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RESEARCH ARTICLE

Effects of cassava stem storage methods and duration on their field establishment and productivity

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ABSTRACT

The quality of used planting materials and the pre-planting exposure of the cuttings significantly influence cassava productivity and yield qualities. In practice, cassava cuttings succumb to bruises and excessive dehydration during preparation, transportation, unconducive storage conditions, and lengthy duration of storage before actual planting. This study evaluated the impacts of cassava stem storage methods and duration on establishment, yield, and yield components in Tanzania. A split-split-plot experiment of six varieties, five storage methods, and five storage durations was replicated three times. Data were collected before and after stem storage, at establishment, and harvesting time, and then analyzed using the R program. The fresh weight, dry matter, and moisture content of stems showed significant differences ($p<0.05$) among varieties before storage. Storage durations greatly influenced the loss of stem moisture and dry matter, and the effect was significant ($P<0.05$) among the test varieties. Chereko stems manifested the highest moisture loss, with subsequent poor sprouting, limited field establishment, and low yield. Covering stems with mulch lowers moisture losses and improves sprouting, field establishment, and yield compared to other storage methods. Based on these results, we recommend covering cassava stems in open spaces with mulch for up to 8 weeks.

Keywords: cassava varieties, yield, pre-planting treatment, stem storage

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an essential staple crop grown widely by smallholder farmers in Africa (Rwegasira, 2022). The crop essentially adds to food security through the ability of its matured roots to remain edible underground for up to three years (Saranraj et al., 2019; Liu Q et al., 2014). The drought-tolerant nature of cassava enables it to yield better in areas with unreliable rainfall patterns where the successful production of other crops is limited. Cassava production in the world is led by Nigeria, which produces over 59 million tons of fresh cassava roots in a year (FAO, 2019). Tanzania ranked number twelve (12) cassava producers in Africa, producing about 6.3 million metric tons of fresh cassava annually (FAOSTAT, 2022). Despite cassava's importance to Tanzania's food security, its production is grossly low due to numerous biotic (occurrence of diseases and insect pests, weed infestations, postharvest tuber deterioration, and the use of poor-quality seeds) and abiotic (soil conditions like salinity, drought, cold, and extreme temperatures, poor agronomic practices, and farmers' socioeconomic circumstances) factors (Opabode, 2018; Robson et al., 2023).

The use of low-quality cassava planting materials was reported, among other factors, to cause a reduction in root yield (Bridgemohan et al., 2014). Poor-quality planting materials lead to poor field establishment, the development of non-vigorous plants, and low yield quality (Leihner, 1983). In addition, the spreading of systemic pathogens like viruses, bacteria, mycoplasmas, and fungi is increased (Oka et al., 1987). Nonetheless, the quality of cassava planting materials is determined by stem age, thickness, and the number of nodes (Bridgemohan et al., 2014). Immature green stems are prone to dehydration; they dry and lose carbohydrates faster after harvest and are easily attacked by pathogens (Nair et al., 1983). The stem cuttings with large diameters have greater chances of sprouting and field establishment (Oka et al., 1987). Cassava cuttings with few nodes produced few storage roots and affected the production of root yield (Bridgemohan et al., 2014).

Even though cassava stems may possess important quality-dependent traits, their quality can be lost due to the low viability nature of cassava stems. The loss of moisture and carbohydrate contents, mechanical bruising of nodes, and any other damage during transportation and storage trigger deterioration and loss of stem qualities. Unfavorable planting conditions and delayed land preparation contribute to added stem storage duration, translating to a loss of stem moisture content and subsequent viability if improperly kept. Sikiru (2019) and Leihner (1983) reported that cassava stems lose moisture faster, about 60% after harvest, because of poor storage. High radiation, air temperature, and low relative humidity during storage trigger a high loss of moisture and carbohydrates (Leihner, 1983). Severe drought and heavy rainfall may also affect the quality of cassava planting material. The degree of stem quality loss depends on cassava varieties; a variety with a low degree of lignification on the stem dehydrates quickly compared to highly lignified varieties.

Vertical stem storage under a well-ventilated shade was reported in Thailand, Malaysia, Colombia, and Brazil to preserve stems for up to 30 days (Andrade and Leihner1980). Elsewhere, vertical storage in open conditions with the bottom part buried in sand and irrigated at intervals of 15 days was reported to improve field establishment by 80% in India when stems were stored for up to 30 days (Sinthuprama, 1980; Ravi and Suryakumari, 2005). These methods may be useful to farmers in Tanzania who mostly retain live stems in the field for future planting materials by conducting partial harvesting or leaving a field portion with unharvested plants. Some farmers in Tanzania harvest all plants in the field and store stems vertically, horizontally, or inverted under tree shades and open space; this is particularly common when cassava root price is higher and when there is hunger, but the efficacy of these storage methods is less reported.

The present study aimed to evaluate the effectiveness of selected pre-planting cassava stem storage methods in reducing the loss of planting materials for improved access and availability to farmers, particularly during the scarcity of planting materials.

