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Effect of time of seed-bed preparation on soil properties and performance of water yam in Owerri southeast, Nigeria

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ABSTRACT

Field experiment was conducted between the months of February and November, 2016 to evaluate the effect of age of seed-bed preparation on soil properties and performance of water yam in Owerri, southeastern Nigeria. Treatments consisted of four time of seed-bed preparations namely 0, 3, 6, and 9 weeks intervals, laid out in a randomized complete block design (RCBD) with three replications. Selected physical and chemical properties of the soil and agronomic parameters of the test crop such as tuber yield (TY) and tuber number (TN) were measured. Data generated were subjected to analysis of variance (ANOVA) and the significant means separated using the Fisher's Least Significant Difference (FLSD) at P=0.05. The statistical results showed that at harvest, the 0 week and 3 weeks tillage intervals significantly improved the tuber yield and tuber number, respectively. Again, the result of the seed-bed preparation at post-harvest revealed that the 0 week interval proved to cause the highest improvement of the soil physical and chemical properties. Essentially, the effect of age of seed-bed preparation on soil C/N ratio indicate that the 3 weeks interval treatment increased the C/N ratio. It was concluded that the 3 weeks tillage treatment showed the highest level of improvement of both the tuber yield and the soil C/N ratio at post-harvest seed-bed preparation, while the 0 week treatment recorded the highest improvement of the tuber number at harvest and of the soil physical and chemical properties at post-harvest, for most of the studied parameters.

1.0 Introduction

Tillage has been used for millennia to prepare the soil prior to sowing many of the annual grain crops. It involves applying power to break up and rearrange the entire topsoil structure. It has the primary aim of destroying weeds and pests but is also important for incorporating, redistributing or releasing nutrients and making the soil texture suitable for seed sowing, seed germination and for easy penetration of seedling roots. According to Murell (2018), tillage systems are sequences of operations that manipulate the soil in order to produce a crop. Different tillage practices cause changes in soil physical properties, such as bulk density (Wander *et al*., 1998), water holding capacity (Trojan and Linden, 1998), pore size distribution (Azooz *et al*., 1996), and aggregation (Chan and Mead, 1988). Stratification of soil organic matter and differences in nutrient distribution has been observed in long-term conservation tillage systems (Kandeler *et al*., 1999 and Staley, 1999).

Yam (*Discorea spp*) is a staple tuber crop for many of the poorest in West Africa, South East Asia, the Caribbean and Oceania. Up to 95% of the world's yams are produced in West Africa (FAO, 2009). The decline of yam yield under continuous cultivation has led to the largely accepted conclusion that yams require a high level of natural fertility (O'Sullivan and Ernest, 2008). The best yields observed on naturally fallow soils can probably be explained by the relatively high organic matter content of these soils that allows for a high rate nutrient release to the plants, and optimum water retention capacity. Diby *et al.* (2009) reported that *D. alata* had higher fresh tuber yield, shoot and tuber than *D. rotundata*, both in the fertile soils and in the non-fertile soils. This confirms the better adaptation of *D. alata* to low fertile soils as already reported by Kowal and Kassam (1978). The better adaptation might be explained by a higher growth plasticity of *D. Alata* when placed in a stressful environment. The better adaptation of *D. Alata* can also be explained by the important development of tuber roots, which probably contributed to nutrient uptake late in the season in the savannah site (Diby *et al.*, 2009).

Information on yam cultivation in Owerri area of southeastern Nigeria are very scanty. Few studies available considered the effects of different soil amendments on the performance of seed yam and tuber storage (Obiefuna *et al.*, 2016; Duruigbo *et al.*, 2014). In a bid to advance the knowledge of yam cultivation and ascertain the best management practices that would guarantee optimum production of yam in the area, this study evaluated the effect of time of seed-bed preparation on soil properties and performance of water yam in Owerri, southeastern Nigeria.

2.0 Materials and Method

2.1*Study site*

This study was conducted at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri (FUTO). The location of the study area is between latitudes $4^{O}45^{'}$N and $7^{O}15^{'}$N, and longitudes $6^{O}50$'E and $7^{O}25^{'}$E and 100 m above sea level (GPS). The mean maximum temperature was 32.1^{O}C while the current minimum temperature was 23.5^{O}C. Two seasons (wet and dry seasons) are observed in the year. The rainy season begins in April and lasts till October. Double maximum rainfall occurs annually with the first maximum in June and the second in September. The study area has a mean relative humidity of 78%. The soils of Owerri are Ultisols, formed from coastal plain sands and are low in mineral reserve and fertility (Eshett, 1993). According to Onweremadu (2006), the soils are dominated by isohyperthermic Arenic Kandiudult, with kaolinite as the dominant clay mineralogy (Uzoho and Oti, 2005)

Field study:

The research covered an area of 225 m^2, with 17 m as length and 15 m as width. The site was delineated with the use of simple surveying equipment such as ranging poles, measuring tape, rope, pegs; and thereafter proceeded by; land clearing. Before the land was cleared, soil samples were collected at points of intersections of diagonals (9 core samples and 9 auger points samples were collected) from 0-30 cm soil depth and thereafter, replicated three (3) times.

