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Energy Requirement for Manual Cassava Harvesting on Coarse Textured Soils in Ibadan, Nigeria

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ABSTRACT

Most cassava farmers in Africa rely solely on manual means of harvesting root and tuber crops due to low level of mechanization. Evaluating the energy required in harvesting cassava and soil properties could guide farmers' decision on stress-free harvesting options and practices. Experiments were conducted at the University of Ibadan (UI) and the International Institute of Tropical Agriculture (IITA) to establish the relationship between energy required in harvesting cassava and soil physical properties. The experiments were laid out in a randomized complete block design with four replications. Salter suspended scale model 235 was used to take energy measurements, while data collected were subjected to analysis of variance at $\alpha = 0.05$. Mean yields from the two locations showed that variety TMS 97/0162 had the highest tuber mass (50,450 kg ha^{-1}) followed by varieties TMS 30572, TMS 98/0505 and TMS 98/0510 (32,200–26,500 kg ha^{-1}) and least by TMS 99/2123 (8,000 kg ha^{-1}). There was a positive relationship between cassava yield and work done (R^2= 0.21) at both locations, suggesting that yield affects the energy requirement in cassava harvesting. Soil moisture content showed a negative relationship with work done (R^2= 0.52 and 0.24 at UI and IITA, respectively), indicating that increase in soil water reduces the force of harvesting. Also, soil bulk density had a negative relationship with work done (R^2= 0.19 and 0.06 at UI and IITA, respectively). Energy required for harvesting cassava planted on coarse-textured soils could be reduced under high soil moisture content and bulk density conditions.

Keywords: Cassava yield, Cassava varieties, Harvesting efficiency, Soil bulk density, Soil moisture.

INTRODUCTION

Cassava (*Manihot esculanta* Crantz) is one of the world's most important crops in the tropics. It is an essential source of food and income for many farmers in the tropics (IFAD *et al*., 2008) and is also a source of raw materials for industrial applications and animal food. Cassava roots are rich in starch, and contain significant amounts of calcium (50 mg 100 g^{-1}), phosphorus (40 mg 100 g^{-1}), and vitamin C (25 mg 100 g^{-1}), with relatively good protein (Katz and Weaver, 2003). Globally, cassava production is a source of livelihood for more than 500 million farmers and numerous processors and traders (FAO and IFAD, 2001). Kudabo *et al*. (2012) explained that cassava could play a vital role in food security due to its capacity to yield under marginal soil conditions, tolerance to drought, and also the products that can be derived from its roots, as well as their industrial and domestic applications.

Although tagged as "Africa's best kept secret", Katz and Weaver (2003) noted that efficient mechanical handling, storage, and processing technologies need expert attention. Furthermore, Kolawole *et al*. (2010) stated that an increase in cassava production in order to sustain the world food security, needs improved machinery to allow its continuous cultivation and processing. However, most of the cassava produced in the tropics are by peasant farmers

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(especially in the rural communities) who depend on crude implements for their field operations. These farmers have contributed to Nigeria's being one of the world's largest producers of the crop. Cassava cultivation involves several field operations. Harvesting is the most important and crucial aspect of crop cultivation. According to Agbetoye (2003), harvesting is the most difficult operation in cassava cultivation. Cassava is harvested once, when it approaches full root maturity at about 12 Months After Planting (MAP) in on-station trials scheduled during a rain-fed cropping season. It could involve the use of mechanical and/or manual approach. Nweke *et al*. (2002) explained that mechanical harvesting of cassava has some engineering constraints, causing technical, resource, socio-economic and organisational challenges. Apart from these constraints, soil dynamics and root shape also cause serious challenges such as soil structure degradation and root breakage under mechanical cassava harvesting practices. Research on mechanical cassava harvesting in Nigeria is yet to come into the limelight. Agbetoye (2004) reported that the major farm operation performed in the cassava growing areas in south-western Nigeria is manual harvesting; and it is done with the aid of machetes and hoes. Amponsah (2011) explained that cassava is mostly harvested by hand-lifting the lower part of stem and pulling the roots out of the ground. This is partly due to the incident of cassava root damage or breakage often associated with mechanical harvesting, hence resulting in the practice of manual harvesting.

In recent times, numerous studies have been carried out to develop and assess the performance of different cultivation and processing machinery in different parts of the world (Yiliep and Mohammaed, 2005; Koloor and Ghaffar, 2007; Dange *et al*., 2011). Similarly, a number of studies have been carried out on the assessment of energy required under various methods and stages of cassava production in some locations in Nigeria (Ajibola, 1987; Kolawole *et al*., 2007; Kolawole and Agbetoye, 2007; Kolawole *et al*., 2011). In these studies, development and performance of different methods and processing conditions of cassava were evaluated.

