Vol. 17(2), pp. 208-214, February, 2021
DOI: 10.5897/AJAR2020.15164
Article Number: BB527FE65952
ISSN: 1991-637X
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African Journal of Agricultural Research

Full Length Research Paper

Evaluation of different methods of multiplying sweet potato planting material in coastal lowland Kenya

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Received 25 August, 2020; Accepted 18 December, 2020

Sweet potato (*Ipomoea batatas* (L.) Lam.) is a staple food that contributes to food security for communities in sub-Saharan Africa. The production of sweet potato in coastal Kenya is low and this has been associated with shortage of planting material during the rainy season. A study was therefore conducted at the Pwani University farm to assess the production of sweet potato planting material using cuttings planted under different methods. The methods that were evaluated in this study were: Planting in pits without lining, planting in pits with lining, planting on ground surface, planting in sacks without lining and planting in sacks with lining. A randomized complete block design was used, with factorial arrangement of treatments. Fifteen treatments were replicated in three blocks. In the long rains season, sweet potato in the treatments without lining produced longer vines than those with lining. Different vine planting methods produced similar vine lengths in the off-season multiplication. The planting methods without lining are recommended for use by farmers during the long rains season multiplication of planting material. It is also recommended that farmers start the multiplication during off-season and continue during the long rains season so as to multiply enough planting material that will allow expansion of the area under sweet potato.

Key words: Food security, *Ipomoea batatas*, low production of sweet potato, off-season multiplication, vine planting methods.

INTRODUCTION

Sweet potato (*Ipomoea batatas* [L.] Lam) is an important tuber crop grown in over 120 countries in the world, on about 8 million hectares of land, and with a total annual production of about 92 million tons with a yield of 11.4 t ha^{-1} (FAO, 2018). The crop grows in a wide range of soils but prefers moderately fertile, well-drained, deep, light and medium textured soils, with pH ranging from 4.5 to 7.0 (Abidin et al., 2017; Makini et al., 2018). It requires annual rainfall of between 750 and 1,000 mm per year and is sensitive to drought during establishment and tuber initiation 30-50 days after planting (Abidin et al., 2017; Makini et al., 2018). Adequate drainage and aeration is important for the crop because it is intolerant to water-logging conditions (Makini et al., 2018). According to Abidin et al. (2017), optimal growth of sweet potato occurs at day-time temperatures of 25 to 30°C and

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night-time temperatures of 15 to 20°C.

Lack of access to sufficient planting material at the beginning of the rains is one of the value chain challenges in the predominantly smallholder-based sweet potato production systems in sub-Saharan Africa (SSA) (Low et al., 2020). According to Low et al. (2020) accessing planting material of adapted cultivars is among the challenges that should be properly tackled for achieving dissemination and wider adoption of improved sweet potato cultivars in SSA. The major constraint hindering the attainment of full production potential of sweet potato in Kenya is inadequate planting material at the onset of planting season (Njeru et al., 2004; Gichuki and Hijmans, 2005). Ume et al. (2016) reported vine shortage as one of the major constraints of sweet potato production in Ebonyi State, Nigeria.

The difficulty in conserving and accessing sweet potato vines during long dry spells was reported as a key sweet potato farming challenge for farmers in Bungoma and Homa Bay counties, Kenya (Mudege et al., 2020). Namanda (2012) showed that farmers in eastern Uganda suffer a chronic shortage of planting material at the beginning of the rainy season. In a study conducted in Ethiopia, Aldow (2017) found that where planting time is once a year in the main rainy season, farmers cannot save sweet potato vines for the next planting season because of the long dry season. However, where farmers plant sweet potato twice a year they are able to save planting material after harvest by planting sweet potato vines near their homes (home garden) during the dry season, to serve as source of planting material for the next planting season (Aldow, 2017; Gurmu et al., 2019). In Malawi, farmers experience insufficient planting material at the onset of rains and have to wait for the sprouting of sweet potato in the early weeks of the rainy season, leading to late planting (van Vugt and Franke, 2018). This is also the case with sweet potato farmers in coastal lowland Kenya.

