Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

Tillage and rice mill wastes mulch and their effects on soil properties and yield of cassava (Manihot spp.) on a Typic psamment at Abakaliliki, Southeastern Nigeria

Nwite J. N[1]., Njoku C[1]., and Okonkwo G.I.[2]

1. *Department of Soil Science and Environmental Management Faculty of Agriculture and Natural Resources Management Ebonyi State University, P.M.B 053, Abakaliki – Nigeria*
2. *Department of Agricultural Education, Nwafor Orizu College of Education, Nsugbe, Anambra State Nigeria*

ARTICLE INFO

Article history:

Received February 12, 2020

Received in revised form April 4, 2020

Accepted April 12, 2020

Available online May 27, 2020

Keywords:

Planting date.,
Variety.,
Water use efficiency

Corresponding Author's E-mail Address:

Chimarco2001@yahoo.com .+2348032261958

https://doi.org/10.36265/njss.2020.300203

ISSN-1597-4488

ABSTRACT

The experiment was undertaken using cassava (*Manihot spp*) to evaluate effects of different tillage practices and mulching (raised mulched bed, raised not mulched bed, flat mulched bed, flat not mulched bed, untilled mulched bed and untilled not mulched bed) on soil properties and cassava sprouting and yield in 2016 and 2017 planting seasons on a *Typic psamment* in Ikwo, Ebonyi State, Southeastern Nigeria. The experimental study is made up of six treatments, arranged in randomized complete block design and replicated four times. The results indicated significantly ($P<0.05$) higher (28.18 – 27.16%) GMC in beds mulched than corresponding values (17.10 – 15.26% and 16.20 – 15.10%) obtained in untilled mulched and untilled not mulched beds for both seasons. Results showed that available P, N, Ca and Mg were respectively higher ($P<0.05$) in mulched raised beds when compared to those of untilled mulched or untilled not mulched beds by 31 – 28%, 32 – 71%, 50 – 33%, 50 – 30%, 89 – 67% and 49 – 26%, 91–71%. At 28 DAP for 2016 and 2017 planting seasons results showed that 90–78% of the planted cassava cuttings sprouted between 14 – 17 days earlier in both tilled mulched beds and tilled not mulched beds compared to untilled mulched or untilled not mulched beds (5 – 48%). These were ($P<0.05$) 40 – 50% and 47–37% significantly higher in tilled mulched and tilled not mulched beds when compared to untilled mulched and untilled not mulched beds. At harvest (300 DAP), highest cassava tuber yield (7.5–7.3t ha^{-1}) were obtained in raised mulched beds for 2016 and 2017. Cassava yields were ($p<0.05$) higher in raised mulched beds by 60 and 59% compared to their counterparts in untilled not mulched beds for the seasons. These findings imply that rice mill wastes mulch provide a good and conducive soil condition for cassava than unmulched or untilled environment and raised mulched beds provide more robust condition for cassava production relative to other treatments tested in this study.

1.0. Introduction

One of the root and tuber crops extensively cultivated in Nigeria and other West African countries is cassava (*manihot spp*). Nigeria is perhaps the largest producer of the crop in the world with up to 34 million tonnage annually representing between 19 – 37% compared to both global and African productions (Ikeorgu and Mbah, 2007). In Nigeria, cassava comes behind yam as the most preferred root and tuber crop and largely taken as carbohydrate staple and thus accounts for more than 40% daily caloric intake of 60% of the populace (NPAFS, 2010). Cassava because of its sturdy nature as well as amendable characteristics can be grown on range of soils; from low to uplands and can tolerate drought and low fertility soils (Nwaobiala and Isaac, 2017; IITA, 2004). Although, cassava is tolerant to many soil conditions, high yields are common in friable, loose and light soils (Nwalobiala and Isaac, 2017) and does not thrive under poorly drained or highly hydromorphic soils. Lower yields are obtained in strong gravel soils. Cassava requires abundant rainfall or intensive irrigation amounting to 1200 – 2000mm or 500 –

