International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 12, No. 1, p. 1-10, 2018

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Effect of storage methods of cassava planting materials on establishment and early growth vigour

Baraka Barnabas Mdenye[*1,2], Josiah Mwivandi Kinama[2], Florence M'mogi Olubayo[2], Benjamin Musembi Kivuva[3], James Wanjohi Muthomi[2]

[1]*Department of Agriculture, Masasi District Council, Masasi, Tanzania*

[2]*University of Nairobi, Faculty of Agriculture, Kenya*

[3]*Kenya Agricultural and Livestock Research Organization (KALRO), Kenya*

Article published on January 05, 2018

Key words: Cassava planting materials, Storage methods, Early growth Vigour, Cuttings

Abstract

Cassava (*Manihot esculenta* Cruntz.) establishment depends on quality of planting materials. The experiment was done to determine the effects storage and variety on crop establishment and early growth vigour. Karembo and KME 4 varieties were stored in clamp under double shade (CUDS), horizontal under shade (HUS), vertical under shade (VUS) and horizontal under open ground (HOUG) as control for 16 weeks. Planting materials was sampled from each storage methods after every 4 weeks and taken to field to evaluate their sprouting ability, number of primary shoots formation, number of leaves, rate of leaf formation and early growth vigour. Data were subjected to ANOVA and means separated by LSD. Sprouting percentage at Kabete was 54.73 % while in Kiboko had 37.78 %. The results showed that Kabete had 1.60 number of primary shoots per plant compared to 1.04 of Kiboko. The results showed KME4 had higher sprouting than Karembo in both sites. This can be due to genetic difference among varieties. The rate of leaf formation at Kiboko was higher as compared to Kabete it could be contribute difference in temperature between locations. Thus, optimum temperature and relative humidity should be factored in cassava cuttings storage to avoid increased death of stored cuttings. In case of storage cassava cuttings, should be stored in clamp under double shade methods under low temperature and moderate RH.

* **Corresponding Author:** Baraka Barnabas Mdenye ✉ bamide2001@gmail.com

Introduction

Cassava is propagated using stem cuttings, bulky and highly perishable as they dry up within a few days after harvest. Its stand establishment require good planting materials free from diseases. In cassava production, problem of stem storage arises when harvest and subsequent plantings are separated by time for several months due to drought, low temperature or floods (Leihner, 1982; Mdenye *et al.*, 2016). The planting stakes of cassava are said to be good if they are of right stem age which is between 8 – 18 months, right stem diameter meaning the diameter of pith is equal to or less than 50% of the total diameter of the cutting (CIAT, 1984; FAO, 2013), adequate number of nodes meaning cuttings of 20-25 cm should have 5-7 number of nodes (Penh, 2015).

Good planting materials come from plants grown from fertile soil or well fertilized. Fertile soil or fertilized soil will provide enough food for new sprout hence vigour and high yield (Leihner, 1983; Penh, 2015). Number of nodes per cuttings vary with length of inter nodes. The higher inter node length means the less nodes per unit distance. The length of internodes varies with response to genotype, plant age and environmental factors (Penh, 2015). This meaning that the cassava stand establishment vary according to genotype. The shoots which develop from cuttings depends on length of cuttings, mother plant, bud dormancy, genotype and environmental conditions (CIAT, 1987). Early crop establishment depend on nutritional status of planting material (Leihner, 1983). The study done by Leihner, (1983) also proved that the cuttings with good nutritional content at crop establishment produce good stand during early growth and the yields higher than cuttings with poor nutrition. Good quality planting material is essential for obtaining good yields.

Cassava are usually harvested in dormant period in between two rain seasons when the root reach better commercial quality with maximum production and starch content of roots (Leihner,1980). So, when stakes are harvested at this season they need to be stored for next planting season.

Moisture loss of cuttings during storage has proven to have strong influence on stake viability and vigour (Leihner, 1983). But also, it may have influence on some biochemical properties of cuttings that has influence on sprouting and nutrition of stored cuttings (Leihner, 1983). Reabsorption of moisture from environment is possible when cuttings are submerged in water but it will absorb very small quantity and only if the cuttings had not lost water to critical level. According to Leihner, (1983) critical moisture level of cassava planting materials in which sprouting below that will be reduced drastically found to be 50%. The aim of the research was to determine effect of storage methods and varieties of planting material to establishment and growth vigour

Materials and methods

Site description

The experiment was carried out in two sites namely Kabete and KARLO Kiboko. Kabete is about 15 km to the west of Nairobi city and lies at 1° 15′S latitude and 36° 44′E longitude and at altitude of 1930 m above sea level (masl) (Onyango *et al.*, 2012). Kabete has a bimodal distribution of rainfall, with long rains from early march to late May and the short rains from October to December (Onyango *et al.*, 2012) and total annual rainfall ranging between 700-1500mm (Wasonga *et al.*,2015). The mean annual temperature is 18 °C. The soils in Kabete are characterized as deep, well drained, dark reddish-brown - dark brown, friable clay (Onyango *et al.*, 2012). The soil is classified as a humid Nitisol (Karuku *et al.,* 2012).

