Assessing Yield Responses of Four Improved Cassava (Manihot Esculenta Crantz) Varieties Using Different Storage Methods in Jos Nigeria

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ABSTRACT

Cassava stakes storage and storage duration pose substantial problems to small scale farmers in terms of moisture loss, carbohydrate loss, yield and income in Nigeria. Hence, an experiment was conducted for two consecutive seasons, 2022 and 2023 in Jos South local government area of plateau state to investigate the effect of planting materials, storage methods and storage duration on stakes moisture loss, stake percent sprouting, stake carbohydrate consumption, and yield of four cassava varieties. The experiment was laid out in a split-split plot design with 3 replications. The main plot treatments consisted of four cassava varieties: TMEB 419, Babataba, IBA000070 and Obasonjo-2. The sub-plot treatments consisted of three storage methods: (1) Placing stakes in perforated nylon bags outdoors by digging a hole approximately 25-30 cm deep, (2) Placing stakes in perforated nylon bags outdoors under the tree shade covered with much materials and (3) Placing stakes in perforated nylon bags outdoors directly under the sun covered with mulch materials, and the sub-sub-plots consisted of 4 storage durations of planting material: 0, 20, 40 and 60 days. The results showed that there were significant differences observed in; storage methods, duration of storage, percentage stake moisture, percentage sprouting, carbohydrate content, and yield of four varieties of cassava. Length of storage duration significantly affected percent moisture, percent carbohydrate content and percent sprouting. The storage methods of placing stakes directly under the sun covered with mulch material drastically reduced percentage stake moisture, percentage sprouting, percent carbohydrate content, yield and yield components of cassava varieties in both seasons than either method of placing stakes under the tree shade covered with mulch materials, or placing in an approximately 25-30 cm hole. In both cropping seasons, variety (IBA000070) consistently maintained high stake moisture, high sprouting percentage, high carbohydrate content at 40 and 60 days, produced lower number of tubers rot plot^{-1}, had higher values of tuber weight plant^{-1}, high yield ha^{-1} as well as in the combined analysis. Conversely, variety (Obasonjo-2) decreased significantly in percentage stake moisture, carbohydrate and sprouting at 40 and 60 days, produced higher number of tubers rot plot^{-1} and lower values of tuber weight plant^{-1} in both seasons. Storage methods of placing stakes under tree shade produced higher yield (30.07 t. ha^{-1}) compare to other methods. For storage duration, the result indicated that 60 days of storage reduced the percentage stake moisture, carbohydrate content and percent sprouting, and affected the final yield. Hence, storage duration of planting material should not exceed between 35-40 days with placing stakes in perforated nylon bags placed under tree shade. Variety (IBA000070) was outstanding among the four varieties can be adopted by farmers in Jos.

Keywords: Percent stake moisture, percent sprouting, carbohydrate content, Variety, Yield

INTRODUCTION

Cassava (Manihot esculenta crantz) is an important economic crop in the world, and it is widely cultivated in tropical and subtropical regions. It serves not only as food crop but also as major source of income for rural households. Nigeria is indisputably the biggest producer of cassava in the world followed by the Democratic Republic of Congo with a production volume of around 46 million metric tons (Waidi, 2023). Its production surpassing other major producers like Brazil, Indonesia and Thailand (Akinpelu et al. 2011). In terms of consumption, cassava is the most important root crop in Nigeria. In fact, Abdoulaye et al., (2014) asserted that cassava is the most important food crop in the country. Thus, cassava constitute an important staple food crop in Nigeria, especially in the Niger Delta area (of which Delta State is a part) and in much of tropical Africa at large. Cassava has the potential to improve food security and livelihoods of the resource-poor rural farmers, processors, and their families (Suárez et al., 2017; Muchira, 2019; Mokhtar, 2020). Mitigating the challenge of cassava planting materials would contribute to increasing land under cassava and hopefully cassava productivity (Mwango'mbe et al., 2013; Shirima et al., 2019).

Good quality planting materials are the main propagation tools, which will be the determining factors of survival and yield per unit area (Polthanee, 2015). There are various factors influencing the quality of planting material: Harvesting period, which should be from the age of 8-12 months and not more than 12 months. The number of buds on stem cuttings, at least 7-10 eyes. The length of stem cuttings: 20 cm for planting cassava during the rainy season, but 25-30 cm for planting at the end of the rainy season. Planting of material that is completely free of disease and insect's pest, and consistent use of planting material planted immediately (Boonma, S.V. 2007) Finally, water stress is also the main problem during cassava growth by affecting on germination, growth and yield components (Bayitse, 2017)

Cassava is propagated using stem cuttings, bulky and highly perishable as they dry up within a few days after harvest. Normally, the use of fresh stakes is preferred to stored planting materials by farmers after harvest for the next growing season. These cassava stakes are kept in the field for a period of time before planting or during tillage preparation. Thus, exposure of the cutting to the sun can result in dehydration leading to cassava planting materials to lose their moisture, carbohydrates and reducing reserves available to stakes after planting. These could also cause poor establishment and finally low yield. Cassava planting by the stakes stored for more than 1 month, its germination and survival rates may reduce to less than 60%. These, problem tend to the reducing of cassava yield and income. Also, problem of stem storage arises when harvest and subsequent plantings are separated by time often as long as several months. This may lead to an undesirable contamination of pest and disease problems and cause difficulties to small scale farmers both economically and when land availability is limited. Therefore, stake storage may be inevitable in certain situations. Hence, the objectives of this study were to assess moisture losses, nutrient content and yield responses of cassava varieties to different storage methods.