MATERIALS AND METHODS

Description of the study area

Rain-fed field experiments were established at Naliendele (Mtwara municipal), Mtopwa (Newala), and Mkumba (Nachingwea) districts from January to September 2023. The environmental characteristics of the experimental sites were as described (Kundy et al., 2015; Dauda & Usman et al., 2019; Imakumbili et al., 2019; Kimata et al., 2021), with further details summarized in Table 1.

Table 1. Descriptions of the study sites

	Mtopwa	Mkumba	Naliendele
Site/ location	Makonde plateau	Masasi-Nachingwea plains	Coastal belt of the Indian Ocean
Coordinates	10°41'S, 39°23'E	10°20'S, 38°46'E	10°22'S, 40°10'E
Altitudes	760 m	465 m	111 m
Soil type	Veti-acric Ferrasols – Xanthic	Veti-acric Ferrasols – Rhodic	Veti-acric Ferrasols – Xanthic
Soil texture	Deep, highly weathered, well-drained sandy clay loam	Deep, highly weathered, red sandy clay loam	Deep, highly weathered, well-drained sandy clay loam
Soil PH	4.5 - 6.5	4.5 - 8.2	4.5 - 6.5
Temperature	23 °C	25 °C	27.9°C
Rainfall	1113 mm	850 mm	950 mm
Relative humidity	75%	78%	86%

Research materials

A dense shade of green cashew plants and an open space area were selected for cassava stem storage. Disease-free and mature cassava stems of six cassava varieties (Kiroba, Kizimbani, Chereko, Mkuranga1, Pwani, and TARICASS2) were selected from the cassava pre basic seed unit at Mtopwa, Newala district. An insecticide "Dursban" of Chlorpyrifos 480 g/L active ingredient was used at 1.5 ml/L to control termites during storage. A systemic fungicide, "Master Kinga" (Mancozeb Dursban 640 g/kg and Cymoxanil 80 g/kg), was applied to protect stems against fungal infection during plating. A thermometer, hygrometer, and rain gauge were installed to measure daily temperature, relative humidity, and rainfall, respectively.

Experimental design

Cassava stems of six varieties were stored in five different storage methods and five durations; the stems were then laid out in a split-split-plot design of three replications and a randomized complete block design arrangement. Cassava varieties, storage methods, and duration were applied to the main plot, sub-plot, and sub-sub-plot factor, respectively. The varieties were Kiroba, Kizimbani, Pwani, TARICASS2, Mkuranga1, and Chereko. The storage methods used were vertical stem storage under tree shade with the bottom part buried into soil and irrigated at one-week intervals (S1), vertical stem storage in open space with their bottom part buried into soil and irrigated at one-week intervals (S2), vertical stem storage in an open area and covered completely with dry grass mulch at 10 cm depth (S3), vertical stem storage in open space without covering with mulch (S4), and inverted stem storage under tree shade without irrigated (S5). The storage durations were 0, 2, 4, 6, and 8 weeks, denoted as T0, T1, T2, T3, and T4, respectively, where T0 was a control plot.

Cassava stems tied into bundles of 30 stems were treated with "Dursban" insecticide to prevent termites before storage. The areas for storage were prepared by removing shrubs and grasses. One bundle of stems was stored per variety, storage method, and duration. After storage, cassava cuttings of 25 cm were prepared from the middle part of the stem; the terminal portions were discarded. The cuttings were tossed in a fungicide solution for 5 minutes and left to dry under ambient conditions before planting. Then cuttings were planted at an angle of 60° at 1 m by 0.5 m apart.

Data collection

Before and after stem storage, five cuttings were selected randomly for fresh and dry weight measurement and moisture content determination. An oven-dry method was set at 80°C for 48 hours to determine stem moisture contents. Air temperature, relative humidity, and rainfall were recorded daily throughout the storage and field establishment. The number of sprouted cuttings and plant vigour were collected 1 month after planting (MAP). Root count, root weight, and fresh weight were collected at 10 MAPs during harvesting to obtain total root yield, plant biomass, harvesting index, and number of marketable roots.

Calculations

Sprouting percentage:

The sprouting percentage was taken as the sum of sprouted cuttings in a plot over the total number of planted cuttings per plot multiplied by 100.

Dry matter and moisture content determination

Dry matter and moisture content were determined using an oven-dry method. For each treatment combination, five stem cuttings were selected randomly and sliced into 200-gram samples of small pieces which were then dried in an oven set at 80°C for 48 hours. The dried samples were reweighed for dry mass determination; DMC (%) and MC were then calculated using:

$$MC\ (\%) = \frac{DM}{FM} \times 100 \ .... (i)$$

Where,

MC = moisture content, DM = dry mass, and FM = fresh mass of the sample.

