ca and Mg.

Table 7: Effect of Tillage Techniques on Leaf Nutrients Concentration of Yam (Dioscorea rotundata)

Treatments	N		P		K		Ca		Mg		Na	
	(%)		(%)		(%)		(%)		(%)		(%)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT	5.25c	3.42bc	0.19c	0.20b	0.48c	0.34b	0.14c	0.10b	0.14b	0.14b	0.13a	0.11a
P	5.50b	3.55b	0.25a	0.24a	0.58b	0.42a	0.18qb	0.12b	0.18ab	0.16a	0.11a	0.11a
PH	5.27c	3.17c	0.23b	0.21b	0.48c	0.38b	0.16b	0.10b	0.16b	0.15ab	0.11a	0.10a
MR	5.55ab	3.57b	0.25a	0.23a	0.56b	0.48a	0.19a	0.14a	0.19a	0.15ab	0.12a	0.10a
MH	5.77a	3.72a	0.27a	0.23a	0.62a	0.46a	0.19a	0.15a	0.19a	0.17a	0.12a	0.12a

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 8 shows the effect of tillage techniques on yield parameters of yam (*Dioscorea rotundata*). Yam tuber yield parameters were significantly influenced ($P>0.05$) by soil tillage techniques. Yam tuber yield parameters were better enhanced in manually ridged and heaped plots than other tillage techniques in the study. Zero-tillage plots produced the poorest yam tuber yield parameters and this was closely followed by ploughed plus harrowed plots. The tuber yield obtained was in the order of MH>MR>P>PH>ZT. Tuber yield from manually ridged plots was not significantly different from the yield of manually heaped plots. The tuber yield in the first cropping (2007) were better than the tuber yield from the second cropping (2008). The tuber yields at the second cropping (2008) were reduced by 17.9%, 17.5%, 24.6%, 14.8% and 14.3% for zero tillage, ploughing, ploughing plus harrowing, manual ridging and manual heaping respectively.

Table8: Effect of TillageTechniques on Yield Parameters of Yam (*Dioscorea rotundata*)

Treatments	Tuber length		Tuber Girth		Tuber Weight		Tuber Yield	
	(cm)		(cm)		(kg/stand)		($t\ ha^{-1}$)	
	2007	2008	2007	2008	2007	2008	2007	2008
ZT	17.50b	15.08b	33.00a	28.85ab	1.78d	1.46e	17.82c	14.63d
P	23.33a	22.07a	30.50b	27.60b	2.68ab	2.24c	26.84b	22.14b
PH	19.83b	19.00b	28.50b	26.22b	2.22c	1.67d	22.21c	16.74c
MR	26.17a	23.17a	33.33a	32.81a	2.83ab	2.41b	28.31ab	24.11a
MH	25.17a	24.21a	29.67b	29.04ab	2.95a	2.53a	29.54a	25.32a

Means with the same letter in the same column are not significantly different at 5% level using DMRT

DISCUSSION

The higher values of moisture content obtained in zero-tillage plots compared to other tillage techniques in the study could be attributed to the fact that crop residues left on the soil provided a mulching effect which enhanced moisture conservation. Also, it might be attributed to less soil disturbance in zero-tillage plots, the soil retained its structure and hence able to absorb and hold more water back from evaporation. In addition, zero-tillage plots are protected by a layer of low conductivity (dry soil) on the surface which reduces evaporation losses. The high moisture content of zero-tillage plots might partly be due to the increase in soil organic matter content of the zero-tillage plots, Ojeniyi et al, [14] obtained similar result in Akure.

The lower soil moisture content of manually heaped and ridged soils could be attributed to the greater evaporating surface and increased movement of atmospheric air produced by heaped and ridged soils. Awodun [15] also observed similar decrease in soil moisture in manually tilled soil. Ridging and heaping exposed soil to drying. When soil is tilled, total porosity is increased, this enhance vapour movement by diffusion and mass flow of air, result in an increase in moisture evaporation. The fragmentation of the soil structure caused by tillage might have led to the creation of more macropores which in turn, made the soil more porous and more susceptible to deep percolation and this would enable the soil to contain moderate water in good proportion needed by the plant and at the same time create room for air space for good aeration which is essential for proper plant growth. The lower soil moisture content of manually tilled plots could also be due to reduction in soil aggregate size and increase in pore size of the tilled plots [16].

A decrease in soil moisture content of the various tillage systems during the second cropping might partly be due to the structural collapse and elimination of transmission pores caused by cultivation and soil compaction which might have enhanced drastic decline in infiltration rate. Also, it might be due to the decrease in soil organic matter contents of the soils under the various tillage methods in the study.