On average, farmers in coastal lowland Kenya, plant 0.5 acres of sweet potato (Makini et al., 2018). Even if farmers wanted to expand their area under sweet potato they are limited by the amount of planting material available at the start of the planting season (Mzinga, personal communication). In a study conducted in Northeastern Uganda, Abidin (2004) observed that sweet potato is mostly planted late in the planting season due to lack of planting material early in the season. Shortage of planting material was reported by more than 80% of farmers in Ethiopia as one of the major sweet potato production constraints in that country (Gurmu et al., 2015).

It has been observed that the dry conditions that are experienced between cropping seasons cause death of sweet potato vines that remain on farms after harvest, thus contributing to their shortage in the succeeding season (Mwololo et al., 2012; Abdallah, personal communication). Mwololo et al. (2012) reported depressed vine yields due to drought in some study sites in coastal Kenya, including Mwaluvanga and Lukore. Farmers in the region have the option of multiplying planting material off-season under irrigation or at the onset of rainy season, since they normally plant their crop mid-season after the peak of the rains.

Gibson et al. (2009) recommended intensive methods of conserving planting material using domestic wastewater as a partial solution to shortage of planting material. Isubikalu (2007) reported that farmers in Soroti district of Uganda developed mechanisms and strategies to manage vine availability. These included plot reservation and use of tubers, establishment of sweet potato gardens under a large shade tree, and planting sweet potato vines in swamps during the dry season. McEwan et al. (2017) showed that farmers in the Lake Zone of Tanzania, who have access to lakesides or swampy areas, were using these lands to conserve planting material during the dry season. In Southern Tigray, Ethiopia, lack of sweet potato planting material has prevented farmers from planting the crop (Aldow, 2017).

Maintenance of planting material during the prolonged dry season is a challenge, and results in delayed planting to allow for the bulking of sufficient planting material early in the rainy season (Stathers et al., 2018). Stathers et al. (2018) therefore recommended vine conservation techniques that included small-scale dry season irrigation to help provide significant quantities of planting material at the beginning of the rains. Okonya and Kroschel (2014) showed that farmers with swamp land in six districts of Uganda were able to benefit from sale of sweet potato vines at the start of the cropping system.

In some parts of coastal Kenya such as Rabai and Kanana, farmers conserve sweet potato vines outside bathrooms (Plate 1) and in swamps (Plate 2) during the dry season in order to have some planting material at the onset of the cropping season. Considering that sweet potato is a supplementary staple to the cereals, as well as a household food security crop (Jia, 2013), there may be food insecurity in the sweet potato growing areas in coastal lowland Kenya if the production is not increased. This calls for efforts to address the constraints limiting the production of the crop, especially inadequacy of planting material during the cropping season. There is also need for sweet potato multiplication technologies that are adaptable to changes in climatic conditions since the swampy areas, where farmers used to multiply planting material, have continued to dry up due to reduced rainfall. A study was therefore conducted to evaluate technologies for production of sweet potato planting material. This study aimed at enhancing sweet potato production in Kwale and Kilifi counties through increased production of planting material and thus increasing its availability to farmers at the onset of the subsequent cropping season. Timely provision of sufficient sweet potato planting material to farmers will help in increasing

Plate 1. Planting material being preserved outside a bathroom in Rabai, Kilifi County, Kenya.

Plate 2. Planting material being preserved in a swampy area in Kanana, Kwale County, Kenya.

production and meeting the demand for the crop in the region.

MATERIALS AND METHODS

Site description

A study to evaluate the production of sweet potato planting material using cuttings planted under different methods was conducted in coastal lowland Kenya in 2018, at the Pwani University farm in Kilifi County. The site is located within the Coastal Lowland Agro-ecological Zone IV (CL4), at an altitude of 15 m above sea level. It lies between latitudes 3 and 4° South and longitudes 39 and 40° East (Jaetzold et al., 2012). The area receives bimodal rainfall, with the annual rainfall ranging from 1,000 to 1,100 mm. The long rains season starts from April and ends in July/August while the short rains season starts from October and ends in December. The area has a long dry season from January to March. The temperature range is from 22 to 30°C and the mean relative humidity is about 80% (Jaetzold et al., 2012). The soils at Pwani University farm are

Plate 3. Multiplication of planting material under shade-net.

mostly Ferralsols, with low organic matter (5-16 g kg^{-1}), low nitrogen content (0.7 g N kg^{-1}) and a pH between 5 and 7.