Despite the extensive studies conducted on cassava along the production value chain, information on energy requirement for manual cassava harvesting as influenced by variation in soil physical properties is scanty. Therefore, we aimed to conduct experiments in Ibadan to establish the relationship between energy required in harvesting cassava manually and soil physical properties.

MATERIALS AND METHODS

Study Area

Two field locations were selected for the study between June, 2011 and May, 2012 in the rain forest zone of South-west Nigeria, namely, University of Ibadan Teaching and Research Farm (UI) (Latitude 7° 30′ N and Longitude 3° 45′ E), and the International Institute of Tropical Agriculture (IITA) (Latitude 7.43° N and Longitude 3.9° E), Ibadan. The two experiments were conducted simultaneously to compare farmers' field (UI) and research field (IITA). Six cassava varieties: TMS 30572, TMS 97/0162, TMS 98/0505, TMS 99/2123, TMS 98/0510 and Oko-iyawo were planted on farmers' field, while five cassava varieties (TMS 30572, TMS 97/0162, TMS 98/0505, TMS 99/2123, TMS 98/0510) were planted on research field in IITA. Treatments were arranged in a Randomized Complete Block Design (RCBD) with four replications in both sites.

Soil Sampling

Soil samples were collected from both experimental sites at 0–30 cm depth at the time of harvesting using a soil auger. The soil samples were sieved with 2 mm sieve to remove stones and dirts, before analyzing the soil physical parameters in the laboratory. The particle size distribution was determined using calgon and water as dispersing agents as described by Gee and Or (2002); while the moisture content was determined following Hillel (2003) method. The soil bulk density was determined according to Grossman and Reinsch (2002), while the hydraulic conductivity was determined as described by Smith (1999). The clay dispersion index, clay flocculation index, aggregated silt and clay, and dispersion ratio were calculated using Middleton (1930) procedure as enumerated in Equations (1-4).

$$Dispersion\ ratio\ (DR) = \frac{\%(silt+clay)\ in\ water}{\%(silt+clay) in\ calgon} \times 100 \quad (1)$$

$$\text{Clay Dispersion Index (CDI)} = \frac{\%clay\ in\ water}{\%clay\ in\ calgon} \times 100 \quad (2)$$

$$\text{Clay Flocculation Index (CFI)} = \frac{\%clay\ in\ calgon - \%clay\ in\ water}{\%clay\ in\ calgon} \times 100 \quad (3)$$

$$\text{Aggregated Silt and Clay (ASC)} = \%(clay + silt)\ in\ clagon - \%(clay + silt)\ in\ water \quad (4)$$

The determination of energy required in cassava harvesting was done using the Salter suspended weigh model 235. At harvest, cassava plants were cut off at 30 cm above the ground by machete and piled at the side of the field. The length of the stalk left was meant for hand-pulling manually as practiced by farmers. A strong rope was tied round the base of the cassava plant after cutting off the stems. The Salter suspended scale was hooked to the loop of the rope and pulled to estimate the amount of energy required for uprooting cassava plant. Force of harvesting (Newton) and work done (Joule) during harvesting were calculated using Equations (5) and (6) sequentially.

$$F = ma \quad (5)$$

$$Work\ done = F \times d \quad (6)$$

Where, d= Distance (length of the rope from the base of cassava plant to the point of application of force of harvesting) (m), F = Force (N), m = Mass of uprooted cassava (kg), a = Acceleration due to gravity (9.80 m s^{-2}).

Statistical Analysis

All experimental data were statistically analyzed using the Analysis Of Variance (ANOVA) based on the randomized complete block design using SPSS version 20 software. Means were compared using Duncan Multiple Range Test (DMRT) at 5% level of significance.

RESULTS

Soil Properties

Particle size distribution determined with and without calgon is presented in Table 1. Texturally, the soil at University of Ibadan (UI) experimental site was predominantly sand, while that at the International Institute of Tropical Agriculture (IITA) was loamy sand. This implies that the degree of coarseness of UI experimental site was higher than at the IITA station. Generally, both sites have coarse textured soils, which could improve the growth and yield performance of cassava since most cassava varieties cannot withstand prolonged waterlogged conditions (Sessahi *et al*., 2008).

