Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 88 (2015) 36230-36241

ISSN: 2229-712X

Stratification of soil physicochemical properties as affected by tillage and NPK fertilization rates under cocoyam (Colocasia esculenta) in two agro-environment of southeastern Nigeria

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ARTICLE INFO

Article history:

Received: 14 September 2015;

Received in revised form: 29 October 2015;

Accepted: 04 November 2015;

Keywords

Stratification ratio,
Soil properties,
Tillage practices,
NPK fertilization,
Cocoyam,
Agro-environment.

ABSTRACT

Soils inherently low in nutrients may respond dramatically to conservation management, yet evaluation of soil nutrients on absolute basis may not detect change. This study was primarily aimed at investigating the depth distribution of soil organic carbon (SOC), total nitrogen (TN), soil carbon: nitrogen ratio (C:N), soil dry bulk density (BD), total porosity (TP), saturated hydraulic conductivity (Ksat) and their stratification ratios as affected by conventional tillage (CT) and no-tillage (NT) under cocoyam in a Typic paleudult in two agroenvironments in southeastern Nigeria. The experiment was conducted at the Teaching and Research farm of the Faculty of Agriculture and Natural Resource Management, Enugu State University of Science and Technology, Agbani Enugu (06◦52' N, 07◦15' E) and The Research and Experimental farm of Enugu State College of Agriculture and Agro-Entrepreneurship, Iwollo (06026'N; 07016'E), respectively during 2013 and 2014 planting season. The design of the experiment was Randomized Complete Block (RCBD) with five replications and four treatments which comprised of conventional tillage with 150 and 300 Kg/ha of NPK15:15:15 and No-Tillage with 150 and 300 Kg/ha of NPK15:15:15. Soil analysis was carried out at both pre- and post planting at two soil depths (0-20cm and 20-40cm) in both locations. The data collected was analyzed using Analysis of variance test (ANOVA). Result showed that Conventionally-tilled plots that received 300 Kg/ha NPK had 0.121percent N. This plot had between 7% - 30% lower N content when compared to No-till plots amended with both 300 and 150 Kg/ha for 2013 and 2014 planting season. The results showed that No-till plots had significantly higher (18-43%) post-harvest percent soil nitrogen, organic carbon and carbon: nitrogen content when compared to conventionally-tilled plots at both 0-20 and 20-40 cm soil depths. The stratification ratio of N (1.09-2.14 and 1.02-2.29 for CT and NT respectively), OC (CT, 1.10-3.07; NT, 1.01-2.42) and C:N (CT, 0.79-3.02; NT, 0.74-1.99) whereas stratification ratio of bulk density (CT,0.72-0.98; NT, 0.74-0.99), total porosity (CT, 0.98-1.20; NT, 0.90-1.22) and hydraulic conductivity (Ksat)(CT,1.07-1.29; NT, 1.03-1.49) for both sites and years did not follow any particular trend. This implies that soils vary in inherent properties and that absolute values of soil properties at the surface can vary. However, a reference is needed to separate inherent from management-induced changes. Generally taller plants ($P>0.05$) were found in Conventionally-till plots when compared with No-till plots. At harvest (210 DAP), the highest corm yield was obtained in Conventionally-tilled with 300kg/ha N plots which gave 8.58 and 7.83t/ha in Iwollo site for 2013 and 2014 planting season respectively followed by no-till treated 300kg/ha of NPK which also had 6.58 and 6.00t/ha. Conventionally-tilled plots amended with 300kg/ha N had 35% and 36% higher yield when compared with No-till plots amended with 150kg/ha of NPK plots for 2013 and 2014 planting season. The high yield advantage of Conventionally-tilled with 300kg/ha N over the other treatments may be due to differences in tillage practices and N fertilization rates. Tillage and fertilization helped increase the rate of crop emergence, improved soil moisture status, soil air (aeration), and improved general edaphic conditions of plants resulting in better yields. The relatively high stratification ratio of soil organic C, and some other soil properties, implies that conservation tillage and fertilizer application can compensate to some degree for the removal of above-ground plant residues.

Introduction

Cocoyam belongs to a group of crops called root and tubers. Root and tubers are the major carbohydrate staples in most countries of West Africa. In Nigeria, it is estimated that 31 million tons of root and tubers such as cassava, yam, sweet potatoes, cocoyam itself e.t.c are produced annually (FAO, 2011). Cocoyam is an ecologically unique crop. It is able to grow in ecological conditions (waterlogged soils, shaded environment etc) which other crop may find difficult or adverse (Anikwe et al, 1999). Cocoyam also require an average daily temperature of above 21^{0c} for normal production and able to

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tolerate heavy soils and it does best in soil pH of 5.5-6.5 (Onwueme, 1999).

Its production however, may be hampered by lack of adequate amounts of soil nutrients as it is a high soil fertility demanding crop and can react too to many soil amendments and manipulations (Ojeniyi, 1999). Most of the ecological constraints in the cocoyam production can be effectively tackled and possibly solved with modifications of the farming systems using conventional and conservational tillage practices, mulching and use of different fertilization practices. These have not been been studied to a great extent in south eastern Nigeria where it is one of the important staple crop (Taiwo et al, 2007).

Tillage is the physical manipulation of soil, performed to create conditions suitable for germination of seeds, seedling emergence and root growth to reduce competition from weeds (Priher et al, 2000). Intensive and continuous tillage may cause enormous losses of soil organic carbon (SOC), thus inducing an increase in soil erosion and a breakage of soil structure (Meiero et al, 2009). As a consequence, agricultural practices that reduce soil degradation are needed to improve soil quality and agricultural sustainability. Conservation tillage minimizes soil disturbances, protects the soil against degradation and improves sustainability (Meiero et al, 2009). It is widely recognized that tillage results in depth stratification of many soil properties such as soil organic carbon (SOC) and nitrogen (Franzlebbers, 2002. Brye et al, 2006. Moreno et al, 2006), nutrients, aggregate stability, porosity, microbial biomass and enzyme activities (Sa and Lal, 2009).

Stratification Ratio (SR) of a soil is defined as the ratio of a value determined for a soil property calculated by dividing values of the upper depth by the subsequently underlying lower depth ((Franzluebbers, 2002). According to Vanlauwe et al (1998) it is used to assess the characteristics of soil C:N ratio which is an important soil fertility indicator due to the close relationship between SOC and the total nitrogen (TN). It also reflect the interaction or coupling between SOC and TN. Although, its values are generally thought to be within a relatively narrow range. The soil C:N ratio is often influenced by many factors such as climate, soil conditions, vegetation types and agricultural managements (Diekow et al, 2005 and Franzluebbers, 2000, Puget and Lal, 2005). Total tillage or conventional tillage has been practiced for thousands of years while conservational tillage most especially, no-till, is still at the beginning stage of adoption. There have been very few reports on stratification of soil properties under tillage practices in Nigeria.