750mm and daily temperature of not less than 29^oC for optimum yield (Aniekwe *et al.,* 2005). It cannot do well under low intensity sunshine for greater part of the year and therefore does not fit into intercropping systems. Cassava can thrive under pH 4.5 – 5.5 but highest yields are possible at a pH 5.5 and 6.5 (Asadu and Nweke, 1999). Tillage is a mechanical manipulation of soil, which is carried out to create suitable conditions for seed germination or seedling emergence, root growth (Prihar *et al*., 2000), enhance nutrients supply, moisture retention, weed and disease control. Mulching the soil after planting has been canvassed as it is often beneficial in cropping culture. For instance, Anikwe *et al.* (2007)noted that polythene film mulch was spread over planted crop rows which conserved moisture and controlled weeds in cocoyam culture. Lal (1979) reported that temperature and moisture regimes as influenced by mulch materials and seedbed preparation showed significant and beneficial effects on yields of maize, cowpea, soybean and cassava. Some other positive responses to mulch by crops include earlier production, greater total yield and reduced pest and disease devastation (Jensen, 1990). Organic mulches have direct effect on the immediate environment around the plant such as modification of moisture regime and heat energy. Mulches such as straw, rice wastes, hay, grass, compost and wood chippings add nutrients to the soil through their decomposition and mineralization (Dickerson, 2007). Rice mill wastes have high absorbent surfaces for direct moisture control on microclimate around the plant as well as moderate C:N (Biswas and Murkherjee, 2008) for effective decomposition and residual effect. These wastes are abundant and commonly found within the agro economy but lack vital information for economic benefit (Nnabude and Mbagwu, 2001).Cassava is an important tropical root crop. It has the advantage of growing and surviving under ecological conditions such as low moisture content, full sun shine intensity or low fertility condition which other alternate crops may find adverse. Constraints limiting high or economical cassava production can be reversed or eliminated through concerted research effort. It is uncommon practice to mulch cassava crops by farmers unlike other crops because of the believe on its high adaptability to soil conditions, however, to breakeven in its production and solve food insecurity problem, there is need for detailed study of the crop. It is imperative to evaluate response of cassava to different ecological conditions such as different tillage practices and rice mill wastes mulching. The objective of this work was to find effect of different tillage manipulations and rice mill wastes mulch on soil properties and yield characteristics of *manihot esculenta.*

2. .0 Materials and Methods

2.1. Location and Site Characteristics

The study was carried out for two seasons of 2016 and 2017 at Faculty Teaching and Research farm, Ebonyi State University, Abakaliki, Nigeria. The area (Latitude 06^O 4 $^/$N and Longitude 08^o 65 $^/$E), has a mean elevation of 650m above sea level. There is bimodal pattern of rainfall (April - July) and (September - November). There is a dry spell in August in between the peak periods. Rainfall ranges between 1700 – 2000 mm for minimum and maximum. Average mean annual rainfall is 1800 mm. Temperature is almost even for the year, but, however hovers between 27^oC and 31^oC for dry and rainy seasons. Relative humidity is 80% during rainy months but declines to 60% in dry season (Nlimet, 2016). The soil has lateritic surface, gravelly and sandy loam textural class. It has an *udic* soil moisture regime and *hyperthermic* soil temperature regime and is classified as *Regosol* (ESU, 2005).

2.2 . Field Methods

The experimental site was cleared of grass. Land area was 0.02 ha marked out for the experiment which lasted between 2016 and 2017 planting seasons on same plots. The field was demarcated into four blocks with each block having six units giving a total of 24 plots. The blocks were separated from each other by 1m alleys while units (beds) which measured 3 m x 3 m were set apart by 0.5 m. The experiment was designed using randomized complete block design. The treatments were: raised mulched bed, raise not mulched bed, flat tilled mulched bed, flat tilled not mulched bed, untilled mulched bed and untilled not mulched bed.

The experimental plots were prepared using traditional hoe. Rice mill wastes were used to cover each plot receiving mulch at the rate of 3.6kg plot^{-1}. Mulching material was evenly spread on individual beds after planting the cassava cottons. The cassava cultivated variety used was tropical *Manihot species* (TMS 30572). Cassava cuttings which weighed between 15 – 30g and 15cm long (4 – 5 nods) were planted at an angle of 45^o. The cuttings were planted at one cutting per hole and spaced 1m apart for inter and intra raw spacing. This gave a total of 9 cuttings per plot giving a total population of 10,000 cassava plants per hectare. Cassava cuttings after three weeks of planting were replaced. The beds were weeded as often as weeds appeared using hands.

2.3. Agronomic and Soil data collection

Twenty undisturbed soil auger samples (chemical properties) and core samples (physical properties) were collected randomly from the site at 0 – 30cm depth and composited except core samples for determination of initial properties of soil. Therefore, five soil core samples for analysis of bulk density, gravimetric moisture content (GMC) and total porosity were equally collected from each bed at 0 – 30cm depth for laboratory determinations. The core dimensions are 96.2cm^3 open faced with area of 18.5cm^3 and 5cm height. The core soil samples were analyzed separately and mean results used but auger samples were mixed and sub-samples (composited) and analyzed in the laboratory. Soil samples for bulk density, GMC, total porosity ad chemical properties were collected at 180 days after planting (DAP). Days to sprouting count started from 14 days. Cassava yield was determined (DAP) at harvest (300 DAP). For agronomic yield characteristics, six plants were sampled from net bed.