MATERIALS AND METHODS

Experimental site and Soil nutrient analysis

Field experiment was conducted in Jos, South local government area of Jos, Plateau State, Nigeria. Located on latitude 09° 55.00" N and longitude 08°53.25" with elevation of 1238 m above the sea level. The experimental site is characterized by a humid tropical climate with a mean annual rainfall of 1411 mm and daily temperature of 20.4^0C; it lies within the middle belt Agro-ecological zone of Nigeria, and it is now degraded to secondary forest due to continuous cropping.

Soil samples were collected from the experimental site prior to the commencement of experiment at 0-20 cm depth with soil auger, about 5-8 sample points were taken from each block, mixed thoroughly to represent a composite sample. One composite soil sample was taken per plot after the experiment for laboratory analysis. The soil samples were air-dried, pulverized and sieved through a 2 mm sieve. Soil samples were analyzed following the procedures outlined by (Udo et al., 2009). Soil pH was determined in 1:2.5 soil: water ratio with a pH meter. Organic carbon was determined by Walkley Black Dichromate Method, Organic carbon was multiplied by 1.724 (The van Bemmeded factor), total N by micro-Kjeldahl method: available P was extracted with Bray – 1 method for acidic soils (Bray and Kurtz, 1945). Exchangeable bases (K, Ca, Na, Mg) were extracted with 0.1 N ammonium acetate, K and Na were read with a flame photometer.

Experimental Design and materials

Cassava varieties (Babataba, IBA000070, Obasanjo, TMEB693) were obtained from International Institute of

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Tropical Agriculture (IITA), Ibadan, Oyo State Nigeria and Fertilizer (NPK) was purchased from the Agricultural Development Program (ADP), Dogon, Dutse, Jos North, Plateau State. Planting material were stored in three methods: Placing outdoors by digging a deep hole of approximately 25-30 cm, placing under the shade of a tree covered with mulching material and placing outdoors directly under the sun covered with mulching materials for 0-, 20-, 40- and 60-days respectively. Planting materials were harvested from each of the storage methods and planted.

The experiment was laid out in a split-split plot design with 3 replications. The main plot treatments consisted of four cassava varieties: TMEB 419, Babataba, IBA000070 and Obasonjo-2. The sub-plot treatments consisted of three storage methods: (1) Placing stakes in perforated nylon bags outdoors by digging a hole approximately 25-30 cm deep, (2) Placing stakes in perforated nylon bags outdoors under the tree shade covered with much materials and (3) Placing stakes in perforated nylon bags outdoors directly under the sun covered with mulch materials, and the sub-sub-plots consisted of 4 storage durations of planting material: 0, 20, 40 and 60 days

Treatment management

The land used for the experiment had been under continuous maize (Zeay maiys) and wheat (Triticum aestivum) cultivation for the past few years, and was occupied by common weeds, including Chromolaena odorata, Cyclocarpa stellaris, Pennisetum polystachion and Imperata cylindrica. It was manually stumped and thereafter about 200-250 ml of Roundup Promax (glyphosate) was mixed in 20 l of water and sprayed to the existing vegetation. Fourteen days after glyphosate application the land was ploughed, harrowed and ridged manually. The stakes of 25 cm length with approximately 5-7 nodes were planted or buried into the soil horizontally with 0.8 × 1 m spacing. Weed control was carried out using pre-emergence herbicide (Primextra gold mixed with glyphosate (Touch down)) at a rate of 150 mL/80 L of water and hand weeding at 1 and half month after planting. The survival rate was counted at 30 days after planting. Similarly, NPK fertilizer was applied as a blanket in split at the rate of 120 kg ha^{-1} to designated plots: one half of the rate was applied to designated plots four weeks after planting and the other half eight weeks after planting.

Determination of moisture loss from stored cassava stem cuttings

The moisture content was determined by constant temperature oven method (ISTA, 2015), from the composite sample, 3 g were measured in triplicate into moisture dishes and put into oven at 100^0C for more than 24 hours to obtain constant weight. Calculation was based on ((ISTA, 2015) formulae:

$$\text{(loss of moisture (g) x 100)/(Initial weight of sample (g))} = (M_2 - M_3 \times 100)/ (M_2 - M_1)$$

Where;

M_1 is the weight of empty container in grams, M_2 is weight in (grams) of container + Sample before drying, M_3 weight in grams of container + Dry sample

Determination of Carbohydrate

For each storage method eight samples of 25 cm cuttings each were taken for carbohydrate determination. The samples were cut at the middle and both sides of the cut were grated to obtain composite sample. The were dried to constant weight and put in container and taken to the laboratory for carbohydrate tests. Total saccharides in samples was estimated by the Anthrone method which is a simple calorimetric method with relative insensitivity to interference from other cellular components (Clegg, 1956; Ravi and Suryakumari, 2005).