Soil Physical Properties in Relation to Energy Requirement

Variation in properties of soils planted to various cassava varieties in UI and IITA is presented in Table 2. In UI, hydraulic conductivity was significantly (P = 0.05) highest (47.5 cm hr^{-1}) in soils planted to TMS 99/2123, while soils planted to Oko-iyawo had the lowest hydraulic conductivity (17.4 cm hr^{-1}). At IITA, hydraulic conductivity was significantly (P = 0.05)

Table 1. Water dispersed and Calgon dispersed particle size distribution of soils of the experimental sites.[a]

Variety	Sand	Silt	Clay	Sand	Silt	Clay	Texture
	Water dispersed (g kg^{-1})			Calgon dispersed (g kg^{-1})			
			IITA				
TMS 98/0505	899.6	40.0	61.6	849.2	48.0	102.8	Loamy sand
TMS 98/0510	912.8	32.0	55.2	856.8	48.0	95.2	Loamy sand
TMS 97/0162	900.8	44.0	55.2	843.6	40.0	104.4	Loamy sand
TMS 99/2123	903.6	40.0	56.4	835.6	56.0	108.4	Loamy sand
TMS 30572	916.8	24.0	59.2	867.6	40.0	92.4	Loamy sand
			UI				
TMS 98/0505	908.5	45.0	46.5	867.0	55.0	78.0	Sand
TMS 98/0510	940.5	10.0	49.5	899.0	35.0	66.0	Sand
TMS 97/0162	927.0	25.0	48.0	897.0	35.0	68.0	Sand
TMS 99/2123	940.0	15.0	45.0	903.5	30.0	66.5	Sand
TMS 30572	927.0	25.0	48.0	875.5	50.0	74.5	Sand
Oko-iyawo	925.0	30.0	45.0	885.0	45.0	70.0	Sand

[a] Means within the same column under each site were not significantly different at $P \leq 0.05$.

Table 2. Micro-aggregate stability indices of soils from IITA and University of Ibadan at harvesting of cassava. [a]

Variety	DR [b]	CDI [c]	CFI [d]	ASC [e]	SHC [f]
			IITA		
TMS 98/0505	68.0a	59.8b	40.2b	4.9c	3.3d
TMS 98/0510	61.5b	58.9b	41.1b	5.6b	6.9c
TMS 97/0162	68.0a	53.4c	46.6a	4.5d	16.4a
TMS 99/2123	58.7b	52.7c	47.3a	6.8a	6.3c
TMS 30572	61.7b	65.0a	35.0c	4.9c	11.9b
SED [g]	1.63	2.23	1.96	0.12	0.86
			UI		
TMS 98/0505	68.2ab	60.3c	39.8a	4.2	30.1c
TMS 98/0510	58.8d	76.0a	24.0d	4.2	31.7bc
TMS 97/0162	72.4a	70.4ab	29.7c	3.0	34.7b
TMS 99/2123	62.4bc	67.7b	32.3bc	3.7	47.5a
TMS 30572	60.7bc	65.6bc	34.4b	5.2	29.1c
Oko-iyawo	66.0abc	65.4bc	34.6b	4.0	17.4d
SED	3.41	2.78	1.30	ns	1.42

[a] Means with the same letter(s) in a column are not significantly different at $P= 0.05$, ns: Means in the same column are not significantly different at $P= 0.05$. [b] Dispersion Ratio, [c] Clay Dispersion Index, [d] Clay Flocculation Index, [e] Aggregated Silt and Clay, [f] Saturated Hydraulic Conductivity. [g] Standard Error of Differences of means.

highest in soils planted to TMS 97/0162 (16.38 cm hr^{-1}), and least in soils planted to TMS 98/0505 (3.3 cm hr^{-1}).

There was no significant (P = 0.05) difference in the soil Aggregated Silt and Clay (ASC) which was in the order of TMS 30572 (5.2%), followed by soils planted to TMS 98/0505 (4.2%) and TMS 98/0510 (4.2%), Oko-iyawo (4.0%), TMS 99/2123 (3.7), and least by TMS 97/0162 (3.0%) in UI. However, there was significant (P = 0.05) difference in the ASC of the soils planted to the cassava varieties in IITA, where soils planted to TMS 99/2123 had the highest *ASC* of 6.8% and the lowest *ASC* (4.5%) was recorded under soils planted to TMS 97/0162.

The Clay Dispersion Index (CDI) was significantly (P = 0.05) different among the

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soils planted to different varieties in both experimental locations. At UI, soils planted to TMS 98/0510 had the highest CDI (76.0%), while the least was recorded under Oko-iyawo (65.4%). At IITA, plots planted to TMS 30572 had the highest CDI value of 65.0%, while the least CDI value was recorded under TMS 99/2123 (52.7%).