The objectives of the study are to:

1) Investigate the depth distribution of some soil physicochemical properties ratio as affected by conventional-till (CT) and no- till (NT) under cocoyam in tropical ultisol in South Eastern Nigeria.

2) Test the relationship between the NPK fertilization rates at different soil depths and its stratification ratios.

3) Determine the effect of tillage and NPK fertilization practices on soil properties, growth characteristics and yield indices of cocoyam (*Colocasia esculenta*)

Materials and methods

Description of Experimental Sites

The experiment was carried out for 2 consecutive seasons (2013 and 2014) at two locations in southeastern Nigeria. The first site was at the Faculty Research Farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Nigeria (06°52' N, 07°15' E; mean elevation 450m above sea level). The area has an annual rainfall of 1700–2010 mm. The rainfall pattern is bimodal between April and October, and the dry season is between November and March. The soil's textural class is loam with an isohyperthermic soil temperature regime (Ezeaku and Anikwe 2006) and is classified as Typic Paleustult (Anikwe *et al*. 1999).

The second site was at the experimental farm site of Enugu State College of Agriculture and Agro-entrepreneurship, Iwollo Nigeria($06^0$26'N; $07^0$16'E). It has an annual rainfall of about 1800-2000mm which spread between April and November. The textural class is silt-loam (Ibudialo et al, 2011).

Field methods

The sites were slashed and cleared of grasses. At each site, a total area of 11 m x 20.5 m (225.5 m2) was mapped out for the experiment. The experiment was carried out on the same plots in the 2013 and 2014 planting seasons. The field was divided into 5 blocks with each block having 4 experimental units giving a total of 20 plots.

The experimental units were demarcated by 1-m alleys and each unit (bed) measured 3m by 3 m ($9m^2$). The experimental beds were prepared manually with traditional hoes. The experimental units comprised two rates (150 kg Ha $^{-1}$ and 300 Kg Ha^{-1}) of NPK 15:15:15 Fertilizer and 2 tillage systems, *viz*. CT (tilled plots on 0-30 m raised beds) and NT plots on flat beds. The treatment matrix included all 4 combinations of tillage and fertilizer treatments. The test crop was a variety of cocoyam (*Colocasia esculenta* Schott, [cultivar: ede ofe]) obtained from the National Root Crops Research Institute, Umudike, Abia State, Nigeria. The choice of the variety stems from the fact that it is one of the most popular varieties grown around the zone. Cocoyam setts weighing 25–30 g were planted at one sett per hole at 5 cm depth using 50cm apart intra - inter row spacing. A total of 35 setts were planted in each plot making a plant population of 40,000 plants per hectare. Lost stands were replaced. Weeding was done once [at 21 days after planting (DAP)], with subsequent rouging. Fertilizer (NPK 15:15:15) was applied in bands 28 DAP.

Observation and data collection

Four undisturbed soil core samples (for analysis of bulk density and hydraulic conductivity) and 4 auger samples [for determination of gravimetric soil water content (GWC)] N, P, K, Ca, Mg, Na, pH, organic carbon, cation exchange capacity (CEC) and textural class were randomly collected from 0 to 20 cm and 20 – 40 cm depths in each plot at 95 days after planting (DAP). The soil core samples, collected using 98.2 cm ^{3} open-faced cores (195mm diameter by 50mm height) were analysed individually and mean results were used, whereas the auger samples were mixed and composite subsamples used for analysis. The soil physicochemical parameters were measured at 95 DAP.

Laboratory methods

A composite soil sample (collected from 10 points in the entire plot before the experiment started in 2013) and the samples collected within the experimental period were analysed in the laboratory for total nitrogen (N), available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), pH, SOC, and cation exchange capacity (CEC). Total N was determined by the macro Kjeldahl method (Bremner 1982). Available P was determined using Bray II method as outlined in Olsen (1982). SOC was analysed by the Walkley/Black procedure (Nelson and Sommers 1982). Soil pH in KCl was measured by the glass electrode pH meter (McLean 1982).The exchangeable cations and CEC were determined by the method described by Thomas (1982). Particle size distribution was determined by hydrometer method (Gee and Orr 2002). Dry bulk density was determined by the core method (Blake and Hartge, 1986)

Data analysis

The data collected from the experiment were analysed using analysis of variance test based on RCBD (using *F*-l.s.d. at *P*=0.05) according to procedures outlined by Steel and Torrie (1980).

Results and discussion

Pre-planting soil properties

The pre-planting analysis of soil properties at both Iwollo and Agbani sites are presented in Table 1.1. The results indicated that Agbani site was made up of **sandy silt** while Iwollo site was sandy loam. Percentage organic carbon (1.68%), organic matter (2.90%) and nitrogen (0.126%) in Iwollo site were higher than Agbani Site (1.08%, 1.86% and 0.056%) respectively. This indicated that Iwollo site had higher values for soil nutrients when compared to Agbani site. The soil pH in water ranged from 5.2 at the Iwollo site to about 5.5 at the Agbani site indicating "slightly acidic" for both sites according to the ratings of Landon (1985). Iwollo had higher exchangeable cations (CEC 23.20, Mg^+ 2.20, K^+ 0.10, Na^+ 0.15, and Al^+ 0.40 $Cmolkg^{-1}$) while Agbani site had CEC 8.4, Mg^+ 1.20, K^+ 0.06, Na^+ 0.09, and Al^+ 0.27 $Cmolkg^{-1}$. The bulk density in both Iwollo and Agbani site were 1.52 and 1.46 Mgm^{-3} respectively while Iwollo site had 39.25g/cm^3 total porosity and Agbani site had 46.04g/cm^3 total porosity. Saturated hydraulic conductivity of 30.30cm^3/hr was found in Iwollo site while 21.72kcm^3/hr was found at Agbani site. Gong et al (2007) elucidated that soils at different sites always differ in properties and fertility, texture and structures but even if they are the same, certain factors such as continuous tillage (cultivation), climate, soil amendments and other farming activities and management could have made them differ in texture and structure which in turn will affect the growth characteristics and yield indices of crops, fertility or nutrient status of the soil.

