Effect of Tillage Practices on Selected Engineering Properties of Cassava (*Manihot esculenta*) Tubers

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ABSTRACT: The main objective of this study was to determine the influence of tillage practices on selected engineering properties of cassava tubers. Two field tests were conducted between May 2014 to April 2015 and May 2015 to April 2016. Eight tillage practices utilized for the experiment were coded as; Ploughing + Harrowing (A), Ploughing + Harrowing + Ridging (B), Manual Ridging (C), Minimum Tillage (D), Ploughing + Harrowing + Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth set at the base (E), Ploughing + Harrowing + Ridging + Sawdust of 10 cm depth set at the base (F), Manual Ridging + Sawdust of 10 cm depth put at the base (G) and Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth put at the base (H). TMS 0581 improved cassava variety and two fertilizer rates 622.50 kg/ha and control were used. Randomized Complete Block Design was used. The experiment was 8x2x1 factorial combinations in split-split plot design with three replications. The effect of different treatments on selected engineering properties of cassava tubers were determined. The results showed that Ploughing + Harrowing (A) tillage practice was significantly different from other tillage practices and gave the most suitable selected engineering properties of size 10.53 ± 0.64^{c} cm, surface area 371.15 ± 45.53^{bc} cm^2, sphericity 39.26 ± 1.74^{a} cm, roundness 21.40 ± 3.29^{ab} , bulk mass 21.43^{h} kg, coefficient of static friction 2.73 ± 0.06^{abc}, compressive strain at break of 2.16 ± 0.03^{e} mm/mm, compressive load at break of 11698.90 ± 178.71^{f} N, compressive stress at break of 2.72 ± 0.04^{d} MPa, energy at break of 191.62 ± 2.93^{e} J, modulus automatic of 1.89 ± 0.031^{c} MPa, followed by F, G, D, C, E, H and B tillage practices respectively. The study had provided some engineering properties for engineers to develop efficient agricultural machines for handling and processing of fresh cassava tubers.

Keywords: Evaluation, influence, tillage practices, engineering properties, cassava tubers.

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I. INTRODUCTION

Tillage is a mechanical and control activity applied on soil to modify soil conditions for cultivating crops of higher yield. Tillage practice stifles weeds, controls soil disintegration and keeps up appropriate soil dampness (Koller, 2003). A decent, soil regulation suite keeps the soil from water and wind erosion, offers a decent weed free seedbed for planting, disrupts hardpans that may limit root growth and permits conservation and even a rise of organic matter (Wright *et al.*, 2008). Tillage embraces all operations of seedbed preparations that optimize soil and environmental conditions for seed germination, seedling establishment and crop growth. Tillage includes mechanical methods based on conventional technologies of ploughing and harrowing, weed control using herbicides and fallowing with cover crops controlled by direct seeding through its residue mulch (Ohu, 2011).

Deep tillage breakdowns high density soil layer advances the water infiltration and drive in soil, boosts root growth, development and rises crop production potential (Bennie and Botha, 1986). Root and tuber crops retort contrarily to zero or minimum tillage. Jongruaysup *et al* (2007) stated that the new root yield of cassava (*Manihot esculenta C.*) cultivated under zero tillage practice was significantly higher than that of cassava cultivated using conventional tillage on fine loamy soil (*Oxic Paleustults*) in Thailand. In any case, in Khaw Hin Sorn and TTDI locations in Thailand, the cassava tuber yield was practically identical while in Huay Pong and Rayong districts of a comparative country most insignificant yield was obtained. Tongglum *et al* (2001) observed no significant difference in cassava root yield between zero and conventional planting in Thailand. In China, slight decline in cassava root yield anyway not at significant level was seen under minimum

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tillage system related to conventional tillage pracice (Weite *et al*., 1998).

A good knowledge on physical properties of designing information is required and critical in the development of machines, storage structures and processing (Esref and Halil, 2007). Mechanical properties of biological materials are the behavior of the materials under applied forces. The study of mechanical properties is required for textural assessment and better understanding of the product quality. Force-deformation testing of agricultural materials can be utilized to consider the damage which occur during harvesting and handling of crops (Mohsenin, 2010).

Attempts at mechanizing the cassava peeling process have been made, however machines are yet to be completely developed (Kolawole *et al*., 2010) as no efficient cassava peeling machine is right now accessible in the market in Nigeria (Ohwovoriole *et al*., 1988; Adetan *et al*., 2003; Agbetoye, 2005; Oriola and Raji, 2013). This is brought about by irregular shape of the tubers and broad contrasts in the thickness of the strip, tuber size and weight crosswise over differing varieties of the tuber (Ezekwe, 1976; Adetan *et al.*, 2006; Kamal and Oyelade, 2010).

A comprehensive information on the designing properties of the tuber is important to mechanize the cassava peeling process (Adetan *et al*., 2003). The absence of satisfactory information on the engineering properties of cassava tubers has been one of the major constraints in the development of an effective cassava tuber peeling machines. A few researchers (Ezekwe, 1979; Odigboh, 1983; Igbeka, 1980, 1984, 1985; Nanda and Matthew, 1996; Nwagugu and Okonkwo, 2009; Sajeev *et al.*, 2009) made appreciable efforts on finding some of the properties of cassava that affects its processing as well as in the design of cassava handling and processing equipment.

The study is required to choose an efficient conservation and conventional tillage practice for better cassava production in the rain-fed regions of Nigeria, West Africa. In this study, effect of different tillage practices on cassava selected engineering properties have been evaluated.

II. MATERIALS AND METHODS

A. Site Description

Two field experiments were conducted between May 2014 to July 2015 and May 2015 to July 2016 on a plot of Teaching and Research Farm of the Federal University of Technology Akure (7^o15^1N, 5^o15^1E). Weather conditions during the growing period were recorded using digital thermometer, rain guage, hygrometer and barometer.

B. Experimental Design

Randomized Complete Block Design (RCBD) was used for the parent split-split plot factorial experiment. Eight tillage practices were used for the experiment and are coded in letters in order as: Ploughing + Harrowing (A), Ploughing + Harrowing + Ridging (B), Manual Ridging (C), Minimum Tillage (D), Ploughing + Harrowing + Manual Digging to a depth of 30 cm + Saw-dust of 10 cm depth put at the base (E), Ploughing + Harrowing + Ridging + Saw-dust of 10 cm depth set at the base subsequent to Ridging (F), Manual Ridging + Saw-dust of 10 cm depth set at the base (G) and Manual Digging to a depth of 30 cm + Saw-dust of 10 cm depth put at the base (H).