The second site was KARLO-Kiboko lies within longitudes 37°.43 212' E and latitudes 2°.12 933'S, and 821.7 m above sea level in Makueni County, 187 km east of Nairobi, Kenya (Kivuva *et al.*, 2015). The location receives between 545 and 629 mm of rainfall coming in two seasons. The long rains season is between April and May while the short rains season is between October and January. The mean annual temperature is 22.6°C, whereby the annual maximum temperature is 28.6°C and annual minimum temperature is16.5°C. The soils are well drained, Fluvisols, Ferralsols and Luvisols (CIMMYT, 2013).

Soil analysis showed pH of experimental sites were 5.85 (H_2O), 5.45 (Cacl) and 5.25 (H_2O), 4.50 (Cacl) Kiboko and Kabete respectively (Table 1).

Experimental design

The trial was split plot design in RCBD (Okoli *et al*, 2010) with main plot as storage method and sub plots being varieties, replicated three times (Mdenye *et al.*, 2016). The storage methods were clamp and double shade (CUDS), horizontal under shade (HUS), vertical under shade (VUS) and the control horizontal under open ground (HOUG) (Mdenye *et al.*, 2016) while varieties were KME 4 and Karembo. In each storage method e-data loggers were installed to record temperature and RH. The sprouting Test was done at interval of 4 weeks (0, 4, 8 12 and 16 weeks after storage) (Mdenye *et al.*, 2016). The spacing between cuttings was 1 m each. Sub plot having varieties had six plants for data collection. Planted cuttings had 20 cm each having 4 -7 nodes and diameter range from 1.5 to 3.4 cm (Table 2). The cuttings were planted at 60^o slanting position and irrigated with three days per week to maintain field capacity moisture level (Bridgemohan and Bridgemohan, 2014). Weed control was done manually using hand hoe. The sprouting percentage of cuttings was scored from week 3 to week 8. Number of leaves per plant and primary shoots were measured from 5 WAP – 8 WAP (Ekanayake, 1997).

Data analysis

Data was subjected to ANOVA to determine the difference among treatments and location using GenStat (Payne., 2012) and means were separated using least significant difference (LSD) at $p \leq 0.005$. Complete model used was:-$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\beta\gamma)_{ik} + (\alpha\gamma)_{jk} + (\beta\gamma\alpha)_{ijk} + \varepsilon_{ijkl}$ (Kroonenberg and van Eeuwijk, 1998; Mdenye *et al.* 2016).

Where μ is the general mean of the population αi, βj, and γk is mean of storage methods, mean of varieties and mean of duration of storage, as main effects while $(\alpha\beta)_{ij}$, $(\beta\gamma)_{ik}$ and $(\alpha\gamma)_{jk}$ are corresponding two-way interaction effect and $(\beta\gamma\alpha)_{ijk}$ three-way interaction effect and ε_{ijkl} represent the expected error (Kroonenberg and van Eeuwijk, 1998; Mdenye *et al.*, 2016).

The data taken were Sprouting percentage, number of primary stem per plant, number of leaves per plant, leaves formation per day and vigour. The vigour score was based on scale 0 = not germinated, 1 = very poor vigour, 3 = poor vigour, 5 = intermediate vigour, 7 = vigorous and 9 = highly vigorous (Ekanayake, 1997).

Results

Weather data during the experiment duration

The data obtained from ICRISAT Kiboko and Kabete meteorological stations (Fig. 1a & 1b) has shown the trend of weather in both sites.

Table 1. Soil analysis data for basic nutrients.

Site	% N	P (ppm)	K Cmol (+)/kg	% Organic Carbon	pH Cacl	pH (H_2O)
Kabete	0.29	8.05	1.10	2.26	4.50	5.25
Kiboko	0.10	14.15	1.33	0.97	5.45	5.85

Sprouting percentage

The results of location of storage, duration of storage, storage methods and variety showed highly significant difference within treatments at $p < 0.001$. The results further showed that overall sprouting of cuttings stored in Kabete was higher of 54.73% as compared to those stored in Kiboko with 37.78%. Also, the results showed that sprouting of cuttings 0 week of storage had the highest sprouting percentage of 81.96 as compared to 16.67 percentage of sprouting after 16 weeks after storage.