Table 1. Initial Soil properties of the study sites collected at 0–30 cm depth

PRE-PLANTING ANALYSIS	IWOLLO	AGBANI
Clay (%)	19 (0.91)	8 (0.98)
Silt (%)	15 (0.18)	7 (0.23)
Sand (%)	66 (1.18)	85 (0.91)
pH (H_20)	6.0 (0.78)	6.4 (0.51)
pH (KCl)	5.2 (0.14)	5.5 (0.34)
Organic Carbon (%)	1.68 (0.43)	1.08 (0.80)
Organic Matter (%)	2.90 (0.48)	1.86 (0.38)
N (%)	0.126 (0.35)	0.056 (0.27)
Na^+ ($Cmolkg^{-1}$)	0.15 (0.52)	0.09 (0.50)
K ($Cmolkg^{-1}$)	0.10 (0.28)	0.06 (0.34)
Ca ($Cmolkg^{-1}$)	3.80 (0.45)	4.2 (0.57)
Mg ($Cmolkg^{-1}$)	2.20 (0.35)	1.2 (0.21)
CEC ($Cmolkg^{-1}$)	23.20 (0.67)	8.4 (0.08)
AL ($Cmolkg^{-1}$)	0.40 (0.72)	0.27 (0.31)
Ex. Acidity ($Cmolkg^{-1}$)	1.80 (0.28)	0.60 (0.13)
Available P($Cmolkg^{-1}$)	7.46 (0.91)	15.64 (0.18)
Bulk density (Mgm^{-3})	1.52 (1.48)	1.46 (0.46)
Total Porosity (g/cm^3)	39.25 (1.41)	46.04 (0.21)
Hydraulic conductivity (Kcm^3/hr)	30.30 (1.18)	21.72 (0.18)

NB: Figures in parentheses are standard deviations.

Effect of Tillage and NPK fertilization rates on soil percent nitrogen content at different soil depths and its stratification in Iwollo and Agbani Sites

The results in Table 2 showed that there were significant differences in soil percent total N amongst the treatments (P=0.05) at various depths in different sites during 2013 and 2014 planting seasons. The soil total nitrogen content at 0-20cm soil depth for Iwollo site was 0.129 and 0.154 percent N respectively for 2013 and 2014 planting season in No-till, 300 Kg/ha N treated plots. This was followed by No-till, 150 Kg/ha N treated plots having 0.126 and 0.142 percent N content. However, no significant treatment differences were found between them. Conventionally-tilled plots that received 300 Kg/ha NPK had 0.121percent N. This plot had 7% and 30% lower N content when compared to No-till with 150 Kg/ha plots for 2013 and 2014 planting season respectively.

Table 2. Effect of tillage and N fertilization rates on soil percent nitrogen content at different soil depths in Iwollo and Agbani Sites during 2013 and 2014 planting season

	IWOLLO SITE				AGBANI SITE			
	0-20 CM		20.40 CM		0-20 CM		20.40 CM	
Treatment	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
CT150	0.112	0.078	0.102	0.057	0.053	0.055	0.053	0.031
CT300	0.121	0.126	0.104	0.059	0.053	0.056	0.055	0.045
NT150	0.126	0.142	0.124	0.062	0.056	0.058	0.056	0.045
NT300	0.129	0.154	0.126	0.078	0.059	0.078	0.057	0.046
F-LSD(0.05)	0.005	0.009	0.002	0.002	0.003	0.002	0.002	0.002

CT150 and CT300 = Conventional Tillage with 150 and 300kg of NPK 15:15:15

NT150 and NT300 = No Tillage with 150 and 300 Kg of NPK 15:15:15

These results showed that No-till plots had significantly higher post-harvest N content when compared to conventionally-tilled plots at 0-20cm soil depths. At Agbani site, the results followed the same trend. No-tilled plots at 0-20cm depths had percent N content of 0.059 and 0.078 for 2013 and 2014 planting season respectively for plots treated with 300 Kg/ha N. For conventionally-tilled plots, no significant treatment differences in mean N content were found for both 2013 and 2014 planting seasons. At 20-40cm soil depth, higher (P>0.05) total N content (0.124 % and 0.126 %) were found in No-till plots respectively when compared to conventionally-tilled plots which had 0.102 and 0.104% N content during 2013 planting season and 0.057 % and 0.059 % N content during 2014 planting season at Iwollo site. The results followed the same trend at Agbani site. The results showed that statistically higher percent N content were found in No-till plots when compared with conventionally-tilled plots. Similarly, higher soil percent N content was found in 0-20cm soil depth when compared with 20-40cm soil depth for all sites.

Results (Table 3) showed the N stratification ratios of the different treatments at both sites in 2013 and 2014 planting season. Higher stratification ratios of N were found in Conventionally-tilled plots when compared with no-tilled plots in both sites and seasons. Conventionally-tilled plots treated with 300kg/ha NPK had the highest N stratification ratio of 1.16 in Iwollo during 2013 planting season while No-tilled plots with 150kg/ha NPK had the highest N stratification ratio 2.29 in Iwollo site in 2014 planting season respectively. This was followed by No-till plots treated with 150kg/ha of NPK which had N stratification ratio of 1.02 respectively during the 2013 and 2014 planting season. However, no significant treatment effect on N stratification ratio was found when it was compared with the stratification ratio of the tilled-plots treated with 150kg/ha of NPK in the same season. Conventionally-tilled plots that received 300kg/ha of NPK with stratification ratio of 1.16 and 2.14 had 13% and 67% higher stratification ratio when compared to No-till plots with 150Kg/ha for 2013 planting season respectively in Iwollo and the results followed the same trend in Agbani site.

These results showed that Conventional-tilled plots had a preponderance of nutrients when compared to No-tilled plots. Similarly, higher stratification ratio of N was found in the conventionally-tilled plots in 2013 and 2014 planting seasons. The results also showed that more of the N in both No-tilled and Conventionally-tilled plots were concentrated at the upper, 0-20cm when compared to the 20-40cm soil depths. This is especially important for cocoyam which had fibrous root system and the roots do not go down the profile to a higher extent to exploit nutrients and water. Yang and Wander (1999) stipulated that soil surface receives more of the nutrients or any amendments applied to the soil at any amount or quantity. Tobert et al (2000) stated that nitrogen in any form has a positive charge and therefore, it is attracted and held a negatively charged soils and soil organic matter (SOM). This means that nitrogen that is not taken up by plants does not move downwards in the soil rather they will be subjected to other changes in the soil system.