Root yield

Root yield was obtained based on the harvested plants per plot as formulated by Misganaw and Bayou (2020);

$$RY\ (t/ha) = \frac{SRM \times 10{,}000}{TPH} \times 100 \ ...\ (ii)$$

Where,

Where; TRM = total root mass, TFM = total fresh mass, TBM = total biomass mass, and TPH = total plant harvested

Data analysis

Data were analyzed using R software, and the List Significant Differences (LSD) was performed to separate the means of the treatment at a 5% significant level.

RESULTS

Agroecological conditions on the growing environment

RY = root yield, SRM = sum of the root mass and TPH = total number of plants harvested

Harvesting Index

The harvesting Index was calculated as the total weight of the storage root to the total biomass mass;

$$HI = \frac{TRY}{TBM} \times 100 \ ....(iii)$$

Where,

HI = harvesting index, TRY = total root yield, and TBM = total biomass mass

(i) Biomass

Biomass

$$TBM\ (t/ha) = \frac{TRM+TFM \times 10{,}000}{TPH} \times 1000 \ ..(iv)$$

The mean amount of rainfall, air temperature, and relative humidity recorded during the period of storage of stem and field establishment varied significantly across sites. Naliendele recorded the highest mean rainfall, and Nachingwea had the highest rainfall intensity (Figure 1a). The mean air temperature was 27.13°C; Naliendele had a higher mean temperature than other sites. During field establishment, Nachingwea had the highest mean air temperature (Figure 1b); the relative humidity ranged from 50.17% to 94.4%; the highest was at Naliendele. However, high RH was recorded at Nachingwea during the last two weeks of storage and the first three weeks of field establishment.

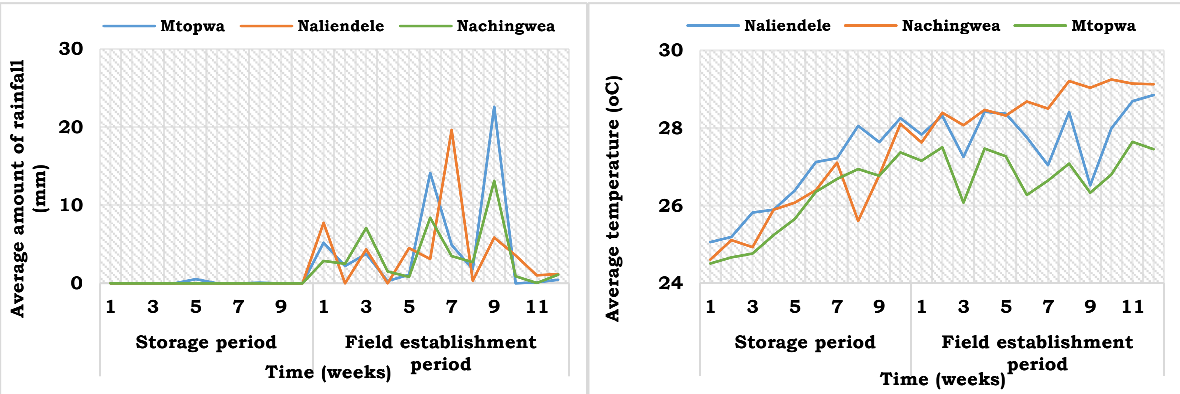

Figure 1. Average amount of rainfall and air temperature recorded during storage and establishment period across the sites

Characteristics of cassava stems

Before storage

The results revealed a significant ($p \leq 0.001$) difference in cassava stems' fresh eight, dry matter, and moisture contents among varieties, storage duration, and their interactions. The percentage sum of squares (SS) due to varieties was greater for dry matter (62.2%) and moisture contents (59.5%), indicating that cassava varieties contribute more to these variations. The percentage SS for the varieties and storage duration interactions was greater (69.2%), implying that they contributed more to the variation of dry contents. Cassava cutting had a mean fresh weight of 66.9 g and dry matter contents of 31.6 g, with Mkuranga1 having the highest mean fresh weight of 70.4 g and dry matter contents of 35.7 g. Considering the duration of storage, the first batch of stem storage showed more loss of fresh weight and dry matter content, but this decreased significantly (p ≤ 0.001) toward the last batch. Stem moisture content ranged from 50.35% to 70.17%, with a mean of 52.9%. Except for the third batch, the stem moisture contents decreased as storage duration increased; the increase in moisture contents in the third batch was due to the occurrence of rainfall. The stem moisture content decreased as the duration of storage increased. Chereko and Kiroba varieties showed the highest and lowest moisture content (Table 2).

Likewise, cassava stems stored at different sites have significantly different amounts of dry matter and moisture content; Naliendele site (p ≤ 0.05) recorded the highest dry matter and moisture content (Table 3).

After storage

Following storage, cassava stems showed a notable decrease in fresh weight, dry matter, and moisture content across cassava varieties, storage methods, and duration. The percentage SS due to storage duration was greater for fresh weight (76.5%) and moisture contents (96.5%), and the percentage SS due to varieties was higher for dry matter contents (44.5%). This indicates long storage strongly affects the loss of fresh weight and moisture content, and varieties significantly influence the loss of dry matter contents. The interaction between varieties and duration of storage was significant for fresh weight and dry matter losses. Also, the interactions between storage methods and duration significantly influenced the loss of moisture content (Table 2).