2.4. Laboratory Determinations

A composite soil sample (twenty auger samples from the site) before commencement of experiment in 2016 was analyzed in laboratory for N, P, K, Ca, Mg, Na, pH, CEC, BS and organic carbon and pH, P, N, Ca, Mg, K as well as for post harvest. The determination of total N was carried out using macrokjeldahl method (Bremner, 1982). Available P was determined by Bray 2 method according to Olsen (1982). The exchangeable cations and CEC were evaluated as described by Thomas (1982). Organic carbon was analyzed using Walkley and Black procedure (Nelson and Sommers, 1982). Soil pH in Kcl was determined using 1:2.5 soil/water solution ratio and values read with glass electrode pH meter. Percent Base saturation was assessed by summation method using values of total exchangeable bases and CEC. Dry bulk density was determined by core method (Gee and Or, 2002). Gravimetric moisture content determination was carried out as outlined by Obi (2000). Total porosity was calculated using the formular:

$$Tp = \frac{\textit{Bulk density (MgM-3)}}{\textit{Particle density } (Mgm^{-3})} \times \frac{100}{1} \qquad 1$$

Where

Tp = Total porosity

Particle density was assumed to be 2.65 MgM^{-3} (average density of mineral soils).

2.5. Data Analysis

The data accumulated from the study were analyzed using analysis of variance test for RCBD and significant means separated with FLSD while significance was accepted at 5% (SAS, 1985 software package).

3.0. Result and Discussion

3.1. Initial Soil Properties

Soil properties (Table 1) at beginning of this study show that the texture was sandy loam. Soil pH (5.4) was strongly acidic. Organic carbon ($0.89kg^{-1}$) and total N ($0.07gkg^{-1}$) were very low but had moderate available phosphorus ($28.70 gkg^{-1}$). Exchangeable bases ranged from low (2.28–0.09 $cmolkg^{-1}$) to very low values. Cation exchange capacity (3.81 $cmolkg^{-1}$) and exchangeable acidity (0.40 $cmolkg^{-1}$) were low. The soil is base (89%) saturated. The soil density was 1.44 MgM^{-3}, with total porosity (5.4%) and 18.24% moisture content as initial physical characteristics.

3.2. Effect of Tillage and Rice Mill wastes Mulch on studied physical properties of soil since planting

Results do not show any significant differences among the treatments in bulk density and total porosity except in gravimetric moisture content for the two seasons (Table 2). For two seasons, results show significantly ($P<0.05$) higher GMC of 28.18 – 27.16% in raised mulched bed and 25.15 – 19.00% for raised not mulch bed when compared to untilled mulched bed and untilled not mulched bed (17.10 – 15. 26% and 16.20 – 15.10%). This accounts 30 – 46% and 40 – 44% higher GMC in raised mulched bed compared to untilled mulched bed and untilled not mulched bed for the period study. All the tilled mulched beds and tilled but not mulched beds had significant higher GMC for two seasons relative to untilled not mulched bed (15.26 - 15.10%) in 2016 and untilled mulched bed (17.10 - 16.20%) in 2017. The results further showed significant differences in GMC among tilled mulched beds and tilled but not mulched beds in 2016 and 2017 planting seasons except flat tilled mulched bed (21.19%) and flat tilled but not mulched bed (20.00%). Raised mulched bed gave least bulk densities (1.36 – 1.38 MgM^{-3}) for the period of study. These were lower by 7 and 6% when compared to corresponding values obtained in untilled mulched bed and untilled not mulched bed for the seasons. Similar trend was followed in bulk density when the raised mulched bed was compared to raised not mulched bed and flat tilled mulched bed with flat tilled not mulched bed for the seasons. In the two seasons, raised mulched bed (49 – 48%) gave the highest total porosity which were higher compared to any other treatment for the two years. Increment of total porosity in raised mulched bed followed a similar trend of bulk density (Table 2). Tillage and mulch had pronounced effect on soil compaction on raised mulched bed more than any other tilled and mulched beds or un-