CUDS had highest average sprouting percentage of 75.57 and 42.22 in Kabete and Kiboko respectively and the lowest was HUOG with 34.44 % both in Kabete and Kiboko. KME4 performed better by having average of 55.83 % sprouting than 36.67 % sprouting of Karembo. Average of sprouted cuttings at Kabete after storage for 16 weeks was 31.25 percentage as compared to 2.08 percentage of cuttings stored in Kiboko. CUDS in Kabete had sprouting of 75.57% while in the Kiboko had 42.22 %.

KME4 performed better by having sprouting percentage of 63.61 in Kabete and 48.06 in Kiboko than 45.84 Kabete and 27.50 in Kiboko of Karembo (Fig.2). KME 4 showed to have high percentage sprouting at 16 weeks after storage of 24.31 as compared to 9.03 of Karembo.

Table 2. Characteristic of cuttings before planting.

Variety	Minimum diameter (cm)	Maximum diameter (cm)	Average diameter (cm)
Karembo	1.50	3.00	1.98
KME4	1.51	3.40	2.14

Number of primary shoots per plant (NPSP-1)

Number of primary shoots showed significant difference among location at $p > 0.01$. The trial at Kabete had 1.60 shoots as compared to 1.04 at Kiboko in 8 months after planting. The results showed that duration of storage, storage methods and variety were significantly different at $p > 0.001$. Among duration of storage, zero weeks of storage (harvested and planted without storage) had an average of 1.95 $NPSP^{-1}$ which decreased gradually as weeks of storage advanced up to 0.82 $NPSP^{-1}$ in 16 WAS.

Table 1. Average number of primary shoots per specified duration of storage, location and storage method.

	Kabete				Kiboko				
WAS	CUDS	HUS	VUS	HUOG	CUDS	HUS	VUS	HUOG	Mean
0	2.31	1.92	2.11	2.15	1.9	1.46	1.66	2.12	1.95
4	1.88	1.56	1.98	2.02	1.89	1.61	1.62	1.88	1.81
8	1.86	1.71	1.68	0	1.8	0.97	0.53	1.09	1.21
12	2.08	1.26	1.5	0	0.85	0.5	0.39	0	0.82
16	1.85	1.75	2.46	0	0	0.17	0.33	0	0.82
Mean	2.00	1.64	1.95	0.83	1.29	0.94	0.91	1.02	1.32
$LSD_{0.05}$									0.26
CV									34.8

Where; WAS = weeks after storage, CUDS = clamp under double shade, HUS = horizontal under shade, VUS = vertical under shade and HUOG = horizontal in under open ground.

The average number of primary stems in CUDS was 1.64 followed by HUS (1.43), VUS (1.29) and the last was HUOG (0.93; LSD = 0.24). Between varieties KME4 had 1.58 $NPSP^{-1}$ as compared to 1.07 of Karembo (LSD= 0.16). The results showed Kabete had 2.12 $NPSP^{-1}$ as compared to 1.78 of Kiboko from zero week that decreased gradually up to 1.52 at Kabete and 0.12 at Kiboko by 16 WAS. As duration of storage was advancing the average number of primary shoots was decreasing depending on storage methods as well as location of storage (Table 3).

There was significance different in performance of varieties in different locations on same storage methods. Variety KME4 and Karembo under CUDS at Kabete had 2.20 and 1.76 $NPSP^{-1}$ respectively while at Kibokohad 1.68 and 0.90 $NPSP^{-1}$ KME4 and Karembo respectively.

Number of leaves per plant (NLP-1)

The results showed the number of leaves per plant at 8 WAP did not differ significantly among locations of experment at $p < 0.05$. Duration of storage, storage methods and variety significantly differed among treatments at $p < 0.001$.

The results showed that cassava cuttings planted soon or few days after harvest had 5.32 leaves by 8 WAP while plants established from cuttings that were stored for 16 weeks had 4.16 leaves at 8 WAP. Further, the results showed that CUDS had 10.27 leaves while other storage methods had 8.32-4.16 NLP^{-1} at 8 WAP. Varieties KME4 had 10.30 while Karembo had 5.00 (LSD = 1.52).

Results showed that at 0 week in both Kabete and Kiboko the number of leaves were 5.04 and 5.61 respectively which increased with increasing weeks of storage to 11.85 and 18.97 at Kabete and kiboko respectively up to 8 weeks of storage then started decreasing as weeks of storage advanced.

The highest number of leaves 31.08 were observed in variety KME4 under CUDS stored for 8 weeks. At 16 of storage plants established from the cuttings had 1.54 and 8.32 leaves per plant at Kiboko and Kabete respectively.