Four tillage sequences beginning from February to April of 0 Week, 3 Weeks, 6 Weeks and 9 Weeks were followed. Ridges of 4 m x 1 m (4 m^2) were made, with a row spacing of 0.5 m and a 1 m. The total ridges per tillage sequences were nine (9), while the total no of ridges were 36. The test crop for the research was *Discorea alata* (Lebanese variety of water yam). A total of 4 seed yams were planted per ridge with a spacing of 1 m by 1 m (4 m by 1 m area of ridge). In general, a total of 144 seed yams were planted (4 seed yams per ridged/un-ridged multiplied by 36 ridged/ un-ridged). The water yam was planted in all the previously tilled soils when the last soil was ridged in April, and a-three week tillage duration was allowed to enable the three weeks complete cycle of duration, while the un-ridged soil was also at the end of tillage durations of the other ridged soils, planted along side. Crop evaluation included, tuber weight at before planting and after harvest number of tubers per stand. Other agronomic activities included staking (individual staking giving rise to 144 stakes) and weeding, which were done as the need arises.

2.2 Laboratory analysis:

The core samples and the auger samples of the soils collected were used to determine the physicochemical properties of the soil such as particle size distribution, bulk density, porosity, moisture content, hydraulic conductivity, cation exchange capacity (CEC), organic matter, available phosphorus, exchangeable base, exchangeable acidity, pH, total nitrogen and micro-nutrients.

Particle Size: The size distribution of less than 2mm fine earth fractions was determined by the Bouyoucus hydrometer method as described by Gee and Bauder (1986).

Bulk Density and Porosity: Bulk Density and Porosity was determined as described by Birkeland (1984) and calculated as thus:

Bulk Density =

$$\frac{\text{Oven dry weight of soil (grams)}}{\text{Volume of cylinder (cm}^3\text{)}} \quad \text{……………equation 1}$$

Total Porosity =

$$\frac{\text{Volume of water in soil at saturation}}{\text{Volume of cylinder (cm}^3\text{)}} \times \frac{100}{1} \quad \text{…equation 2}$$

Capillary Porosity =

$$\frac{\text{Volume of water refined at 60cm of tension (grms)}}{\text{Volume of cylinder (cm}^3\text{)}} \times \frac{100}{1} \quad \text{....equation3}$$

Saturated Hydraulic Conductivity: The saturated hydraulic conductivity was determined using the method of Klute and Dirkson (1986), and will be calculated as thus: $K = Q/At \times \Delta H$ ………… equation 4

Where: K= Darcy Coefficient (Cm/hr)

Q= Steady state volume of flow from an entire soil column (m^3).

A= Cross sectional area of the core (cm^2)

t= the time of collection (minutes)

h=Depth of soil (cm)

ΔH=Change in hydraulic head

Soil Moisture Regimes: The selected soil moisture regimes of % moisture in undisturbed soil at field capacity, moisture in soil on volume basis and moisture at hygroscopic coefficient/oven dry mass basis were determined as described by Jaiswal (2011) and were calculated as thus:

% moisture in undisturbed soil at field capacity =

$$\frac{\text{[Mass of moist soil collected at field capacity in g} - 1000] \; 100}{\text{Mass of the soil after drying in the oven in g}} \quad \text{…….. equation 5}$$

Hygroscopic coefficient = $\frac{\text{Loss of moisture on oven drying in g * 100}}{\text{Oven dry mass of the soil sample}}$…equation 6

Moisture in soil on volume basis = moisture at hygroscopic coefficient * Bulk density……………equation 7

The soil pH was determined in a 1:2 soil to water suspension using a pH meter (Maclean, 1982).The soil pH in KCl was measured by the glass electrode pH meter (Maclean, 1982).

Soil organic carbon: Soil organic carbon was determined by Walkley and Black wet oxidation method as modified by Nelson and Sommers (1982) was used in the determination of the SOC and the organic matter was calculated by multiplying the value of organic carbon by a factor of 1.724 (Van Bermelen's Factor). Exchangeable Bases such as Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K) was extracted using normal ammonium acetate (Thomas, 1982). The exchangeable K and Na so extracted was determined, while the exchangeable Ca and Mg were determined by using atomic absorption spectrophotometer. The exchangeable acidity was extracted with potassium chloride (KCl) solution exchangeable. The exchangeable acidity and the exchangeable aluminum were determined by titration as described by Thomas (1996). The exchangeable hydrogen were got by subtracting exchangeable acidity (Al + H). Total nitrogen was determined by micro Kjeildahl digestion and distillation method of Bremner as modified by Udo et al, (2009). Available phosphorus was determined by the Bray and Kurt No 1 method as described by Udo *et al.* (2009).Effective Cation Exchange Capacity (ECEC) was determined as the sum of total exchangeable acidity and bases.