Table 1. Soil Properties (0-30cm depth) at commencement of study

Sand (gkg^{-1})	**482**
Silt (gkg^{-1})	348
Clay (gkg^{-1})	170
Texture	Sandy loam
pH (KCl)	5.4
Organic carbon (gkg^{-1})	0.89
Nitrogen (%)	0.07
Available P	28.70
Calcium ($cmol_{(+)}kg^{-1}$)	2.00
Magnesium ($cmol_{(+)}kg^{-1}$)	1.20
Potassium ($cmol_{(+)}kg^{-1}$)	0.11
Sodium ($cmol_{(+)}kg^{-1}$)	0.09
Cation exchange capacity ($cmol_{(+)}kg^{-1}$)	3.81
Exchangeable acidity ($cmol_{(+)}kg^{-1}$)	0.40
Base saturation (%)	89
Bulk density (MgM^{-3})	1.44
Total porosity (%)	54
Gravimetric moisture content (%)	18.24

tilled mulched bed. Effect of tillage and mulching on compaction was more glaring on early sprouting of cassava on raise mulched bed (Table 4). This is because sprouting of cassava is facilitated by extent of looseness of soil, cassava stem soil contact, moisture content and viability of planting material. Unlike in cocoyam emergence (Anikwe *et al.,* 2007), soil compaction could have influenced cassava sprouting since the area of soil that was loosened to plant cassava cuttings in untilled beds could have not been enough to elicit positive edaphic characteristics for early sprouting of cassava. Results further showed that effect of tillage which was more spectacular than mulching on soil compaction increased with time. This is supported by Hamza *et al.* (2013) finding that intensive tillage increased soil compaction. Since soil compaction is expressed in a unit form of bulk density, therefore, its increase would decrease water storage pores as well as moisture content (Table 2). Tillage and mulching are good practices in soil manipulation for reducing compaction (Daniells, 2012) and improving other physical properties. High bulk density is deleterious and limiting to root penetration, proliferation and inimical to soil productivity.

From the results for the two seasons, general trend in soil GMC is raised mulched bed > raised not mulched bed > flat tilled mulched bed > flat tilled not mulched bed > untilled mulched bed > untilled not mulched bed. This shows that tillage and mulch influenced soil moisture content more than untilled mulched bed and untilled not mulched bed. This disagrees with Anikwe *et al.* (2007) probably because it was not plastic mulched as was the case in his study. Comparing the tilled mulched beds, raised mulched bed had highest water storage which indicate that tillage could increased water storage pores in raised bed. This could be so since tillage can create good tilth and friable structure that readily absorbs and retains moisture. This condition is further improved by rice mill wastes mulch which prevented evaporation losses and better edaphic environment. In tilled mulched beds, untilled mulched bed and untilled not mulched beds, there was no advantage of rapid water seepage as in raised bed. On the contrary, temporary water ponding especially during heavy down pours caused sealing and crusting which was exacerbated by mulching in flat tilled mulched or not mulched beds as well as untilled mulched or untilled not mulched beds. Constant water ponding could create deleterious conditions such as denitrification and anaerobiosis (Linn and Doran, 1984) and this can affect crop's potential yield.

Table 2. Effect of tillage and rice mill wastes mulch on soil studied physical properties (0 – 30cm depth)

Treatment	2016			2017		
	BD(MgM^{-3})	TP(%)	GMC (%)	BD(MgM^{-3})	TP (%)	GMC (%)
Untilled mulched bed	1.44	46	17.10	1.46	45	16.20
Untilled not mulched bed	1.45	45	15.26	1.47	45	15.10
Raised mulched bed	1.36	49	28.18	1.38	48	27.16
Raised not mulched bed	1.40	47	25.15	1.42	46	19.00
Flat tilled mulched bed	1.41	47	22.20	1.43	46	21.19
Flat tilled not mulched bed	1.43	46	20.12	1.45	45	20.08
FLSD (P<0.05)	Ns	Ns	2.22	ns	ns	Ns

ns – not significant, BD – bulk density, TP – total porosity, GMC – gravimetric moisture content,

Total porosity followed the trend of bulk density and GMC in tilled mulched, tilled not mulched, untilled mulched and untilled not mulched beds for the planting seasons. The trend is raised mulched bed > raised not mulched bed > flat tilled mulched bed > flat tilled not mulched bed > untilled mulched bed > untilled not mulched bed. This shows that tillage and mulch to some extent affected porosity of soil. Porosity as a volume of soil free from solid and water is dependent on bulk density. The more loose a soil becomes, the more porosity and hence attains reasonable aeration status. Tillage created ideal condition for good aeration of soil which was favourable to elicit positive responses for release of nutrients to beef up soil fertility and productivity.

