Modeling of the Physio-thermal storability properties of TME419 cassava stem cuttings under prevalent room temperature

Ola I.A[1], Dairo, O. U[1], Ajayi O.A[2], Ayedun P[3] and Ajisegiri E.S.A[1]

[1] Department of Agriculture and Bio-Resources Engineering. Federal University of Agriculture, Abeokuta, Nigeria
[2] Department of Agriculture and Environmental Engineering. Obafemi Awolowo Uiversity, Ile-Ife. Nigeria
[3] Department of Mechanical Engineering. Federal University of Agriculture, Abeokuta, Nigeria

ABSTRACT

Exposures of cassava stem cuttings to prevalent atmospheric dehumidification process, as well as, the relationship in variation of the stem physical properties and related physiothermal studies at room temperature were investigated. Vital information on cassava stem parameters that could serve as a basis of developing devices for timely handling of stems on field during planting was obtained. 50 samples of TME 419 variety cassava stem cuttings were prepared in lengths of 5, 10, 15, 20, 25 and 30 cm. were used for the study. Samples were allowed to dry naturally for a period of between 0 and 672 hours (28 days) under natural room condition in order to obtain the intrinsic fall rate of the drying process. The relative humidity and weight losses were monitored over time intervals of T_{24H}, T_{120H}, T_{168H}, T_{264H} and T_{672H}. Trends of proportionality between parameters was obtained from the data analyzed to a model for the weight loss in terms of Length, Time, Diameter The obtained weight loss model had a coefficient of determination of 0.981 with all parameters except height of node having a positive correlation with weight obtained after exposure. There is a gradual reduction in the weights of cassava stem cuttings as the moisture content is lost to the ambient temperature at removal rate of 0.9g./sec. An initial negative correlation was observed for stem cuttings drying at T_{24H} to T_{120H}, showed that the period was the duration of time the stem remained viable for planting. Any time beyond this period of drying might not be a feasible for stem germination. This information is vital on the field while planning the best time allotted time available to harvest and process cassava stem cuttings for perennial propagation.

Key words; Physio-thermal, weight loss,, handling, cassava stem, moisture content

Corresponding author: olaia@funaab.edu.ng

INTRODUCTION

Productions of cassava in Nigeria are still at rudimentary level. Only few stages of productions along the production chain line are handled with appropriate machinery while the rest operations are done manually. Unfortunately, unavailable or missing data bank of research findings conducted in the area of cassava mechanization on cassava crop production in Nigeria and its characteristics, properties and features of crop are major setback for actualizing full mechanization. Researchers, such as, Nur 'Izzati *et al.* (2016), Reeb. (1995), Igbeka, (1992) Wahab *et al* (1977), Schulte *et al* (1973), Odigboh, (1976, 1977,1983) among others have conducted studies on cassava productions. However, vital information required in the development of the crop are not readily accessible to machine designers and developers, hence there is need to conduct various researches to bridge up the information gap required in the design of adequate and precise machines for full mechanization of the crop.

Handling of cassava stem cuttings to secure its vitality and reduce germination losses are vital issues to be considered while using a machine to meter the stems into formed ridges. In this study, physical and thermal properties of the cassava were evaluated in order to develop models of the physio-thermal properties of stem useful for developing appropriate field handling machine with less stem mutilation and weight loss during planting. The physio-thermal properties of cassava cuttings which entail the thermal behavior of the harvested stem cuttings in response to the dynamic weight loss were investigated. The weight loss is due to moisture loss to the atmosphere and this reduction also affects the stem properties in terms of dimensional size (like diameter, length and weight). This change, removal of moisture content into the environment from the stem cuttings have not been reported in literatures recently. The existing relationship between the stem diameter, weight and moisture content losses is unknown. The physio-thermal behavior of the stem cuttings when exposed to the prevalent atmospheric condition resulting to loss of water from the stem to the atmosphere was evaluated in this research work. The outcome would reveal the natural mechanism of water loss or its removal to the atmosphere at planting stage as well as help to design an appropriate handling device.