The range of soil temperature obtained in the study fall within the optimum temperature range of 25^0C-35^0C required for good yam growth and yield. This observation was in agreement with the report of Adekayode, [17]. Manually ridged, manually heaped and ploughed plots had higher soil temperature compared with zero-tillage and ploughed plus harrowed plots. This relatively higher temperature in manually tilled and ploughed plots can be attributed to the breaking of the soil structure caused by tillage operations which loosened the soil and making it porous. Also, ridging, heaping and ploughing exposed the soil to drying and increased the maximum soil temperature. The relatively low temperature under zero-tillage can be attributed to the influence of residues on the surface, which intercepted in coming radiation and thus reduced soil temperature. Temperature progressively decline as the time after planting increased. This progressive decline in soil temperature can be attributed to the gradual development of plant foliage, which increasingly shaded the ground as well as the decreasing air temperature.

At both planting seasons, bulk density was found to be highest in zero-tillage plots and lowest in manually heaped plots. This finding is in an agreement with the findings of Aluko and

Lasisi, [18]. The high bulk density of zero-tillage plots has implications for root growth and yam tuber induction. Roots rarely enter soil if its bulk density is greater than 1.5 -1.8 cm^{-3} [19] High soil density could cause mechanical impedance to root and tuber growth and this would adversely affect nutrient and water uptake. In support of this, Ohiri, [20] found that zero-tillage plots in Umudike resulted in low cassava yield owing to high bulk density of 1.6 g cm^{-3} and high mechanical impedance.

The soil bulk density values increased with time after tillage operations in all the tillage techniques investigated. This increase in soil bulk density with time after tillage operations can be attributed to the combined effect of rainfall impact and cycles of wetting and drying of the soils. Similarly, Fohrer et al, [21] observed an increase in the surface soil bulk density of sandy loam soil from 1.15 to 1.49 g cm^{-3} after just four simulated rainfalls of about 6cm at the intensity of 3 cm hr^{-1}. Single rainstorms with depth of about 10cm and intensity as high as 6 cm hr^{-1} are not uncommon in the southern parts of Nigeria [22]. This finding is in line with the findings of Osunbaintan et al.[23] for a loamy sand soil in southwestern Nigeria. The relatively high bulk density of ploughed plus harrowed plots during the second cropping of the plots could be attributed to the cumulative effect of tractor weight on the soil. Bulk density increased with increase in the number of traffic passes [24. It is implied that the use of tractor on continuous basis might compact the soil and lead to degradation of soil physical properties that are important in soil fertility.

Soil total porosity was relatively higher in tilled plots (MH, MR, P and PH) compared to untilled plots (ZT), this is a consequence of soil loosening and the associated formation of additional macropores. Improved soil total porosity of the tilled plots has implication for root growth, proliferation, water infiltration, aeration and nutrients uptake which could reflect in the performance of crops. This finding is in agreement with the finding of Osunbitan et al, [23]. 5Macropores play a major role in water movement and also serve as channels for root growth and solute movement.

Soil total porosity decreased with increase in time after soil preparation in all the tillage techniques in the study, this can be attributed to compaction due to the impact of rain drops and particle resettlement within the soil. . Also, Osunbitan et al, 2005 [23] indicated that increased total porosity of conventionally tilled plots is usually temporary as persistent actions of rainfall on the soil results in their compaction. Larger pores formed as a result of tillage readily collapse under the impact of rainfall and surface runoff.

Zero-tillage plots had the highest organic matter content, available P, exchangeable Ca and soil pH and therefore could be said to be the most fertile soil but this failed to translate to yield probably because of the poor soil physical conditions which might have hindered root growth and nutrient uptake especially nitrogen and phosphorus that are essential for crop yield. The high soil N, P and Ca status of zero-tillage plots can be related to the presence of high organic matter of zero-tillage plots when compared with ploughed plus harrowed plots (Akter et al, [25]. The relatively high concentration of nutrients in manually heaped and ridged plots might be due to the fact that heaps and ridges are built by concentrating nutrient rich surface soil. In support of this, Salako, [26] reported that soil chemical properties were generally significantly higher on the manually tilled plots than mechanically tilled plots except for cations which were generally similar between the two treatments.