During storage, an average of 35.9 g of fresh weight and 12 g of dry matter contents were lost from the stems. Loss of dry matter increased with longer storage. The loss in fresh weight was more pronounced during the first two weeks of storage and lessened as storage duration advanced. The loss increased significantly (p ≤ 0.001) with the increase in the duration of storage. Losses in moisture contents ranged from 1.9% to 44.9% with a mean of 17.5%. Mkuranga1 and Pwani varieties lost the highest and lowest fresh weight and dry matter content, respectively (Figure 2).

Storage of cassava stems by covering with mulch in the open space had significantly (p ≤ 0.05) less moisture than other storage methods. The storage in open spaces without mulch or irrigation experienced the highest moisture loss. Chereko and Kiroba varieties lost the highest and lowest moisture content, respectively (Figure 3).

Environmental conditions significantly (p ≤ 0.001) affect the amount of fresh weight, dry matter, and loss of moisture contents. The highest losses in fresh weight, dry matter, and moisture content were noted at Nachingwea. Following site comparisons, Chereko and Pwani had higher moisture losses at Nachingwea and Naliendele, respectively (Figure 4).

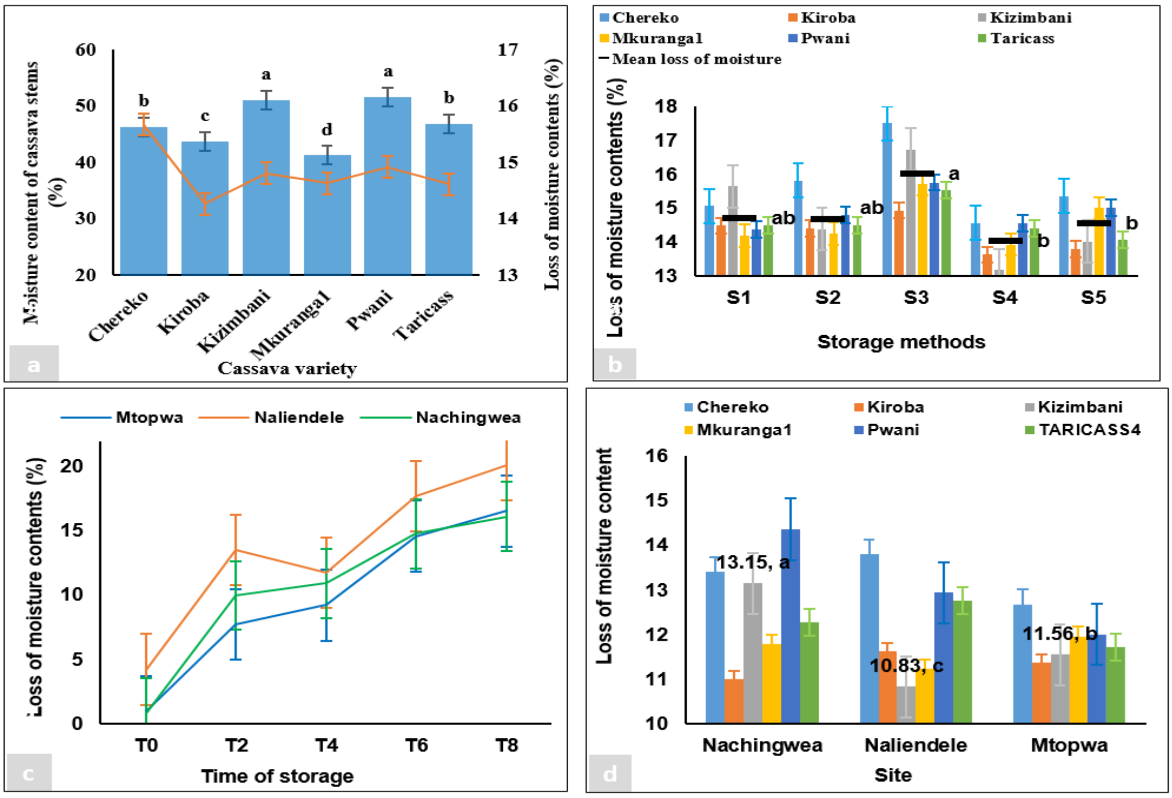

Figure 2. Percentage of moisture contents lost from cassava stems during storage by varieties (a), storage methods (b), storage duration (c), and experimental site.