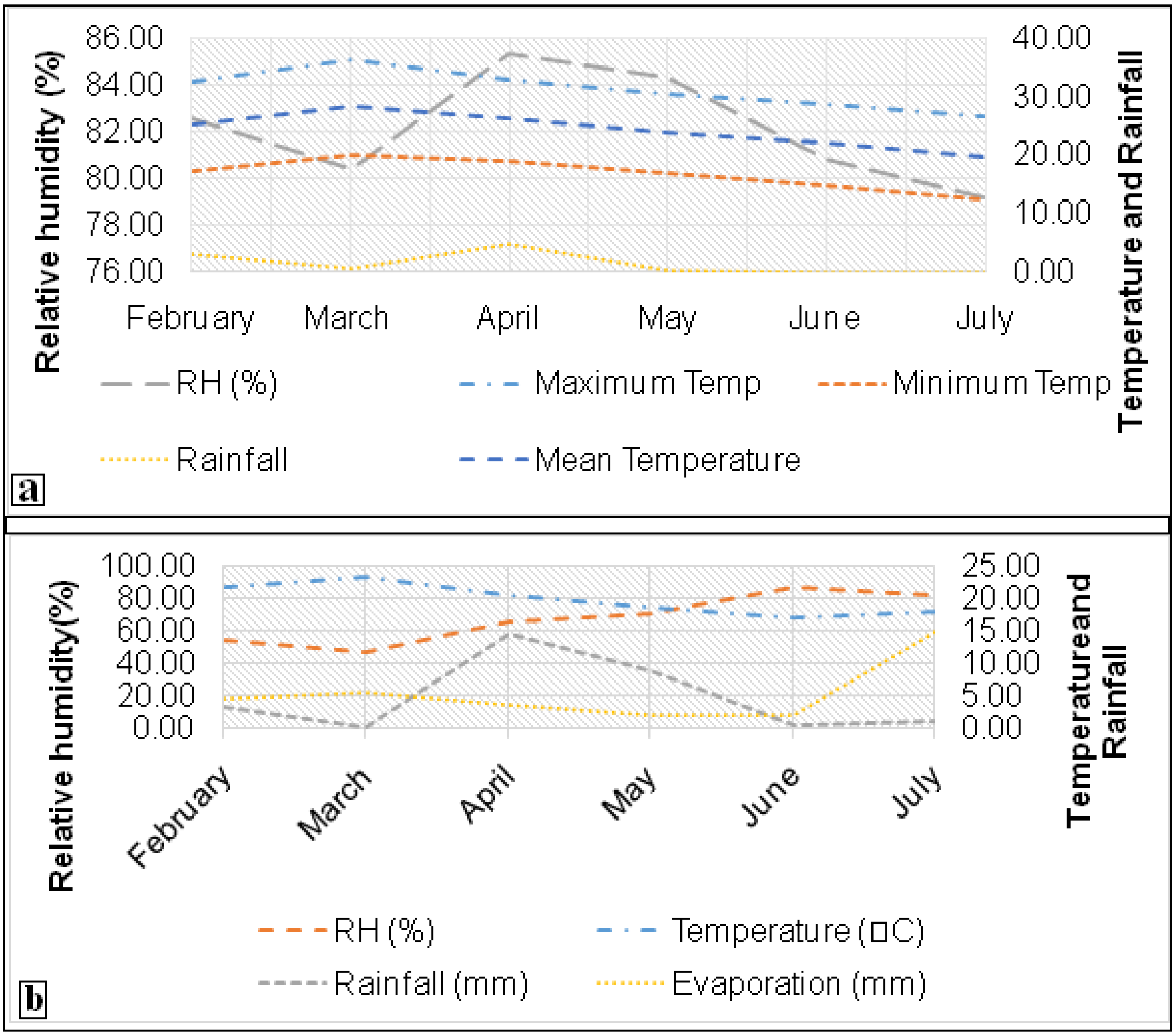

Fig. 1. A, b. Average Temperature, RH, rainfall and evaporation (a) Kiboko (b) Kabete in 2016.

The number of leaves per plant for CUDS were 9.27 and 11.27 in Kabete and kiboko resectively and the lowest were observed at HUOG, 1.61 and 6.72 Kabete and Kiboko respectivly.

Variety KME4 had 8.53 and 12. 08 NLP^{-1}in Kabate and Kiboko respectively while Karembo had 5.72 and 4.28 NLP^{-1} in Kabete and Kiboko respectively.

Rate of leaves formation per day (LFD-1)

There was significant difference between location at $p < 0.05$, where the rate of leaf formation per day was, 0.60 and 0.39 for Kiboko and Kabete respectively.

Duration of storage, storage methods and variety were significantly different at $p < 0.01$ among treatments applied.The highest leaf formation rate (0.81) was observed at 8 weeks of storage(Fig. 3)and lowest rate (0.09) at 16 weeks of storage (LSD = 0.12). The rate of leaf formation at of harvested cuttings and planted few daysafter was 0.76 per day. Variety KME4 had 0.60 while Karembo had 0.38 rate of leaf formation per day (LSD =0.07). CUDS had 0.61 followed by HUS (0.49), VUS (0.48) and the last was HUOG (0.40; LSD = 0.12).