Ola *et, al* (2015) evaluated some physical properties of 60 cassava stem cuttings from TME 419 prepared in the length of 150 mm with average moisture content of 81.1 % (w.b) and obtained a power model relating the stem diameter to the weight of the stem cuttings in the form of Eq (1) with a R^2 value of 0.913. Sobowale (2014) also obtained a power model given by Eq (2) from a study on 30 samples of Texaco white species obtained from a farm in FUNAAB (Nigeria). However, the models were only related to the stem diameter.

$$y = 0.0362\, x^{2.2834} \qquad (1)$$

$$y = 0.4135x^{1.7944} \qquad (2)$$

where Y is weight of stem cuttings and x is stem diameter

The different in values of the constant for these two equations and the power factor require further investigation to determine the effect of moisture content, length of stems or specie type on the model relating diameter, weight, length, moisture content, node height and number of nodes per length of cassava stem cuttings. It is therefore important to investigate the thermo-physiological properties of cassava stem cuttings under a monitored environmental condition.

MATERIALS AND METHODS

Cassava variety used for the study was TME 419 variety obtained from Federal University of Agriculture, Abeokuta. The weights of the samples were determined using a sensitive electronic balance (AMPUT, model APTP457A) with a sensitivity of 0.01g, while moisture content was determined using gravimetric method by drying in an electric oven at a temperature of 110^{O}C. 25 samples were randomly selected from a stock of 100 cuttings and were dried in the oven (DHG-9030-ISA) for 6 hours until there is no significant change in weight. The initial weight of the stem cuttings and the final weight after being oven dried were recorded. The average moisture content (w.b) values were obtained for the stem cuttings.

RESULTS AND DISCUSSION

The average values of physical dimensions of 50 samples of cassava stem cuttings prepared in lengths of 5, 10, 15, 20, 25 and 30 mm and all measurement made are presented in Table 1. The stem diameter and final diameter varied from 19.8 to 23.97 and 18 to 21.71 respectively. The node height varied from 4.9 mm to 6.4 mm while the number of nodes varied from 2 to 15. The correlation coefficient between all the parameters measured are presented in Table 2, The time for the experiment varied from 0 to 672 hours of moisture content removal from the stem at air drying process labeled $T_{1,20H}$ to T_{672H} presented in Table 1 and evaluated for correlation in between parameters in Table 2.

TABLE 1: Avarage measurement of Physiothermal properties of 50 samples of cassava stem cuttings ME419 under air drying process

Stem Length		5	10	15	20	24	25	30	Average of all
	Time(Hr)	Weights loss (g)							
T_{0H}	0	18.49	47.53	85.84	162.67	75.3	106.72	216.81	105.62
T_{120H}	120	16.21	44.17	80.74	154.48	73.07	101.42	205.88	99.90
T_{168H}	168	13.02	41.91	77.74	151.19	71.52	98.01	198.46	96.25
T_{264H}	264	13.51	39.30	72.77	143.63	68.08	93.46	191.77	91.96
T_{672H}	672	5.39	13.45	23.57	47.39	19.64	29.07	57.92	29.32
Initial Diameter(mm)		22.71	23.97	23.63	23.26	19.8	22.88	22.78	22.72
Final Diameter(mm)		20.52	21.71	21.29	20.77	18	20.63	20.30	20.46
Node height		5.5	5.6	5.6	5.6	4.9	5.6	6.4	5.6
Number of of nodes		2	2	4	6	8	11	15	6

Table 2: Correlations between parameters

	Length	Weight	diameter	Number of Nodes	T_{120s}	T_{168s}	T_{264s}	T_{672s}
Length	1.00	0.98	-0.23	0.78	-0.29	0.67	0.76	0.72
Weight	0.98	1.00	-0.04	0.83	-0.22	0.65	0.74	0.70
Diameter	-0.23	-0.04	1.00	-0.03	0.41	0.01	-0.04	0.04
Number of Nodes	0.78	0.83	-0.03	1.00	0.07	0.50	0.53	0.51
T_{120H}	-0.29	-0.22	0.41	0.07	1.00	-0.01	-0.18	-0.10
T_{168H}	0.67	0.65	0.01	0.50	-0.01	1.00	0.97	0.98
T_{264H}	0.76	0.74	-0.04	0.53	-0.18	0.97	1.00	0.99
T_{672H}	0.72	0.70	0.04	0.51	-0.10	0.98	0.99	1.00

Marked correlations are significant at $p < .05000$

The correlation value of 0.98 was obtained between the length and the weight as compared to the values of -0.04 and -0.23 for correlation between the stem diameter/weight and stem diameter/length respectively. The negative values showed that diameter had an inverse correlation with the stem weight or length at an insignificant level, which opposed the initial model equations obtained in Ola *et. al.*(2015) and Sobowale (2014) studies. The significant value obtained between the length and weight in Table 2 showed that the longer the length the more the weight increases. This indicates a positive correlation between the weight and the length of the stem cuttings. However, any change in the diameter of the stems is having an inverse effect on length or weight stem cuttings. The negative values showed an inverse relationship of the parameters as shown in Table 2.