Determination of yield

Yield evaluation was done at 12 months after planting by harvesting a 5 x 5 m quadrant from each plot. The yield parameters measured were number of stands and number of stems per plot, obtained by counting before harvesting. At harvesting, number of roots per plot, number of rotten roots and weight of tubers or roots per plot were estimated.

No. of tubers $plant^{-1}$ = (Number of tubers harvested)/(Number of plants harvested)

Average Tuber weight: Tubers harvested from each net plot were counted and weighed and the average tubers were calculated as:

Average Tuber Weight (g) = (Weight of tuber (g))/(Number of tubers)

Tuber Yield $Plant^{-1}$ (g $plant^{-1}$): Tubers harvested from plants within each net plot were weighed in grams. The fresh tuber yield in grams per plant was calculated as;

Tuber yield $plant^{-1}$ (g $plant^{-1}$) = (Weight of tubers from harvested plants in net plot (gram))/(Plant population per plot)

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using the split-plot model. Significant means were separated using the Fisher's protected least significant difference at 5%

RESULTS

Nutrient Status of Experimental Site

The pH of the soil was 4.8 (moderately acidic) for cassava crop. The soil organic carbon and total nitrogen contents were low compared to the benchmark set by (Aduayi et al., 2011) for Nigerian soils. The low nutrients observed prior fertilizer application can be attributed to continuous cropping without soil amendments inputs, which led to depletion of organic carbon, organic matter, total nitrogen, available phosphorus and exchangeable cations as presented in Table 1., the critical threshold for soil organic carbon and organic matter concertation that could result in optimal crop yield in tropic soils is between 1.9 to 2.2%, and 3 to 6 % respectively. The soil at experimental site had high proportion of sand content with low cation exchange capacity which implies that cations would be easily leached as soil texture determines the degree of retention or leaching of basic cations (Muamba et al., 2022). However, prior to application of NPK fertilizer, available P, Na and K were seemingly low based on the ratings of (FMANR 1996) for the ecological zone. According to (Peng et al., 2013) the critical soil nitrogen content in the soil for maximizing crop growth has to be above 0.2%. The results from soil analysis, therefore, indicated a deficiency in nitrogen content, which justifies the application of inorganic fertilizer.

Carbohydrate content of stored cuttings

The average effects of methods of storage, duration of storage and cassava variety on carbohydrate loss for 2022/2023 cropping season is presented on table 2. The average amount of carbohydrate content in stake cuttings differed significantly among the varieties with storage methods and duration of storage. The results indicated that variety IBA000070 maintained high carbohydrate content when stakes were stored under tree shade covered with mulch materials at 60 days of storage duration compare to other storage methods, while variety Obasanjo-2 had the least carbohydrate content when stakes were stored directly under the sun covered with much materials. The result showed that the longer stakes are stored the more cuttings consume carbohydrate for maintenance. The interaction between duration of storage and variety was highly significant at $p < 0.002$. The results showed that the longer cassava cuttings are stored the more they loss carbohydrate even when the moisture content of cuttings are maintained. This showed that environmental conditions, storage methods, duration of storage and variety contribute significantly in carbohydrate consumption during storage.

The effect of storage methods on planting materials percent moisture and sprouting of cassava varieties after different days of storage

The effect of storage methods on stake percent moisture and sprouting of cassava varieties after different days of storage in 2022 and 2023 is presented on Table 3. The results showed that the storage methods in 2022, were significantly different in percentage stake moisture at 20, 40 and 60 days of storage duration respectively, while in 2023, the percentage stake moisture for storage methods were significant at 40 and 60 days of storage duration.

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Similarly, the sprouting percentage were significantly different for storage methods at all storage duration in 2022, whereas, in 2023,

Table 1: Nutrients status of experimental site

Characteristics	**Values**
pH in (H_2O) 1:1 ratio	4.8
Organic Carbon (g/kg).	12.1
Nitrogen (g/kg)	0.76
Available P (mg/kg)	7.72
Sand (g/kg)	81
Silt (g/kg)	4
Clay (g/kg)	15
Calcium (cmol/kg/g	1.93
Magnesium cmol/kg	0.59
Potassium cmol/kg)	0.28
Sodium (cmol/kg	0.06
Zinc (m/kg)	8.09
Copper (m/kg)	4.26
Manganese (m/kg)	8
Iron (m/kg)	135
Textural class	Sandy loam

Table 2. The average effects of methods of storage, duration of storage and cassava variety on carbohydrate loss for 2022/2023 cropping season

Treatment	**Variety**	**Duration of Storage (days)**	**% CHO**
Under tree shade	TMEB 419	0	7.77
		20	5.75
		40	2.23
		60	1.39
	Babataba	0	8.45
		20	5.32
		40	2.99
		60	1.87
	IBA000070	0	9.89
		20	9.01
		40	7.98