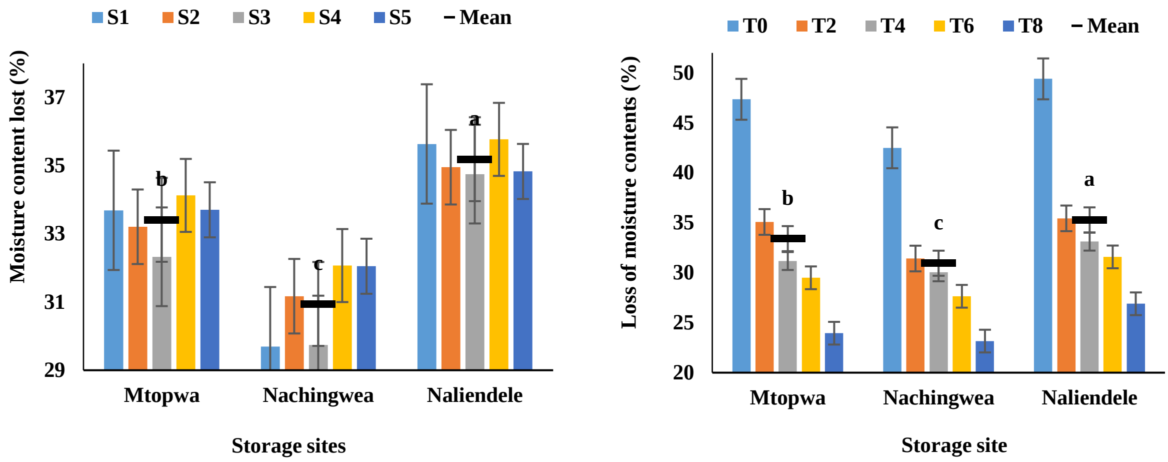

Figure 3. Mean values for moisture contents lost from cassava stems stored at different sites by method of storage and duration of storage.

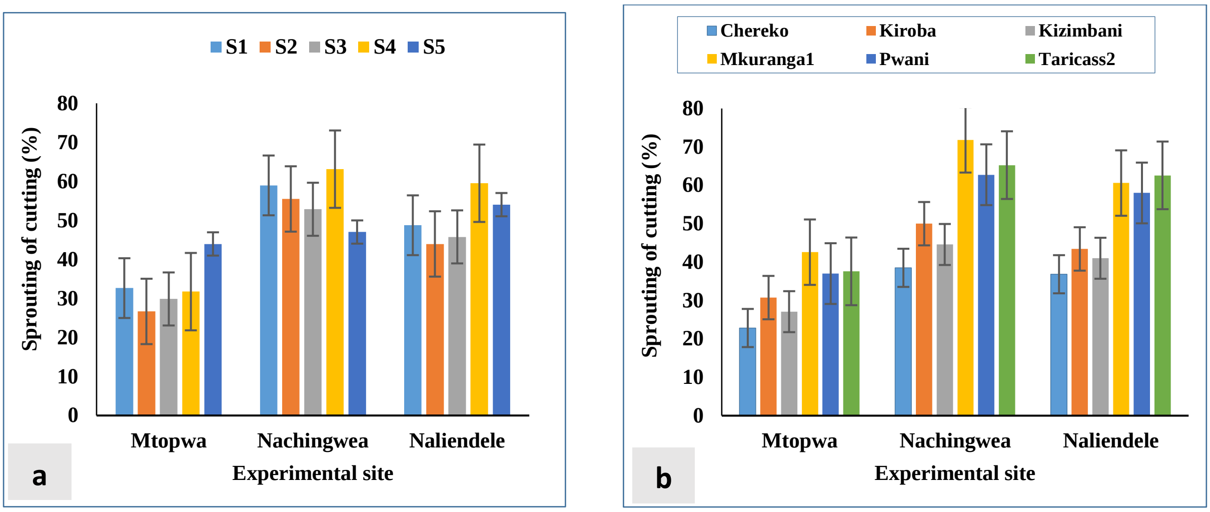

Figure 4. Environmental effects on sprouting of cassava cuttings between storage methods (a) and Cassava varieties.

Sprouting of cuttings

The ANOVA results revealed significant ($p \leq 0.001$) variation in sprouting of cassava cuttings between varieties, storage methods, and duration of storage. Cassava varieties significantly contributed to sprouting variation (52.1%), followed by storage duration (40.9%) (Table 3). The sprouting of cuttings ranged from 0% to 80%, with a mean of 46.3%. The sprouting percentage decreased significantly as the duration of storage increased. Cassava stems covered with mulch in open spaces showed a higher sprouting percentage. In contrast, those from stems stored in open areas without mulching or irrigation revealed the lowest sprouting percentage. Mkuranga1 and Chereko varieties had the highest and lowest sprouting percentages, respectively (Table 3).

The environmental conditions of the growing area had significantly ($p \leq 0.001$) influenced the sprouting of cuttings based on variety, storage methods, and storage duration. The conditions at Nachingwea favored a higher sprouting rate of cuttings (55.5%) than other sites. Cassava stems covered with mulch in the open space had the highest sprouting percentage at Nachingwea and Naliendele, while the invented stems stored under tree shade recorded the highest sprouting at Mtopwa. Mkuranga1 cuttings had the highest sprouting percentage at Mtopwa and Nachingwea, while Kiroba and Pwani cuttings attained the highest sprouting at Mtopwa (Figure 4).