Similarly, the correlations between the Number of nodes with length and weight, which are 0.78, and 0.83 respectively were significant ($p< 0.05$). The number of nodes was inverse correlated with the stem diameter with a value of 0.03. The high values of correlations observed for number of nodes with length and weight showed that the more number of nodes the more avenue for stems nourishment that led to increase in weight and length as observed in the measurements made. It could also indicate that the more nodes that are available in a given stem cuttings the more weight and length of stem cuttings. The time range in exposing stems was also included in the correlation analysis to observe the trend in variation in loss of weight to the atmosphere at T_{24H}, T_{120H}, T_{168H}, T_{264H} and T_{672H}. Partial correlations were observed for variation in time as related to the diameter and length. There was an inverse relationship between the varied time of exposure of cassava stem cuttings to the prevalent ambient air-drying and the diameter. However the partial correlation between the time of ambient air drying of stems and the length or weight illustrates that the elongation of time of exposure affects the two parameters significantly ($p< 0.05$). It was also observed that as the time of exposure to the ambient condition extends from T_{24H} to T_{672H}, the value of correlation coefficients increases from negative to positive values of -0.29 to 0.72 as given in Table 2. This observation observed in the behavior of the inverse correlation coefficients at the time of exposure to the ambient condition from T_{24H} to T_{120H} showed that at these duration of time of air-drying, the stems are still viable and are not readily losing any of its moisture to the atmosphere.

The stems were still behaving as a living cell hence the negative trend obtained initially. However, beyond the time of T_{120H} to T_{672H} a positive correlation obtained showed that the stems are no more conservative of the moisture within thereby losing it to the atmosphere. This further showed that the longer the length (corresponding to increase weights of the sample) there was increased correlation value of the moisture content of water removed from the stem as the time increases from 0 to 672 hours. Figure 1 shows the variation of weight loss across samples measurement and the variation of the time of exposure of the stems under the prevalent atmospheric condition. It was observed from the figure that whatever model that is involved in the loss of weight as related to time of exposure there is a consistent trend of reduction in sizes with equal falling rate of water removal in all the samples used. This observation showed that the water loss to the atmosphere by all samples were of the same predictable trend and equal

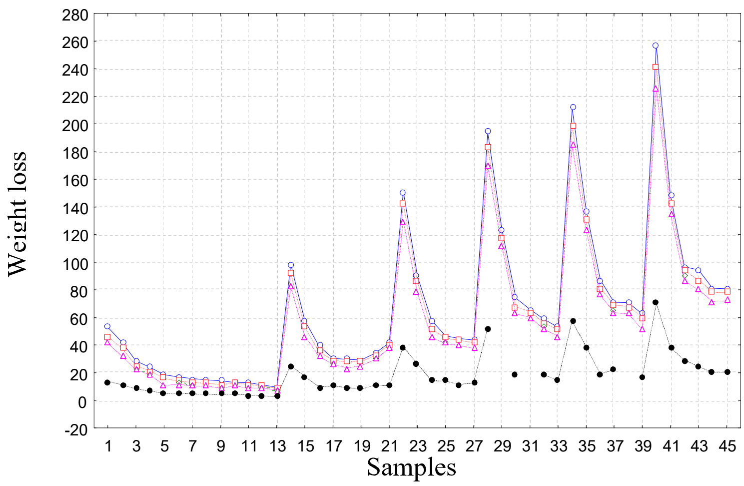

Figure 1: Line Plot of weight loss of cassava stem cuttings over 0 to 672 hours of dehumidification.

proportions of water removal for each proportionate stem length and weight. The consistent trend in the plots showed that under the same condition of drying at room temperature, away from the direct sunlight and in a controlled drying room there is a consistent mode of water loss to the atmosphere.

Further analysis on the data was done using another statistical software (STATISTICA 8) to detect which parameters have significant correlation and relationship to each other using an *exponential function* of the form of Eq, 3

$$y = b*\exp(-q*x) \qquad 3$$

where the constants *b* and *q* are determined by the least squares method.