Treatments

The following treatments were evaluated in this study:

Factor A: Three sweet potato clones bred for drought tolerance
(i) Drought tolerant sweet potato clone 4.2B - (C_7)
(ii) Drought tolerant sweet potato clone 7.6B - (C_8)
(iii) Drought tolerant sweet potato clone 4.2A - (C_9)

Factor B: Vine method of planting
(i) In pit with lining (PL)
(ii) In pit without lining (PWL)
(iii) In sack with lining (SL)
(iv) In sack without lining (SWL)
(v) On ground surface (OG)

Experimental design

A randomized complete block design was used, with a factorial arrangement of treatments. The treatments were replicated three times. Plots for Block 1 were established under a tree, those for Block 2 under shade-net (Plate 3) and those for Block 3 in the open field.

Crop establishment and management

The first trial coincided with the long rains season (April to July 2018), while the second trial was conducted off-season (August to October 2018), purely under irrigation. The first trial was meant to mimic the current farmers' practice of multiplying sweet potato planting material at the onset of the long rains season while targeting to plant the crop in May/June. Plots measuring 0.3 ×0.6 m were established. Each plot consisted of two rows, each 0.6 m long and spaced 0.2 m apart. Each row was planted with 6 vine cuttings, spaced 10 cm apart. Cuttings of three nodes were planted, with two nodes buried in soil. Di-ammonium phosphate (DAP) fertilizer was applied at planting, at the rate of 50 kg of P_2O_5 ha^{-1}. Irrigation water was applied as required to ensure the plots had optimal soil moisture throughout the growing period. Plants were hand weeded in the early growth stages of the crop. An insecticide, Dynamec 1.8 EC (Abamectin 1.8 g/l), was applied at the rate of 250 ml/ha as required to control insect pests (leaf defoliators and mites). Vines were trained to minimize their spread onto adjacent plots.

Data collected

Vine yield from each plot was determined by measuring the vine length using a tape measure at eight weeks after planting. The two rows of sweet potato in each plot were harvested for the determination of total vine length per plot. The total vine length per plot was then converted to total vine length per square meter (that is, vine yield or vine production potential) by using the following formula:

$$Y_v = \frac{L_p}{A_p}$$

where Y_v = vine yield (m m^{-2}), L_p = total vine length (m) per plot, and A_p = plot area in m^2.

The vine yield (vine production potential) was then used to calculate the land size that would be required to multiply enough sweet potato planting material for one acre, using the following formula:

$$A_a = \frac{C \ x \ L_c}{Y_v}$$

where A_a = land size (m^2) required to multiply enough sweet potato planting material for one acre, C = number of cuttings required to

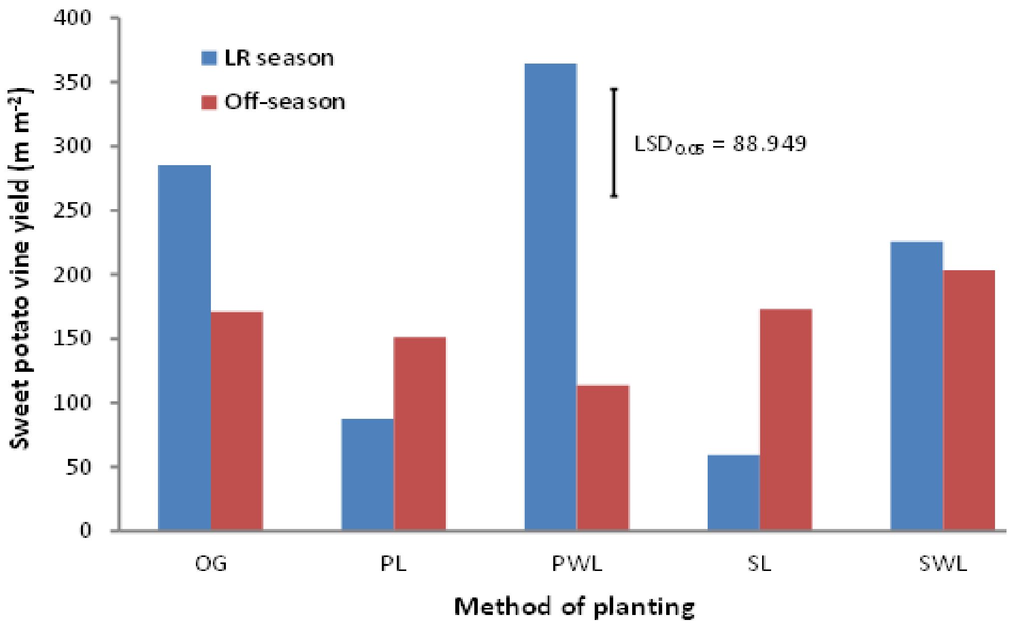

Figure 1. Effect of cropping season and method of planting on sweet potato vine length. LR = Long rains.

plant one acre, L_c = length (m) of a cutting, and Y_v = vine yield (m m^{-2}).