Determination of yield characteristics of water yam

Sixteen (16) plants were evaluated from T_1, T_2, T_3 and T_4 in the four tillage sequences at 9 Weeks, 6 Weeks, 3 Weeks and 0 Week which were selected based on the best performing plant in each of the tillage sequence and the three (3) replications (a, b, and c) in all. The tuber weight and number of tubers per heap were determined after harvesting. Total plant yield was determined by weighing with a weighing balance.

Statistical analysis

The data was subjected to the analysis of variance (ANOVA) and the significant means separated using the Fisher's Least Significant Difference (FLSD) according to Gomez and Gomez (1984).

3.0 Results and Discussion

Initial soil physical and chemical properties

The results of the initial soil properties are presented in Table 1. The soil was dominated by high sand fractions and very little silt and low clay percent which gave rise to the soil textural class of loamy sand. The bulk density was lower than 1.6 mg/m^3, this lower bulk density values indicated the porous and non-compacted nature of the soil which is reflected by the high total porosity values obtained from the soil of the studied area. Water exists in the soil in various forms. Field capacity and the gravimetric water content were the major soil water regimes in relation to plant development and growth that were studied. The result of the hydraulic conductivity followed the same trend of low bulk density and higher total porosity to indicate a rapid hydraulic conductivity class and a permeability index rating of 6. The soil pH was moderately acid for pH (water) and acid for pH (KCl). The soil total nitrogen and exchangeable calcium were lower than the critical values while the exchangeable potassium was within the critical values whereas the exchangeable magnesium and organic matter content were indicative of higher values. The exchangeable sodium was far lower than the values that can cause saline or sodic state of the soil. Furthermore, the total exchangeable bases showed that the soil is highly weathered, and the effective cation exchange revealed the presence of anions (exchangeable Al and H which are known to be the major contributors to soil acidity) which

Table 1: Soil properties before tillage

	Measured Values	
		88.96
	1.28	
Clay (%)	9.76	
T. Class	LS	
BD (mgm^{-3})	1.23	
TP (%)	53.58	
MHC (%)	9.56	
SMVB (%)	11.76	
Soil Properties	10.57	
	23.26	
Sand (%)	RAPID	
Silt (%)	6	
pH (H_2O)	5.7	
pH (KCl)	4.8	
Total N (%)	0.098	
OM (%)	2.86	
Avail. P (mgkg$^-$1)	7.14	
Exch. K (Cmolkg^{-1})	0.21	
Exch. Ca (Cmolkg^{-1})	1.6	
Exch. Mg (Cmolkg^{-1})	0.6	
Exch. Na (Cmolkg^{-1})	0.24	
TEB (%)	2.65	
Exch. Acidity (Cmolkg^{-1})	1.24	
ECEC (Cmolkg^{-1})	3.89	

Effect of seed-bed preparation on yield characteristics of water yam

Yam tuber yield:

The yam tuber yield changes were observed as decrease was recorded from the 3 Weeks, 6 Weeks, 0 Week to the 9 Weeks of the seed-bed preparation treatments. The result revealed that there was statistically significant difference in the tillage treatments in the tuber yield when the treatments were compared with the 9 Weeks and when the 3 Weeks tillage treatment were compared with the 6 Weeks and 0 Week tillage treatments. There was 12.25, 11.25 and 24.25 more tuber yield in the 3 Weeks of the tillage when compared with the 0 Week, 6 Weeks and 9 Weeks tillage treatments respectively. Also, there was 1 and 13 more tuber yield in the 6 Weeks tillage treatment, when compared with the 0 Week and 9 Weeks tillage treatments. The 0 Week tillage treatment indicated 12 more tuber yield when compared with the 9 Weeks tillage treatment; while the 9 Weeks tillage treatment never showed any increase in tuber yield over the other tillage treatments. The result of the study supported the works by Kang and Wilson (1986); Walter (2004) and Agbede (2006) who revealed that the total yield reduction in zero tillage may in part be related to physical soil impendence.

Tuber number at harvest:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments in the tuber number when the following tillage incubation treatments of 0 Week, 3 Weeks and 6 Weeks were compared with 9 Weeks tillage treatment. There was 0.25, 0.25 and 1.25 more tuber number in the 0 Week of the tillage treatment when compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments respectively. Also, there was 1 and 0 more tuber number in the 3 Weeks tillage treatment, when it was compared with the 9 Weeks and 6 Weeks tillage treatments respectively. The 6 Weeks tillage treatment indicated 1 more tuber number when compared with the 9 Weeks tillage treatment; while the 9 Weeks tillage treatment never showed any increase in tuber formation over the other tillage treatments. The tuber number changes were observed as decrease was recorded from the 3 Weeks, 6 Weeks, 0 Week to the 9 Weeks of the tillage treatments. This is supported by Odjugo (2008) who noted that Zero tillage (445) produced greater number of tubers followed by ridge tillage (340) and mound (320).