Table 3. Stratification ratio of soil percent nitrogen content as affected by CT and NT for two sites in 2013 and 2014 planting seasons

	IWOLLO SITE		AGBANI SITE	
Treatment	2013	2014	2013	2014
CT150	1.09	1.37	0.00	1.77
CT300	1.16	2.14	0.96	1.24
NT150	1.02	2.29	1.00	1.29
NT300	1.02	1.97	1.04	1.70
F-LSD (P=0.05)	0.63	0.52	0.02	0.38

CT150 and CT300 = Conventional Tillage with 150 and 300kg of NPK 15:15:15

NT150 and NT300 = No Tillage with 150 and 300 Kg of NPK 15:15:15

Effect of Tillage and NPK fertilization rates on soil percent organic carbon content at different soil depths and its stratification in Iwollo and Agbani Sites

The result in Table 4 indicated significant differences (P=0.05) in percentage organic carbon content in Iwollo and Agbani sites at both depths (0-20cm and 20-40cm) and planting seasons (2013 and 2014) respectively. The soil percent organic carbon content at 0-20cm soil depth for Iwollo site was 2.84 and 3.71 percent respectively for 2013 and 2014 planting season in No-till plots treated with 300 Kg/ha of NPK. This was followed by No-tilled plots treated with 150 Kg/ha of NPK which had 2.71and 2.91 percent organic carbon content. However, no significant treatment differences were found between them. Conventionally-tilled plots that received 300 Kg/ha NPK with 1.64 percent organic carbon had 42% and 41% higher organic carbon content when compared to No-till with 150 Kg/ha plots for 2013 and 2014 planting season respectively. These results showed that No-till plots had significantly higher post harvest content of organic carbon when compared to conventionally tilled plots at 0-20cm soil depth. At Agbani site, the results followed the same trend. No-tilled plots at 0-20cm depth had percent organic carbon content of 1.84 and 2.60 for 2013 and 2014 planting season respectively for plots treated with 300 Kg/ha of NPK. For Conventionally-tilled plots, no significant treatment differences in organic carbon content were found for both 2013 and 2014 planting seasons for plots treated with 150 and 300 Kg/ha. At 20-40 cm soil depth, higher (P>0.05) total percent organic carbon content (1.04 and 1.49) were found in No-till plots respectively when compared to conventionally tilled plots which had 2.69 and 2.80 percent organic carbon during 2013 planting season whereas 2.40 and 2.53 percent organic carbon was found at Iwollo site during 2014 planting season. The results followed the same trend at Agbani site. The results showed that statistically higher percent organic carbon content was found at No-till when compared with conventionally tilled sites. Similarly, higher soil percent organic carbon content was found in 0-20cm soil depths when compared with 20-40cm soil depths for all sites. This indicates that tillage practices significantly reduced soil organic carbon (SOC) content. Cabel et al (2000) stated that conventional tillage decreases in both soil C and N compared to no-tillage no matter the level of the soil amendments and management.

Table 4. Effect of tillage and N fertilization rates on percentage organic carbon at different soil depths in two sites and two seasons

	IWOLLO SITE				AGBANI SITE			
	0 -20 cm		20 - 40 cm		0 -20 cm		20 - 40 cm	
Treatment	2013	2014	2013	2014	2013	2014	2013	2014
CT150	1.64	2.17	1.04	1.25	0.40	1.32	0.13	0.81
CT300	1.64	2.22	1.49	1.31	0.48	1.38	0.23	0.90
NT150	2.71	2.91	2.69	2.40	1.75	2.50	0.92	1.03
NT300	2.84	3.71	2.80	2.53	1.84	2.60	0.98	1.99
F-LSD(0.05)	0.3	1.02	0.7	0.09	0.06	0.3	0.02	0.8

CT150 and 300 = Conventional Tillage with 150 and 300 Kg of NPK 15:15:15

NT150 and 300 = No Tillage with 150 and 300 Kg of NPK 15:15:15

Results (Table 5) showed the stratification ratio of organic carbon content of the different treatments at both sites in 2013 and 2014 planting season. Higher stratification ratios of carbon were found in Conventionally-tilled plots when compared with No-tilled plots in both sites and season. Conventionally-tilled plots treated with 150 Kg/ha NPK had organic carbon stratification ratios of 1.58 and 1.74 in Iwollo site in 2013 and 2014 planting season respectively. This was followed by Conventionally- tilled plots treated with 300 Kg/ha of NPK which had C stratification ratios of 1.10 and 1.69 respectively during the 2013 and 2014 planting seasons. No-tilled plots with 300 Kg/ha had C stratification ratios of 1.01 and 1.47 during 2013 and 2014 planting season respectively.

Table 5. Stratification Ratio of percentage (%) organic carbon as affected by CT and NT in two sites in 2013 and 2014 planting seasons

	IWOLLO SITE		AGBANI SITE	
Treatment	**2013**	**2014**	**2013**	**2014**
CT150	1.58	1.74	3.07	1.63
CT300	1.10	1.69	2.09	1.53
NT150	1.01	1.21	1.90	2.42
NT300	1.01	1.47	1.88	1.31
F-LSD (P=0.05)	0.08	0.13	0.19	0.13

CT150 and 300 = Conventional Tillage with 150 and 300 Kg of NPK 15:15:15

NT150 and 300 = No Tillage with 150 and 300 Kg of NPK 15:15:15

However, no significant treatment effect on stratification ratios was found when it was compared with the stratification ratios of No-tilled plots treated with 150kg/ha of NPK in the same season (1.01 and 1.21). Conventionally-tilled plots that received 150 Kg/ha of NPK with stratification ratios of 1.58 and 1.74 had 36% and 30% higher stratification ratios when compared with 150 Kg/ha plots for 2013 and 2014 planting seasons respectively in Iwollo. The results followed the same trend at Agbani site. The results showed that Conventionally-tilled plots had higher stratification ratios of organic carbon when compared with No-tilled plots.

The results also showed that more of the C in both conventional and No-tilled plots is concentrated at the upper, 0-20cm when compared to the 20-40cm soil depth.

From the results above, it is observed that soil organic carbon (SOC) generally increases in top soil than in sub soil layers. This could be due to continuous cultivation and application of organic matter on the top soil where most of the nutrients applied in the soil are being received. Reicosky (2002) also stated that in tillage systems, most of the nutrients received in the top soil are being pulverized and generally mixed together to encourage nutrient absorption. That enhances the even distribution of nutrient in the soil and tilled-plots provide a good environment for nutrient uptake.

Effect of Tillage and NPK fertilization rates on soil carbon: nitrogen ratio at different soil depths and its stratification in Iwollo and Agbani Sites

The result in Table 6 indicated significant differences (P=0.05) in C:N ratio in Iwollo and Agbani sites at both depths (0-20cm and 20-40cm) and planting seasons (2013 and 2014) respectively. The C:N ratio at 0-20cm soil depth for Iwollo site was 22.0 and 24.1 respectively for 2013 and 2014 planting season in No-till plots treated with 300 kg/ha of NPK. This was followed by No-tilled plots treated with 150kg/ha of NPK which had 21.5 and 20.5 C:N ratio.

Table 6. Effect of tillage and N fertilization rates on C:N ratio at different soil depths in two sites and two seasons

	IWOLLO SITE				AGBANI SITE			
	0 -20 cm		20 - 40 cm		0 - 20 cm		20 - 40 cm	
Treatment	2013	2014	2013	2014	2013	2014	2013	2014
CT150	14.6	27.8	10.2	21.9	7.6	24.0	2.5	26.1
CT300	13.6	17.6	14.3	22.2	9.1	24.6	4.4	20.0
NT150	21.5	20.5	21.7	38.7	31.3	43.1	16.4	22.9
NT300	22.0	24.1	22.2	32.4	31.2	33.3	17.2	43.3
F-LSD (P=0.05)	1.4	1.3	2.9	1.01	2.2	1.92	1.11	0.98

CT150 and 300= Conventional Tillage with 150 and 300 Kg of NPK15:15:15.