Improved cassava variety TMS (*Tropical Manihot Species*) 0581 was acquired from Agricultural Development Project (ADP) Akure, Ondo State, Nigeria and was coded V. Two fertilizer rates (622.50 and 0) kg/ha of NPK 15:15:15 were utilized and were coded F1 and F0 individually. Rain-fed cassava field was also coded Rfd. The tillage treatments and fertilizer rates were imposed on rain-fed cassava field of annual rainfall of 1365.48 mm. The experiment was 8x2x1 factorial combinations of tillage methods, fertilizer rates and rain-fed or irrigated scheme arranged in split-split plot design with three replications comprising eight tillage practices, two fertilizer rates and one cassava variety of three replications. The tillage methods constituted the main plot while fertilizer rate and soil moisture levels were the sub and sub-sub plots.

The treatment plots were 3x3 m while the total field plot was 432 m^2. A line spacing of 1 meter between the cassava plants was observed. Cassava stems of 20 cm long were planted at depth of 5-10 cm. The cassava plants were harvested 10^{th} -11^{th} months after planting. Tables 2.1 and 2.2 presented the experimental design of the treatments and equations used for the determination of the physical properties of cassava tubers respectively. The effect of treatments on some physical and mechanical properties of cassava tubers were evaluated at the department of Agricultural Engineering, Federal University of Technology Akure (FUTA).

C. Determination of Mechanical Properties of Cassava Tubers

The physical properties of the cassava tubers were determined using standard formulae and equations as presented in Table 2 prior to the determination of the mechanical properties of the cassava tubers. The mechanical properties of cassava tubers were carried out at the research facility of Engineering Materials Development Institute (EMDI), Ondo Road, Akure, Ondo State Nigeria utilizing INSTRON 3369 Universal testing machine. A 2 cm x 2 cm square shape of cassava tuber for each treatment was prepared and then subjected to compression test at loading rate of 30 mm/min. The compression test was carried out in triplicate for each of the treatment. The mechanical properties determined include compressive extension at break (standard), compressive strain at break(standard), compressive load at break (standard), compressive load at break (standard), energy at break (standard), extension at break (standard), compressive load at maximum compressive extension, compressive strain at maximum compressive extension, maximum compressive extension, compressive stress at maximum compressive extension, modulus (automatic), compressive load at yield (zero slope), compressive extension at yield (zero slope), compressive strain at yield (zero slope), compressive stress at yield (zero slope).

D. *Statistical Analysis*

Excel was used to compute the raw data. Descriptive and inferential statistics were used to analyze influence of tillage practices on the crop parameters. Duncan Multiple Range was used for Post hoc Test. Statistical Package for Social Science (SPSS 21 version) was utilized to analyze the data generated from this study.

Table 1: Experimental design of the treatments.

Treatments	Description	Codes
T1	Ploughing + Harrowing + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	AVRfdF1
T2	Ploughing + Harrowing + Ridging + TMS 0581 + Rainfed + 622.50 kg/ha of N PK 15:15:15 manure	BVRfdF1
T3	Manual Ridging + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	CVRfdF1
T4	Minimum Tillage + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	DVRfdF1
T5	Ploughing + Harrowing + Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth placed at the base after Manual Digging + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	EVRfdF1
T6	Ploughing + Harrowing + Ridging + Sawdust of 10 cm depth placed at the base after Ridging + TMS 0581 + Rainfed + 622.50 kg/ha of N PK 15:15:15 manure	FVRfdF1
T7	Manual Ridging + Sawdust of 10 cm depth placed at the base after Manual Ridging + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	GVRfdF1
T8	Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth placed at the base after Manual Digging + TMS 0581 + Rainfed + 622.50 kg/ha of NPK 15:15:15 manure	HVRfdF1
T9	Ploughing + Harrowing + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	AVRfdF0
T10	Ploughing + Harrowing + Ridging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	BVRfdF0
T11	Manual Ridging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	CVRfdF0
T12	Minimum Tillage + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	DVRfdF0
T13	Ploughing + Harrowing + Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth placed at the base after Manual Digging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	EVRfdF0
T14	Ploughing + Harrowing + Ridging + Sawdust of 10 cm depth placed at the base after Ridging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	FVRfdF0
T15	Manual Ridging + Sawdust of 10 cm depth placed at the base after Manual Ridging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	GVRfdF0
T16	Manual Digging to a depth of 30 cm + Sawdust of 10 cm depth placed at the base after Manual Digging + TMS 0581 + Rainfed + 0 kg/ha of NPK 15:15:15 manure	HVRfdF0

Table 2: Determination of physical properties of cassava tubers.

Property	Method or equation for determining of physical properties	Reference
L	Measuring tape	Olukunle and Akinnuli, 2012
W	Digital vernier caliper	Olukunle and Akinnuli, 2012
T	Measuring three different segments of the cassava tubers using digital vernier caliper	Olukunle and Akinnuli, 2012.
D_g	$D_g = (LWT)^{1/3}$	Ozguven and Vursavus (2005); Akaaimo and Raji (2006).
R_a	W/T100%	Burum, 2004.
S_a	$S_a = \pi {D_g}^2$	Yalcin *et al*. 2007 and Olukunle and Akinnuli, 2012.
S_p	$S_p = \frac{(LWT)^{1/3}}{L} 100\%$	Yalcin *et al*. 2007 and Olukunle and Akinnuli, 2012.
R_o	$R_o = \frac{A_P}{A_C}$	Yalcin *et al*. 2007 and Olukunle and Akinnuli, 2012.
α	The apparatus consisting of plywood box with a fixed stand attached with a protractor and an adjustable plate at the surface	Tabatabaeefar, 2003.
μ	μ = tan α	Yalcin *et al*. 2007 and Olukunle and Akinnuli, 2012.
m	A digital weighing balance 10 kg was used in weighing each of the cassava tubers	Yalcin *et al*. 2007 and Olukunle and Akinnuli, 2012.
V_t	By putting a known mass of a (unit) sample into a cylindrical container of water, change in level of the liquid in the cylinder gives the unit volume	Ozguven and Vursavus 2005
ρ_t	$\rho_t = \frac{W_t}{V_t}$	Akaaimo and Raji (2006) and Yalcin *et al*. 2007
ρ_b	$\rho_b = \frac{W_s}{V_s}$	Akaaimo and Raji (2006) and Yalcin *et al*. 2007
bm	By weighing together all the cassava in a bucket	Olukunle and Akinnuli, 2012.
bv	The whole sample in a stand was put into the cylindrical container of water, and the change in level of the liquid in the cylinder	Ozguven and Vursavus 2005.
ε	$\varepsilon = (1 - \frac{\rho_b}{\rho_t}) \times 100$	Akaaimo and Raji 2006.

where D_g is the equivalent diameter; L is the length; W is the width and T is the thickness, R_a is the aspect ratio; S_a is the surface area; S_p is the sphericity; R_o is the roundness; A_p is the largest projected area of object in natural resting position; A_c is the area of the smallest circumscribing circle; μ is the coefficient of static friction and α is the angle of repose; ρ_t is the true density; W_t is the true weight; m is the mass; V_t is the true volume; bm is the bulk mass; bv is the bulk volume; ρ_b is the bulk density in kg/m^3; W_s is the weight of the sample in kg; V_s is the volume occupied by the sample in m^3; ε is the porosity, ρ_t is the true density and ρ_b is the bulk density.