		60	4.56
	Obasanjo-2	0	8.99
		20	4.66
		40	1.99
		60	0.19
Digging hole	TMEB 419	0	7.45
		20	4.75
		40	2.23
		60	1.09
	Babataba	0	6.45
		20	3.99
		40	2.01
		60	1.07
	IBA000070	0	9.98
		20	7.31
		40	3.61
		60	2.98
	Obasanjo-2	0	8.19
		20	4.66
		40	2.67
		60	1.09
DUSC	TMEB 419	0	7.89
		20	3.75
		40	2.23
		60	0.09
	Babataba	0	8.45
		20	2.99
		40	2.01
		60	0.07
	IBA000070	0	9.65
		20	5.33
		40	2.01
		60	0.23
	Obasanjo-2	0	8.99

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		20	2.66
		40	0.67
		60	0.09
LSD (0.05) Duration of storage			0.002
LSD (0.05) Methods of storage			0.001
LSD (0.05) Variety			0.001
LSD (0.05) DS x MS x V			0.002
Percentage (%) carbohydrate., DS= Duration of storage., V= variety., DUSC= Direct under the sun covered with mulch materials., MS= Method of storage			

Table 3: Effects of storage methods on percent moisture and sprouting of cassava varieties after different days of storage.

		20 days		**40 days**		**60 days**	
Year	**Treatments**	**Moisture %**	**Sprouting %**	**Moisture %**	**Sprouting %**	**Moisture %**	**Sprouting %**
2022	**Methods of storage (MS)**						
	Control	73.55	99.00	73.55	99.00	73.55	99.00
	Under tree shade	70.81	95.00	68.11	88.10	67.15	83.34
	Digging hole	67.11	94.00	68.01	72.33	71.51	67.45
	DUSC	65.43	95.00	57.21	51.23	53.11	48.11
	LSD (0.05)	4.5	0.84	5.35	12.01	13.79	15.21
	Varieties (V)						
	TMEB 419	63.67	93.45	61.11	87.21	60.91	73.55
	Babataba	69.78	95.77	58.73	91.33	58.11	87.23
	IBA000070	70.11	98.62	67.44	93.42	63.24	97.33
	Obasanjo-2	65.21	92.21	56.21	77.10	53.61	81.08
	LSD (0.05)	Ns	Ns	6.33	9.01	6.55	12.14
	MS X V						
2023	**Methods of storage (MS)**						
	Control	70.11	95.00	70.11	96.21	70.11	95.44
	Under tree shade	69.33	97.00	67.23	89.43	66.34	93.66
	Digging hole	68.44	95.00	64.23	88.21	63.34	90.11
	DUSC	65.56	92.00	62.44	80.55	57.77	51.09
	LSD (0.05)	Ns	Ns	3.51	7.11	8.67	8.88

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	Varieties (V)						
	TMEB 419	60.66	93.33	58.21	92.45	54.88	73.45
	Babataba	65.76	95.11	60.33	85.23	57.23	80.11
	IBA000070	69.67	99.43	68.33	98.45	67.44	95.33
	Obasanjo-2	64.33	87.43	62.45	81.77	60.37	78.44
	LSD (0.05)	Ns	10.12	6.33	12.67	7.55	12.71
	MS X V	3.01	7.71	0.0014	0.0007	0.0052	0.0033
	MS X V X Y	0.0007	0.0002	0.0001	0.0001	0.0003	0.006
DUSC= Direct under the sun covered with mulch materials							

the sprouting percentage for storage methods were significant at 40 and 60 days of storage methods. The stake moisture percentage of storage method of placing direct under the sun covered with mulch materials reduced by more (57.21 and 53.11% in 2022, and, 62.44 and 57.77% in 2023 respectively) than either of placing under the shade or placing in an approximately 25-30 cm hole. Similarly, this trend occurred for sprouting percentage for similar storage method of placing direct under the sun covered with mulch materials reduced by more (51.23 and 48.11% in 2022, and, 80.55 and 51.09% in 2023 respectively) than either of placing under the shade or placing in an approximately 25-30 cm hole. Length of storage duration significantly affected percent moisture and percent sprouting. Duration of storage on stake percent moisture and sprouting of cassava varieties were significant in 2022 and 2023 at 40 and 60 days respectively. And remained statistically similar at 20 days in 2022, and in 2023. The percentage stake moisture for storage method of placing stakes in perforated nylon bags in an approximately 25-30 cm hole increased with duration of storage in 2022 and reduced in 2023. However, on the average, for the two consecutive seasons, the storage methods of placing stakes under the tree shade had high percent moisture content of 68.16% compared to other storage methods. This resulted to high percent sprouting and low carbohydrate loss. With respect to varieties, in 2022, variety (Obasanjo-2) decreased significantly in percentage stake moisture of 56.21 and 53.61%, respectively. The stake moisture content was reduced by 23.57 and 27.12% in 2022, and, in 2023, stake moisture content was reduced by 10.92 and 13.90% at duration period of 40 and 60 days respectively. whereas, in both cropping seasons variety IBA000070 consistently maintained low reduction in stake moisture loss of 63.24 and 67.44%. The stake moisture content was reduced by 8.3 and 14% in 2022, and, in 2023 the stake moisture content was reduced by 2.5.and 3.80% at duration period of 40 and 60 days respectively. Also, produced high sprouting percentage of 97.33 and 95.33 compare to other three varieties after 60 days of storage.