Also, Clay Flocculation Index (CFI) was significantly (P = 0.05) highest in plots planted to TMS 98/0505 (39.8%), while the lowest CFI (24.0%) was recorded under TMS 98/0510 at UI. At IITA, CFI was significantly (P = 0.05) highest (47.3%) in plots planted to TMS 99/2123, while soils planted to TMS 30572 recorded the lowest CFI value of 35.0%. Results of the clay dispersion analysis revealed that Dispersion Ratio (DR) values were significantly (P = 0.05) different at both experimental locations. For instance, soils planted to TMS 97/0162 had the highest DR value of 72.4%, while those planted to TMS 98/0510 had the lowest DR value of 58.8% in UI. In IITA, soils planted to TMS 98/0505 had the highest DR value of 68.0%, while the lowest DR value (58.7%) was recorded under TMS 99/2123.

Effect of Cassava Varieties on Energy Requirement for Harvesting

Table 3 shows the result of force applied and work done in harvesting six cassava varieties in UI and IITA. The force and work done used in harvesting cassava were significantly (P = 0.05) influenced by the varieties in both study locations. Although, TMS 98/0510 with the highest yield of 25,000 kg ha^{-1} had a work done of 617.3 kJ Plants^{-1} ha^{-1}, work done in cassava harvesting was highest (981.3 kJ Plants^{-1} ha^{-1}) under TMS 30572 with a yield of 21,800 kg ha^{-1}, while TMS 99/2123 with the lowest yield of 7,500 kg ha^{-1} had the lowest work done (523.8 kJ Plants^{-1} ha^{-1}) at UI. At IITA, there was significant (P = 0.05) variation in the yield of the cassava varieties, the force applied, and the work done in harvesting the yields. Here, TMS 30572 with mean yield of 42,600 kg ha^{-1} had the highest value for work done (1,256.8 kJ Plants^{-1} ha^{-1}). This was followed by TMS 97/0162 which required 1138.8 kJ Plants^{-1} ha^{-1} to uproot 90,600 kg ha^{-1} weight of tubers, TMS 98/0510 (1,136.2 kJ Plants^{-1} ha^{-1}) with a mean yield of 28,000 kg ha^{-1}, TMS 99/2123 (988.2 kJ Plants^{-1} ha^{-1}) with mean yield of 8,500 kg ha^{-1} and least by TMS 98/0505 (979.2 kJ Plants^{-1} ha^{-1}) with mean yield of 35,600 kg ha^{-1}. In addition, the highest force of 5,586.0 kN was required to harvest TMS 30572 which had a mean yield of 42,600 kg ha^{-1}, while TMS 98/0505 with mean yield of 35,600 kg ha^{-1} required the lowest force of 4,351.2 kN for yield harvesting.

Table 3. Effects of cassava varieties on energy required for harvesting cassava manually in Ibadan.[a]

Variety	UI			IITA		
	Yield (kg ha^{-1})	Force (kN) of pulling plants ha^{-1}	Work done (kJ) harvest^{-1} ha^{-1}	Yield (kg ha^{-1})	Force (kN) of pulling plants ha^{-1}	Work done (kJ) harvest^{-1} ha^{-1}
TMS 98/0505	19,000b	3361.5bc	756.5c	35,600c	4351.2c	979.2c
TMS 98/0510	25,000a	2744.0cd	617.3d	28,000d	5049.2b	1136.2b
TMS 97/0162	10,300c	3822.0ab	859.8b	90,600a	5060.8b	1138.8b
TMS 99/2123	7,500c	2327.5d	523.8e	8,500e	4390.4c	988.2c
TMS 30572	21,800ab	4361.0a	981.3a	42,600b	5586.0a	1256.8a
Oko-iyawo	19,800b	3307.5bc	744.3c	–	–	–
SED	1890.9	358.7	34.61	1209.5	160.7	39.3

[a] Means with the same letter in a column are not significantly different at *P*= 0.05, ns: means in the same column are not significantly different at *P*= 0.05, –: Data were not observed for Oko-iyawo in IITA, *SED*: Standard Error of Differences of means.