III. RESULTS AND DISCUSSION

The effect of tillage practices on physical of TMS 0581 cassava tubers for a rain fed soil + 622.50 Kg/Ha fertilizer for 2014/2015 Planting Season are presented in Tables 3-8 whereas the mechanical Properties of the cassava tubers are presented in Figures 1a-1h and 2a-2h respectively.

A. Influence of Tillage Practices on Physical Properties of TMS 0581 Cassava Tubers under a Rain-fed Soil + 622.50 kg/ha Fertilizer 2014/2015.

The influence of different tillage treatment plots on physical properties of TMS 0581 cassava tubers under a rain-fed + 622.50 kg/ha fertilizer for planting season 2014/2015 are presented in Table 3. There was significant ($p<0.05$) difference of tillage practices on size of cassava tubers. Ploughing + Harrowing + Ridging + Sawdust of 10 cm depth placed at the base after Ridging (F) tillage practice gave the highest size 10.66±0.91^{c} cm, followed by A, E, D, G, B and H tillage practices respectively while C tillage practice offered the lowest size of 7.50±0.82^{a} cm. Tillage method improves the physical state of the soil by manipulating and pulverization the soil (Kolawole *et al*., 2010, Oriola and Raji, 2013; Ahmad *et al*., 1996; Mahajan, 1996; Hammel, 1989). There was significant ($p<0.05$) on surface area of cassava tubers. F tillage practice gave the maximum surface area of 383.47±62.09^{c} cm^2, trailed by A, E, D, G, H respectively but C tillage practice offered the minimum surface area of 200.21±38.96^{a} cm^2. Tillage prepared a good seedbed in which if the crop is placed can grow satisfactory for development and growth. The results corroborate result obtained by other researchers (Kolawole *et al.*, 2010; Oriola and Raji, 2013).

There was significant ($p<0.05$) effect of tillage practices on sphericity of cassava tubers. H tillage practice offered the uppermost sphericity of 51.58±3.82^{b} %, tailed by F, C, D, E, A and B tillage practices respectively although G tillage practice provided the lowermost sphericity of 37.24±4.22^{a} %. Earlier study by (Adetan *et al.*, 2006; Kamal and Oyelade, 2010) also supports the results of this study. B tillage practice presented the peak roundness of 23.20±3.83^{b}, tracked by G, A, E, D, F and H tillage practices however C tillage treatment offered the lowermost roundness of 10.60±3.03^{a}. Thus, B tillage practice will enhance uniform roundness of cassava tubers (Ohwovoriole *et al.*, 1988).

Tillage practice (A) furnished the uppermost bulk mass of 21.43^{h} kg, tailed by F, G, D, C, E and H tillage treatments respectively although C tillage treatment presented the lowermost bulk mass of 3.17^{a} kg. Choice of an appropriate tillage practice for crop generation is critical for best development and yield.

B. The Effect of Tillage Methods on Mechanical Properties of TMS 0581 Cassava Tubers under the Rain-fed + 622.50 kg/ha Fertilizer for Planting Season 2014/2015.

The effect of tillage practices on mechanical properties of TMS 0581 cassava tubers for a rain-fed + 622.50 kg/ha fertilizer for planting season 2014/2015 are presented in Table 4. There was significant ($p<0.05$) effect of tillage treatments on the mechanical properties of cassava tubers. Fresh root cassava tubers of A tillage practice offered the most suitable selected engineering properties respectively, tailed by F, G, D, C, E, H and B tillage practices. The behavior of the materials under applied forces. These results agree with the findings of other researchers (Mohsenin, 2010).

Table 3: Influence of tillage practices on physical properties of TMS 0581 cassava tubers under a rain fed soil + 622.50 kg/ha fertilizer.

Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
L (cm)	28.02±2.18^{ab}	22.82±2.34^{ab}	17.48±1.89^{ab}	23.26±2.60^{ab}	25.43±3.25^{ab}	23.00±3.13^{ab}	29.89±3.95^{b}	18.30±2.34^{a}
W (cm)	6.47±0.45^{ab}	5.86±0.31^{a}	5.98±0.49^{a}	6.49±0.51^{ab}	6.56±0.44^{ab}	7.82±0.56^{b}	5.85±0.33^{a}	6.39±0.39^{ab}
T (cm)	6.63±0.40^{b}	4.91±0.26^{ab}	4.76±0.65^{a}	5.96±0.35^{ab}	6.15±0.43^{b}	6.96±0.45^{b}	5.21±0.29^{ab}	5.57±0.29^{ab}
DG (cm)	10.53±0.64^{c}	8.63±0.48^{ab}	7.50±0.82^{a}	9.56±0.65^{ab}	10.01±0.82^{c}	10.66±0.91^{c}	9.40±0.56^{ab}	8.53±0.62^{ab}
AR (%)	24.82±1.87^{a}	27.06±2.42^{ab}	36.66±3.97^{c}	29.53±2.59^{ab}	27.86±2.68^{ab}	38.09±3.39^{c}	25.41±4.58^{ab}	40.43±4.27^{c}
SA (cm^2)	371.15±45.53^{bc}	239.35±28.11^{a}	200.21±38.96^{a}	299.49±37.55^{ab}	331.73±49.97^{abc}	383.47±62.09^{c}	290.89±35.47^{a}	241.94±37.65^{ab}
SP (%)	39.26±1.74^{a}	39.08±2.19^{a}	45.02±4.36^{ab}	42.66±2.04^{ab}	41.37±2.47^{ab}	50.23±3.11^{b}	37.24±4.22^{a}	51.58±3.82^{b}
R	21.40±3.29^{ab}	23.20±3.83^{b}	10.60±3.03^{a}	15.21±2.19^{ab}	21.25±5.49^{ab}	13.17±2.53^{ab}	21.56±4.59^{ab}	12.56±2.68^{ab}
M (kg)	1.17±0.23^{b}	0.39±0.10^{a}	0.49±0.13	0.69±0.16^{ab}	0.68±0.14^{ab}	0.84±0.23^{ab}	0.56±0.10^{a}	0.39±0.09^{a}
V (m^3)	1.23±0.24^{b}	0.42±0.09^{a}	0.48±0.12^{a}	0.65±0.16	0.60±0.13^{a}	0.74±0.21^{ab}	0.49±0.09^{a}	0.33±0.09^{a}
TD (kg/m^3)	0.94±0.02^{a}	0.95±0.08^{ab}	0.99±0.08^{ab}	1.07±0.04^{bc}	1.17±0.03^{c}	1.17±0.02^{c}	1.17±0.01^{c}	1.20±0.02$^{c\backslash\backslash}$
BM (kg)	21.43^{h}	3.17^{a}	5.96^{d}	7.07^{e}	5.54^{c}	9.33^{g}	7.95^{f}	4.76^{b}
BV (m^3)	20.70^{h}	2.80^{a}	5.40^{d}	6.20^{e}	5.01^{c}	8.44^{g}	7.20^{f}	4.31^{b}
BD (kg/m^3)	1.04^{a}	1.13^{e}	1.10^{b}	1.14^{f}	1.11^{d}	1.11^{c}	1.11^{c}	1.11^{c}
P (%)	11.78±3.19^{ab}	24.74±11.09^{a}	23.90±15.28^{a}	7.51±5.25^{ab}	4.72±2.50^{b}	5.15±1.55^{b}	4.62±1.08^{b}	7.52±1.39^{b}
AP (^{0})	69.78±0.38^{bc}	70.00±0.42^{bc}	68.41±0.42^{ab}	69.20±0.29^{bc}	69.00±0.50^{ab}	68.09±0.46^{a}	70.64±0.72^{cd}	71.75±0.45^{d}
CF	2.73±0.06^{abc}	2.75±0.06^{bc}	2.54±0.05^{ab}	2.64±0.04^{ab}	2.62±0.07^{ab}	2.50±0.06^{a}	2.89±0.11^{cd}	3.05±0.08^{d}