The Effect of seed-bed preparation on yield characteristics

The effect of seed-bed preparation on yield characteristics is presented in table 2

Table 2: Tuber yield and tuber number of water yam

Tillage Treatments	Yam Yield	Tuber Number at Harvest
9 WKS	(10^{c})	3^{b}
6 WKS	(23^{b})	4^{a}
3 WKS	(34.25^{a})	4^{a}
0 WK	(22^{b})	4.25^{a}
F-LSD $_{p=0.05}$	10.38	0.974

Legend: WKS means weeks after sowing

Evaluation of time of seed-bed preparation on soil chemical properties at post-harvest

The evaluation of the effect of seed-bed preparation on soil properties at post-harvest is presented in Table 3.

Exchangeable Calcium:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil calcium content at post-harvest when the 3 Weeks tillage treatment was compared with the 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest while the 0 Week and 6 Weeks tillage treatments at post-harvest showed a statistical significant difference when compared with the 9 Weeks tillage treatment at post-harvest. There was 0.5 more calcium content in the 0 Week of the tillage treatment at post-harvest when compared with the 9 Weeks tillage treatment at post-harvest. Also, there were 0.25, 0.25 and 0.75 more calcium content in the 3 Weeks tillage treatment at post-harvest when it was compared with the 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest respectively. The 6 Weeks tillage treatment indicated 0.5 more calcium content when compared with the 9 Weeks tillage treatment at post-harvest; while the 9 Weeks tillage treatment never showed any increase in calcium over the other tillage treatments. Furthermore, the results from 0 Week compared with 6 Weeks showed 0 value of the calcium content of the tillage treatment at post-harvest. The soil exchangeable calcium changes were observed as decrease was recorded from 9 Weeks, 0 Week, 3 Weeks to 6 Weeks tillage treatments at post-harvest. This study correlated with the study conducted by Adeyemo and Agele (2010), which were able to show that tillage alone reduced the values of exchangeable Ca.

Exchangeable Magnesium:

The result revealed that there was no statistically significant difference in the seed-bed preparation treatments on the soil magnesium content at post-harvest. There was 0.25 more magnesium content in the 0 Week of the tillage treatments at post-harvest when compared with the 9 Weeks tillage treatment at post-harvest. Also, there was 0.25 more magnesium content in the 3 Weeks tillage treatment at post-harvest when it was compared with the 9 Weeks tillage treatment at post-harvest. The 6 Weeks tillage treatment indicated 0.25 more magnesium content when compared with the 9 Weeks tillage treatment at post-harvest; while the 9 Weeks tillage treatment never showed any increase in the magnesium over the other tillage treatments. Furthermore, the results from 0 Week compared with 6 Weeks, 0 Week compared with 9 Weeks and 6 Weeks compared with 9 Weeks showed 0 value of the magnesium content of the tillage treatments at post-harvest. The soil exchangeable magnesium changes were observed as decrease was recorded from the 6 Weeks, 0 Week, 3 Weeks to 9 Weeks tillage treatments at post-harvest. The result revealed that the treatments were above the critical limit of exchangeable magnesium. The critical exchangeable magnesium level is in the range of 0.2-0.4 mg/kg (Adeoye and Agboola, 1985).

Exchangeable Sodium:

The result revealed that there was statistically significant difference in the tillage treatments on the soil sodium content at post-harvest when 0 Week tillage treatment was compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest while the 3 Weeks and 9 Weeks tillage treatments at post-harvest showed a statistical significant difference when compared with the 6 Weeks tillage treatment at post-harvest. There was 0.5, 0.25 and 0.25 more sodium content in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest. Also, there were 0.25 more sodium content in the 6 Weeks tillage treatment at post-harvest when it was compared with 3 Weeks tillage treatment at post-harvest. The 9 Weeks tillage treatment indicated 0.25 more sodium content when compared with the 3 Weeks tillage treatment at post-harvest; while the 3 Weeks tillage treatment never showed any increase in sodium over the other tillage treatments. Also, the results from 6 Weeks compared with 9 Weeks showed 0 value of the sodium level of the tillage treatments at post-harvest. The soil exchangeable sodium changes were observed as decrease was recorded from the 3 Weeks, 6 Weeks, 0 Week to 9 Weeks tillage treatments at post-harvest. The values as supported by Augie et al. (2014), though less than 15% to cause any harm to plants and soil physical conditions, farmers should be advised to ensure proper tillage to facilitate the leaching of sodium so as to prevent its further accumulation to the detrimental level.

