Research Note: Effect of Vine Age and Storage Duration on Regeneration Potential of Sweetpotato Vines in Drier Areas of Tanzania

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Introduction

Sweetpotato (*Ipomoea batata* L.) is one of the most widely grown root crops in sub-Saharan Africa (SSA), covering around 2.9 million hectares with an estimated production of 12.6 tons of roots in 2007 (FAOSTAT, 2008). The crop is particularly important in countries surrounding the great Lakes in Eastern and Central Africa (Woolfe, 1992). Sweetpotato has been reported to contain Carbohydrates, Vitamins, Fibres and Minerals (USDA, 2015). It likewise offers desirable nutritional and health benefits such as antioxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and immunomodulatory activities (Chandrasekara. and Kumar, 2016). The crop is expanding faster than any other crop, and it can be found at varied altitude from sea level up to 2500masl (Ndunguru *et al.,* 1998). Sweetpotato produces a lot of yield per unit area at a given time, superior to other major staples. It tolerates occasional dry spells and yields fairly even on less fertile soils compared to other crops such as maize (Low *et al.,* 2009). As agriculture becomes more market-oriented, sweetpotato is one of several crops that farmers can produce to obtain cash income (Best *et al.,* 2006). In addition to subsistence food security, supply and demand factors are therefore increasingly becoming determinants of the role sweetpotato will play in a more market-oriented small holder farm sector (Ndunguru *et al.,* 1998; Tomlins *et al.,* 2000; Best *et al.,* 2006).

Sweetpotato growers are concerned with how long they can hold on to the transplants (vines) before actual planting without adverse effect on the expected yield. Delays in planting vines into the main field could be caused by adverse weather or soil conditions that often occur during the transplanting season (Hammett, 1985). Some researchers observed that the storage of sweetpotato planting materials usually does not impair survival and may result in improved vigour, growth and yield. However, it depends on the precautions that are taken (Hall, 1985). Treatments such as occasional spray with water to avoid desiccation and avoidance of deep pilling may induce anaerobiosis, and placement of vines under the shade during storage may increase their shelf life (Hammett, 1985). Farmers in drought stricken areas like Central Tanzania are often short of planting materials at the onset of rains and growing season shortly after long dry spells. They are usually forced to solicit vines from distant places, a process that takes appreciable time on handling and transportation. Planting immediately after the vines are available is sometimes curtailed by the intermittent drought that occurs during the growing season forcing the need to store vines for sometimes before planting. Scarcity of planting materials does not only affect timely planting, but also making use of immature sprouts, which may compromise the regeneration ability of the newly established crop. Some farmers in Central Tanzania suggested vines from new sprouts regenerate faster than those from the mature crop, but there is no evidence to support the claim. Elsewhere, sweetpotato growers tend to store vines for few days before planting, especially when the conditions are not favorable for planting to allow cuttings to form callus for root development prior to planting (Bartolini and Fabbri, 1988; Briccoli-Bati and Lombardo, 1988). The aim of the present study were; i) to examine if length of time for which vines are stored has any effect on their regeneration ability, ii) to determine the response of vines from different varieties to delayed planting, and iii) to examine if the crop age (source of vines) has any effect on sprouting ability of the vines when subjected to delayed planting. The finding from this study was meant to guide farmers on the appropriate conducts with securing, handling and storage of vines prior to planting for appreciable sweetpotato crop yield.

Materials and Methods

The study was conducted at Gairo, a District in the Morogoro Region which is dominated by dry weather condition typical of Central Tanzania. The soil characteristic of the experimental site was clay loam. The area is characterized by prolonged dry spells of about five months with short rains, which normally begins in October. The average annual rainfall ranges from 500 to 800 mm. The district is a hilly (class T-Hypsographic) located at an elevation of 1531 meters above sea level (Rees *et al.,* 2001). Sweetpotato varieties viz Naspot 11, Morogoro and Polista were used in the current study. Various sweetpotato varieties were established at the SUA Crop Museum to serve as seedling nursery (source of vines) prior to experimentation. The vines (30 cm long) were harvested from a 2-month and 4-month old crop. The experiment was laid out as 2 x 3 x 3 factorial combinations on a randomized complete block design (RCBD). These factors were crop age at vine harvesting (two and four months), varieties (Naspot 11, Morogoro and Polista), and storage period prior to planting (immediately planted after harvest, stored for three days and stored for six days). The first course of the experiment was conducted at the onset of short rains from November 2015 to January, 2016 and repeated at the onset of long rains from March to May, 2016.