Values are means for triplicates and standard error. Means values including distinctive superscript inside a similar line are altogether significant ($P<0.05$). L is the length in cm, W is the width in cm, T is the thickness in cm, DG is the size in cm, AR is the aspect ratio in %, SA is the surface area in cm^2, SP is the sphericity in cm, R is the roundness, M is the unit mass in kg, V is the unit volume in m^3, TD is the true density in kg/m^3, BM is the bulk mass in kg, BV is the bulk volume in m^3, BD is the bulk density in kg/m^3, P is the porosity in %, AP is the angle of repose in ^{0} and CF is the coefficient of static friction.

Table 4: Effect of tillage practices on mechanical properties of TMS 0581 cassava tubers under the rain fed soil + 622.50 kg/ha fertilizer.

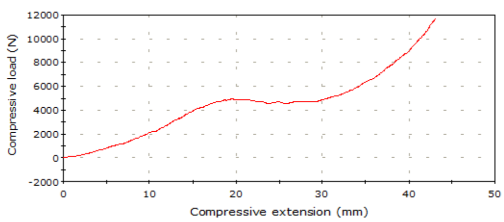
Parameters	A	B	C	D	E	F	G	H
CE (mm)	43.16±0.66^{b}	40.27±0.61^{a}	39.72±0.61^{a}	46.87±0.72^{c}	40.18±0.61^{a}	40.4±0.62^{a}	40.08±0.61^{a}	40.13±0.61^{a}
CS (mm/mm)	2.16±0.03^{e}	1.68±0.02^{b}	1.80±0.03^{c}	1.56±0.02^{a}	1.82±0.03^{c}	1.92±0.03^{d}	1.91±0.03^{d}	2.23±0.03^{e}
CL (N)	11698.90±178.71^{f}	5390.15±82.33^{b}	4536.35±69.29^{a}	8306.18±126.88^{d}	6548.95±100.04^{c}	5511.80±84.19^{b}	8894.27±135.87^{e}	13538.30±206.80^{g}
CSR (MPa)	2.72±0.04^{d}	1.13±0.02^{ab}	1.08±0.02^{a}	1.57±0.02^{c}	1.24±0.02^{b}	1.19±0.02^{ab}	2.60±0.04^{d}	6.37±0.10^{e}
EB (J)	191.62±2.93^{e}	122.95±1.88^{c}	96.82±1.48^{a}	211.15±3.23^{f}	137.33±2.09^{d}	103.98±1.59^{b}	123.44±1.88^{c}	105.53±1.61^{b}
EX (mm)	-43.16±0.66^{b}	-40.267±0.61^{c}	-39.72±0.61^{c}	-46.87±0.72^{a}	-40.18±0.61^{c}	-40.40±0.62^{c}	-40.08±0.61^{c}	-40.13±0.61^{c}
CLM (N)	11698.90±178.71^{f}	5390.15±82.33^{b}	4536.35±69.29^{a}	8306.18±126.88^{d}	6548.95±100.04^{c}	5511.23±84.19^{b}	8894.27±135.87^{e}	13538.30±206.80^{g}
CSM (mm/mm)	2.16±0.03^{e}	1.68±0.02^{b}	1.80±0.03^{c}	1.56±0.02^{a}	1.82±0.03^{c}	1.92±0.03^{d}	1.91±0.03^{d}	2.23±0.03^{e}
MCE (mm)	43.16±0.66^{b}	40.27±0.61^{a}	39.72±0.61^{a}	46.87±0.72^{c}	40.18±0.61^{a}	40.41±0.62^{a}	40.08±0.61^{a}	40.13±0.61^{a}
CSMC (MPa)	2.72±0.04^{d}	1.13±0.02^{ab}	1.08±0.02 ^{a}	1.57±0.022^{c}	1.24±0.019^{b}	1.19±0.019^{ab}	2.6±0.040^{d}	6.37±0.098^{e}
MA (MPa)	1.89±0.031^{c}	1.60±0.02^{a}	1.85±0.031^{c}	2.29±0.03^{e}	2.01±0.03^{d}	1.70±0.03^{b}	3.36±0.05^{f}	2.11±0.03^{d}
CLY (N)	4966.40±75.86^{d}	4702.85±71.84^{c}	4295.01±65.61^{b}	6686.41±102.12^{g}	4931.8±75.34^{d}	5598.31±85.52^{f}	5196.80±79.38^{e}	2493.33±38.09^{a}
CSY (mm)	19.65±0.30^{a}	26.20±0.40^{b}	28.05±0.43^{c}	30.10±0.46^{d}	19.95±0.31^{a}	35.75±0.55^{e}	26.62±0.40^{b}	19.10±0.29^{a}
CSTY (mm/mm)	0.98±0.02^{b}	1.09±0.02^{c}	1.28±0.02^{e}	1±0.02^{b}	0.91±0.01^{a}	1.70±0.03^{f}	1.16±0.02^{d}	1.06±0.02^{c}
CSTYZ (MPa)	1.16±0.02^{d}	0.98±0.02^{ab}	1.03±0.02^{b}	1.27±0.02^{e}	0.93±0.01^{a}	1.20±0.02^{d}	1.10±0.02^{c}	1.18±0.02^{d}