Exchangeable Potassium:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil potassium content at post-harvest when 0 Week, 6 Weeks and 9 Weeks tillage treatment were; compared with the 3 Weeks tillage treatments at post-harvest. There was 0.25 more potassium content in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks tillage treatment at post-harvest. Also, there was 0.25 more potassium content in the 6 Weeks tillage treatment at post-harvest when it was compared with the 3 Weeks tillage treatment at post-harvest. The 9 Weeks tillage treatment indicated 0.25 more potassium content when compared with the 3 Weeks tillage treatment at post-harvest; while the results from 0 Week compared with 6 Weeks, 0 Week compared with 9 Weeks and 6 Weeks compared with 9 Weeks showed 0 value of the potassium content of the tillage treatments at post-harvest. The soil exchangeable potassium changes were observed as decrease was recorded from 0 Week, 3 Weeks, 6 Weeks to 9 Weeks respectively in the tillage treatments at post-harvest. The exchangeable potassium was above the threshold of critical limits to fertilization. The critical exchangeable potassium level is in the range of 0.16-0.25 cmol/kg (Akinrinde and Obigbesan, 2000). This result is in tandem with the work done by David *et al*. (2006) in 2003, which showed that the extractable K were higher in the 15-30 cm depth than in 1989 for both tillage treatments.

Total Exchangeable Bases:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil total exchangeable bases content at post-harvest when the 3 Weeks tillage treatment was compared with the 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest while the 0 Week and 6 Weeks tillage treatments at post-harvest showed a statistical significant difference when compared with the 9 Weeks tillage treatment at post-harvest. There was 1 more total exchangeable bases content in the 0 Week of the tillage treatment at post-harvest when compared with the 9 Weeks tillage treatment at post-harvest. Also, there were 0.25, 0.25 and 1.25 more total exchangeable bases content in the 3 Weeks tillage treatment at post-harvest when it was compared with the 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest respectively. The 6 Weeks tillage treatment indicated 1 more total exchangeable bases content when compared with the 9 Weeks tillage treatment at post-harvest; while the 9 Weeks tillage treatment never showed any increase in the total exchangeable bases over the other tillage treatments. Furthermore, the results from 0 Week compared with 6 Weeks showed 0 value of the total exchangeable base content of the tillage treatments at post-harvest. The soil total exchangeable bases changes were observed as decrease was recorded from the 0 Week, 6 Weeks, 3 Weeks to 9 Weeks tillage treatments at post-harvest. The increased values obtained from the total exchangeable bases is supported by Wrobel and Nowak-Winiarska (2007) and Weber (2010) who revealed that conservation methods of soil tillage increase the content of soil organic matter, which positively influences physical, chemical and biological properties of the soil.

Exchangeable Aluminium and Hydrogen:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil exchangeable aluminium and hydrogen content at post-harvest when 0 Week, 3 Weeks and 6 Weeks tillage treatment were compared with the 9 Weeks tillage treatment at post-harvest. There was 1 more exchangeable aluminium and hydrogen content in the 0 Week of the tillage treatment at post-harvest when compared with the 9 Weeks tillage treatment at post-harvest. Also, there was 1 more exchangeable aluminium and hydrogen content in the 3 Weeks tillage treatment at post-harvest when it was compared with the 9 Weeks tillage treatment at post-harvest. The 6 Weeks tillage treatment indicated 1 more exchangeable aluminium and hydrogen content when compared with the 9 Weeks tillage treatment at post-harvest; while the 9 Weeks tillage treatment never showed any increase in the exchangeable aluminium and hydrogen over the other tillage treatments. Furthermore, the results from 0 Week compared with 3 Weeks, 0 Week compared with 6 Weeks and 3 Weeks compared with 6 Weeks showed 0 value of the exchangeable aluminium and hydrogen content of the tillage treatments at post-harvest. The soil exchangeable acidity changes were observed as decrease was recorded from the 3 Weeks, 0 Week, 6 Weeks to 9 Weeks tillage treatments at post-harvest. The result of the study indicated the presence of Al and H which are known to be the major contributors to soil acidity. Ufinomue *et al*. (2014); revealed that high leaching rate that is favoured by rainfall, coupled with the porous nature of the soil due to its texture and parent materials is reflected in the soil pH showing acidic scale.

Effective Cation Exchange Capacity:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the effective cation exchange capacity at post-harvest when the 3 Weeks tillage treatment was compared with 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest; while 0 Week tillage treatment at post-harvest showed a statistical significant difference when compared with the 6 Weeks and 9 Weeks tillage treatment at post-harvest. Statistical significant difference was also observed when the 6 Weeks tillage treatment at post-harvest was compared with the 9 Weeks tillage treatment at post-harvest. There was 0.5 and 2 more in the 0 Week of the tillage at post-harvest when compared with the 6 Weeks and 9 Weeks tillage treatments at post-harvest. Also, there was 0.5, 1 and 2.5 more effective cation exchange capacity in the 3 Weeks tillage treatment at post-harvest when it was compared with the 0 Week, 3 Weeks and 9 Weeks tillage treatments at post-harvest. The 6 Weeks tillage treatment indicated 1.5 more in effective cation exchange capacity when compared with the 9 Weeks tillage treatment at post-harvest; while the 9 Weeks tillage treatment never showed any increase in the effective cation exchange capacity over the other tillage treatments. The soil effective cation exchange capacity changes were observed as decrease was recorded from the 3 Weeks, 0 Week, 6 Weeks to 9 Weeks tillage treatments at post-harvest. Since the value obtained from the effective cation exchange capacity was lower than the 12 cmol/kg, Esu *et al.* (2014) revealed that the soil was highly weathered and highly leached to the oxic state. The low effective cation exchange capacity and nutrient reserves of the studied area have been attributed to the fact that soils of south eastern Nigeria are strongly weathered (Irene *et al*., 2014).