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

However, no significant treatment differences were found between them. Conventionally-tilled plots that received 300 Kg/ha NPK with 13.6 and 17.6 C:N ratio had 38% and 26% lower C:N ratio when compared to No-till with 150 Kg/ha plots for 2013 and 2014 planting season respectively. These results showed that No-till plots had significantly higher post harvest C:N ratio when compared to Conventionally-tilled plots at 0-20cm soil depth. At Agbani site, the results followed the same trend. No-tilled plots at 20-40cm depth had C:N ratio of 22.2 and 32.4 for 2013 and 2014 planting season respectively for plots treated with 300 Kg/ha of NPK. For Conventionally tilled plots, no significant treatment differences in C:N ratio were found for both 2013 and 2014 planting seasons for plots treated with 150 and 300 Kg/ha. At 20-40cm soil depth, higher (P>0.05) C:N ratio (22.2 and 21.7) were found in No-till plots respectively when compared to Conventionally-tilled plots which had 14.3 and 10.2 C:N ratio during 2013 planting season whereas 22.2 and 21.9 C:N ratio was found at Iwollo site during 2014 planting season. The results followed the same trend at Agbani site. The results showed that statistically higher percent C:N ratio was found at No-till when compared with conventionally tilled sites. Similarly, higher soil C:N ratio was found in 20-40cm soil depth when compared with 0-20cm soil depth for all sites. This indicates that tillage practices significantly reduced the C:N ratio by depth.

From the result, despite the fact that conventional tillage (CT) provides suitable edaphic conditions for plant growth and also provides a favorable soil conditions which enhance microbial decomposition, no-tillage conserve more nutrients due to lesser disturbances (During et al, 2000 and Wright et al, 2007).

Under conventionally-tilled plots, the mixing effect by tillage practices has relatively homogenized the distributions of residues and roots. The soil C:N ratio was relatively uniformly distributed over the tillage depth from 0-20cm in our study at both sites (Iwollo and Agbani) while no-till systems accumulates nutrients more especially at soil surface.

Results (Table 7) showed the stratification ratio of C:N ratio of the different treatments at both sites in 2013 and 2014 planting season. Higher stratification ratios of C:N ratio were found in conventionally-tilled plots when compared with No-tilled plots in both sites and season. Conventionally-tilled plots treated with 150 Kg/ha NPK had C:N stratification ratios of 1.43 and 1.27 in Iwollo site in 2013 and 2014 planting season respectively. This was followed by conventionally-tilled plots treated with 300 Kg/ha of NPK which had C:N stratification ratios of 0.95 and 0.79 respectively during the 2013 and 2014 planting seasons. No-tilled plots with 300 Kg/ha had C:N stratification ratios of 0.99 and 0.74 during 2013 and 2014 planting season respectively. However, no significant treatment effect on stratification ratios was found when it was compared with the stratification ratios of No-tilled plots treated with 150 Kg/ha of NPK in th same season (0.99 and 0.53). Conventionally-tilled plots that received 150 Kg/ha of NPK with stratification ratios of 1.43 and 1.27 had 31% and 58% higher stratification ratios of C:N ratio when compared with 150kg/ha plots for 2013 and 2014 planting seasons respectively in Iwollo. The results followed the same trend at Agbani site. The results showed that Conventionally-tilled plots had a preponderance of nutrients when compared to No-tilled plots. Similarly, higher stratification ratios of C:N ratio were found in the conventionally-tilled plots with high level of nutrient application when compared with No-tilled plots.

Table 7. Stratification Ratio of C:N ratio as affected by tillage and N fertilization rates in two sites during 2013 and 2014 planting season

	IWOLLO SITE		AGBANI SITE	
Treatment	2013	2014	2013	2014
CT150	1.43	1.27	3.02	1.92
CT300	0.95	0.79	2.17	1.23
NT150	0.99	0.53	1.91	1.88
NT300	0.99	0.74	1.81	0.77
F-LSD (P=0.05)	0.02	0.11	0.19	0.14

CT150 and 300= Conventional Tillage with 150 and 300 Kg of NPK15:15:15.

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

The results also showed that more of the carbon and nitrogen in both Conventionally-tilled and No-tilled plots were concentrated at the upper, 0-20cm when compared to the 20-40cm soil depth. Thus, the C:N ratio was majorly stratified to show the trend with increasing depth within 0-40cm and this changes suggests decomposition degree of soil organic carbon and nitrogen (Yamashita et al, 2006). Xu et al (2011) also stipulated that if the residue has a wide range C:N ratio, it may be necessary to apply additional amounts of nitrogen to a soil or chose a residue with a narrower range because it is said that every two parts of carbon, there should be one part of nitrogen for net mineralization.

Effect of Tillage and NPK fertilization rates on soil dry bulk density and total porosity at different soil depths and its stratification in Iwollo and Agbani Sites

The result in Table 8 indicated significant differences (P=0.05) in the soil dry bulk density in Iwollo and Agbani sites at both depths (0-20cm and 20-40cm) and planting seasons (2013 and 2014) respectively. The bulk density at 0-20cm soil depth for Iwollo site was 1.60 Mg/m^3 and 1.59 Mg/m^3 respectively for 2013 and 2014 planting season in No-till plots treated with 300 Kg/ha of NPK. This was followed by No-tilled plots treated with 150 Kg/ha of NPK which had 1.59 Mg/m^3 and 1.58 Mg/m^3. However, no significant treatment differences were found between them. Conventionally tilled plots that received 300 Kg/ha NPK with 1.45 Mg/m^3 and 1.50 Mg/m^3 had 8% and 6% lower bulk density when compared to No-till with 150 Kg/ha plots for 2013 and 2014 planting season respectively.