Table 2: ANOVA table for the fresh weight, dry matter, and moisture contents measured on cuttings of six varieties before and after storage of stems.

Before storage							
		Means squares and significant test			% SS of squares		
SV	df	WF	WDM	MC	WF	WDM	MC
E	2	0.01 ●	0.1***	0.2***	0.0	0.0	0.0
TM	4	167.5***	252.1***	249.6***	5.8	17.8	16.8
V	5	581.1***	703.5***	704.9***	25.0	62.2	59.5
TM*V	20	401.4***	56.4***	70.1***	69.2	19.9	23.7
Residuals	418	0.01	0.0	0.0	-	-	-
Total	449	-	-	-	-	-	-
After storage							
E	2	1874.7***	387.9***	465.8***	-	-	-
SM	4	45.5 ns	5.3 ns	1490.6***	1.3	0.8	33.4
TM	4	2656.8***	170.1***	2889.5***	76.5	25.1	64.8
V	5	614.8***	402.6***	61.9***	22.1	74.1	1.7
SM*TM	16	30.1 ns	8.4 ns	100.5***	4.0	5.9	55.1
SM*V	20	37.3 ns	9.4 ns	13.9 ns	6.2	8.3	9.5
TM*V	20	441.5***	71.9***	19.7 ns	74.0	63.1	13.5
SM*TM*V	80	23.6 ns	6.5 ns	8.0 ns	15.8	22.8	21.9
Residuals	298	40.3	9.7	11.8	-	-	-
Total	449	-	-	-	-	-	-

Note: SS sq.=Sum of squares, SV=source of variation, df=degree of freedom, SM=storage methods, TM=duration of storage, E=environment, V=cassava varieties, WF=weight of fresh, WDM=weight of dry matter, MC=moisture content, *** and ● =significant different at 0.001 and 0.05, respectively and ns=not significant different

Table 3. Means values for the fresh weight, dry matter, and moisture contents measured on cuttings of six varieties before and after storage of stems.

	Cassava varieties							
	V1	V2	V3	V4	V5	V6	Mean	Standard error
Before storage								
WF (g)	66.8^{d}	62.0^{f}	68.0^{c}	70.4^{a}	66.3^{e}	68.1^{b}	66.9	0.07***
WDM (g)	31.1^{c}	27.1^{f}	30.1^{e}	35.8^{a}	31.1^{d}	34.2^{b}	31.6	0.01***
MC (%)	53.3^{c}	56.4^{a}	55.7^{b}	48.8^{f}	53.2^{d}	49.9^{e}	52.9	0.01***
After Storage								
LFW (g)	37.3^{a}	30.1^{b}	36.1^{a}	37.9^{a}	36.1^{a}	37.7^{a}	35.9	8.86***
LDM (g)	12.4^{b}	8.1^{d}	10.6^{c}	14.4^{a}	12.1^{b}	14.1^{a}	12.0	13.30***
LMC (%)	18.5^{a}	17.8^{ab}	17.7^{ab}	15.9^{c}	18.1^{a}	16.8^{bc}	17.5	9.8***

Note: WF=fresh stem weight, WDM=weight of dry matter, MC=moisture content, LFW=loss of fresh weight, LDM=loss of dry matter, LMC=loss of moisture content, V1=Chereko, V2=Pwani,V3=Kizimbani, V4=Mkuranga1, V5=TARICASS2 and V6=Kiroba.

Table 4. Mean sprouting percentage of six cassava cuttings at different storage methods and times

Variety	Sprouting (%)	SM	Sprouting (%)	TM	Sprouting (%)
Mkuranga1	58.33^{a}	S4	51.46^{a}	T0	58.38^{a}
TARICASS2	55.14^{ab}	S5	48.33^{ab}	T2	50.95^{b}
Pwani	52.58^{b}	S1	46.78^{bc}	T6	44.95^{c}
Kiroba	41.39^{c}	S3	42.82^{cd}	T4	44.49^{c}
Kizimbani	37.56^{c}	S2	42.04^{d}	T8	32.66^{d}
Chereko	32.72^{d}	-	-	-	-
Mean	46.29		46.287		46.287
LSD	4.778		4.361		4.361
CV (%)	56.769		55.796		55.796
P value	< 0.001		< 0.001		< 0.001

Note: the varieties that are denoted by the same letter are not significantly different, SM=storage methods, TM=duration of storage.

Table 5. ANOVA table for the yield performance of six cassava varieties' stems stored by different methods and durations pre-planting.