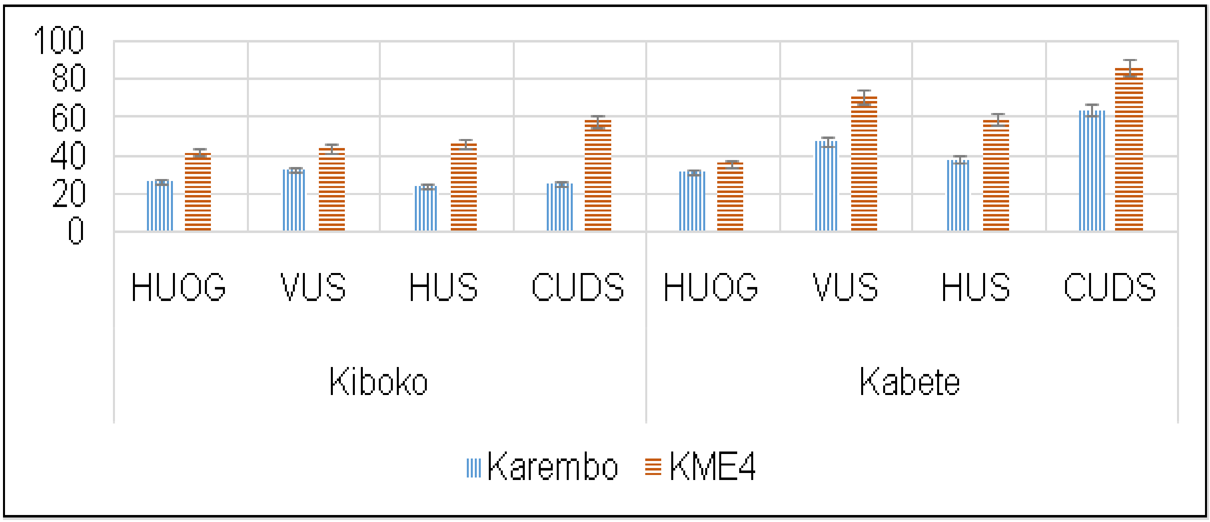

Fig. 2. Sprouting percentage of different variety of cuttings from different storage methods and Location.

The results showed that KME4 performed better in Kiboko as compared to Kabete while variety Karembo had lower rate in Kiboko as compared to Kabete (Fig. 4).

Plant vigour

Plant vigour did not siginificantly differ between locations but differed significantly among duration of storage , storage methods as well as variety at $p < 0.05$. The growth vigour was 4.33 at 0 week of storage and 0.94 at 16 weeks of storage. The highest vigour was observed at 4 weeks of storage. CUDS had growth vigour of 3.7 and the lowest growth vigour of 2.35 was observed at HUOG (Fig. 5). Variety KME4 was more vigourous than Karembo by having difference of 1.05 (LSD = 0.34). The results showed that at 8 weeks of storage the vigour of cuttings in both sites reduced drastically.

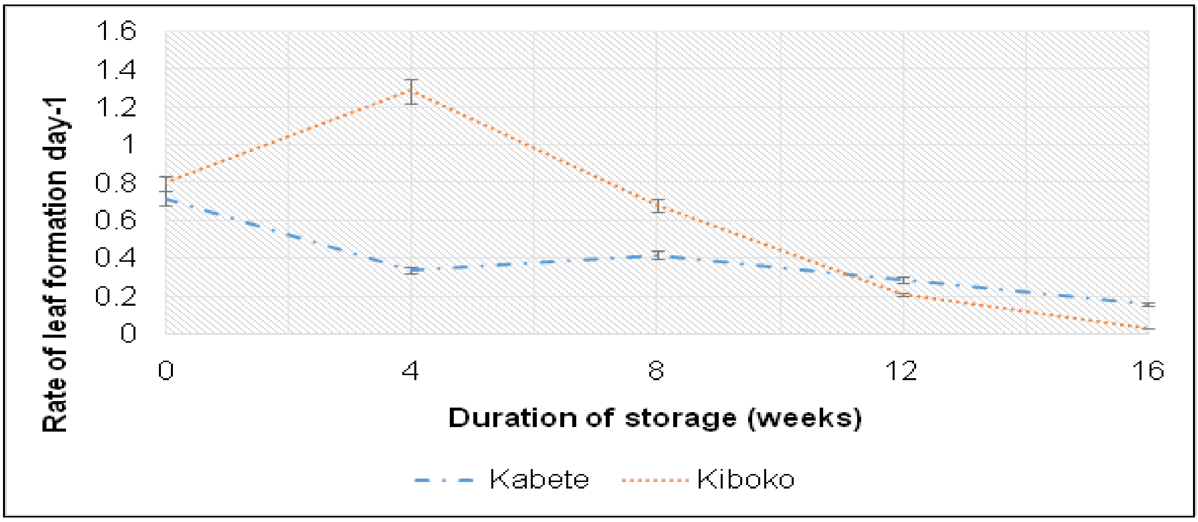

Fig. 3. Rate of leaf formation per day in different storage duration and location