The interaction between method of storage and variety (MS x V) were significant at all length of duration for both percent stake moisture and percent sprouting, similarly, interaction among year, method of storage and variety (Y X MS x V) were significant at all length of duration for both percent stake moisture and percent sprouting

Effects of storage methods and cassava varieties on number of stems per plot, number of stands per plot, number of tubers per plot and tubers weight

Effects of storage methods and cassava varieties on number of stems plot^{-1}, number of stands plot^{-1}, number of tubers plot^{-1}, number of tubers rot plot^{-1}and tubers weight in 2022 and 2023 is presented on Table 4. The result showed that, number of stands plot^{-1}, number of tubers plot^{-1}, number of tubers rot plot^{-1}and tubers weight was significantly different in both cropping seasons for storage methods. Storage methods were significantly similar for number of stem plot^{-1} in 2022 and 2023 respectively. Significant higher number of stands plot^{-1}, number of tuber plot^{-1}, tubers weight plant^{-1} and lower number of tubers rot plot^{-1} were observed with storage method of placing stakes under the tree shade compare to other methods in both cropping seasons, while higher number of tuber rot plot^{-1} was associated with the storage method of placing stake direct under the sun covered with mulch materials in 2022, and, in 2023, it was observed with storage methods of digging and placing stakes in hole of approximately 25-30 cm respectively. Storage method of placing stakes under the tree shade produced the highest tuber weight plant^{-1} compare to others in both crop seasons. Among the four cassava varieties, all the yield parameters were significantly different except for number of tuber plot^{-1} in 2023. Yield parameters obtained were significantly influenced by cassava varieties. Variety IBA000070, significantly produced lower number of tubers rot plot^{-1} and higher values of tuber weight plant^{-1}, conversely, variety (Obasonjo-2) produced higher number of tubers rot plot^{-1} and lower values of tuber weight plant^{-1} in both seasons.

Table 4: Effects of storage methods and cassava varieties on number of stems per plot, number of stands per plot, number of tubers per plot and tubers weight

Year	Treatments	Number of stem plot^{-1}	Number of stands plot^{-1}	Number of tuber plot^{-1}	Number of tuber rot plot^{-1}	Weight of tubers (Kg plant^{-1})
2022	**Methods of storage (MS)**					
	Control	58.45	20.00	98.65	14.23	2.55
	Under tree shade	57.11	21.00	158.80	2.01	2.71
	Digging hole	43.31	16.00	145.00	2.34	2.41
	DUSC	47.23	21.00	116.20	6.34	1.61
	LSD (0.05)	Ns	1.19	20.23	9.11	0.01
	Varieties (V)					
	TMEB693	45.45	23.63	225.50	28.50	4.32
	Babataba	49.23	23.65	202.80	15.00	3.73
	IBA000070	59.56	26.00	238.50	4.75	6.25
	Obasanjo-2	42.33	21.00	158.50	37.00	2.01
	LSD (0.05)	11.45	1.29	25.33	9.03	0.045
	MS X V					
2023	**Methods of storage (MS)**					
	Control	29.2	20.01	69.50	11.31	1.83
	Under tree shade	38.2	27.23	163.20	2.41	3.79
	Digging hole	36.8	25.06	109.50	8.23	3.52
	DUSC	32.2	21.32	106.80	7.41	1.88
	LSD (0.05)	Ns	0.78	18.77	0.07	0.001
	Varieties (V)					
	TMEB693	34.25	20.45	126.20	18.6	3.29
	Babataba	34.25	19.62	123.80	17.7	3.09
	IBA000070	45.75	25.67	97.20	5. 5	4.03

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	Obasanjo-2	29.25	10.34	96.80	21.7	1.79
	LSD (0.05)	12.66	8.11	ns	7.44	0.033
	Ms x V	Ns	ns	0.0003	2.023	0.004
	MS X V X Y	4.065	0.006	0.0002	0.016	1.67
DUSC= Direct under the sun covered with mulch materials						

The least value for number of tuber rots plot^{-1} was recorded for the same variety (IBA000070) in 2022 and in 2023 respectively, and the highest values for number of tuber rots plot^{-1} was obtained with variety Obasanjo-2 in both years.

The interaction between method of storage and variety (MS x V) were significant number of tubers plot^{-1}, number of tubers rot plot^{-1}and tubers weight while interaction among method of storage, variety and year, (MS x V x Y) were significant for number of stems plot^{-1}, number of stands plot^{-1}, number of tubers plot^{-1}, number of tubers rot plot^{-1}and tubers weight.

Effects of storage methods and cassava varieties on tuber yield.