The least values of soil organic matter, N, available P, exchangeable K and Mg recorded for ploughed plus harrowed plots could be due to inversion of the top soil during ploughing and harrowing operations which brought less fertile subsoil to the surface. Also, it might be due to leaching and removal of soil nutrients through erosion. Erosion was observed to be more pronounced in mechanized tillage plots during the field experiment. In a similar view, Alli et al, [27] reported that conventional tillage produce the least values of soil organic matter, total N, exchangeable K, Ca and Mg. they concluded that conventional tillage reduced soil fertility compared with manual tillage. Also, higher degree of reduction in some soil chemical properties such as soil pH, organic matter, nitrogen, available P and yam tuber yield in ploughed plus harrowed plots in the second cropping season compared to manually tilled plots implies a faster rate of soil degradation in ploughed plus harrowed plots. These findings are in agreement with the findings of Ohiri and Ezumah, [16] they obtained a significant reduction of 32% in soil organic carbon over the initial soil value in conventionally tilled plots. Also, Salako [26] reported that soil degradation was higher in mechanized tillage plots than manually tilled plots. Decrease in soil organic matter after the second planting might be due to the fact that cultivation resulted in the provision of conducive conditions for the action of soil microbial activities with resultant accelerated organic matter decomposition [27]. This implies that continuous cultivation will consequently result in a marked reduction in soil fertility and attendant decline in crop yield. The decrease in soil total N, available P and K can be attributed to the decrease in soil organic matter, as N, P and K like other nutrient elements are integrally tied to the soil organic matter [28], [29]; hence, the maintenance of soil organic matter is paramount in sustaining other soil quality. Lam, [31] obtained similar reduction in soil nutrients with cassava cultivation. In support of these findings, Godo and Yeboua, [32] reported that soil fertility declined under different tillage techniques over time.

Nutrients concentration in yam leaf tissue was better enhanced in tilled plots than untilled plots (ZT). The soil density of zero-tillage plots might have caused mechanical impedance to root growth and this would have adversely affected nutrients uptake, hence yam grown on zero-tillage plots had relatively lower leaf nutrients concentration. Higher concentration of nutrients in yam leaf tissue of the tilled (MH, MR, P, PH) plots might be due to the improved microporosity and aeration due to tillage which might have enhanced better root growth and uptake of nutrients. The implication of this is that some form of soil tillage techniques that loosen the soil is required for optimum yam growth and tuber yield. Tilled plots allowed deeper root penetration and improvement of the rhizophere. Deeper root penetration allowed the yam in the tilled plots to tap enough mineral and water. Low root density of yam in the zero tillage plots might have been responsible for low nutrients concentration in the yam leaf tissue. In support of this, Ogunremi et al, [33] attributed better performance of rice in tilled plots compared to zero-tillage plots to greater uptake of N, Mg and K in tilled plots. Also [37] attributed low dry matter and N-accumulation in leaves to low root density of crops grown on zero-tillage plots. The results of the influence of tillage techniques on leaf nutrients concentration obtained in this study are in agreement with the earlier studies by Awodun and Ojeniyi, [34] attributed lower nutrient content and performance of yam on untilled soil to high bulk density which adversely affected tuber growth and nutrients uptake. The relatively high level of K compared to P in yam leaf tissue could be attributed to high demand for K to enhance translocation of assimilates to the tuber [35, 36]. Also, the low relative P content of leaves compared to N and K might be due to low P mobility in the plants and its eventual accumulation in the tuber at harvest [37].

The yields obtained from manually heaped and ridged plots were better than those obtained from zero-tillage plots and ploughed plus harrowed plots. This might be due to the fact that manually tilled plots had lower bulk density and higher total porosity which might have improved root penetration and tuber induction in the soil. In support of this, Ohiri and Nwokoye [38] indicated that yam requires a loose, deep soil to allow permeability of air and water to tubers. Higher bulk density of soils under zero-tillage and ploughed and harrowed plots might have adversely affected tuber initiation and tuber growth.

In spite of the higher moisture content and nutrients content of the zero-tillage, the yield from this treatment was lower than manually heaped and ridged plots in this study. This probably be due to the negative effects of soil compaction and its associated high bulk density. In addition, high moisture content in a zero tillage plot might have resulted in unfavourable soil aeration and reduced uptake of nutrients. In support of this, Ohiri and Nwokoye [38] reported that zero-tillage in Umudike, Nigeria resulted in low cassava yield owing to high bulk density of 1.6 g cm^{-3} and high mechanical impedance. High bulk density may have more detrimental effect on the rhizosphere than gains accruing from increase moisture content. Varsa et al. [39] indicated that tillage reduced bulk density by loosening the soil particles thus increasing root penetration and hence yield of crop. Hence, plots with lower soil bulk density had the highest yield in this study. The yields during the first cropping season were better than the second cropping season, this might be due to the decline in soil physical properties caused by the continuous cropping of the plots. The relatively higher bulk density and lower yield obtained in the second cropping could be attributed to cumulative effect of continuous cultivation on the soil. It is implied that continuous cultivation without proper soil management will lead to soil degradation of the Alfisols located in the southwestern part of Nigeria.

Conclusion

Soil physical and post-harvest soil chemical properties, yam nutrient uptake and tuber yields were significantly influenced by tillage techniques, hence, yam production on an Alfisol requires tillage and loose soil structure for tuber development.

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