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Relationship between Energy Requirement in Harvesting and Cassava Yield

Figure 1 reveals that increase in yield resulted in increase in the force of harvesting in UI (R^2= 0.07) and IITA (R^2 = 0.21). In UI, the lowest uprooting force (2,327.5 kN Plants^{-1} ha^{-1}) with resultant work done of 523.8 kJ Plant^{-1} ha^{-1} in cassava harvesting was found in the plots with the lowest yield (7,500 kg ha^{-1}), while the highest force (4361.0 kN Plants^{-1} ha^{-1}) with highest work done (981.3 kJ Plants^{-1} ha^{-1}) was found in the plots with the highest yield (21,800 kg ha^{-1}). Force and work done required to harvest cassava yield of 19,000 kg ha^{-1} were 3,361.5 kN Plant^{-1} ha^{-1} and 756.5 kJ Plants^{-1} ha^{-1}, while others included 25,000 kg ha^{-1} required 2,744.0 kN Plants^{-1} ha^{-1} and 617.3 kJ Plants^{-1} ha^{-1}; 10,300 kg ha^{-1} required 3,822.0 kN Plants^{-1} ha^{-1} and 859.8 kJ Plants^{-1} ha^{-1}; and 19,800 kg ha^{-1} required 3307.5 kN Plants^{-1} ha^{-1} and 744.3 kJ Plants^{-1} ha^{-1}, respectively. In IITA, cassava yield of 46,200 kg ha^{-1} required 5,586.0 kN Plants^{-1} ha^{-1} and 1,256.8 kJ Plants^{-1} ha^{-1} for harvesting, whereas 8,500 kg ha^{-1} yield required a force of 4,390.4 kN Plants^{-1} ha^{-1} and work done of

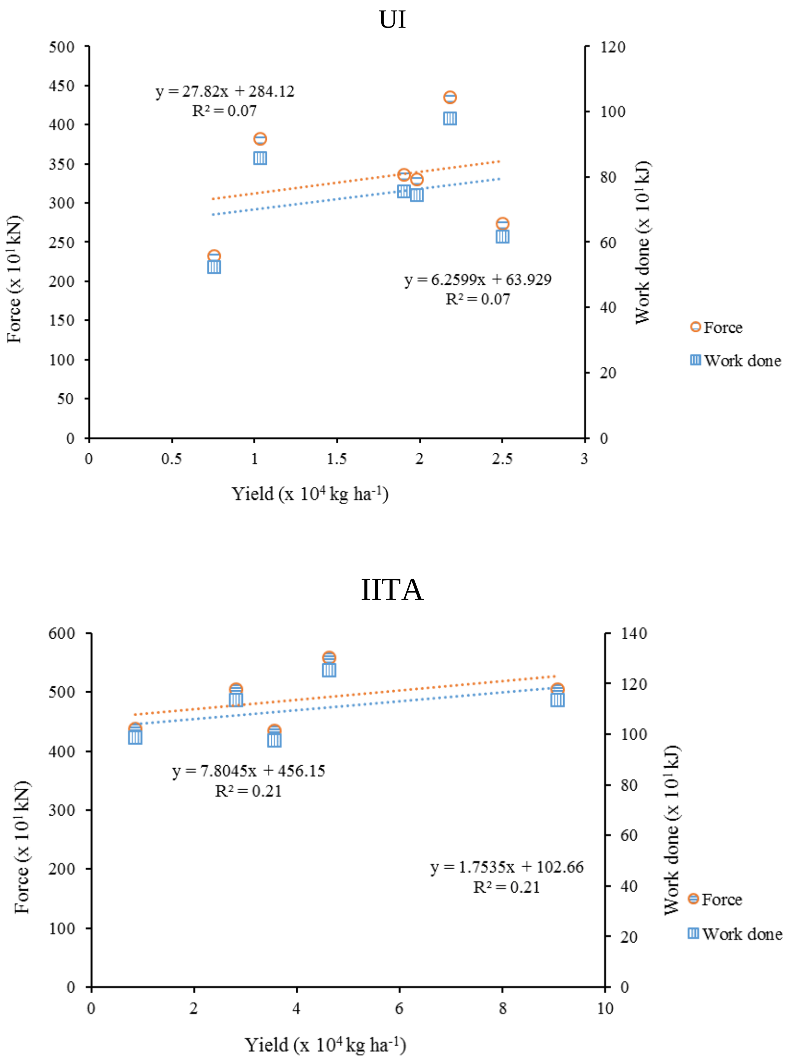

Figure 1. Effect of cassava yield on energy requirement for harvesting at UI and IITA.

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988.2 kJ Plants^{-1} ha^{-1}. Other yields with their corresponding force and work done include: 28,000 kg ha^{-1} required 5049.2 kN Plants^{-1} ha^{-1} and 1,136.2 kJ Plants^{-1} ha^{-1}; 35,600 kg ha^{-1} requiring 4,351.2 kN Plants^{-1} ha^{-1} and 979.2 kJ Plants^{-1} ha^{-1}; and 90,600 kg ha^{-1} requiring 5,060.8 kN Plants^{-1} ha^{-1} and 1,138.8 kJ Plants^{-1} ha^{-1}, respectively.