pH (KCl)

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil exchangeable pH KCl at post-harvest when 9 Weeks tillage treatment was compared with the 0 Week, 3 Weeks and 6 Weeks tillage treatments at post-harvest. There was 0.75 more pH KCl in the 9 Weeks of the tillage treatment at post-harvest when compared with the 0 Week, 3 Weeks and 6 Weeks tillage treatments at post-harvest. Furthermore, the results from 0 Week compared with 3 Weeks, 0 Week compared with 6 Weeks and 3 Weeks compared with 6 Weeks showed 0 value of the pH KCl of the tillage treatments at post-harvest**.**

pH Change

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil pH change at post-harvest when 3 Weeks, 6 Weeks and 9 Weeks tillage treatments were compared with the 0 Week tillage treatment at post-harvest. There was 0.5 more pH change in the 3 Weeks of the tillage treatment at post-harvest when compared with the 0 Week tillage treatment at post-harvest. Also, there was 0.5 more pH change in the 6 Weeks tillage treatment at post-harvest when it was compared with the 0 Week tillage treatment at post-harvest. The 9 Weeks tillage treatment indicated 0.5 more in pH change when compared with the 0 Week tillage treatment at post-harvest; Furthermore, the results from 3 Weeks compared with 6 Weeks, 3 Weeks compared with 9 Weeks and 6 Weeks compared with 9 Weeks showed 0 value of the pH change of the tillage treatments at post-harvest. The result of the study showed that there was a decrease of the soil pH from the 9 Weeks, 6 Weeks, to 9 Weeks and the 0 Week at post-harvest. The soil pH was moderately acid for pH (water) and acid for pH (KCl) for all the tillage treatments at post-harvest. The low pH value may generally be the cause of the low nutrient status of the soil as reported by Brady (1974) and Mckenzie *et al.* (2004). The negative pH change value shows that the soil can adsorb cations and the soil is rich in nutrient that can support plant growth and productivity. The result of the study as supported by Esu (2010) and Udo *et al*. (2009) indicated that as a result of the soil reaction with respect to pH, it promoted the presence of Al^{3+} and H^{+} significantly to affect plant growth

Organic Matter:

There was 0.25 more organic matter; in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks and 6 Weeks tillage treatments at post-harvest; while the results from 9 Weeks indicated 0.25 more organic matter when compared with 3 Weeks and 6 Weeks. Results of 0 Week compared with 9 Weeks and 3 Weeks compared with 6 Weeks showed 0 value of the organic matter content of the tillage treatments at post-harvest. The soil organic matter content changes were observed as decrease was recorded from 3 Weeks, 6 Weeks, 0 Week to the 9 Weeks tillage treatments at post-harvest. The soil organic matter was medium. This suggests the claim Carter (1992) who reported that conservation tillage practices may lead to high soil organic carbon (SOC) contents in surface soil than conventional tillage system or mould board plough.

Total Nitrogen:

The soil total nitrogen content changes were observed as decrease was recorded from the 9 Weeks, 0 Week to 6 Weeks and 3 Weeks seed-bed preparation treatments at post-harvest. The soil total nitrogen was medium for the 9 Weeks tillage treatment at post-harvest and indicated a low rating for the other tillage treatments at post-harvest. This according to Obasi *et al.* (2014) noted that the low total nitrogen content could be related to an effective microbial degradation of organic matter resulting to low fertility characteristics of the soils of south eastern Nigeria. The critical N level is in the range of 1.5-2.0 g/kg (Sobulo and Osiname, 1981) and the result obtained was below the critical N level. This result revealed the work done by Adeyemo and Agele (2010), which showed that tillage alone reduced the values of total N.

Available Phosphorus:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the soil available phosphorus content at post-harvest when the 0 Week tillage treatment was compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest while the 6 Weeks and 9 Weeks tillage treatments at post-harvest showed a statistical significant difference when compared with the 3 Weeks tillage treatment at post-harvest. There was 6, 4 and 4 more available phosphorus content in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest. Also, there was 2 more; available phosphorus in the 6 Weeks and 9 Weeks tillage treatments at post-harvest when it was compared with the 3 Weeks tillage treatment at post-harvest. Results of 6 Weeks compared with 9 Weeks showed 0 value of the available phosphorus content of the tillage incubation treatments at post-harvest. The 3 Weeks

Table 3: Effect of Seed-bed Preparation on Soil Chemical Properties at Post-Harvest