Values are means for triplicates and standard error. Means values including distinctive superscript inside a similar line are altogether significant ($P<0.05$). Where CE is the compressive extension at break, CS is the compressive strain at break, CL is the compressive load at break, CSR is the compressive stress at break, EB is the energy at break, EX is the extension at break, CLM is the compressive load at maximum compressive extension, CSM is the compressive strain at maximum compressive extension, MCE is the maximum compressive extension, CSMC is the compressive stress at maximum compressive extension, MA is the modulus automatic, CLY is the compressive load at yield, CSY is the compressive extension at yield, CSTY is the compressive strain at yield and CSTYZ is the compressive stress at yield.

C. The Effect of Tillage methods on Compressive Test of TMS 0581 Cassava Tubers under the Rain-fed + 622.50 kg/ha Fertilizer for Planting Season 2014/2015.

The result of tillage practices on compressive test of TMS 0581 cassava tubers for a rain-fed + 622.50 kg/ha fertilizer for planting season 2014/2015 are shown in Figure 1. The results showed that the compressive load at maximum compressive extension are approximately (11700, 5390, 4540, 8300, 6500, 5500, 8900 and 13500) N respectively however the compressive extension at break (standard) are about (43, 40, 40, 47, 40, 40, 40 and 40) mm correspondingly for A, B, C, D, E, F, G and H tillage practices respectively. All the eight tillage practices gave almost the same value of compressive extension at break (standard) at different compressive load at break (standard) excluding tillage practices A and D which presented dissimilar values of compressive extension at break (standard). These results reveal that A and D tillage practices produce cassava tubers which tend to have higher mechanical properties compared to other tillage practices. These cassava tubers may not be prone to damages during transportation, handling and processing processes compared to other cassava tubers from other tillage practices. This may be on the grounds that tillage affects rising movement of moisture to the soil surface, vapour transfer from the surface to the atmosphere, heat transfer to the soil, provides an ideal opportunity to break up nutrients formed in the deep zones of the soil, and disrupts pests and pathogen cycles. These results are in accordance with discoveries by different analysts (Kolawole *et al*., 2010; Adetan *et al*., 2003).

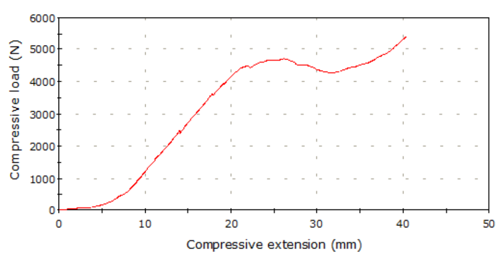
A



A

Figure 1a: Influence of Tillage Practice A on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

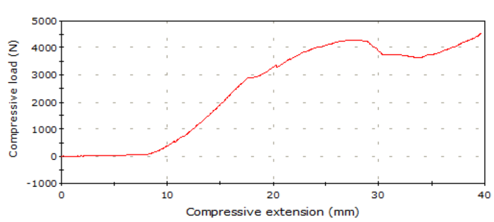
B



B

Figure 1b: Influence of Tillage Practice B on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

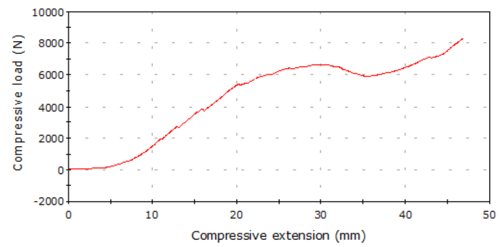
C



C

Figure 1c: Influence of Tillage Practice C on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

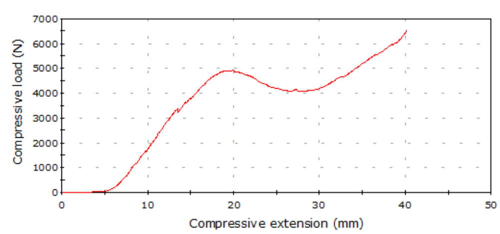
D



D

Figure 1d: Influence of Tillage Practice D on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

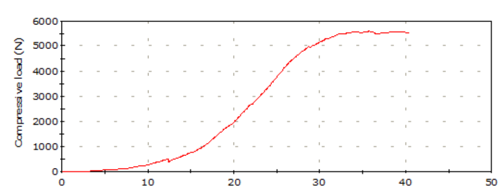
E



E

Figure 1e: Influence of Tillage Practice E on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

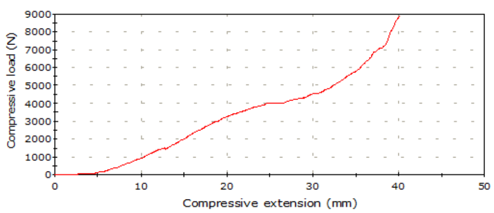
F



F

Figure 1f: Influence of Tillage Practice F on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

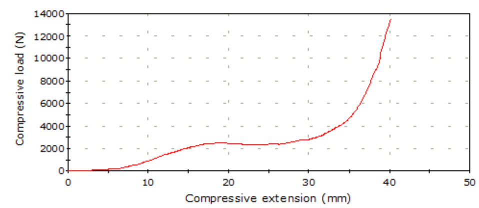
G



G

Figure 1a: Influence of Tillage Practice G on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

H



H

Figure 1h: Influence of Tillage Practice H on Compression Test of TMS 0581 Cassava Tubers for a Rain Fed Soil + 622.50 kg/ha Fertilizer.

D. The Effect of Tillage Practices on physical properties of TMS 0581 Cassava Tubers under a Rain-fed + 622.50 kg/ha Fertilizer for Planting Season 2015/2016.

The result of tillage practices on physical properties of TMS 0581 cassava tubers for a rain-fed + 622.50 kg/ha fertilizer for planting season 2015/2016 are presented in Table 5. There was significant ($p<0.05$) effect of tillage practices on the size of cassava tubers. F tillage practice presented the peak size of 12.46 ± 0.60^{c} cm, followed by G, E, C, B, H and D tillage practices of sizes 10.88 ± 0.65^{c} cm, 8.79 ± 0.65^{b} cm, 8.64 ± 0.31^{ab} cm, 8.49 ± 0.96^{ab} cm, 8.25 ± 0.64^{ab} cm and 7.71 ± 0.38^{ab} cm respectively while A tillage practice gave the lowest size of 6.88 ± 0.66^{a} cm. These outcomes uncovered that the F tillage practice arranged a decent seedbed which grants appropriate condition for advancement and development of the yield. These outcomes likewise concurred with the discoveries of different specialists (Kolawole *et al*., 2010, Ohwovoriole *et al*., 1988; Adetan *et al*., 2006; Kamal and Oyelade, 2010), who discovered wide inconsistencies in the size of the tubers.