Data collection

Data were collected on various growth parameters including; the time to sprouting, crop vigour, stem size, number of roots, root size and sprout length for two months after planting. Number of days to first sweetpotato vine sprouting was obtained as the difference between the date of planting and date of emergence of the first sprout. The number of days to 50% sprouting was obtained as a difference between the date of planting and date when 50% of planted vine cuttings had produced sprouts. The number of roots per stem cutting was obtained by carefully up-rooting the cutting and counting the number of developed roots per cutting one month from the date of planting. Prior to uprooting digging of soils were carefully done around the stem at approximately 30 cm radius. The whole plant and surrounding soils was lifted carefully onto a plain polyethene bag (used as a matt) and the soils dislodged to free the plant roots. Only roots attached to the vines were counted and in any case of some root pieces observed in the soils but not directly connected to the vines, they were disregarded in the counting. The sprout size was determined by measuring the length and diameter of sprout at 5 cm from the knuckle of the first sprout one month from the planting date. The measurements were obtained by using a ruler and manual veneer caliper (Figure 1). The root size was estimated by measuring the length and diameter at 2 cm from the knuckle of the first root, one month from the date of planting. The measurement was also taken by using a veneer caliper.

Data handling and analysis

The collected data were subjected to statistical analyses for ANOVA and mean separation test in a CoStat (Version 6.45) Computer Software.

Results

The days to the first sprout were significantly ($P<0.05$) influenced by the crop age at which the vines were harvested (Table 1). Vines that were obtained from four months old crop took fewer days (15 days) to produce the first sprout compared to those obtained from two months old crop that took 21 days. The duration of vine storage prior to planting; likewise influenced significantly ($P<0.05$) the time to first and 50% sprout (Table 1). Vines that were stored for three and six days took longer days (18 and 21 days respectively) to produce the first sprout than those planted immediately after harvest which took 16 days. A comparative analysis of the interaction among varieties with age of crop and vine storage time suggested insignificant influence (P>0.05) on duration to the first sprout production. Results on the interaction among varieties and crop ages from which vines were obtained were insignificant (P>0.05), as well as the interaction between varieties and storage time (Table 2).

The days to 50% sprouting was significantly (P<0.05) influenced by varieties, age and storage time. The interaction between crop age from which the vines were obtained and the vine storage time prior to planting; likewise influenced the duration significantly to 50% sprouting (Table 2). Varied responses were demonstrated by the varieties, whereby Polista and Naspot 11 took longer time (19 days) to attain 50% sprouting while Morogoro took fewer days (17 days) to attain the same (Table 1). Vines aged four months took fewer (14) days to attain 50% sprout, especially those planted immediately after harvest than vines obtained from the younger crop (two months) and stored for three and six days.

Root formation trend observed at one months after planting suggested a significant (P<0.05) influence of varieties and crop age during which vines were harvested. The interaction between crop age and storage time was also significant (P<0.05) (Table 2). Assessment of varieties indicated that Morogoro had more roots per stem than Polista and Naspot 11 (Figure 1). Sweetpotato vines obtained from a four-month crop had fewer roots per stem than ones from a two-month old crop. The storage duration before planting insignificantly (P>0.05) affected the number of roots. Likewise, the interaction between varieties, crop age and storage time did not influence the observed number of roots.

Obtained results on sprout diameter and length suggested a significant difference

Figure 1: Regeneration of sweetpotato vines subjected to varied treatments prior to planting: A, vines planted immediately after harvesting; B, Sweetpotato vines stored for three days prior to planting; C, Sweetpotato vines stored for six days prior to planting.