A further analysis using a *Nonlinear Estimation* to analyzed all data obtained for the parameters; diameter, moisture content, weight and node height and fitted in linear functions of multiple (predictors) variables inside the exponent expression (Eq. 4)

$$y = \exp(a+b_1*x_1+...+b_k*x_k) \quad .(4)$$

Fitting the experimental data to Eq (4) gave an equation that relates the weight of cassava stem cutting as an independent variable predictable by five parameters as given by Eq. (5) with R^2 value of 0.981

$$Y = -14.6008 + Exp(1.737 + 0.0526X_1 + 0.10X_2 + 0.0390X_3 - 0.0391X_4 + 0.00385X_5 \quad (5)$$

Where, Y is Weight , *X_1 is length, X_2 is Time, X_3 is Final diameter of stem, X_4 is height of node and X_5 is Number of nodes,*

CONCLUSION

The modeling weight changes due to moisture loss to environment as a function of stem cuttings diameter, length, mode height, number of nodes and time of exposure was investigated. Moisture loss to the atmosphere as the time of exposure increases had a significant strong correlation to the weight loss. The obtained weight loss model had a coefficient of determination of 0.981 with all parameters except height of node having a positive correlation with weight obtained after exposure. There is a gradual reduction in the weights of cassava stem cuttings as the moisture content is lost to the ambient temperature at removal rate of 0.9g./sec. An initial negative correlation was observed for stem cuttings drying at T_{24H} to T_{120H}, showed that the period was the duration of time the stem remained viable for planting. Any time beyond this period of drying might not be a feasible for stem germination. Other models obtained in the analyses are potential information needed for developing machine for stem handling during planting. Information of the storability of the stems before planting are also accessible for securing viable stem propagation.

REFERENCES

Igbeka, J.C, M. Jory and D. Griffon, (1992): Selective Mechanization for Cassava Processing. Journal of A.M.A., Tokyo Vol. 33 (1): 45-50.

Nur 'Izzati I, Kamarulzaman N, Norhayati H, Mohd Ariff J and Shahril Anuar B. (2016). Physical Properties of Cassava (Manihot Esculenta) Stem at Different Locations Along The Height. *International Journal of Advances in Science Engineering and Technology*, ISSN: 2321-9009 4(3):115-118.

Odigboh, E U (1977): Problems and process in field mechanisation of Nigerian root and Tuber crops. Proceedings of First National Seminar on Root aed Tuber Crops (Ene, LSO ed) NRCRI, Umudike (pp 113 - 120).

Odigboh, E U (1976): A cassava peering machine: development design construction. *J of Agric Engineering Res* 21 (3) 361 – 469

Odigboh, E U (1983): Mechanization of tillage in Nigeria: facts and fables. Paper presented at NSAE sponsored National Tillage Symposium. National Centre for Agricultural mechanization, florin, Nigeria (21 - 23) November

Ola, I.A., Aremu, O.O., Aderinlewo, A. A., Aiyedun, P.O. , Ajayi,, A.O. Ajisegiri, ESA(2015) Simulation of the dynamics of cassava stem cuttings on an inclined wood surface. *Joural of atural Science, Engineering ad Technology*, 14(2): 106 - 115.

Reeb J. E. 1995. "Wood and Moisture Relationships,"Rehabilitation, no. July, pp. 1–8.

Schulte, E E, Makanjuola, G A and Onochie, B F (1973). Mechanization CUMV production I: Planting. Paper presented at the third International Symposium on Tropical Root Crops. University of Ibadan, Nigeria.

Sobowale, A. B. (2014). Development of a Vibrating Metering Mechanism for Cassava Stem. Unpublished project report submitted to Department ofAgric and Bioresources Engineering Federal University Of Agriculture Abeokuta, Ogun State. Nigeria.

Velmurugan, V., Bharathithasan, I. and Nirmala Grace A. (2016). Synthesis and Physiothermal Analysis of Boron Nitride Based Nanofluid. *Indian Journal of Science and Technology*, Vol 9(39), DOI: 10.17485/ijst/2016/v9i39/100782, October 2016 ISSN (Print) : 0974-6846 ISSN (Online) : 0974-5645

Wahab, A H, Robinson, R P and Hassan, I (1977). Mechanised planting of cassava stem cuttings on Gugana's light peat and peaty clays. *Turrialba* 27 (2): 137 - 141.

Yothin Ungkoon, Chadchart Sittipunt*, Pichai Namprakai, Wanvisa Jetipattaranat, Kyo-Seon Kim, and Tawatchai Charinpanitkul, (2007) Analysis of Microstructure and Properties of Autoclaved Aerated Concrete Wall Construction Materials. *J. Ind. Eng. Chem.,* 13(7): 1103-1108