Soil Moisture Content in Relation to Energy Requirement in Cassava Harvesting

The relationship between the force of harvesting cassava yield and soil moisture content for both UI and IITA is presented in Figure 2. There were increases and decreases in the trends of force and work done in relation to soil moisture content. In UI, plots with the lowest moisture content at 6.4% had the highest force (4,361.0 kN Plants^{-1} ha^{-1}) and work done (981.3 kJ Plants^{-1} ha^{-1}) for harvesting, while plots with 12.9% soil moisture content resulted in the lowest force (2,327.5 kN Plants^{-1} ha^{-1}) and work done (523.8 kJ Plants^{-1} ha^{-1}).

Furthermore, a similar trend was observed in IITA, where soils with the lowest moisture content value (4.4%) had the highest force (5,586.0 kN Plants^{-1} ha^{-1}) and

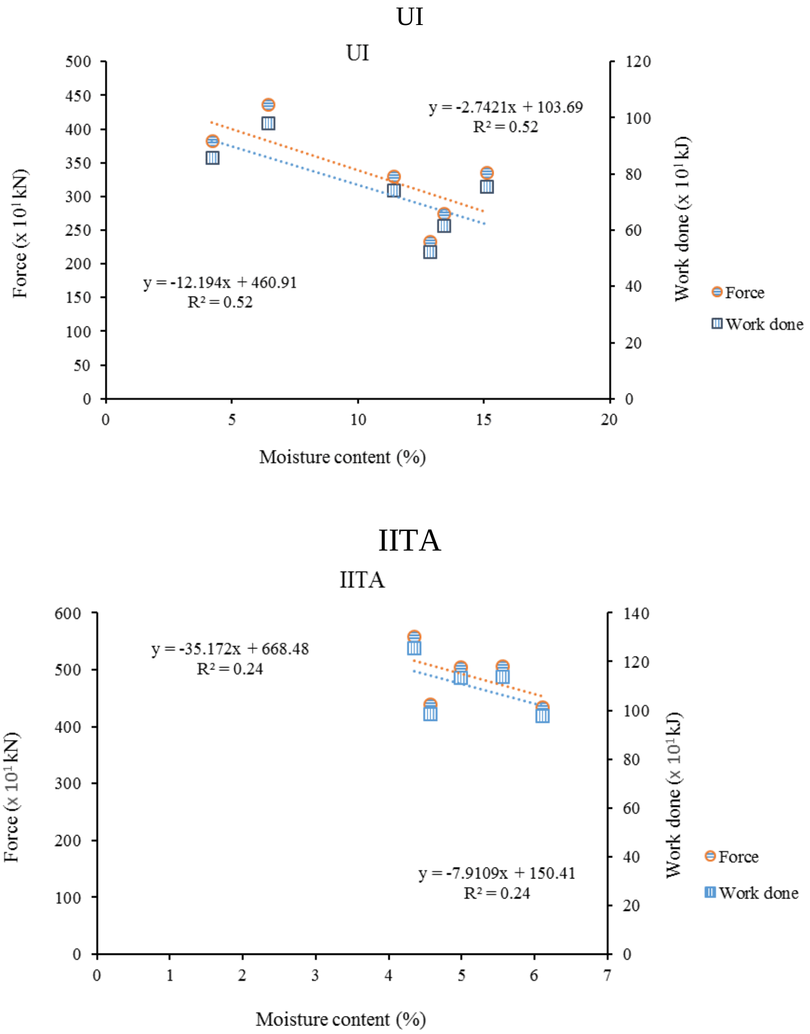

Figure 2. Energy required for harvesting cassava as influenced by soil moisture content at UI and IITA.

work done (1,256.8 kJ Plants^{-1} ha^{-1}) in harvesting cassava. Although plots with soil moisture content value of 4.6% required the lowest force (439.04 kN Plants^{-1} ha^{-1}), plots with soil moisture content value of 6.1% resulted in the lowest work done (97.92 kJ Plants^{-1} ha^{-1}) in harvesting yields.