Table 1: Effect of varieties, Vine age and storage time on regeneration of sweetpotato vines

Varieties	Growth parameters						
	Days to 1st sprout	Days to 50% sprout	No. of roots	Sprout diameter	Sprout length	Root diameter	Root length
Naspot 11	9.17a	18.44a	11.59b	5.69a	18.23b	1.57b	18.07a
Morogoro	8.44a	16.94b	16.78a	5.09b	14.48c	1.97ab	8.62c
Polista	9.83a	19.33a	11.68b	4.95b	24.96a	2.24a	11.54b
Mean	9.15	18.24	13.35	5.26	19.22	1.92	12.74
SD	2.94	5.123	12.61	1.59	22.46	1.42	20.54
CV%	32.21	28.08	94.5	30.3	117.04	73.84	161.15
P-Values	0.0714	0.0002	0.0001	0.0002	0.0001	0.0013	0.0001
Age of vines							
2 Months	11.33a	20.93a	17.72a	3.98b	17.09b	1.13b	10.29b
4 Months	6.96b	15.56b	8.98b	6.54a	21.34a	2.71a	15.19a
Mean	9.15	18.24	13.35	5.26	19.22	1.92	12.74
SD	16.06	19.74	32.13	9.41	15.59	5.81	18.08
CV%	175.53	108.18	240.67	178.81	81.13	301.88	141.48
P-Values	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Storage period							
0 days	7.89b	16.72c	13.78a	5.31a	20.63a	2.08a	13.12a
3 days	8.94b	18.06b	12.76a	5.29a	19.20ab	1.85a	12.24a
6 days	10.61a	19.94a	13.51a	5.18a	17.83b	1.84a	12.87a
Mean	9.15	18.24	13.35	5.26	19.22	1.92	12.74
SD	5.823	6.87	2.253	0.298	5.946	0.581	1.911
CV%	63.65	37.66	16.88	5.66	30.94	30.22	14.993
P-Values	0.0002	0.0001	0.417	0.691	0.013	0.268	0.585

Values followed by same letters in the column are statistically insignificant; Where a>b>c

Table 2: Combined effect of varieties, storage time and crop age on regeneration of sweetpotato

Variables	Growth parameters						
	Days to 1st sprout	Days to 50% sprout	No of roots	Sprout diameter	Sprout length	Root diameter	Root length
Replications	3.63ns	6.02ns	382.5***	2.27***	98.96***	3.66***	74.2***
Variety(A)	8.69ns	26.24***	159.17***	2.54***	506.05***	2.02**	421.7***
Age(B)	257.85***	389.35***	1032.28***	88.53***	243.19***	33.7***	325.1***
Storage days(C)	33.91***	47.19***	5.08ns	0.09ns	35.35*	0.34ns	3.65ns
AXB	0.13ns	0.69ns	6.33ns	0.10ns	5.54ns	2.58***	10.56ns
AXC	0.91ns	1.63ns	3.19ns	1.08**	47.02***	0.18ns	4.63ns
BXC	100.46***	122.74***	198.13***	3.79***	24.86*	1.09*	88.73***
AXBXC	0.07ns	2.074ns	5.72ns	0.21ns	11.16ns	0.06ns	2.53ns
Error	3.041	2.293	5.659	0.237	7.106	0.246	6.701
CV%	19.063	8.302	17.82	9.252	13.869	25.806	20.315

*Where * ; ** and *** are significant at P<0.05, 0.01& 0.001 respectively, ns is non-significant*

($P<0.05$) among sweetpotato varieties, age of crop at vine harvesting and storage time (Table 2). Generally, the sprout size was much influenced by the botanical of respective varieties. Naspot 11 had a larger sprout diameter than Morogoro and Polista (Table 1) regardless of vine storage time prior to planting (Figure 1). Sprouts from vines that were obtained from a crop aged four months had a relatively larger diameter than those obtained from a two-month aged crop (Table 1). The vine storage period insignificantly ($P>0.05$) affected the sprout size.