Effects of storage methods and cassava varieties on tuber yield is presented on Table 5. Cassava yield (t. ha^{-1}) was influenced significantly by varieties and methods of storage in both cropping season and in the combine analysis. The percentage stake moisture loss, percentage sprouting, weight of roots plot^{-1}, and the final yield obtained are related as the results obtained follow the same trend. On the average effect, in 2022, 2023 and in combine analysis the variety (Obasanjo-2) recorded significantly lower yield of (18.53, 15.69 and 17.14 t. ha^{-1}) respectively while the yield obtained with variety (IBA000070) was significantly higher and different from varieties (Babataba and TMEB693). Similarly, the percentage stake moisture loss and sprouting influenced the final yield obtained for storage methods. Storage methods of placing stakes directly under the sun covered with mulch material produced lower yield in both years and in the combine analysis. While storage methods of placing stakes under tree shade produced higher yield (30.07 t. ha^{-1}) in 2022 compare to storage methods of digging hole in 2023 and in combine analysis where yield was 29.35 and 29.03 t. ha^{-1}) respectively. In 2022 and 2023, interaction between method of storage and varieties were not significant for UTS and DH. In combine analysis interaction among methods of storage, varieties and year were significant.

Table 5: Effects of storage methods and cassava varieties on tuber yield						
		Tuber yield t. ha-1				
Year	**Treatments**	**Control (0 kg ha^{-1})**	**UTS + NPK (120 kg ha^{-1})**	**DH + NPK (120 kg ha^{-1})**	**DUSC + NPK (120 kg ha^{-1})**	**Mean**
2022	**Varieties (V)**					
	TMEB693	10.23	32.16	33.74	20.76	24.22
	Babataba	10.43	26.53	25.44	19.90	20.56
	IBA000070	12.25	40.23	32.44	21.42	26.59
	Obasanjo-2	9.25	21.34	23.21	20.33	18.53
	Mean	10.54	30.07	28.71	20.60	
	LSD (0.05) MS	ns	9.06	9.11	Ns	2.04
	LSD (0.05) Varieties	ns	14.09	8.08	Ns	4.57
	LSD (0.05) MS X V	ns	3.03	Ns	Ns	0.007

2023	**Varieties (V)**					
	TMEB693	8.97	27.31	34.42	14.71	21.35
	Babataba	8.01	22.11	28.11	16.99	18.80
	IBA000070	11.50	38.33	33.67	19.42	25.73
	Obasanjo-2	9.17	15.13	21.21	17.23	15.69
	Mean	9.41	25.72	29.35	17.08	
	LSD (0.05) MS	1.27	9.09	5.11	Ns	1.19
	LSD (0.05) Varieties	ns	7.19	4.08	Ns	7.07
	LSD (0.05) MS X V	ns	1.02	Ns	Ns	0.004
Combine						
	Varieties (V)					
	TMEB693	9.60	29.74	34.08	17.74	22.79
	Babataba	9.22	24.32	26.78	18.45	19.69
	IBA000070	11.87	39.28	33.05	20.42	26.15
	Obasanjo-2	9.21	18.23	22.21	18.92	17.14
	Mean	9.97	27.89	29.03	18.88	
	LSD (0.05) MS	0.067	11.29	3.18	Ns	2.57
	LSD (0.05) Varieties	ns	12.65	Ns	Ns	0.004
	LSD (0.05) MS X V x Y	**	**	**	**	**
MS= Methods of Storage; UTS= Under tree shade; DH= Digging hole; DUSCM= Direct under sun covered with mulch materials						

DISCUSSION

Nutrient Status of Experimental Site

The experimental soil was characterized by high acidity and low rate of exchangeable cations that cannot support optimal crop production without the use of soil amendment. The percentage of soil nitrogen was less than 1.50 g kg-1 which is below the critical level for performance of maize crops. The percentage organic carbon that is important in determining responses to N and P fertilization was equally lower than the critical level of 3%. The percentage of available phosphorous in the soils of the experimental sites falls within average level for most crops; which could explain the reason of low level or poor in essential plant nutrients. The soils were acidic sand with low level of nutrient which is a typical characteristic of basaltic soil. The findings of this study about the soils agree with (Hassan et al., 2015) who reported that basaltic constitute the main agricultural lands of Northern Nigeria (Jos plateau) and are deficient in essential plant nutrients and high in acidity. The observation is also in harmony with the findings of (Olim et al., 2019) who observed that the basaltic soil of Southeastern Nigeria (Ikom) are low in exchangeable calcium, magnesium and potassium. The deficient levels of the major nutrients in the soil of the experimental site were compensated for in those sub- plots treated with inorganic fertilizer during the two cropping seasons.

Influence of storage methods and time of duration on planting materials percent moisture and sprouting of cassava varieties.