Soil Bulk Density in Relation to Energy Requirement in Cassava Harvesting

Figure 3 depicts the relationship between work done and force as influenced by soil bulk density. In UI, soils with bulk density value of 1.38 Mg m^{-3} had the highest force (4,361.0 kN Plants^{-1} ha^{-1}) and work done (981.3 kJ Plants^{-1} ha^{-1}) in harvesting cassava yield, while bulk density value of 1.45 Mg m^{-3} resulted in the lowest force (2,327.5 kN Plants^{-1} ha^{-1}) and work done (523.8 kJ Plants^{-1} ha^{-1}).

Also, in IITA, soils with the lowest bulk density value of 1.22 Mg m^{-3} required the highest force (5,586.0 kN Plants^{-1} ha^{-1}) and work done (1,256.8 kJ Plants^{-1} ha^{-1}) in harvesting cassava yield, while other bulk density values of 1.40, 1.50, 1.58 and 1.26 Mg m^{-3} had corresponding work done values of 1,138.8, 979.2, 1,136.2, and 988.2 kJ Plants^{-1} ha^{-1}, respectively.

DISCUSSION

The result of the particle size distribution

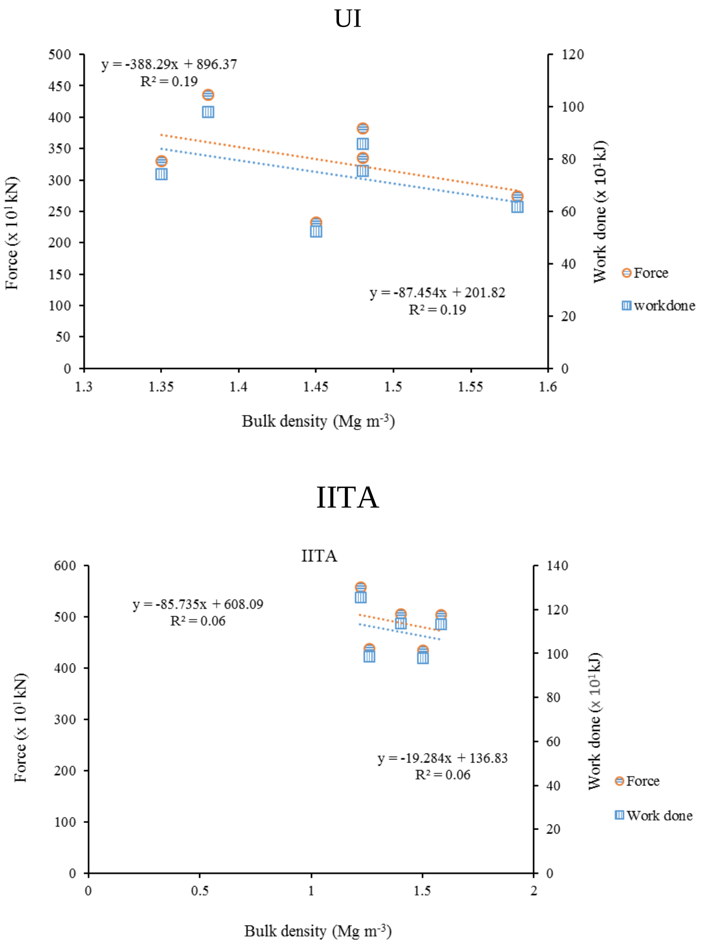

Figure 3. Energy required for harvesting cassava as influenced by soil bulk density at UI and IITA.

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showed the dominance of sand sized particles in both locations. The higher value of sand fraction compared to silt and clay fractions is typical of soils in south-western Nigeria (Babalola *et al*., 2000). Chris-Emenyonu and Onweremadu (2011) reported that these soils are formed largely from the coastal plain sands. The higher value of sand sized particles in water dispersion medium is a result of the binding effect of cementing agents in the soils due to lack of chemical dispersant. The variation in dispersion ratio, clay dispersion index, clay flocculation index, aggregated silt and clay, bulk density, hydraulic conductivity and soil moisture content within and among the locations could be attributed to their respective soil textural differences. Pravin *et al*. (2013) reported that soil physical properties are influenced by soil texture. However, there was no significant difference in aggregated silt and clay, soil moisture content, and dispersion ratios in the two locations.