Growth vigour at Kiboko and Kabete was 4.38 and 4.28 respectively at 0 week of storage decreased as duration of storage advanced to 0.37 at Kiboko and 1.51 Kabete at 16 weeks of storage. The highest growth vigour (6.52) was recorded at Kiboko at 4 weeks of storage while at Kabete it was 4.12. Variety KME4 had growth vigour of 3.91 and 3.18 at Kiboko and Kabete respectively while Karembo had 2.39 and 2.58 at Kiboko and Kabete respectively.

Where; CUDS = clamp under double shade, HUS = horizontal under shade, VUS = vertical under shade and HUOG = horizontal in under open ground.

Discussion

Sprouting percentage

The study results have shown that cassava crop establishment depends on variety and storage condition of the cuttings planted. KME4 has shown to have better storability than Karembo. Variety KME4 stored in Kabete in CUDS storage methods for 16 weeks still had sprouting of 94.44% as compared to 33.33% of Karembo under similar conditions.

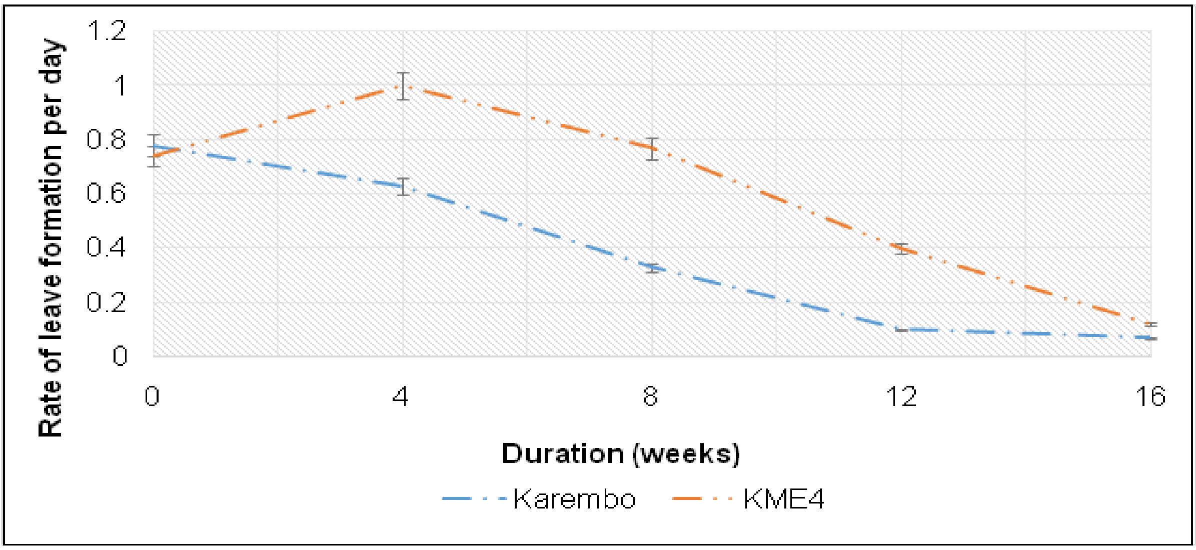

Fig. 4. Rate of leaf formation with reference to duration of storage and variety.

This may be due to genetic variability among the varieties. Similar results were obtained by Oka *et al.*, (1987). He was storing two cultivars of cassava and found that one cultivar dehydrated more than the other which contributed to reduction in sprouting of planted cuttings. Also, the causes of this variability among cultivars might be physiological differences among stem structure from one cultivar to another. Nassar *et al.* (2010) found differences in collenchyma and internal parenchyma among cultivars of cassava and such differences may be the reason for differences in storability of KME4 and Karembo. But also, this difference in storability indicate that when selecting planting materials for storage, it requires knowledge of the characteristics of cultivar. The results also indicated that there was significant influence of environmental factors in storability and sprouting of cassava. Kabete had average temperature of 20.32 ^{o}C and 65.55 % RH while Kiboko had 31.34 ^{o}C and 82.15 RH. This difference can be major contributor to performance of cassava storability and establishment. The results showed sprouting and crop establishment depends mostly an initial moisture content of cuttings. In Kiboko cuttings lost moisture content at high rate due to high average temperature to the extent that they lost viability and vigour in short period than in Kabete.