There was significant ($p<0.05$) influence of tillage practices on the surface area of cassava tubers. F tillage practice presented the peak surface area of 496.53 ± 44.24^{c} cm^2, followed by G, E, B, C, H and D tillage practices of surface area 387.58 ± 46.01^{b} cm^2, 256.06 ± 36.10^{a} cm^2, 246.59 ± 50.27^{a} cm^2, 238.56 ± 16.68^{a} cm^2, 222.99 ± 33.32^{a} cm^2 and 191.98 ± 18.64^{a} cm^2 respectively however A tillage practice gave the lowermost surface area of 159.31 ± 30.47^{a} cm^2. These results revealed that the tillage practice prepared a fine seedbed for ideal germination and better start of the seedlings. Earlier study observed wide variations in the thickness of the peel across different varieties of the crop which follows the result obtained in this research (Ohwovoriole *et al.*, 1988; Oriola and Raji, 2013).

There was significant ($p<0.05$) effect of tillage practices on the sphericity of cassava tubers. G tillage practice gave the highest sphericity of 44.29 ± 2.87^{d} %, followed by D, F, C, E, H and B tillage practices of sphericity 39.35 ± 2.13^{ab} %, 38.62 ± 3.20^{cd} %, 36.95 ± 2.12^{bcd} %, 33.39 ± 1.20^{abc} %, 31.82 ± 3.64^{abc} % and 29.68 ± 2.23^{ab} % respectively whereas A tillage practice gave the lowest sphericity of 28.42 ± 0.71^{a} %. These results showed that the G tillage practice combines the good effect of surface planting with the conservation features of contour listing hence the physical condition of the soil on the ridge is least affected, in which, ridges are formed with a traditional hoe. The ridges are built on the contour and the stems are planted on the ridges manually. This system is most suited for areas of high rainfall. Previous study by Adetan *et al.,* 2006; Kamal and Oyelade (2010) also supports the results of this study.

There was significant ($p<0.05$) effect of tillage practices on the roundness of cassava tubers. A tillage practice gave the highest roundness of 90.62 ± 19.87^{d}, followed by H, E, F, C, B and G tillage practices of roundness 71.37 ± 17.93^{cd}, 44.45 ± 8.41^{bc}, 40.71 ± 11.19^{ab}, 35.74 ± 5.43^{ab}, 30.20 ± 7.19^{ab} and 14.47 ± 1.50^{ab} respectively whereas D tillage practices gave the lowest roundness of 12.24 ± 1.84^{a}. These results demonstrated that A tillage practice improves the physical condition by controlling and thrashing the dirt, which gives reasonable condition to germination and development and supplies free oxygen and accessibility of soil dampness and fundamental supplements to plants. These findings are in consistence with that of the discoveries of (Ohwovoriole *et al*., 1988; Oriola and Raji, 2013; Adetan *et al*., 2006), who discovered fluctuated differences in the thickness of the strip crosswise over various assortments of the yield.

There was significant ($p<0.05$) outcome of tillage practices on the bulk mass of cassava tubers. G tillage practice gave the maximum bulk mass of 9.43^{h} kg, followed by F, C, E, H, A and D tillage practices of bulk mass 8.79^{g} kg, 7.56^{f} kg, 6.05^{e} kg, 4.97^{d} kg, 4.41^{c} kg and 3.99^{b} kg respectively however B tillage practice gave the lowest bulk mass of 3.88^{a} kg. These findings indicated that the G tillage practice joins the great impact of surface planting with the protection highlights of shape posting henceforth the physical state of the dirt on the edge is smallest influenced. These results agree with that of the findings of Jongruaysup *et al.* (2007), who stated that the fresh root yield of cassava (*Manihot esculenta* Crantz.) grown-up beneath zero tillage system was significantly greater than that of cassava grown using conventional tillage on fine loamy soil (*Oxic Paleustults*) in Thailand.

There was significant ($p<0.05$) effect of tillage practices on the coefficient of friction of cassava tubers. A tillage practice presented the highest coefficient of friction of 3.59±0.19^{b}, tailed by D, E, C, G, B and F tillage practices of coefficient of static friction 3.13±0.15^{a}, 3.07±0.26^{a}, 3.00±0.09^{a}, 2.84±0.08^{a}, 2.83±0.06^{a} and 2.81±0.13^{a} respectively however H tillage practice gave the lowest coefficient of static friction of 2.69±0.07^{a}. These results indicated that A tillage practice provide the highest value of coefficient of friction of cassava tubers. The coefficient of friction between the granular materials is equal to the tangent of the angles of the internal friction for the materials; when tubers started to motion, the tangent of slip angle shows it coefficient of friction. The outcome in this research follows the study other researchers (Nwagugu and Okonkwo, 2009; Sajeev *et al.,* 2009).

Table 5: Effect of tillage methods on physical properties of TMS 0581 cassava tubers under a rain fed soil + 622.50 kg/ha fertilizer (2015/2016 planting season).