The statistical disparity in soil hydraulic conductivity, clay dispersion index, and clay flocculation index within and among the locations may be due to the difference in soil types and farm management practices carried out over time. Soil moisture content and bulk density both had a negative but significant relationship with force and work done required in harvesting cassava, indicating that an increase in soil moisture content would lead to a decrease in energy required to harvest cassava manually. This could be a result of the effect of soil moisture and bulk density on soil strength. Utset and Cid (2001) reported that soil strength is highly influenced by soil moisture. It can also be deduced from the positively significant relationship between yield and work done in both locations that an increase in yield would result in a corresponding increase in energy requirement in cassava harvesting. These observations agree with the reports of Sheriff and Kurup (1992) and Amponsah *et al*. (2014) who reported that harvesting force requirement for CMR cassava variety on upland mound land form was significantly and positively correlated with yield per plant and number of root tubers. The low R^2 values showed that the linear model is not a good model for representing the variations in the variables. This is contrary to the result of Dange *et al*. (2011) who had R^2 values above 90%, using the polynomial model. However, inconsistencies in some of the work done values as determined by yield were noted. This could be as a result of the variation in bending strength along the length of cassava root tuber and also its moisture content. Kolawole *et al*. (2010) stated that strength properties are important data required to predict the behaviour of crop materials during harvesting.

CONCLUSIONS

Energy requirement in cassava harvesting is affected by root tuber yield, soil bulk density and soil moisture content to a greater extent. However, regardless of the cassava yield, certain inherent and spatial factors such as shape of tuber and heterogeneity in soils influence, beyond human manipulation, the work done and force required in cassava harvesting. These can be said to be responsible for the lower yield of some varieties having higher values for force and work done when compared to higher yield of other varieties. The result obtained indicated that energy required in harvesting cassava tuber increases with the reduction of soil moisture content. The implication is that manual method of harvesting cassava tuber is better done during the wet season so that more area of land can be harvested.

It is, however, recommended that soil properties such as bulk density and moisture content be considered in measuring the efficiency of labourers in manual harvesting. For better manual harvesting efficiency, cassava should be grown on a coarse textured soil and harvested in the wet season. This would improve the production efficiency and conserve the energy of the local farmers via making them work more

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comfortably and improving their performance. However, there is a need to further evaluate manual method of cassava harvesting over a wide range of soil conditions under different high yielding cassava varieties.

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انرژی مورد نیاز برای برداشت دستی کاساوا در خاک های درشت بافت در منطقه ایبادان در نیجریه

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چکیده

بیشتر کشاورزانی که در افریقا کاساوا می کارند، برای برداشت ریشه و غده محصول از ابزارهای دستی استفاده می کنند و دلیل آن پایین بودن درجه مکانیزاسیون است. در این ارتباط، ارزیابی انرژی لازم برای برداشت محصول و ویژگی های خاک می تواند کشاورزان را در تصمیم گیری برای انتخاب عملیات برداشت بی دردسر راهنمایی کند. از این رو، به منظور تعیین رابطه بین انرژی لازم برای برداشت محصول کاساوا و ویژگی های فیزیکی خاک، آزمایش هایی در دانشگاه ایبادان(UI) و در موسسه بین المللی کشاورزی استوایی(IITA) اجرا شد. آزمایش ها با طرح بلوک های کامل تصادفی در چهار تکرار پیاده شد. برای اندازه گیری مقدار انرژی از دستگاه Salter suspended scale model 235استفاده شد و داده های جمع آوری شده در سطح $\alpha = 0.05$تجزیه واریانس شد. میانگین عملکرد دو محل اجرا نشان داد که رقم TMS 97/0162 بیشترین وزن عملکرد را داشت(۵۰۴۵۰

کیلوگرم در هکتار) و بعد از آن رقم TMS 30572 و TMS 98/0510 و TMS 98/0505 با عملکرد هایی درمحدوده ۳۲۲۰۰ تا ۲۶۵۰۰ کیلوگرم در هکتار بود و کمترین عملکرد مربوط به رقم TMS 99/2123 (برابر ۸۰۰۰ کیلوگرم درهکتار) بود. نتایج حاکی از یک رابطه مثبت بین عملکرد کاساوا و کار انجام شده در هر دو محل بود ($R^2 = 0.21$) و چنین اشاره داشت که عملکرد روی انرژی لازم برای برداشت کاساوا اثر داشت. مقدار رطوبت خاک با کار انجام شده رابطه منفی نشان داد ($R^2 = 0.52$ در UI و $R^2 = 0.24$ در IITA). و چنین اشاره داشت که افزایش رطوبت خاک باعث کاهش نیروی لازم برای برداشت شد. همچنین، جرم مخصوص ظاهری نیز با کار انجام شده رابطه منفی نشان داد ($R^2 = 0.19$ در UI و $R^2 = 0.06$ در IITA). بنا براین، در شرایط بالا بودن طوبت خاک و جرم مخصوص ظاهری، انرژی لازم برای برداشت کاساوای کشت شده در یک خاک درشت بافت کاهش می یابد.

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