Mean squares and significant test					
Sources of variation	df	Root yield (t/ha)	Root number	Harvesting index	Biomass (t/ha)
Rep	2	1106***	55.2***	0.108***	9473***
Site	2	48845***	1323.8***	0.893***	353968***
SM	4	1074***	17.97***	0.021*	6699***
TM	4	499***	5.4	0.019*	1204*
V	5	2945***	50.9***	0.233***	6044***
SM x TM	16	188***	8.3***	0.005	1043***
SM x V	20	118*	6.4**	0.010	521
TM x V	20	60	3.6	0.013*	300
SM x TM x V	80	91*	4.0*	0.011•	428
Residuals	1196	74	3.0	0.008	372
Percentage sum of squares					
SS due to SM (%)		20.4	20.7	6.5	43.3
SS due to TM (%)		9.5	6.2	5.8	7.8
SS due to V (%)		70.1	73.2	87.7	48.9

Note: df = degree of freedom, SM=storage methods, TM=duration of storage, V=cassava varieties ***, **, *, =s ignificant difference at 0.001, 0.01, 0.05, and 0.1, respectively, and ns=not significantly different

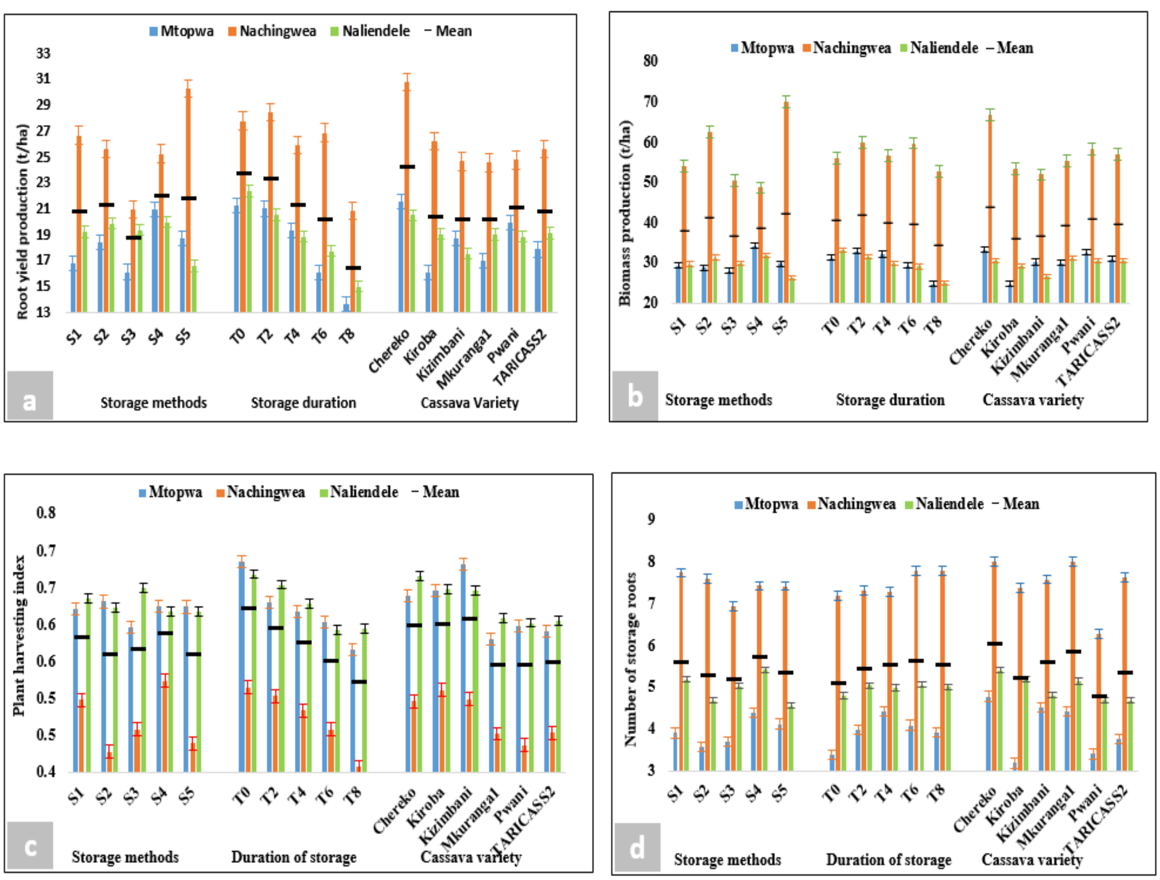

Figure 5. Environmental effects on root yield (a), Plant biomass (b), Harvesting index (c), and root number (d) production among varieties, storage methods, and duration of storage before planting.

Root yield and yield component productions

The pooled analysis indicated that root number, root yield, plant biomass production, and root harvesting index varied significantly among the test cassava varieties, storage methods, and duration. The percentage sum of squares due to varieties was high in root yield (70.23%), root number (73.15%), harvesting index (87.71%), and plant biomass production (48.87%). These results suggest cassava variety characteristics influenced most of the observed variation in root yields and yield components. The root yield and yield component production were significantly influenced by the combination of storage methods, storage duration, and cassava varieties (Table 4). The number of storage roots ranged from 1 to 16 per plant. The cassava stems covered with mulch in open space significantly ($p \leq 0.001$) produced the highest number of storage roots, followed by the inverted stems stored under tree shade. Chereko variety developed more storage roots than others (Figure 5d). The average root yield production was 23.01 t/ha, with the productivity ranging from 1.8 to 81.33 t/ha (Table 5).