Number of primary shoots per plant (NPSP-1)

The number of primary shoots from the cuttings depends on carbohydrate and nutrient composition of planting materials. The results showed significant differences between location. This can be due to difference in loss of carbohydrate between cuttings stored in Kabete and Kiboko as repoted by Mdenye *et al.* (2016) in similar experiment where stored cuttings were sampled in each location and results showed that Kiboko lost more carbohydrate than Kabete. Oka *et al.* (1987); Ravi and Suryakumar, (2005) reported cassava having low early growth vigour as a result of lost carbohydrate in storage especially when stored under hot conditions. Also similar results were observed in planting materials stored in different storage methods, CUDS had low temperature and RH around 70% which resulted to reduction in rate of moisture and carbohydrate loss hence more primary shoots and number of leaves than cuttings stored in different methods and environment with high temeperature.

Number of leaves per plant (NLP-1), rate of leaves formation per day (LFD-1) and Plant vigour

The results showed that the rate of leaf formation per day was significant among locations. Kiboko had higher rate of 0.60 per day as compared to 0.39 per day in Kabete. Akparobi *et al.*, (2000) found simiral results.

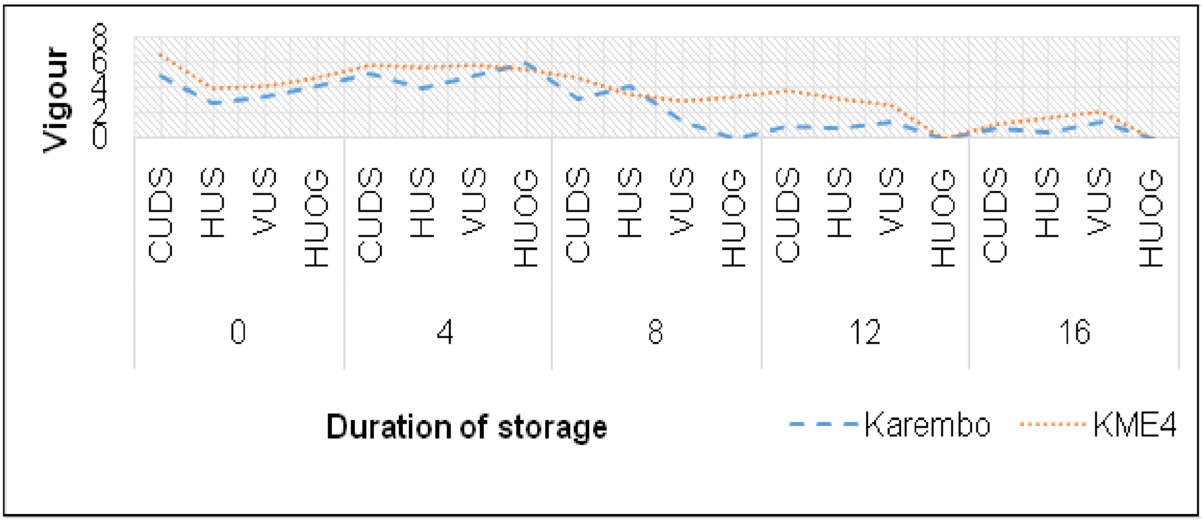

Fig. 5. Growth vigour of cassava plants under different storage methods, duration of storage and varieties.

The rate of leaf formation in low temperature is less compered to enviroment with temperature mean around 30 °C. In Kabete the mean of 20 °C and the minimum temperature of 12.7 °C around June which could influence low growth vigour in cassava plants at Kabete. The results also showed significant different among storage methods, where by CUDS had planting materials more vigourous than other methods. This might be due to less carbohydrate and reduced moisture loss during storage than other methods. Similar results have been reported by Hobman *et al.*(1987). This is further illustratted by poor stand establisment in Kiboko from 4 weeks of storage to 16 weeks of storage. In all parameters the optimum vigour was observed at 4 weeks of storage then after reduced as weeks of storage advanced explained by reduced carbohydrate due to metabolism and reduction of moisture content of stored cuttings.

Conclusion

According to the results of this study, the most important factor for cassava crop etablishment and early growth vigour is the storage of cuttings under double shade which reduced temperature and protected cuttings from direct radiation. Also observation showed that crop establishment depends on variety genotype.

For these reason in case of commercial cuttings production they should consider parameter of storability to ensure muximum stand establishment. In hot environment duration of storage should be as short as possible to avoid loss of carbohydrate and moisture which results to poor crop establshment and reduced early growth vigour.

Acknowledgement

The authors appreciate Alliance for a Green Revolution in Africa (AGRA) for funding the study. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of AGRA.