Data analysis

Vine yield data were subjected to the analysis of variance (ANOVA) using the General Linear Method (GLM) procedure of the Statistical Analysis System, SAS, Version 9.1 (SAS Institute, Inc, 2002). Square root transformation of the original data (n) was performed before analysis so as to improve the normality of the data. Where the F values were significant, treatment means were separated using the Least Significant Difference (LSD) at the 5% level of significance. The land size required to multiply sweet potato planting material for one acre was regressed against the vine production potential of sweet potato under different methods of multiplication.

RESULTS AND DISCUSSION

The results of this study showed significant (P = <.0001) interaction effect of cropping season and method of planting on sweet potato vine length (Figure 1). During the long rains season, sweet potato planted in pits without lining (PWL), or on ground surface (OG), or in sack without lining (SWL) had significantly longer vines than that planted in pits with lining (PL) or sack with lining (SL). This observation was not evident during off-season. This is probably an indication that when multiplication of sweet potato planting material is done solely under irrigation (as was done off-season), any of the methods of planting would give the same vine yield.

Sweet potato growth is known to be adversely affected by waterlogged conditions, according to Lin et al. (2006) who reported that the roots translocate low amounts of nutrients to the leaves when sweet potato is subjected to waterlogging conditions. It appears that rainfall received during the long rains season led to accumulation of excessive amounts of water in the soil for treatments with lining, leading to waterlogged conditions. The lack of significant differences between treatments (planting methods) without lining and those with lining during off-season is probably an indication that the irrigation water did not create waterlogged conditions in the treatments with lining, leading to similar rates of elongation of sweet potato vines with or without lining.

The results of this study also showed significant (P = <0.0001) interaction effect of cropping season and method of planting on the land area required to produce enough sweet potato vines to plant one acre of land (Figure 2). Sweet potato planted in the LR season on ground surface (OG), or in pits without lining (PWL), or in sack without lining (SWL) required significantly smaller land area than that planted in sacks with lining (SL). Similar results were not evident during off-season. This may have been an indication that when multiplication of sweet potato planting material is done solely under irrigation (as was done off-season), the same land area would be required under any of the methods of planting to produce material required for planting one acre. The lack of significant differences between planting methods without lining and those with lining during off-season may mean that any of the methods of planting would give the same amount of planting material required to plant one acre of sweet potato.

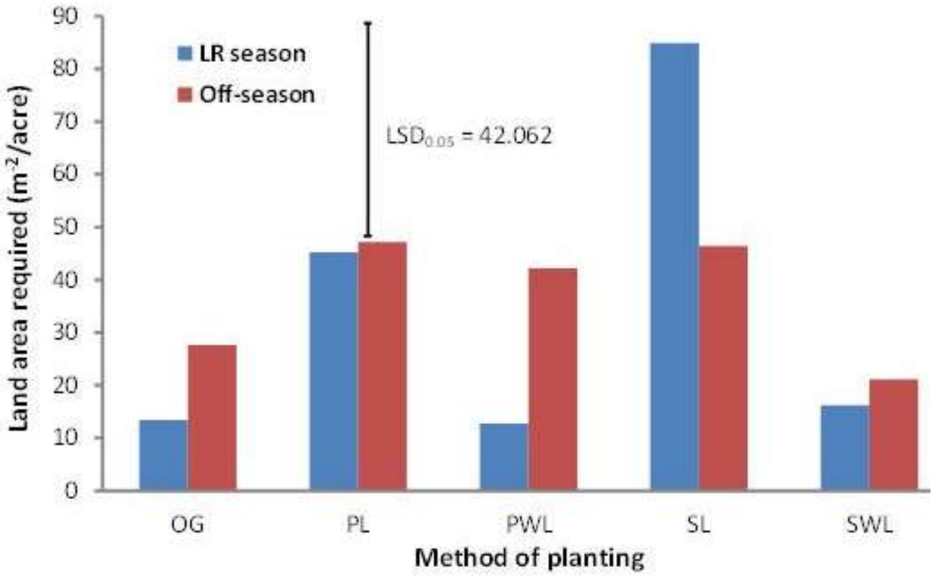

Figure 2. Effect of cropping season and method of planting on the land area required to produce enough sweet potato vines to plant one acre. LR = Long rains.