3.3. Effect of Tillage and Rice mill wastes mulch on chemical properties of soil since planting

Results of tillage and rice mill wastes mulch on chemical properties of soil (Table 3) indicates significantly (P<0.05) higher available P (29.00–28.00 mgm^{-1}) and total N (0.13 – 0.12gkg^{-1}) on raised mulched bed when compared to untilled not mulched bed (20.00$mgkg^{-1}$ – 0.08gkg^{-1} and 19.00$mgkg^{-1}$ – 0.06gkg^{-1}) bed for 2016 and 2017. This represents 31 – 32% and 39 – 50% significant increments in available P and N in raised mulched bed relative to untilled mulch bed for the period. Similarly, Ca and Mg (4.00 – 1.80 cmol(+)kg^{-1} and (3.50–1.70 cmol(+)kg^{-1}) were significantly higher in raised mulched bed than their corresponding values (2.00 – 2.80 cmol(+)kg^{-1} and 0.60 – 0.08 cmol(+)kg^{-1} and 1.80 – 2.60 cmol(+)kg^{-1} and 15 – 0.50 cmol(+)kg^{-1}), respectively obtained in untilled mulched and untilled not mulched beds for the seasons. These account for respective 50 – 30%; 89 – 67% and 49 – 26%, 91– 71% significant increments in Ca and Mg in raised mulched bed compared to untilled mulched and untilled not mulched beds over the years of study. There are not significant differences in available P, N, Ca and Mg among tilled mulched and tilled not mulched beds throughout the seasons. Soil pH and K were not significantly affected by tillage practices and mulching but nevertheless values varied among the treatments for the seasons. Highest values (5.5 – 0.16 $cmol_{(+)}kg^{-1}$ and 5.4 – 0.14 $cmol_{(+)}kg^{-1}$) were recorded for these chemical parameters for the period. These values are 9 – 38% and 11-36% higher than their corresponding counterparts in untilled not mulched beds for the years. There were marginal variations in pH and K of tilled mulched and tilled not mulched beds for the seasons.

The results imply that mulching and tillage preconditioned the soil for significant positive response in nutrients improvement. There is an indication that the marginal increase in soil chemical properties (Table 3) especially in first season could be attributed to mulching rather than tillage. This is because chips of the mulch materials could have been decomposed to mineralize some nutrients to the soil. Mulch protects and enhances nutrients supply in soil (Mosaddeghi *et al.,* 2009). In 2016 significant available P, Ca and Mg in raised mulched bed could be due to soil pH which moved away from strongly acidic to moderately acidic status (Tables 1-3). This condition acted as a boost to precipitation of nutrients which gave rise to early sprouting and significant yields in the beds when compared to other treatments (Table 4). Results further show marginal and non-significant reductions in values of some studied soil chemical properties in preceding planting season. These reductions could possibly indicate utilization (Aulak *et al.,* 2007) by the cassava crop for growth and yield expression. Cassava is a heavy feeder and because of the mulch, significant drain on the nutrients that could have occurred was salvaged. Mulched beds consistently maintained highest soil chemical properties relative to their corresponding counterparts in other treatments. This might be because of the more loose soil, ideal edaphic, chemical and microbiological conditions (Mosaddeghi *et al.,* 2009) provided through tillage and enhanced by mulching.

3.4. Effect of Tillage and Rice mill waste mulch on sprouting (%) and yield (tha^{-1}) of cassava at 28-300 days after planting and harvest

Cassava sprouting count and yield are shown in Table 4. There were significant ($p<0.05$) differences between tilled mulched and tilled unmulched beds (60-90% and 58-85%) and untilled mulched and untilled not mulched beds (40-50%and 38-58%) for both planting seasons. Results showed that for the two years, bed mulched consistently gave highest (85-90%) sprout count. These were 44-55% and 44-56% significantly higher than untilled mulched and untilled not mulched bed. Raised mulched bed had 22-33% and 20-32% significantly higher cassava sprout count than flat tilled mulched or flat tilled not mulched beds for the period of study. Similarly, the raised not mulched bed had 78-80% cassava sprout count more than 58-60% sprouts recorded in flat tilled not mulched bed. These were 23 and 25% significantly higher compared to their corresponding sprout counts in flat tilled not mulched beds for both years. Generally, for the seasons, cassava sprout count followed the trend of raised mulched bed > raised not mulched bed > flat tilled mulched bed > flat tilled not mulched bed > untilled mulched bed > untilled not mulched bed.