Chemical Properties	O Week	3 Weeks	6 Weeks	9 Weeks	F-LSD $_{p=0.05}$
Exch. Ca (cmol/kg)	1.75^{b}	2.0^{a}	1.75^{b}	1.25^{c}	0.306
Exch. K (cmol/kg)	1^{a}	0.75^{b}	1^{a}	1^{a}	0.177
Exch. Mg (cmol/kg)	1.0^{a}	1.0^{a}	1.0^{a}	0.75^{a}	0.339
Exch. Na (cmol/kg)	1.25^{a}	0.75^{b}	1^{b}	1^{b}	0.27
TEB (cmol/kg)	5^{b}	5.25^{a}	5^{b}	4^{c}	0.339
Exch. acidity (cmol/kg)	2^{a}	2^{a}	2^{a}	1^{b}	0.2
ECEC (cmol/kg)	7.0^{b}	7.5^{a}	6.5^{c}	5^{d}	0.289
pH change	0.5^{b}	1.0^{a}	1.0^{a}	1.0^{a}	0.354
pH (KCl)	4^{b}	4^{b}	4^{b}	4.75^{a}	0.177
OM (%)	2.5^{a}	2.25^{a}	2.25^{a}	2.5^{a}	0.177
Avail. P (mg/kg)	15^{a}	9^{c}	11^{b}	11^{b}	0.177

tillage treatment never showed any increase in available phosphorus content over the other tillage incubation treatments. The soil available phosphorus changes were observed as the 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest showed low available phosphorus rating; while the 3 Weeks tillage treatment indicated a very low rating for available phosphorus. The decreasing order for available phosphorus was indicated from the 6 Weeks, 9 Weeks, 0 Week to 3 Weeks tillage treatments respectively. A study by Adeyemo and Agele (2010), showed that tillage alone reduced the values of OM, total N, available Phosphorous and exchangeable K, Ca, and Mg contents after the first and second seasons of cultivation of 2006 and 2007 experiments. The available P corresponded with the report revealed by Enwezor *et al.* (2009).

Effect of seed-bed preparation on soil physical properties at post-harvest

The result of the effect of seed-bed preparation on soil physical properties at post-harvest is presented in Table 4

Soil particles:

The result of the study only indicated slight changes in the soil fractions after the seed-bed preparation treatments at post -harvest. The soil was dominated by high sand fractions and very little silt and low clay percent. The soil textural class was not the same for all the treatment at post-harvest. The 9 Weeks, 6 Weeks and 0 Week treatments showed the presence of loamy sand, while the 3 Weeks treatment showed the presence of sandy loam. This soil type could provide a suitable environment for the growth of different crop types under good management practices. This is supported by findings done by Isirimah *et al*. (2010), who revealed that the soil fractions have the ability to retain residual soil moisture as well as a reasonable quantity of exchangeable cations. Kolay (2000) also observed that such soil is well drained and aerated.

Bulk density:

The bulk density decreased from the 0 Week, 3 Weeks, 9 Weeks to 6 Weeks tillage treatments at post-harvest. The bulk densities were all lower than 1.6 mg/m^3, this result according to Esu (2010) revealed that air and water movement in the soil is optimum for plant growth. Higher bulk density according to Janssen *et al*. (1977), may lead to reduction in crop yield. The variation in bulk densities is in tandem by works done by Cassel (1982), who stressed the need to recognize that bulk density may also vary for reasons other than imposition of tillage.

Total porosity:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments on the total porosity at post-harvest when the 0 Week tillage treatment was compared with 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest; while 9 Weeks tillage treatment at post-harvest showed a statistical significant difference when compared with the 3 Weeks and 6 Weeks tillage treatment at post-harvest. Statistical significant difference was also observed when the 3 Weeks tillage treatment at post-harvest was compared with the 6 Weeks tillage treatment at post-harvest. There was 2, 4.25 and 1 more total porosity in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks, 6 Weeks and 9 Weeks tillage treatments at post-harvest. Also, there was 2.25 more total porosity; in the 3 Weeks tillage treatment at post-harvest when it was compared with the 6 Weeks tillage treatment at post-harvest. The 9 Weeks tillage treatment indicated 1 and 3.25 more total porosity when compared with the 3 Weeks and 6 Weeks tillage treatments at post-harvest; while the 6 Weeks tillage treatment never showed any increase in total porosity over the other tillage treatments. The result of the study showed that there was a decrease of the total porosity from the 6 Weeks, 9 Weeks, 3 Weeks to the 0 Week tillage treatments at post-harvest. The high total porosity values obtained from the soil of the studied area according to Esu *et al*. (2014) revealed that the soil is well aerated within the soil solum.