Parameters	A	B	C	D	E	F	G	H
L (cm)	24.61±2.78^{ab}	30.13±4.06^{bc}	24.58±1.75^{ab}	20.18±1.43^{a}	26.66±2.19^{abc}	34.26±3.54^{c}	25.80±2.21^{ab}	29.25±4.57^{bc}
W (cm)	3.85±0.36^{a}	4.93±0.57^{ab}	6.82±0.26^{c}	5.52±0.31^{b}	5.45±0.40^{b}	8.73±0.68^{d}	7.87±0.49^{cd}	4.98±0.23^{ab}
T (cm)	3.45±0.30^{a}	4.22±0.48^{ab}	4.05±0.29^{ab}	4.20±0.24^{ab}	4.73±0.37^{b}	6.76±0.28^{c}	6.50±0.35^{c}	4.05±0.17^{ab}
DG (cm)	6.88±0.66^{a}	8.49±0.96^{ab}	8.64±0.31^{ab}	7.71±0.38^{ab}	8.79±0.65^{b}	12.46±0.60^{c}	10.88±0.65^{c}	8.25±0.64^{ab}
AR (%)	16.01±0.63^{a}	17.62±1.90^{a}	29.93±2.47^{c}	28.53±2.24^{cd}	20.86±1.14^{ab}	28.25±4.44^{cd}	32.93±3.36^{d}	20.50±3.61^{ab}
SA (cm^2)	159.31±30.47^{a}	246.59±50.27^{a}	238.56±16.68^{a}	191.98±18.64^{a}	256.06±36.10^{a}	496.53±44.24^{c}	387.58±46.01^{b}	222.99±33.32^{a}
SP (%)	28.42±0.71^{a}	29.68±2.23^{ab}	36.95±2.12^{bcd}	39.35±2.13^{ab}	33.39±1.20^{abc}	38.62±3.20^{cd}	44.29±2.87^{d}	31.82±3.64^{abc}
R	90.62±19.87^{d}	30.20±7.19^{ab}	35.74±5.43^{ab}	12.24±1.84^{a}	44.45±8.41^{bc}	40.71±11.19^{ab}	14.47±1.50^{ab}	71.37±17.93^{cd}
M (kg)	0.49±0.10^{ab}	0.48±0.07^{ab}	0.52±0.06^{a}	0.31±0.04^{ab}	0.55±0.14^{ab}	1.12±0.17^{c}	0.76±0.14^{ab}	0.32±0.07^{a}
V (m^3)	0.44±0.10^{ab}	0.33±0.07^{a}	0.41±0.13^{ab}	0.27±0.04^{a}	0.53±0.12^{ab}	1.18±0.19^{c}	0.78±0.15^{b}	0.29±0.06^{a}
TD (kg/m^3)	1.20±0.08^{a}	1.61±0.11^{ab}	2.46±0.59^{b}	1.19±0.14^{a}	0.96±0.06^{a}	1.02±0.08^{aa}	1.47±0.54^{ab}	1.17±0.12^{a}
BM (kg)	4.41^{c}	3.88^{a}	7.56^{f}	3.99^{b}	6.05^{e}	8.79^{g}	9.43^{h}	4.97^{d}
BV (m^3)	4.10^{c}	3.60^{a}	6.20^{f}	3.92^{b}	5.94^{e}	9.20^{g}	9.80^{h}	4.60^{d}
BD (kg/m^3)	1.08^{d}	1.22^{d}	1.08^{e}	1.02^{c}	1.02^{c}	0.96^{a}	0.96^{a}	1.08^{d}
P (%)	7.83±4.92^{a}	30.80±4.88^{a}	-6.98±31.93^{a}	-4.30±14.94^{a}	-10.89±7.60^{a}	-1.95±13.98^{a}	-38.01±45.23^{a}	-5.42±18.49^{a}
AP (^{0})	69.78±0.38^{bc}	70.00±0.42^{bc}	68.41±0.42^{ab}	69.20±0.29^{bc}	69.00±0.50^{ab}	68.09±0.46^{a}	70.64±0.72^{cd}	71.75±0.45^{d}
CF	3.59±0.19^{b}	2.83±0.06^{a}	3.00±0.09^{a}	3.13±0.15^{a}	3.07±0.26^{a}	2.81±0.13^{a}	2.84±0.08^{a}	2.69±0.07^{a}

Values are means for triplicates and standard error. Means values including distinctive superscript inside a similar line are altogether significant ($P<0.05$).

E. Influence of Tillage Practices on Physical Properties of TMS 0581 Cassava Tubers under the Rain-fed Soil + 0 kg/ha Fertilizer.

The effect of tillage methods on physical properties of TMS 0581 cassava tubers for a rain-fed + 0 kg/ha fertilizer for planting season 2014/2015 are presented in Table 6. There was significant ($p<0.05$) effect of tillage practices on the size of cassava tubers. G tillage practice presented the peak size of 10.52±1.02^{d} cm, followed by E, F, A, H, B and C tillage practices of size 10.43±0.72^{d} cm, 10.35±0.95^{d} cm, 9.80±0.88^{ab} cm, 9.61±0.71^{bcd} cm, 9.12±0.62^{cd} cm and 8.51±0.75^{a} cm respectively although D tillage practice offered the lowest size of 7.84±0.38^{abc} cm. These results showed that the G tillage practice gave the maximum size. The results are alike with that of the findings of Adetan *et al. (*2006); Kamal and Oyelade (2010), who observed anomaly in the size of the tubers across diverse varieties of the crop.

G tillage practice gave the highest surface area of 370.65±67.18^{c} cm^2, followed by E, F, A, H, B and C tillage practices of surface area 358.67±50.33^{c} cm^2, 356.37±58.60^{c} cm^2, 319.05±55.06^{ab} cm^2, 311.10±42.29^{bc} cm^2, 272.16±34.72^{ab} cm^2 and 241.87±42.09^{a} cm^2 respectively but D tillage practice gave the lowest surface area of 198.32±19.79^{a} cm^2. These results showed that the G tillage practice gave can decrease water runoff from fields and provides a slower but more even rate of nutrient release. These results agree with that of the findings of Adetan *et al.* (2006); Kamal and Oyelade (2010), who detected indiscretion in the thickness of the peel across different varieties of the crop.

F tillage practice gave the peak sphericity of 58.19±4.65^{c} %, followed by E, H, B, G, D and A tillage practices of sphericity 56.48±3.84^{c} %, 50.07±2.85^{bc} %, 49.62±4.69^{bc} %, 44.10±4.11^{ab} %, 40.88±1.79^{ab} % and 36.86±2.76^{a} % respectively however Manual Ridging (C) tillage practice presented the lowermost sphericity of 34.43±2.97^{a} %. These results specified that the F tillage practice arranged a good seedbed suitable for germination and better start of the seedlings. These results are like that of the findings of (Kolawole *et al.,* 2010; Oriola and Raji, 2013; Kamal and Oyelade, 2010), who observed wide variations in the size and shape of cassava tubers.C tillage practice gave the highest roundness of 28.59±7.20^{c}, followed by A, G, D, B, H and E tillage practices of roundness 21.86±4.76^{bc}, 19.82±6.49^{abc}, 14.62±2.12^{ab}, 11.03±2.94^{ab}, 10.73±1.31^{ab} and 9.35±2.22^{a} respectively whereas Minimum Tillage (D) tillage practice gave the lowest roundness of 8.61±3.18^{a}.

The results revealed that Manual ridging (C) combines the good effect of surface planting with the conservation features of contour listing hence the physical condition of the soil on the ridge is least affected. The results are similar with that of the findings of Adetan *et al*. (2006); Kamal and Oyelade (2010), who observed anomaly in the shape of the tubers across different varieties of the crop.