Table 3. Effect of Tillage and Rice mill wastes mulch on some soil chemical properties since planting

Treatment	2016						2017					
	pH (H_2O)	**P ($mgkg^{-1}$)**	**N (%)**	**Ca**	**Mg ($cmol_{(+)}kg^{-1}$)**	**K**	**pH (H_2O)**	**P ($mgkg^{-1}$)**	**N (%)**	**Ca**	**Mg ($cmol_{(+)}kg^{-1}$)**	**K**
Untilled mulched bed	5.0	20.00	0.08	2.00	0.20	0.10	4.8	19.00	0.06	1.80	0.15	0.09
Untilled not mulched bed	5.1	21.00	0.09	2.80	0.60	0.11	5.0	20.00	0.08	2.60	0.50	0.10
Raised mulched bed	5.5	29.00	0.13	4.00	1.80	0.16	5.4	28.00	0.12	3.50	1.70	0.14
Raised not mulched bed	5.4	27.00	0.12	3.60	1.60	0.15	5.2	27.00	0.11	3.40	1.50	0.13
Flat tilled mulched bed	5.3	26.00	0.11	3.20	1.30	0.14	5.2	25.00	0.10	3.10	1.20	0.12
Flat tilled not mulched bed	5.2	25.00	0.10	3.00	1.20	0.12	5.1	24.00	0.09	3.00	0.10	0.11
FLSD ($P<0.05$)	Ns	8.64	0.05	0.75	0.80	ns	Ns	8.60	0.04	0.72	0.76	ns

Ns – not significant

Yields obtained in raised mulched bed and raised not mulched beds (7.5-7.3 t ha^{-1}) and (6.6-6.8 t ha^{-1}) were significantly higher than those recorded in untilled mulched bed and untilled not mulched bed (3.0-3.0 t ha^{-1} and 4.3-4.5 t ha^{-1}) for both planting seasons. These accounted for 60-40% and 56-34% as well as higher yields when compared to yield values obtained in untilled mulched or untilled not mulched beds for the years. There were no significant differences in cassava yields among tilled mulched and tilled not mulched beds for both planting seasons. Cassava yields followed a trend of raised mulched bed > raised not mulched bed > flat tilled mulched bed > flat tilled not mulched bed > untilled mulched bed > untilled not mulch bed for the period.

The results indicate that tillage and rice mill wastes mulch enhanced cassava sprouting more than in untilled mulched and untilled not mulched practices. Since counting started from 14 days after planting (DAP) till 28 days when maximum sprouting had occurred, tillage conditioned by mulching reduced number of days required to obtain 85 – 90% maximum sprouting (21 DAP) by more than 7 days in both 2016 and 2017 seasons in raised mulched bed. This finding could be attributed to loose soil and superior GMC of the plot (Table 2). There are probably indications that increased moisture content and soil cassava stem cuttings contact of the raised mulched or raised not mulched beds influenced cassava sprouting more than mechanical impedance of adverse effects as there were no statistical differences among mulched and not mulched beds, untilled mulched or untilled not mulched beds. Anikwe *et al.* (2007) reported that plastic film mulch increased soil moisture content which facilitated emergence of cocoyam corns in tilled plots earlier than it would have otherwise lasted. Sprouting or germination could be greatly determined by cassava stem zone soil water potential, rate of oxygen diffusion and mechanical impedance whereas its sustenance depends on post sprouting edaphic environment in the root and above ground micro environment (Gajiri *et al.,* 2002). In addition, angle and depth of planting which is believed to have been greater in raised beds as well as GMC induced faster sprouting of cassava more than in flats tilled and untilled beds (Table 4). From all indications, more loose soil, GMC and soil cassava stem contact influenced cassava sprouting positively in tilled soil than mechanical impedance encountered due to non-tillage. This opposes a finding that early and faster corn emergence was recorded in untilled plot than tilled one (Anikwe *et al.,* 2007), although, it received plastic film mulch and not rice mill wastes. Again, this study did not consider temperature as imperative to sprouting of cassava as in corn emergence.