However, root yield production decreased significantly ($p \leq 0.001$) with an increased storage duration. Stems covered with mulch during storage produced the highest root yield. Chereko and Pwani had theplant harvest index (HI) ranged from 0.17 to 0.88; this decreased significantly with storage duration. The cassava stems covered with mulch during storage had the highest mean HI. The lowest HI was for vertically stored stems in the open space without mulching and watering, regardless of the varieties. Nonetheless, Chereko and Pwani had the highest and lowest HI (Figure 5c).

The average plant biomass production was 49.7 t/ha, ranging from 0.35 to 186.2 t/ha. The inverted stem storage method under a tree shade produced the highest mean plant biomass, while the lowest was for the storage method in an open space under sunlight without mulching and water (Figure 5b). Environmental conditions had a significant ($p \leq 0.001$) influence on the root yield among varieties, storage methods, and duration of storage (Table 4). Nachingwea had the highest number of storage roots, high yield, and plant biomass, followed by Naliendele. Mtopwa site had the highest plant HI.

DISCUSSION

The quality of cassava stems is determined by their genetic makeup, physiology, and health status. The quality stems sprout into vigorous plants with high root-yielding capacity (Javier López et al., 2012). However, genetic quality depends on the variety, while physiological status involves plant nutrition, stem age, and viability factors (Bridgemohan et al., 2014; Javier López et al., 2012). Stem viability directly influences the stem moisture content, with 70% of stems containing water. The sprouting ability of cuttings becomes reduced when the moisture content decreases beyond the required level. López et al. (2012) reported a loss of 20% of moisture contents to reduce cutting sprouting by 50% and low-yield production.

Cassava stems had an average of 31.6 g of dry matter content, which varied significantly among varieties. Similar findings were reported by Manano et al. (2018), who found a significant variation in stem dry matter content between Nyamatia, Nyarukeca, NASE 3, NASE 14, and NASE 19 varieties in Uganda. Also, the mean value for stem dry matter content lies between 24.2 g and 47.2 g (López et al., 2012).

The mean moisture content was 45%; these results range between 50.4% and 70.2% of moisture content, as reported by Veiga et al. (2016). Furthermore, the dry matter and moisture content varied with storage time and were influenced by the environment. Also, a significant variation in biomass production and moisture content was attributed to drought and rainfall (Connor et al. 1981).

Losses in moisture content of about 35.4% after storage significantly varied among varieties and increased as the storage time increased. These results concur with Javier López et al. (2012), who reported a significant decrease in stem moisture content during storage. The effect of mulching in reducing direct heat, lowering the temperature, and increasing relative humidity significantly counteracted the dehydration of cassava stems kept in the open space. Moisture losses in stems kept on the open ground without mulch were higher because they were directly exposed to high temperatures and excessive heat. The variation in loss of moisture content among varieties concurs with observations by Bridgemohan et al. (2014).

The environmental conditions at the experimental sites significantly contributed to the moisture loss, with Naliendele losing the most compared to the rest. The high temperature recorded at Naliendale could have been attributed to the excessive moisture loss. As observed by other workers, loss of stem moisture content affects cuttings' sprouting ability and root yield production (Leihner, 1983). The dehydration of stems below the critical stage (60%) reduces sprouting from 85 to 30%, and the loss of moisture below 50% leads to sprouting failure. The study by Ravi and Suryakumari (2005) established root yield loss of between 15.8% and 28% due to loss of moisture during storage of stems pre-planting. Our study findings suggested that losses of stem moisture reduced the sprouting of cuttings by 7.4% to 25.7% compared to fresh cuttings, and the impact was more significant with storage time/duration. The enhanced sprouting of stem cuttings and root yield production by 9% and 19%, respectively, in the present study compares well with the report by Javier López et al. (2012).

CONCLUSION

Loss of stem moisture content is a fundamental contributor to the reduction of cassava stem viability. This consequently leads to poor establishment, low stand counts, limited vigor, and low yield production. The dehydration levels differ among varieties; the length of storage duration and conditions under which stems are kept before and after planting significantly contribute to moisture loss. Covering stems with mulch in the open space or inverted storage of stems under tree shade reduced the dehydration of stems by 35.4% and promoted sprouting, fair field establishment, and yield production. Farmers, seed entrepreneurs, and research institutions should use these proven technologies to improve seed multiplication, distribution, and productivity.

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AUTHOR CONTRIBUTION STATEMENT

MDG: Data curation, Formal analysis, Methodology, Writing – original draft – review and editing. RGM: Conceptualization of research, Design of Methodology, Supervision of research, review and editing of manuscript. MDG & MEJ: Methodology, Writing – review and editing, Supervision

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CONFLICTS OF INTEREST

The authors declare that no conflicts of interest regarding the publication of this paper.

ETHICAL APPROVAL

Not applicable

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