Sweetpotato varieties and crop age at which vines were harvested suggested significant ($P<0.05$) influences on root diameter and length for the new sprouts (Table 2). The vine storage period did not affect ($P>0.05$) root size. Significantly ($P<0.05$) larger root size (diameter and length) was recorded in variety Polista compared to var. Morogoro and Naspot 11 (Table 1). Vines obtained from a four-month crop set larger root sizes than two months aged crop and the difference was significant ($P<0.05$). Variety Naspot 11 had significantly ($P<0.05$) longer roots compared to Polista and Morogoro.

Discussion

Results suggested that vines stored for three and six days took relatively longer to produce sprouts than those planted immediately after harvest. The present findings contradict the report by Hammett (1985), who indicated that storing vines for less than 7 days provides callus formation, hence early sprouts. The possible cause for such observation is the limited obstruction of the growth hormones and less accumulation of Abscisic acid (ABA) in immediately planted vines compared to late planted ones as was observed elsewhere (Holwerda and Ekanayake, 1991). Conversely, the same growth inhibiting hormone was triggered by delayed planting such that the numbers of days taken to first sprout were proportional to the vine storage duration before planting. The ABA promotes dormancy in seeds and vegetative buds particularly when conditions are unsuitable for plant's proper growth (Wikipedia, 2020).

During the storage period, roots will develop at the base of the cuttings, which is called pre-sprouting or callusing, and the cuttings can be carefully planted with the roots. The importance of storing the vine cuttings is to harden them; that is, they become tougher and more resistant to the shock of planting. The establishment is faster when vine cuttings are pre-sprouted (Huaman, 1992). The reported findings (Bartolini and Fabbri, 1988) that storing vines for some days before planting allows cuttings to form callus for root development before planting, thereby providing for fast regeneration, could not be justified in the present study. Suggestively, the time taken for regeneration of vines, regardless of whether directly planted or kept for few days, depends on the varieties characteristics and prevailing weather conditions. Storage of vines before planting was more damaging to vines obtained from immature compared to mature crop. It took longer for the former to sprout compared to the later.

Physiologically immature plants are often prone to excessive water losses due to high number of stomata and limited cellulose accumulation, making them prone to evapotranspiration losses. Stomata of young leaves are insensitive to major closure signals by the ABA (Pantin *et al.,* 2013). Moreover, young vines do not have enough food reserves (Calverley, 1998) to allow extended stay out of the ground prior to actual planting. Thus, the shock suffered could have led to delayed regeneration of vines after planting. According to Stathers *et al.* (2013), sweetpotato vines can be kept for a maximum of seven days before deterioration, leading to a substantial reduction in storage root yield, while storing vine cuttings for one to three days does not adversely affect the final yield.

Although the yield losses attributed to delay in planting within seven days are limited the magnitude may sometimes be compounded by the field conditions during planting, particularly when moisture stress is prevalent. Gibson *et al.* (2009) suggested that desiccation with subsequent rotting that may lead to total loss of sweetpotato planting materials is a common phenomenon in drier areas of East Africa where vines are harvested and traded for some days prior to planting. Leihner's work on cassava (Leihner, 1984) indicated that loss of moisture is among the important processes that occur on planting materials during storage which has a strong influence on viability of cassava planting material and probably affects the biochemical transformations within the stakes. Once lost from a stake, moisture is reabsorbed only in small quantities when dehydrated stakes are submerged in water and rehydration only improves sprouting, growth and eventually yields when the moisture content had not fallen below a critical level Sungthongwises *et al.* (2016). Therefore, sweetpotato vines should be directly planted, but if not possible, the storage period should not exceed six days.

Conclusion

The present study suggested that planting vines should be harvested from a crop older than two months particularly when directly planting in uncertain. Vines obtained from a four-month old crop can be stored for about three to six days without affecting the sprouting, although the delayed establishment of newly planted crop should be expected. Harvested vines should be directly planted in the field to avoid delayed sprouting and subsequent crop establishment. In dry areas like Gairo where a shortage of vines is not uncommon and direct planting is hard to achieve, the shortest time possible of about three days should be allowed before actual planting to avoid desiccation and deterioration of vines which often affects the establishment of the resultant crop.

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