High yield advantage recorded in raised mulched and raised not mulched beds when compared to their respective flat tilled mulched and flat tilled mulched beds as well as untilled mulched and untilled not mulched beds could be due to differences in tillage practices and depth of implement. Raised mulched bed absorbed more moisture and thus improves its water storage status (Table 3), loosened the soil, reduce weed, pest and disease incidence and generally enhanced edaphic environmental conditions of cassava plant giving rise to early sprouting and higher yield (Table 4). Comparing the yields of tilled mulched and tilled not mulched beds and untilled mulched and untilled not mulched beds, results indicated a total yield variation of 17.4 – 16.9 t h_a^{-1} for 2016 and 2017 seasons. The differences point to probably the tillage practices employed. Mulched beds generally had higher yield because tillage loosened and softened the soil creating ideal tilth or aggregates, friable and increased depth of soil, a condition which made infiltration of water easier in the root rhizosphere. Significantly lower yield obtained in untilled mulched and not mulched beds is supported by report of Gajiri *et al.* (2002) that non tillage practice recorded significantly lower yield in contrast to tillage practices. Furthermore, increased soil moisture in mulched bed could have promoted organic matter decomposition and mineralization thereby making more nutrients available in the raised beds. Results (Table 4) showed that untilled mulched bed and not mulched one had an average of 232% lower cassava yield than tilled mulched and not mulched beds for both planting seasons. The difference in yield may be adduced to difference in practices used. Untilled not mulched bed recorded least mean yield and this could be because the bed had the least ideal edaphic conditions for the cassava crop. The untilled bed had high bulk density which may have limited root proliferation and penetration, a condition which would reduce water and nutrients uptake in the crop (Anikwe *et al.,* 2007). Again, increased bulk density can result to decreased porosity which can limit proportion of water filled pores and this would create aeration problem (Kooistra and Tovey, 1994). The side effect is stifled microbial action, limited decomposition rate of organic matter and poor release of nutrients to crops. This is evidenced in untilled mulched and untilled not mulched beds (Table 3).

4.0. Conclusion

The results of this research have indicated that tillage practices and rice mill wastes mulch significantly influenced soil properties and cassava yield indices. Tillage and mulch influenced depth of soil, tilth, friability, soil-cassava stem contact, moisture content and nutrients availability; all of which culminated in early sprouting and high yield of cassava. Raised mulched bed gave robust (1.36 – 1.38 Mgm^{-3}; 49 – 48% and 28.18 – 27.16%) for bulk density, total porosity and gravimetric moisture content and (5.5 – 5.4; 29.00 – 28.00 Mgm^{-3}; 0.13 – 0.12 gkg^{-1}), for soil pH, available P, total N as well as highest exchangeable bases. This was followed by raised not mulched bed, flat tilled mulched, flat tilled not mulched beds whereas untilled mulched and untilled not mulched beds had least soil properties. Similarly, raised mulched bed comparatively had the highest cassava yield of 7.5 – 7.3 t ha^{-1} closely followed by raised not mulched bed (6.8 – 6.6 t ha^{-1}) leaving untilled not mulched bed with least yield of 3.0 t ha^{-1} each for both seasons. This implies that raised mulched bed treatment more than any other tillage practice provided ideal edaphic conditions for the test crop in this experiment. The tillage practices and mulching used in this study positively influenced soil properties and yield performance of cassava. The untilled bed treatments had least soil productivity indices. It could be concluded that tillage practices and rice mill wastes mulch have the potential to influence soil properties especially moisture content for sustainable and profitable production of cassava in the tropics.

Table 4. Effect of tillage and rice mill wastes on cassava sprout (%) and yield (t ha-1)

	Sprout (%)		Yield(t ha^{-1})	
Treatment	**2016**	**2017**	**2016**	**2017**
Untilled mulched bed	40	38	3.0	3.0
Untilled not mulched bed	50	48	4.5	4.3
Raised mulched bed	90	85	7.5	7.3
Raised not mulched bed	80	78	6.8	6.6
Flat tilled mulched bed	70	60	5.6	5.3
Flat tilled not mulched bed	60	58	5.0	5.0
FLSD (P<0.05)	21	20	3.8	3.5

References

Anikwe, M. A. N., Mbah, C. N., Ezeaka, P. I., Onyia, V.N. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia escuenta*) on an ultisol in southern Nigeria. Soil and tillage Res. 93,264-272.

Anikwe, M.A.N., Onyia, V. N., Ngwu, O. E., Mba, C. N. 2005. Ecophysiology and cultivation practices of Arable crops. New Generation Books. Ogui Road, Enugu, Nigeria pp., 5-318.

Asadu, C. L. A., Nweke, F. I. 1999. Soil of Arable crop fields in sub-saharan Africa: Focus on cassava-growing areas collaborative study of cassava in Africa Working paper no.18. Resources and crop management, division, IITA Ibadan, Nigeria p., 182

Aulak, M. S., Garg, A. k., Kabba, B. S. 2007. Phosphorus accumulation, leaching and residual effects on crop yield from long-term applications in the subtropics. Soil use and Management 23,417-427.

Biswas, T. D., Murkherjee, S.K.2008. Textbook of soil science. 2nd ed. Tata Mc Graw-Hill publishing company Ltd, New delhi p., 422.

Bremner, J. M. 1996. Nitroged-total. *In:* Sparks, D.L. (ed). Methods of soil Analysis. Chemical Methods .Amer. Soc. Agron. 5(3), 1085-1121.