References

Akparobi SO, Togun AO, Ekanayake IJ. 2000. Temperature effects on leaf growth of cassava (*Manihot esculenta* Crantz) in controlled environments. African Journal of Root and Tuber Crops. **(4)1,** 1-4.

Bridgemohan P, Bridgemohan RSH. 2014. Effect of initial stem nodal cutting strength on dry matter production and accumulation in cassava. Journal of Plant Breeding and Crop Science. **6(6),** 67-72.

Centro Internacional de Agricultura Tropical (CIAT). 1987. Cassava Breeding: A Multidisciplinary review: Proceedings of a Workshop Held in the Philippines, 4 - 7 March 1985

Cheng B, Shao J. 2006. Testing Treatment Effects in Two-Way Linear Models: Additive or Full Model? The Indian Journal of Statistics **68,** 392–408.

Cock JH. 2011. Cassava growth and development. In: Centro International de Agricultura Tropical (CIAT)**.** 2011. The Cassava Handbook. A Reference Manual based on the Asian Regional Cassava Training Course, held in Thailand.

Ekanayake IJ, Osiru DSO, Porto MCM. 1997. Agronomy of cassava. Research guide 60 Training guide International Institute of tropical agriculture (IITA). Ibadan, Nigeria.

El-Sharkawy MA. 2004.Cassava biology and physiology. Plant Molecular Biology **56,** 481–501.

Food and Agriculture Organization of the United Nations (FAO). 2013. Save and grow: Cassava. Italy, Rome.

Hobman FR, Hammer GL, Shepherd RK. 1987. Effects of planting time and harvest age on cassava (*Manihot esculenta*) in Northern Australia. II. Crop growth and yield in a seasonally-dry environment. Expl. Agric. **(23),** 415-424.

Howeler HR. 2002. Agronomic practices for sustainable cassava production in Asia, In: Howeler, H.R. (Eds) 2002. Cassava research and development in Asia: Exploring new opportunities for an ancient crop. Proceeding of the seventh regional workshop held in Bangkok, Tailand. October 28-November 1, 2002.

Karuku GN, Gachene CKK, Karanja N, Cornelis W, Verplancke H, Kironchi G. 2012. Soil hydraulic properties of a nitisol in Kabete, Kenya. Tropical and Subtropical Agroecosystems, **15,** 595 – 609.

Kivuva BM, Sibiya J, Githiri SM, Yencho GC. 2015. Screening sweet potato genotypes for tolerance to drought stress. Field Crops Research. **(171),** 11–22.

Kroonenberg FA, Van E, PM. 2016. Multiplicative Models for Interaction in Three-Way ANOVA, with Applications to Plant Breeding. International Biometric Society Stable **54(4),** 1315–1333.

Leihner DE. 1982. Current practices in the production of cassava planting material. In: Cock, J.H. (Eds) Global workshop on root and tuber crops propagation: Proceedings of a Regional Workshop held in Cali, Colombia, 13-16 September. 41-46 p.

Leihner DE. 1983. Storage effects on planting material and subsequent growth and root yield of cassava (*Manihot esculenta* Crantz). In: Proceedings of the sixth symposium of the international society for tropical root crops. Lima, Peru, February 20-25, 1983.

Mdenye BB, Kinama JM, Olubayo FM, Kivuva BM, Muthomi JW. 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.

Nassar NMA, Abreu LFA, Teodoro DAP, Graciano-Ribeiro D. 2010. Drought tolerant stem anatomy characteristics in *Manihot esculenta* (Euphorbiaceae) and a wild relative. Genet. Mol. Res. **9(2),** 1023-1031.

Oka M, Sinthuprama S, Limsila J. 1987. Variations in some characteristics of cassava stems during storage prior to taking cuttings. Japan Agricultural Research Quarterly **(21)**3.

Onyango CM, Harbinson J, Imungi JK, Onwonga RN, Kooten O. 2012. Effect of nitrogen source, crop maturity stage and storage conditions on phenolics and oxalate contents in vegetable amaranth (*Amaranthus hypochondriacus*). Journal of Agricultural Sciences. **4(7)** p 219-230.

Payne R. 2012. A Guide to Anova and Design in Gen Stat (15th Edition). VSN International, Hertfordshire HP1 1ES, UK.

Penh P. 2015. Cassava handbook. UNDP trilateral cooperation cassava project phase II, Cambodia.

Ravi V, 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**, p 123-129.

Wasonga DO, Ambuko JL, Chemining'wa, GN, Odeny DA, Crampton BG. 2015. Morphological characterization and selection of spider plant (*Cleome Gynandra*) Accessions from Kenya and South Africa. Asian Journal of Agricultural Sciences **7(4),** p 36-44.