Table 8. Effect of tillage and N fertilization rates on bulk density (Mgm^{-3}) at two sites of the experiment in 2013 and 2014 planting seasons

	IWOLLO SITE				AGBANI SITE			
	0-20 cm		20-40 cm		0-20 cm		20-40 cm	
Treatment	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
CT150	1.48	1.49	1.50	1.57	1.11	1.01	1.26	1.40
CT300	1.45	1.50	1.54	1.58	1.20	1.19	1.24	1.48
NT150	1.59	1.58	1.61	1.59	1.21	1.11	1.27	1.51
NT300	1.60	1.59	1.65	1.63	1.27	1.25	1.39	1.53
F-LSD(0.05)	0.03	0.01	0.12	0.92	0.75	0.30	0.11	0.08

CT150 and 300 = Conventional tillage with 150 and 300 Kg of NPK15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

These results showed that No-till plots had significantly higher post harvest soil bulk density when compared to conventionally-tilled plots at 0-20cm soil depth. At Agbani site, the results followed the same trend. For conventionally tilled plots, no significant treatment differences in mean bulk density were found. No-tilled plots at 20-40cm depth had soil bulk density of 1.65 and 1.63 Mg/m^3 for 2013 and 2014 planting season respectively for plots treated with 300 Kg/ha of NPK. For conventionally-tilled plots, no significant treatment differences in soil bulk density were found for both 2013 and 2014 planting seasons for plots treated with 150 and 300 Kg/ha. At 20-40cm soil depth, higher (P>0.05) soil bulk density (1.61 Mg/m^3 and 1.65 Mg/m^3) were found in No-till plots respectively when compared to Conventionally-tilled plots which had 1.54 Mg/m^3 and 1.50 Mg/m^3 during 2013 planting season whereas 1.59 Mg/m^3 and 1.58 Mg/m^3 was found at Iwollo site during 2014 planting season. The results followed the same trend at Agbani site. The results showed that statistically higher percent soil bulk density was found at No-till when compared with conventionally tilled sites. Similarly, higher soil bulk density was found in 20-40cm soil depth when compared with 0-20cm soil depth for all sites. This indicates that tillage practices significantly reduced the soil bulk density by depth which indicates that tillage practices and organic matter application influenced soil compaction to a great extent. Franzluebbers (2000) said that tillage has an inverse impact on soil bulk density and direct impact on soil porosity. The effect of tillage on soil compaction was more prominent at the early stages of the crop growth but did not influence crop emergence especially in No-Tilled plots 150 and 300 Kg/ha N because seed holes were opened for planting and that loosened the area around the emerging corms. If bulk density is above 1.60 Mg/m^3 in the plough horizon on medium heavy soils has a negative effect on the growth and development of agricultural crops and was regarded as a threshold value of adverse soil compaction.

The result in Table 9 showed the stratification ratio of the soil bulk density of the different treatments at both sites in 2013 and 2014 planting season. Higher stratification ratios of the soil bulk density were found in No-tilled plots when compared with conventionally-tilled plots in both sites and season. No-tilled plots treated with 150 Kg/ha NPK had stratification ratio of soil bulk density of 0.98 and 0.99 in Iwollo site in 2013 and 2014 planting season respectively. This was followed by No-tilled plots treated with 300 Kg/ha of NPK which had stratification ratio of soil bulk density of 0.96 and 0.97 respectively during the 2013 and 2014 planting seasons. Conventionally-tilled plots with 150 Kg/ha of NPK had stratification ratio of soil bulk density of 0.98 and 0.95 during 2013 and 2014 planting season respectively. However, no significant treatment effect on the stratification ratio was found when it was compared with the stratification ratio of tilled plots treated with 300 Kg/ha of NPK in the same seasons (0.94 and 0.94). No-tilled plots that received 150 Kg/ha of NPK with stratification ratio of 0.98 and 0.99 had 4% and 5% higher stratification ratio when compared to conventionally-tilled plots with 300 Kg/ha plots for 2013 and 2014 planting season respectively in Iwollo. The results followed the same trend at Agbani site.

Table 9. Stratification Ratio of soil bulk density as affected by tillage and N fertilization rates in two sites of 2013 and 2014 planting seasons

	IWOLLO SITE		AGBANI SITE	
Treatment	**2013**	**2014**	**2013**	**2014**
CT150	0.98	0.95	0.88	0.72
CT300	0.94	0.94	0.97	0.80
NT150	0.98	0.99	0.95	0.74
NT300	0.96	0.97	0.91	0.82
F-LSD (P=0.05)	0.04	0.01	0.05	0.02

CT150 and 300 = Conventional tillage with 150 and 300 Kg of NPK15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

Similarly, higher stratification ratios of bulk density were found in the No-tilled plots when compared with Conventionally-tilled plots. Soil bulk density was higher at the lower 20-40cm when compared to the 0-20cm soil depth.

Bulk density is a parameter that is used to quantify soil compactness because the higher the bulk density, the higher the compaction of the soil. Soil compaction increases bulk density and decreases bulk volume (Kooistra and Tovey, 1994). Continuous cultivation always decreases soil compaction. The differences in bulk density could be as a result of continuous cultivation.

The result in Table 10 and Table 11 indicated significant differences (P=0.05) in the soil percent total porosity and stratification ratio of soil total porosity in Iwollo and Agbani sites at both depths (0-20cm and 20-40cm) and planting seasons (2013 and 2014) respectively. Soil total porosity is inversely related to soil bulk density. Oliveira and Merwin (2001) stipulated that increased porosity is especially important for the crop development since it may have a direct effect on the soil aeration and enhances the root growth while the improved root growth will also enhance increase plant water as well as nutrient uptake.

Table 10. Effect of tillage and N fertilization rates on percent Total Porosity (%) at different soil depths during 2013 and 2014 planting seasons

	IWOLLO SITE				AGBANI SITE			
	0-20 cm		20-40 cm		0-20 cm		20-40 cm	
Treatment	2013	2014	2013	2014	2013	2014	2013	2014
CT150	48.09	40.38	40.00	40.08	49.06	47.36	48.12	48.09
CT300	46.01	40.74	41.89	40.38	48.62	42.49	44.41	41.82
NT150	40.61	37.75	39.00	32.92	36.04	41.17	40.00	35.91
NT300	39.05	30.38	35.42	30.10	39.24	39.25	36.17	32.21
F-LSD(0.05)	0.87	0.25	2.32	1.9	3.20	2.50	2.62	1.80

CT150 and 300 = Conventional tillage with 150 and 300 Kg of NPK15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

Table 11. Stratification ratio of Total Porosity as affected by CT and NT in two sites of the experiment in 2013 and 2014 planting seasons

	IWOLLO SITE		AGBANI SITE	
Treatment	2013	2014	2013	2014
CT150	1.20	1.01	1.02	0.98
CT300	1.09	1.01	1.09	1.02
NT150	1.04	1.15	0.90	1.15
NT300	1.10	1.01	1.08	1.22
F-LSD (P=0.05)	0.6	0.9	0.9	1.0

CT150 and 300 = Conventional tillage with 150 and 300 Kg of NPK15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

Effect of Tillage and NPK fertilization rates on soil saturated hydraulic conductivity at different soil depths and its stratification in Iwollo and Agbani Sites

The result in Table 12 indicated significant differences (P=0.05) in the soil hydraulic conductivity in Iwollo and Agbani sites at both depths (0-20cm and 20-40cm) and planting seasons (2013 and 2014) respectively.