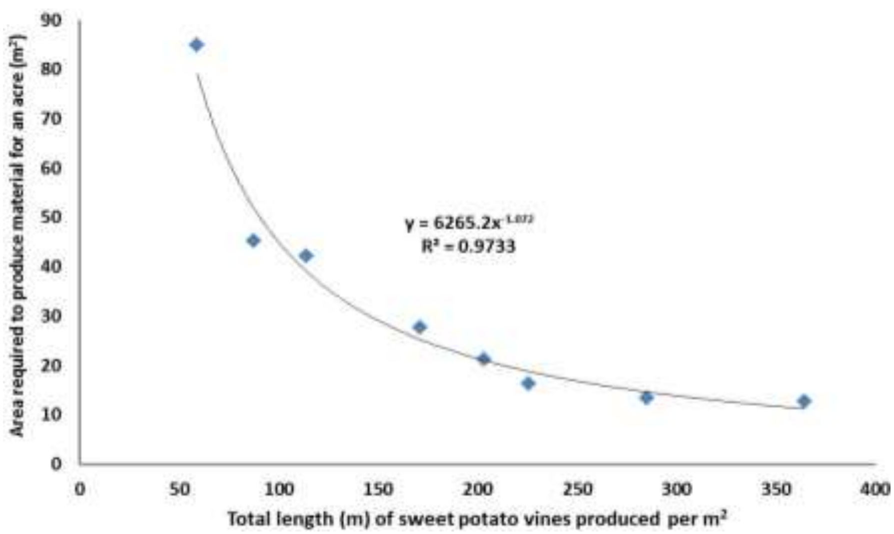

Figure 3. Relationship between vine yield and area required to produce material enough for an acre.

The amount of sweet potato vines used by farmers for multiplication of planting material under their current practice is normally limited due to the loss of vines experienced during the January-March dry spell that proceeds the long rains season. Off-season multiplication of planting material with irrigation would minimize the death of sweet potato vines due to drought, as it is currently experienced by farmers in coastal lowland Kenya. The material obtained from the off-season multiplication would enable farmers start the LR season multiplication with a lot more vines than they would without having done any multiplication during the preceding off-season. If farmers were to adopt off-season followed by LR season multiplication of planting material, they would produce enough material that would enable them expand the area under sweet potato production.

The results of this study showed that there is an exponential decrease in the land area required to produce enough sweet potato vines to plant one acre with increase in the total length of sweet potato vines produced from one square metre of land (Figure 3). The coefficient of determination (R^2 =0.9733) shows that around 97% of the land area required to produce enough sweet potato vines to plant one acre could be explained by the increase in the total length of sweet potato vines produced on one square metre of land, and only 3% of the results was due to random variation. Figure 3 is therefore a useful tool that may be used by farmers who are planning to produce sweet potato planting material. Using this tool, they would be able to estimate the land area they will have to set aside for the production of sweet potato planting material, depending on the vine production potential of a given sweet potato variety. The higher the vine production potential of a given sweet potato variety, the less the land size needed to multiply enough planting material for one acre.

Conclusion

During the long rain season, treatments without lining had longer sweet potato vines and required smaller land area to produce material required to plant one acre of sweet potato than those with lining. However, in the off-season multiplication of vines with irrigation all the treatments had similar vine length and therefore required the same land area to produce material to plant one acre.

For the long rains season multiplication of sweet potato planting material, it is recommended that farmers plant the vines on ground surface or in pits without lining or in sacks without lining. This would allow free drainage of water and minimize chances of waterlogging. For off-season multiplication under irrigation, farmers can use any of the methods of planting. To multiply enough planting material that will enable farmers expand the area under sweet potato, it is recommended that they start the multiplication during off-season and continue during the long rains season.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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