One important process that occurs in cassava planting material during storage is loss of moisture which has a strong influence on stake viability and also affecting biochemical transformations within the stakes which may lead to the diminishing sprouting vigour and establishment of cassava. This study showed that the percentage stake moisture of storage method of placing direct under the sun covered with mulch materials reduced by more (57.21 and 53.11% in 2022, and, 62.44 and 57.77% in 2023 respectively) than either of placing under the tree shade or placing in an approximately 25-30 cm hole. Similar trend occurred for sprouting percentage for storage method of placing direct under the sun covered with mulch materials reduced by more (51.23 and 48.11% in 2022, and, 80.55 and 51.09% in 2023 respectively) than either of placing under the tree shade or placing in an approximately 25-30 cm hole. In this study, the author found out that the reduction in percent stake moisture, sprouting, and carbohydrate loss observed with storage method of placing direct under the sun covered with mulch materials could be to due high rate of temperature that resulted to high transpiration, and high relative humidity as well as bruises in epidermis of stakes obtained during storage which will lose more moisture as it will be losing from two cut ends and in bruised epidermis. This finding agrees with (Zhu, et al., 2015) found that when cassava stakes are stored in high temperature, the rate of transpiration and carbohydrate loss is high, also, similar results were obtained by (Oladejo A.O. and Sikiru G.K. 2019), and Leihner, (2002). They found that if cassava stakes were stored under low temperature and relative humidity around 70%, there is reduction in the rate of carbohydrate, moisture loss and high sprouting percentage as it is been observed by the author with storage methods of placing stakes under tree shade. This is also, agrees with the finding of (Kiriya et al., 2016) who reported that threshold moisture content of stakes was around 60%; below that level, viability of cassava stakes suffered seriously affecting biochemical transformations within the stakes. Storage methods of placing stakes under the tree shade was outstanding in keep respiration at a low level since respiration losses reduce reserves available in stakes. With regard to stake storage, the author found the importance of creating storage conditions that avoid dehydration since the viability of planting material is irreversibly affected when this process is allowed to advance beyond established limits. With regard to carbohydrate loss, these data show the practical importance of selecting storage conditions that keep respiration at a low level since respiration losses reduce reserves available to stakes after planting and thus diminish sprouting vigor and establishment.

Variety IBA000070 consistently maintained low reduction in stake moisture loss of 63.24 and 67.44% with storage methods of placing stakes under the tree shade. The stake moisture content was reduced by 8.3 and 14% in 2022, and, in 2023, the stake moisture content was drastically reduced by 2.5.and 3.80% at duration period of 40 and 60 days respectively. on the contrary, variety (Obasanjo-2) decreased significantly in percentage stake moisture of 56.21 and 53.61%, respectively. The stake moisture content was highly reduced by 23.57 and 27.12% in 2022, and, in 2023, stake moisture content was reduced by 10.92 and 13.90% at duration period of 40 and 60 days respectively. This result agrees with (Boonma et al., 2007) who reported that in cassava varieties, planting material storage method and planting material storage durations differed significantly in percentage stake moisture and percentage germination. The study also showed that cassava crop sprouting and establishment depends on variety and storage condition of the stakes planted. On the average variety (IBA000070) had better sprouting of 96.33% compare to other varieties at 60 days storage duration. This may be due to genetic variability among the varieties. Similar results were obtained by (Mndeye et al., 2018 and Kiriya et al., 2016) they stored three varieties of cassava and found that one cultivar dehydrated more than the other which contributed to reduction in sprouting of planted cuttings. From this research the author found that cassava planting material should not be stored longer than 35-40 days due to variability among varieties, which might be physiological or genetical differences among stem structure from one variety to another, this agrees with the findings of (Nassar et al., 2010) who found differences in collenchyma and internal parenchyma among variety of cassava and such differences may be the reason for differences in storability of TMEB419, Babataba, IBA000070, and Obasanjo-2.

CONCLUSION AND RECOMMENDATION

In conclusion, the research underscores the significant impact of storage methods and cassava variety selections on tuber yield and moisture retention. Among the methods, storing planting materials under tree shade proved most effective, maintaining higher moisture content, reducing respiration rates, and preserving sprouting viability, which in turn led to the highest tuber yield and weight, particularly when combined with NPK application. The variety IBA000070 consistently outperformed others, demonstrating superior resistance to environmental stresses and higher productivity, while varieties like Obasanjo-2 were more prone to rot and yield loss. These findings emphasize the importance of optimizing storage conditions and carefully selecting high-yielding, disease-resistant cassava varieties to enhance productivity and minimize post-harvest losses, providing valuable insights for improving cassava farming practices in tropical regions.

Farmers should adopt the practice of storing cassava planting materials under tree shade covered with mulch materials to sustain stake viability, similarly, farmers are encouraged to prioritize the cultivation of cassava varieties like IBA000070, which demonstrated superior yield and moisture retention, and resilience to environmental stresses. This will enhance productivity and reduce post-harvest losses.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript

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REFERENCE

1. Abdoulaye, T., Abass, A., Maziya-Dixon, B., Tarawali G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V., & Ayedun B. (2014). Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. Journal of Development and Agricultural Economics. 6(2): 67–75
2. Aduayi, E. A., V. O. Chude, B. O., Adebusuyi, S. O. & Olayiwola (eds) (2011). Fertilizer use and management practices for the crops in Nigeria (4 ed.). Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja, 229 pp
3. Akinpelu, O., Amamgbo, L. E. F., Olojede, A. O., & Oyekale, A. S. (2011). Health implications of cassava production and consumption. *Journal of Agriculture and Social Research*, 11(1): 118-125.
4. Boonma, S., Vichukit, V., & Sarobol, E. (2007). Effects of cutting storage duration and methods on germination, growth and yield of cassava (Manihot esculenta Crantz.). Proceedings of 45th Kasetsart University Annual Conference on Plants, January 30-February 2, 2007, Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok, pp: 131-138.
5. Bray, R. H., & Kurtz, L.T. (1945). Determination of Total Organic and Available Forms of Phosphorus in Soils. Soil Science, (59): 39-45. http://dx.doi.org/10.1097/00010694-194501000-00006
6. Clegg, K.M. (1956). The application of the anthrone reagent to the estimation of starch in cereals. J. Sci. Food Agric. (7) 40.
7. FMANR (Federal Ministry of Agricultural and Natural Resources). Soil fertility investigation and fertility ratings (In 5 volumes). Produced by the Federal Ministry of Agriculture, Lagos state, Nigeria, 1996.
8. ISTA. International Rules for Seed Testing, (2015) Vol. 215, Introduction, i-1-6 (10). The International Seed Testing Association, Bassersdorf.
9. Kiriya, S., Arunee, P., Anucha, L., & Anan, P. (2016). Effects of methods and duration storage on cassava stake characteristics. Asian Journal of Plant Science.15(3-4):86-91. https://doi.org/10.3923/ajps.2016.86.91.
10. Leihner, D. (2002). Agronomy and cropping system. 91-113: In Hillocks R. J., Thresh, J.M., Ballots, A.C. 2002. (Eds.) Cassava: Biology, production and utilization. CABI International.
11. Mdenye, B. B., Kinama, J. M., Olubayo, F. M., Kivuva, B. M., & Muthomi, J. W. (2016). Effect of storage methods on carbohydrate and moisture of cassava planting materials. Journal of Agricultural Science. (8) 12:100 -111 p. http://dx.doi.org/10.5539/jas. v8n12p100.
12. Mdenye, B. B., Kinama, J. M.., Florence, M. O., Kivuva, B. W., & Muthomi, J. W. (2018). Effect of storage methods of cassava planting materials on establishment and early growth vigor. International Journal of Agronomy and Agricultural Research. 12(1): PP 1-10.

13. Mokhtar, M. W. (2020). Development of extruded food snack using modified cassava flour (MOCAF) with addition of local herbs (doctoral dissertation). University of Nairobi, Nairobi, Kenya.
14. Muchira, J. K. (2019). Development of cassava-soy bean breakfast flakes with improved protein and minerals (Doctoral dissertation). University of Nairobi, Nairobi, Kenya.
15. Muamba, K. E., Amali, P. E., Caleb, N. M., and Izang, I. (2022). Influence of Agronomic Practices on the Performance of a Low-N Tolerant Maize Variety in the Savannah Forest Zone of Nigeria. International Journal of Applied Research and Technology. 11(04): 28 – 40.
16. Mwango'mbe, A.W., Mbugua, S. K., Olubayo, F. O., Ngugi, E. K., Mwinga, R., & Munga, R. (2013). Challenges and opportunities in cassava production among the rural households in Kilifi County in the coastal region of Kenya. J. Biol. Agric. Healthc. 3, 30–35.
17. Nassar, N.M.A., Abreu, L.F.A., Teodoro, D.A.P. & Graciano-Ribeiro, D. (2010). Drought tolerant stem anatomy characteristics in Manihot esculenta (Euphorbiaceae) and a wild relative. Genet. Mol. Res. 9 (2): 1023-1031
18. Oladejo, A.O., & Sikiru G. K. (2019). Storage effects on cassava planting material quality and subsequent viability and germination. International Journal of Pure and Applied Science. 17(9):2019
19. Olim, D. M., Afu, S. M., Ediene, V. F., Uko, I. E. & Akpa, E. A. (2019). Morphological and Physicochemical Properties of Basaltic Soils on a Toposequence in Ikom, South Eastern Nigeria. World News of Natural Sciences. 22 (2019) 84-92
20. Peng, Y., Yu, P., Li, X., & Li, C. (2013). Determination of the critical soil mineral nitrogen concentration for maximizing maize grain yield. Journal of Plant Soil science. 372: 41–51. https://doi.org/10.1007/s11104-013-1678-0
21. Polthanee, A. & Manuta, P. (2015). Effect of stake priming with nutrient solution on growth and yield of cassava grown under greenhouse and field conditions. Khon Kaen Agr. J., 43(2): 379-386.
22. Ravi, V. and Suryakumari, S. (2005). Novel technique to increase the shelf life of cassava (Manihot esculenta L.) stems stored for propagation. Advances in Horticultural Science (19) 3. 123-129.
23. Suárez, G., Carmona, G., & José T. (2017). Recent Advances in the Development of Biodegradable Films and Foams from Cassava Starch. Nova Science Publishers 15, 297–312.
24. Udo, E. J., Ibia, T. O., Ogunwale, A., Ano, O. & Esu, I. (2009). Manual of Soil, Plant and Water Analysis Lagos. Sibon Books Limited, Festac Town, Amuwo-Odofin, Lagos.
25. Waidi, G. A. (2023). Cassava production in Africa: A panel analysis of the drivers and trends. Heliyon. 9(9) e191939
26. Zhu, W., Lestander, T.A., Orberg, H., Wei, M., Hedman, B., Ren, J., Xie, G., & Xiong, S. (2015). Cassava stems: a new resource to increase food and fuel production. GCB Bioenergy 7, 72–83 https://doi.org/10.1111/gcbb.12112