Daniells, I. G. 2012. Hardsetting soils: A review. Soil Res.50, 349-359.

Dickerson, G. W. 2007. Commercial vegetable production with plastic mulches. Corperative Extention Services, New Mexico State University. Guide H-,245.

Esu, I. E. 2005. Characterization, Classification and Management problems of the major soil order in Nigeria.26th Inaugoral lecture, University of Calabar, Nigeria P., 66.

Gajiri, P. R., Aroka, V. K., Prihar, S. S. 2002. Tillage for sustainable cropping, Food products press, New York.

Gee, G. W., Or, D. 2002. Particle size Analysis, *In*: Dane, J. H., Topp, G. C. (ed). Methods Soil Sci Amer 5, 255-293.

Hamza, M. A., Anderson, W. K. 2013. Soil compaction in cropping systems: a review of the nature, causes and possible solutions. Soil and Tillage Res.82,121-145.

Ikeorgu, J. E. G., Mbah, E.U. 2007. Productivity of cassava/okra intercropping systems as influenced by okra planting Density. Afri J. Agric. 3(1), 1-10.

IITA. 2004. Competitiveness Workshop in opportunities for cassava in Nigeria. Bonkanga, IITA. Ibadan

Jensen, M. H. 1990. Protected cultivation. A global review of plastics in Agriculture. Proceedings of the 1st Int. Conf. on the use of plastics in Agric., 26thFeb.-2ndMarch,1990,New Delhi, India pp.,3-10.

Kooistra, M. J., Tovey, N. K. 1994. Effects of compaction on soil microstructure. *In*: Soane B.D., Van Onwerkerk, c. (Eds). Soil compaction in crop production. Elservier, New York, pp, 91-111.

Lal, R. 1979. Soil and micro-climate considerations for developing tillage systems in the tropics. *In*: Lal, R. (Ed). Soil tillage and crop production proceeding series No.2. International institute for Tropical Agriculture, Ibadan, Nigeria.

Linn, D. M., Doran, J. W. 1984. Effect of water-filled pore space on carbon dioxide and nitrous oxide production in tilled and non-tilled soils. Soil Sci. Soc Amer.J.48, 1267 -1272

Mosddeghi, M. R., Mahboubi, A. A., Safadoust, A. 2009. Short-term effects of tillage and manure on some soil physical properties and maize root growth in a sandy loam soil in western Iran. Soil and tillage Res.104,173-179.

Nelson, D. W., Sommers, L.E.1982. Total carbon, organic carbon, and organic matter. *In*: Page, A.L., Miller, R. H., Keeny, D. R. (Eds.), Methods of soil Analysis. Part 2, 2nd ed. Agronomy monograph No.9.ASA and SSSA, Madison, Wl, pp.,539-579.

Nimet. 2016. Weather data for Abakaliki. National Meteorological Institute, Oshodi, Lagos, Nigeria pp.,1-5.

Nnabude, P. C. Mbagwu, J.S.C. 2001. Physico-chemical properties and productivity of a Nigerian Typic-Haplustult amended with fresh and burnt rice mill wastes. Biores. Tech. 76, 265-272.

Nwaobiala, C.U., Isaac, C. A. 2017. Farmers Perception on improved cassava varieties cultivated in Abia State, Nigeria. The Nig. Agric. J. 48(2), 275-283.

NPAFS. 2010. Federal Ministry of Agriculture and Rural Development. Report of the Agricultural Production Survey, P., 76.

Obi, M. E. 2000. Soil Physics: A compendium of Lectures. Atlanto Publishers, Nsukka, Enugu, Nigeria. Pp., 11-40.

Olsen, S. R. 1982. Phosphorus. *In*: Page, A. L., Miller, R. H., Keeny, D. R. (Eds.), Methods of Soil Analysis. Part 2, 2nd ed. Agronomy Monograph No. 9. ASA and SSSA, Madison, Wl, pp., 403-430.

Thomas, G. W. 1982. Exchangeable cations. *In*: Page, A.L., Miller, R. H. Keeeny, D. R. (Eds.), Methods of Soil Analysis. Part 2, 2nd ed. Agronomy Monograph No. 9. ASA and SSSA, Madison, Wl, pp., 159-165.

Prihar, S. S., Gajiri, P. R., Benbi, D. K., Arora, V. K. 2000. Intensive Cropping: Efficient Use of Water Nutrients and Tillage. The Haworth Press, Inc., Binghamton, N.U.

SAS. 1985. User's Guide 1985 (ed.), Statistical Analysis Systems Institute, Inc., Cary, N. C.