E tillage practice gave the highest bulk mass of 7.84^{h} kg; followed by H, B, F, A, G and C tillage practices of bulk mass 7.74^{g} kg, 6.23^{f} kg, 5.86^{e} kg, 5.60^{d} kg, 5.50^{c} kg and 5.05^{b} kg correspondingly while D tillage practice gave the lowest bulk mass of 4.27^{a} kg. These results revealed that the E tillage practice break through and shatter plough soles and layers impermeable soil horizons or other barriers to the movement of moisture and roots through the soil profile, thus providing suitable and conducive environment for the cassava plant growth and development which resulted in the greatest yield of tillage practice E.

These results agree with that of the findings of Jongruaysup *et al.* (2007), who stated that the fresh root produce of cassava (*Manihot esculenta C.*) grown beneath zero tillage system was meaningfully greater than that of cassava fully-fledged using conventional tillage on fine loamy soil (*Oxic Paleustults*) in Thailand. A tillage practice gave the maximum coefficient of static friction of 2.87±0.05^{c}; followed C, B, G, H, D and E tillage practices of coefficient of static friction 2.86±0.06^{c}, 2.67±0.05^{b}, 2.62±0.05^{ab}, 2.62±0.06^{ab}, 2.53±0.05^{ab} and 2.51±0.05^{ab} respectively however F tillage practice presented the minimum coefficient of static friction of 2.49±0.06^{a}. These results reveal that the tillage practice A gave the highest value of coefficient of friction of cassava tubers. The results corroborate the findings of Mohsenin, 2010.

Table 6: Effect of tillage methods on physical properties of TMS 0581 cassava tubers for a rain-fed soil + 0 kg/ha fertilizer (2014/2015).

Parameter	A	B	C	D	E	F	G	H
L (cm)	26.96±2.02^{b}	20.70±3.21^{ab}	26.00±3.30^{ab}	19.39±0.99^{ab}	19.46±2.06^{ab}	18.70±2.55^{a}	25.52±3.74^{ab}	20.13±2.02^{ab}
W (cm)	6.87±0.78^{ab}	7.25±0.42^{ab}	5.54±0.60^{a}	5.76±0.39^{a}	8.36±0.69^{b}	8.33±0.88^{b}	7.21±0.59^{ab}	7.13±0.49^{ab}
T (cm)	5.25±0.63^{ab}	5.41±0.33^{ab}	4.49±0.39^{ab}	4.39±0.23^{a}	7.28±0.55^{b}	7.42±0.77^{b}	6.52±0.56^{b}	6.38±0.47^{ab}
DG (cm)	9.80±0.88^{ab}	9.12±0.62^{cd}	8.51±0.75^{a}	7.84±0.38^{abc}	10.43±0.72^{d}	10.35±0.95^{d}	10.52±1.02^{abc}	9.61±0.71^{bcd}
AR (%)	25.97±2.81^{a}	41.37±5.47^{ab}	22.79±3.17^{a}	30.06±2.07^{ab}	46.28±4.77^{b}	47.51±5.39^{b}	31.43±4.52^{b}	38.17±3.26^{ab}
SA (cm^2)	319.05±55.06^{ab}	272.16±34.72^{ab}	241.87±42.09^{a}	198.32±19.79^{a}	358.67±50.33^{c}	356.37±58.60^{c}	370.65±67.18^{bc}	311.10±42.29^{bc}
SP (%)	36.86±2.76^{a}	49.62±4.69^{bc}	34.43±2.97^{a}	40.88±1.79^{ab}	56.48±3.84^{c}	58.19±4.65^{c}	44.10±4.11^{ab}	50.07±2.85^{bc}
R	21.86±4.76^{bc}	11.03±2.94^{ab}	28.59±7.20^{c}	14.62±2.12^{ab}	9.35±2.22^{a}	8.61±3.18^{a}	19.82±6.49^{abc}	10.73±1.31^{ab}
M (kg)	0.70±0.15^{a}	0.62±0.13^{a}	0.56±0.09^{a}	0.35±0.05^{a}	0.75±0.16^{a}	0.75±0.16^{a}	0.75±0.17^{a}	0.55±0.10^{a}
V (m^3)	0.67±0.17^{a}	0.47±0.09^{a}	0.55±0.09^{a}	0.33±0.03^{a}	0.65±0.14^{a}	0.66±0.15^{a}	0.65±0.14^{a}	0.48±0.09^{a}
TD (kg/m^3)	1.15±0.11^{ab}	1.33±0.09^{b}	1.01±0.06^{a}	1.15±0.06^{ab}	1.16±0.02^{ab}	1.15±0.02^{ab}	1.15±0.02^{ab}	1.16±0.01^{ab}
BM (kg)	5.60^{d}	6.23^{f}	5.05^{b}	4.27^{a}	7.84^{h}	5.86^{e}	5.50^{c}	7.74^{g}
BV (m^3)	5.40^{d}	6.00^{f}	4.90^{b}	4.20^{a}	7.70^{h}	5.70^{e}	5.40^{c}	7.64^{g}
BD (kg/m^3)	1.06^{b}	1.45^{f}	1.03^{a}	1.19^{e}	1.11^{c}	1.11^{d}	1.11^{d}	1.11^{c}
P (%)	3.12±7.54^{b}	-14.14±8.51^{a}	-4.63±6.42^{ab}	-6.19±5.98^{ab}	4.22±1.26^{b}	3.54±1.82^{b}	3.14±1.79^{b}	4.17±1.04^{b}
AP (^{0})	70.75±0.03^{c}	69.40±0.37^{b}	70.67±0.33^{c}	68.33±0.38^{ab}	68.18±0.38^{ab}	68.00±0.40^{a}	69.00±0.37^{ab}	69.00±0.46^{ab}
CF	2.87±0.05^{c}	2.67±0.05^{b}	2.86±0.06^{c}	2.53±0.05^{ab}	2.51±0.05^{ab}	2.49±0.06^{a}	2.62±0.05^{ab}	2.62±0.06^{ab}

Values are means for triplicates and standard error. Means values including distinctive superscript inside a similar line are altogether significant ($P<0.05$).

IV. CONCLUSION

There were significant differences among the eight tillage practices used in this study for the selected engineering properties. This indicate that tillage practices had significant influence on engineering properties of cassava tubers. Ploughing + Harrowing (A) tillage practice gave the most suitable and uniform engineering properties, followed by F, G, D, C, E and H tillage practices. It is therefore advisable for farmers to adopt a conventional tillage practice [Ploughing + Harrowing (A)] which will enable cassava tubers to come in uniform and suitable engineering properties which will enhanced improvement in the existing cassava peeling machines which has constitute a bottle- neck toward the full automation of the processing system. The study had provided appropriate tillage practice needed by farmers to grow cassava tubers with uniform engineering properties. It had also provided enough data for engineers to design and fabricate systems for handling and processing of cassava tubers into useful products.

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