Moisture in soil on volume basis:

The result revealed that there was statistically significant difference in the tillage treatments on the moisture in soil on volume basis at post-harvest when the 6 Weeks tillage treatment was compared with 0 Week, 3 Weeks and 9 Weeks tillage treatments at post-harvest; while 9 Weeks tillage treatment at post-harvest showed a statistical significant difference when compared with the 0 Week and 3 Weeks tillage treatment at post-harvest. Statistical significant difference was also observed when the 0 Week tillage treatment at post-harvest was compared with the 3 Week tillage treatment at post-harvest. There was 6.45 more moisture in soil on volume basis in the 0 Week of the tillage treatment at post-harvest when compared with the 3 Weeks tillage treatment at post-harvest. Also, there was 11, 17.45 and 6 more moisture in soil on volume basis; in the 6 Weeks tillage treatment at post-harvest when it was compared with the 0 Week, 3 Weeks and 9 Weeks tillage treatments at post-harvest. The 9 Weeks tillage treatment indicated 5 and 11.45 more moisture in soil on volume basis when compared with the 0 Week and 6 Weeks tillage treatments at post-harvest; while the 3 Weeks tillage treatment never showed any increase in moisture in soil on volume basis over the other tillage treatments. Different tillage practices cause changes in soil physical properties, such as water holding capacity (Trojan and Linden, 1998).

Hydraulic Conductivity:

The result of the hydraulic conductivity indicated a different result by 9 Weeks, 6 Weeks and 3 Weeks having a rapid hydraulic class rating at post-harvest; while the 0 Week indicated a very rapid hydraulic class rating at post-harvest. This difference is supported by Wu *et al.* (1992) and Fuentes *et al*. (2004) who revealed that some sites present larger Ksat values whereas Hubbard *et al*. (1994), reported smaller KSat values.

Table 4.: Effect of time of Seed-bed Preparation on Soil Physical Properties at Post-Harvest

Physical Properties	Seed-bed Preparation Treatments				$F\text{-}LSD_{p=0.05}$
	O Week	3 Weeks	6 Weeks	9 Weeks	
TP (%)	52.25^a	50.25^c	48^d	51.25^b	0.339
BD (g/cm^{-3})	1.0^a	1.0^a	1.0^a	1.0^a	1
MVB	9^c	3^d	16^a	13^b	0.177
MMB	11^c	4.55^d	22^a	16^b	0.177
MFC	18^a	15^b	9.25^c	4^d	0.177

TP = total porosity, BD = bulk density

Determination of the effect of Seed-bed preparation on soil C/N ratio

The determination of the effect of seed-bed preparation on soil C/N ratio is presented in Table 5.

Carbon sequestration:

The result revealed that there was statistically significant difference in the seed-bed preparation treatments of the soil C/N at post-harvest when the 3 Weeks tillage treatment was compared with 0 Week, 6 Weeks and 9 Weeks tillage treatments at post-harvest; while the 6 Weeks tillage treatment at post-harvest showed a statistical significant difference when compared with the 0 Week and 9 Weeks tillage treatments at post-harvest. Also, there was a significant difference in the 0 Week tillage treatment at post-harvest when compared with the 9 Weeks. There was 5.03 more of the C/N in the 0 Week of the tillage treatment at post-harvest when compared with the 9 Weeks tillage treatment at post-harvest. Also, there were 8.79, 0.57 and 13.82 more of the C/N in the 3 Weeks tillage treatments at post-harvest when it was compared with the 0, 6 Weeks and 9 Weeks respectively in the tillage treatments at post-harvest. The 6 Weeks tillage treatment indicated 8.22 and 13.25 more of the C/N when compared with the 0 Week and 9 Weeks tillage treatments at post-harvest; while the 9 Weeks tillage treatment never showed any increase in the C/N over the other tillage treatments. The result of the study showed that there was a decrease of the soil C/N from the 3 Weeks, 6 Weeks, 0 Week and 9 Weeks tillage treatments at post-harvest. Bahman and Ginting (2003), emphasized the need for storing C in the soil, as the soil not only become more productive but also the negative effect of increased C in the atmosphere is reduced. Further studies by Hendrix *et al.* (1988) and Franzluebbers *et al.* (1995); have shown contrasting results where CO_2 emissions have been both decreased and increased by no-till compared with conventional tillage

Table 5: Effect of time of Seed-bed Preparation on soil C/N ratio at post-harvest

Time of Seed-bed Preparation	C/N Ratio Values
0 Week	13.21^{c}
3 Weeks	22^{a}
6 Weeks	21.43^{b}
9 Weeks	8.18^{d}
F-LSD $_{p=0.05}$	0.283

Conclusion

The research work can be concluded by deducing that seed-bed preparation treatment of 3 Weeks tillage showed the highest level of improvement of the tuber yield and the soil C/N ratio at post-harvest sampling whereas the 0 Week treatment recorded the highest improvement of the tuber number at harvest and soil physical and chemical properties at post-harvest for some of the selected studied parameters. Conclusion from the 9 Weeks seed-bed preparation treatment is that it should not be applied in the conservation of the soil and water yam production as it showed the least level of improvement based on some of the selected studied parameters (the reason can be attributed to the influence of tillage age, soil organic matter turn-over rate and rapid mineralization and loss through seepage, thermal and microorganism effects). Other researchers may consider investigating the remote causes of the least result obtained for both yield characteristics and soil physical and chemical properties at the 9 Weeks tillage treatment.

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