Table 12. Effect of tillage and N fertilization rates on saturated hydraulic conductivity (cm/hr) of the soil in two sites of the experiment during 2013 and 2014 planting season

	IWOLLO SITE				AGBANI SITE			
	0-20 cm		20-40 cm		0-20 cm		20-40 cm	
Treatment	2013	2014	2013	2014	2013	2014	2013	2014
CT150	40.21	39.30	34.75	34.14	49.71	46.14	42.25	40.10
CT300	39.61	37.25	30.61	30.30	43.72	42.69	40.72	38.15
NT150	35.79	31.60	27.43	24.75	40.21	39.67	39.16	32.15
NT300	34.78	30.19	27.28	20.15	35.15	38.19	36.22	30.10
F-LSD(0.05)	1.8	1.0	0.9	0.5	2.0	2.1	0.9	1.1

CT150 and 300 = Conventional Tillage with 150 and 300 Kg of NPK 15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK 15:15:15

The soil hydraulic conductivity at 0-20cm soil depth for Iwollo site had 40.21cm/hr and 39.30 cm/hr respectively for 2013 and 2014 planting season in Conventionally-tilled plots treated with 150 Kg/ha of NPK. This was followed by Conventionally-tilled plots treated with 300 Kg/ha of NPK which had 39.61cm/hr and 37.25 cm/hr. However, no significant treatment differences were found between them. No-tilled plots that received 150 Kg/ha NPK with 35.79 cm/hr and 30.19 cm/hr had 15% and 23% lower hydraulic conductivity when compared to Conventionally-tilled with 150 Kg/ha plots for 2013 and 2014 planting season respectively. These results showed that Conventionally-tilled plots had significantly higher post harvest soil hydraulic conductivity when compared to No-tilled plots at 0-20cm soil depth. At Agbani site, the results followed the same trend. For conventionally tilled plots, no significant treatment differences in mean soil hydraulic conductivity were found. Conventionally-tilled plots at 20-40cm depth had soil hydraulic conductivity of 34.75 cm/hr and 34.14 cm/hr for 2013 and 2014 planting season respectively for plots treated with 150kg/ha of NPK. For No-tilled plots, no significant treatment differences in soil hydraulic conductivity were found for both 2013 and 2014 planting seasons for plots treated with 150 and 300 Kg/ha. At 20-40cm soil depth, higher (P>0.05) soil hydraulic conductivity (34.75 cm/hr and 30.61cm/hr) were found in Conventionally-tilled plots respectively when compared to No-tilled plots which had 27.43 cm/hr and 27.28 cm/hr during 2013 planting season whereas 34.14 cm/hr and 30.30 cm/hr of the soil hydraulic conductivity was found at Iwollo site during 2014 planting season. The results followed the same trend at Agbani site. The results showed that statistically higher soil hydraulic conductivity was found at Conventionally-tilled sites when compared with No-tilled sites. Similarly, higher soil hydraulic conductivity was found in 0-20cm soil depth when compared with 20-40cm soil depth for all sites. This indicates that tillage practices significantly increased the soil hydraulic conductivity by depth.

Agbede (2009), reported that hydraulic conductivity is attributed to be higher in tilled soils than no-till soils due to the greater number of voids and abundant soil macro-pores caused by the tillage implementation but soil hydraulic conductivity decreased with increased intensity of soil manipulations by tillage practices. These results imply that tilled plots transmit water better under saturation than no-till plots.

The result in Table 13 showed stratification ratio of hydraulic conductivity of the different treatments at both sites in 2013 and 2014 planting season. Higher stratification ratios of hydraulic conductivity were found in No-tilled plots when compared with conventionally-tilled plots in both sites and seasons. No-tilled plots treated with 150 Kg/ha of NPK had the highest stratification ratio of hydraulic conductivity of 1.30 cm/hr in Iwollo site during 2013 planting season while No-tilled plots with 300 Kg/ha NPK had the highest hydraulic conductivity stratification ratio of 1.49 in Iwollo site in 2014 planting season.

Table 13. Stratification Ratio of Hydraulic Conductivity as affected by CT and NT in two sites of the experiment during 2013 and 2014 planting seasons

	IWOLLO SITE		AGBANI SITE	
Treatment	2013	2014	2013	2014
CT150	1.16	1.15	1.18	1.15
CT300	1.29	1.23	1.07	1.12
NT150	1.30	1.28	1.03	1.23
NT300	1.27	1.49	0.97	1.27
F-LSD (P=0.05)	0.04	0.81	0.09	0.07

CT150 and 300 = Conventional tillage with 150 and 300 Kg of NPK15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK15:15:15

This was followed by conventionally-tilled plots treated with 300 Kg/ha of NPK which had hydraulic conductivity stratification ratio of 1.29 and 1.23 respectively during the 2013 and 2014 planting season. However, no significant treatment effect on hydraulic conductivity stratification ratio was found when it was compared with the stratification ratio of the No-tilled plots treated with 150 Kg/ha of NPK in the same seasons. No-tilled plots that received 150 and 300 Kg/ha of NPK with stratification ratio of 1.30 and 1.49 had 11% and 22% higher stratification ratio when compared to Conventionally-tilled plots with 150 Kg/ha for 2013 and 2014 planting season in Iwollo and the results followed the same trend in Agbani site.

The results showed that No-tilled plots had a fairly uniform stratification ratio of water transmissivity when compared to conventionally-tilled plots in 2013 than 2014 in Iwollo site at 0-40 cm depth although higher stratification ratio of the hydraulic conductivity was found in the No-tilled plots in 2013 and 2014 planting seasons respectively. The results also showed that more of the hydraulic conductivity in both No-tilled and conventionally-tilled plots are concentrated at the upper, 0-20cm when compared to the 20-40cm soil depths.

Previous research as demonstrated by Pikul and Aese (1999 and 2003) showed that continuous tillage over a long period can develop a compacted layer that impeded water movement at a depth. Patel and Singh (1981) reported that soil macro pores and aggregations under no-till (NT) formed by decayed roots can be preserved under NT whereas conventional tillage (CT) breaks up the continuity of these macrospores. Microspores generally occupy a small fraction of the soil volume but their contribution to water flow in soil is high (Jabro et al, 2009)

Effect of Tillage and NPK fertilization rates on plant height and corm yield of cocoyams at Iwollo and Agbani Sites

The results in Tables 14 and 15 showed that there were significant differences in plant height of cocoyam amongst the treatments (P=0.05) at 35, 65 and 95 DAP during 2013 and 2014 planting seasons. The plants were taller at Iwollo site (28.20cm, 56.63cm and 90.7cm at 35, 65 and 95 DAP respectively) in 2013 planting season in Conventionally-tilled, 300kg/ha of N treated plots.

Table 14. Effect of tillage and N fertilization rates on plant height (cm) of cocoyam at 35, 65 and 95 DAP in Iwollo and Agbani sites

DAYS AFTER PLANTING (DAP)												
	IWOLLO SITE						AGBANI SITE					
	35		65		95		35		65		95	
Treatment	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
CT150	20.84	19.26	42.2	41.68	77.04	69.04	19.16	20.7	41.6	37.06	66.7	60.58
CT300	28.2	18.46	56.63	39.58	90.7	72.38	27.42	24.3	56.18	44.64	77.26	65.68
NT150	13.54	16.64	27.76	41.16	58.18	69.42	13.26	13.3	29.68	23.20	55.62	50.52
NT300	21.72	17.04	45.52	40.06	77.28	69.12	19.82	17.0	40.5	28.94	73.9	50.62
F-LSD(0.05)	7.7	NS	7.6	NS	0.01	NS	5.8	0.08	1.2	7.8	6.0	0.05

NS = No significant effect

CT150 and CT300 = Convention Tillage with 150 and 300 Kg of NPK 15:15:15

NT150 and NT300 = No tillage with 150 and 300 Kg of NPK 15:15:15

F-LSD = Fisher's Least Significant Difference.

Table 15. Effect of tillage and N fertilization rates on yield (t/ha) of cocoyam at harvest (210 DAP) during 2013 and 2014 planting season in Iwollo and Agbani sites

	IWOLLO SITE		AGBANI SITE	
Treatment	2013	2014	2013	2014
CT150	6.46	5.95	6.26	5.81
CT300	8.58	7.83	8.16	7.72
NT150	5.54	4.98	4.92	4.19
NT300	6.58	6.00	5.7	5.30
F-LSD (P=0.05)	2.8	2.06	1.2	0.65

CT150 and 300 = Convention tillage with 150 and 300 Kg of NPK 15:15:15

NT150 and 300 = No tillage with 150 and 300 Kg of NPK 15:15:15

F-LSD = Fisher's Least Significant Difference.

Generally taller plants (P>0.05) were found in Conventionally-till plots when compared with No-till sites.

At harvest (210 DAP), the highest corm yield was obtained in Conventionally-tilled with 300kg/ha N plots which gave 8.58 and 7.83t/ha in Iwollo site for 2013 and 2014 planting season respectively followed by no-till treated 300kg/ha of NPK which also had 6.58 and 6.00t/ha. Conventionally-tilled plots amended with 300kg/ha N had 35% and 36% higher yield when compared with No-till plots amended with 150kg/ha of NPK plots for 2013 and 2014 planting season. These results showed that Conventionally-tilled plots had significantly higher corm yield when compared to No-till plots. At Agbani site, the results followed the same trend in both 2013 and 2014 planting season.

The high yield advantage of Conventionally-tilled with 300 Kg/ha N over the other treatments, Conventionally-tilled with 150 Kg/ha N, No-tilled plots with 150 and 300 Kg/ha N respectively may be due to differences in tillage practices and N fertilization rates because Conventionally-tilled with 300 Kg/ha creates room for better root penetration which led the plants to explore greater soil volume for nutrients and water . Tillage and fertilization helped increase the rate of crop emergence, improve soil moisture status, soil air (aeration), reduced weed competition and improve in general edaphic conditions of plants resulting in better yields.

Gajri et al (2002) noted that no tillage gave significantly lower yield than any other tillage treatments. This usually affects the yield because tillage softened and loosened the soil aggregates thereby making water infiltration in the root zone easier. Tillage always facilitates organic matter decomposition and mineralization, thereby making more nutrients available to the tilled plots (Abu-Hamdeh, 2014). In no-till plots, soil bulk density was higher and this may lead to restriction of rooting depth, which reduces the uptake of water and nutrients in plants. Similarly, increase in soil bulk density may result in decreased pore volume and at constant water content, this increases the proportion of water filled pore spaces leading to aeration stress and decreases soil temperature (Kooistra and Tovey, 1994). These affect the activities of micro organisms by decreasing the rate of decomposition of soil organic matter and subsequent release of nutrients.

No significant differences in corm yield were found between Conventionally-tilled plots with 300 and 150 Kg/ha N and between No-tilled plots with 300 and 150 Kg/ha N at both sites. This means that better edaphic conditions provided by conventional tillage was compensated for by higher doses of N fertilizer. This indicated that in places where No-till is preferable so as to reduce costs and negative effects of continuous tillage on soil properties, Fertilizer application can be used to increase yield and to compensate for the negative effect of No-till on crop yield.

Conclusions

The results presented in this study indicated that stratification of soil organic carbon (SOC), and total nitrogen (TN) as well as soil carbon-nitrogen (C:N) ratio increased under conventional tillage (CT) and no-tillage (NT) systems. At Iwollo site, CT and NT with different rates of NPK fertilization rates significantly increased soil organic carbon (SOC) stocks and total nitrogen (TN) at the surface depths 0-20cm and in turn at the entire profile (0-40 cm). These results indicate that stratification of SOC and TN as well as C:N ratio vary depending on specific study sites and edapho-climatic conditions. It was also observed that SOC and TN are more concentrated at the soil surface (0-20cm) where cocoyam absorbs them more than at deeper soil depth (20-40 cm).

Conventional tillage (CT) decreased the soil bulk density and increased the total soil porosity. Stratification ratio values of bulk density and total porosity could be used as soil quality parameters in the assessment of the impact of tillage on soil quality. From the results of the experiment, SOC, TN, C:N ratio, bulk density and total porosity qualify as tools or parameters to be used for assessing the quality of soil. They enable soils from different environments to be compared using similar indices because of an internal normalization procedure that reflect soil differences.

The results also showed that tillage practices and N fertilization rates significantly (P=0.05) affected some growth characteristics and yield indices of cocoyam. Conventional-tillage with 300 Kg of NPK 15:15:15 had the highest corm yield, followed by No-till with 300 Kg/ha, Conventional-till with 150 Kg/ha and lastly No till with 150 Kg/ha. This means that Conventional till with 300 Kg/ha provided a better edaphic environment for the crop than other treatments used in the study. The tillage techniques used and N fertilization rates influenced cocoyam growth. The No-tilled plots with 150 Kg of NPK 15: 15: 15 were found to have the least yield. NPK fertilization rates and tillage practices can be used to manipulate the soil environment (especially soil bulk density, SOC, TN, C:N ratio etc.) of cocoyam for profitable production of this important crop in the tropical climate (Anikwe et al., 2006).

The study indicated that soils under NT are not disturbed and remain intact. NT can also conserve nutrients and water. Nitrogen and carbon are higher in NT plots than CT due to the ability to retain and conserve nutrients as a result of limited soil disturbances but CT provided a suitable edaphic condition for plant growth, development and survival that was the reason for higher crop yield in Conventionally-tilled plots compared to No-till plots at harvest.

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