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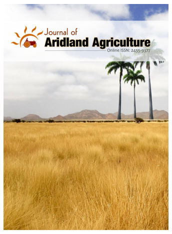

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Effect of cutting position and vine pruning level on yield of Sweet Potato (*Ipomoea Batatas* L.)

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ABSTRACT

There is yawning variation in yield of storage roots and vines of sweet potato (*Ipomoea batatas*) among farmers due to use of different cutting positions and pruning of vines at different levels. This study was carried out to establish the cutting position and the vine pruning level that give the best yield of both the storage roots and vines. The study was conducted in a 3x3 factorial arrangement in Randomized Complete Block Design (RCBD) with three replications. Treatments included cutting position at three levels (apical cutting, middle cutting and basal cutting) and pruning at three levels, 0%, 25% and 50% respectively. Pruning was done. 50 days after planting. And storage root harvesting was done 100 days after planting. The two measurements were summed up to give the total vine weight. Storage root length, diameter and weight were measured at 100 DAP. Storage root length indicated significant difference ($P<0.05$) only among cutting positions with highest mean length (16.20 cm) obtained from apical cutting and the lowest (11.98 cm) from basal cutting. Storage root diameter, storage root weight and vine weight indicated significant interaction ($P<0.05$) of cutting position and vine pruning level. Highest mean root diameter and root weight were obtained from middle cutting and 25% vine pruning level, with the lowest being obtained from basal cutting and 50% vine pruning level. Highest vine weight was recorded from middle cutting and 50% vine pruning level, with the lowest being recorded from basal cutting and 0% vine pruning level. Both middle and apical stem cuttings can be recommended for higher storage root and vine yield. Vine pruning at 25% can be adopted for higher storage root yield while pruning at 50% can be suggested for higher vine yield.

KEYWORDS: Sweet potato (*Ipomoea batatas* L.), cutting position, vine pruning, storage root, yield

INTRODUCTION

Sweet potato (*Ipomoea batatas L.*) is a herbaceous perennial root crop belonging to *Convolvulaceae* family. It is characterised by creeping vines and adventitious roots [1-3]. The crop came into Africa through trade from South America where it originated [4]. Africa's average yield is 6 t/ha while the world production reaches the average yield of 14 t/ha [5]. Among root and tuber crops grown in many parts of tropical and Sub-Sahara Africa, sweet potato ranks third after Irish potato and cassava in consumption [6].

Sweet potato performs well even in drier parts of Zimbabwe [7]. Intensive production is mainly referred to agro-ecological regions I, II and III in which Manicaland, Mashonaland, Midlands and some parts of Masvingo are located [3,5]. Prodigious increase in prices of fertilizers and pesticides caused resource-poor farmers to gravitate from maize, cotton and tobacco production to less input demanding sweet potato [8]. Adaptability of sweet potato to marginal environments allows resource-poor farmers to achieve higher yields of up to 15 t/ha with minimum use of fertilizers and herbicides [3,9]. However, yield of up to 50 t/ha can be attained with sufficient moisture, proper fertilization and improved varieties [3,10].

Among common sweet potato varieties grown in Zimbabwe; Bambas, Brondal, Imby, Chigogo, Cordner and German 2 are red skinned while the white skinned varieties are ChiZambia and Pamhai [5]. Sweet taste and prolonged shelf-life make German 2 popular at Bulawayo and Gweru vegetable markets.

Annual consumption per capita of sweet potato storage roots is gradually increasing, being estimated at 1-7kg in urban and 3-5kg in rural communities of Zimbabwe [3,5,7]. However, sweet potato is not only grown for human consumption but the forage is an essential resource for feeding animals [4,11,12].

In Zimbabwe, sweet potato is mainly propagated by stem cuttings using atavistic experience through indigenous knowledge systems. Some farmers plant apical stem cuttings only while others plant apical, middle and basal cuttings. Belehu [1] stipulated that cuttings from apical portion are preferred to those from the middle and basal portions of the stem [1]. However, Low *et al*. [13] reported that there is shortage of planting material in Sub-Sahara Africa because nurseries owned by smallholder farmers are small and most of them are located at small backyard spaces or near washing areas where they are irrigated by hard water [13]. Middle and basal stem cuttings can be used when there is bottleneck in supply of planting material [1].

Vine management is also done through indigenous knowledge systems. Some farmers prune vines at different levels depending on the purpose of pruning while others do not practise pruning. Use of sweet potato shoots as vegetable, planting material or forage promotes shoot removal and this is expected to decrease the supply of photosynthates to the growing storage roots [11]. Use of pruned sweet potato vines for feeding animals in developing countries may be beneficial due to gradual increase in prices of commercial feeds [14].

Although sweet potato is a crucial root crop with increasing annual consumption per capita in Zimbabwe, its production is limited by shortage of planting material and improper vine pruning regimes for feeding animals. Mulungu stipulated that both the storage roots and vines are essential resources for human and animal consumption [11]. The information about dual-purpose attributes of different sweet potato cultivars and vine harvesting regimes to optimize yield of fodder without disturbing root yield is limited [15]. Consequently, planting of stem cuttings from different positions along the stem and pruning of vines at different levels might have resulted in yield variations among farmers. This research therefore sought to determine the best cutting position and vine pruning level for farmers to meet high and reliable yield of both the storage roots and vines.

MATERIALS AND METHODS

Site Description

The experiment was conducted at Midlands State University located in Midlands Province under Zimbabwe's Agro-ecological region III. The average annual rainfall is 674 mm. The study site is characterized by sandy loam soil which falls under fersialitic group with dominant kaolinite clay minerals [16]. The pH of the soil before conducting the experiment was 5.8.

Experimental Design

A 3x3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications was used. There were two factors (cutting position and vine pruning). Apical, middle and basal cuttings were used. Vine pruning was expressed as 0%, 25% and 50% respectively.

Experimental Procedure

The experimental plot was tilled to a depth of 40 cm using a disc plough. Twenty-seven identical ridges were aptly constructed. The length, width and height of each ridge were 120 cm, 50 cm and 40 cm respectively. The space between ridges was 50 cm while the distance between blocks was 100 cm. Compound S (7: 21:7) was banded at a rate of 450 kg ha^{-1} and covered with soil to a depth of 10 cm.

The popular variety in the area, German 2, was used. This is superior in terms of vine production, yield per unit area and keeping quality. It is characterised by purple stems and branched green leaves. Storage roots are red skinned and white fleshed. It is a short-season variety which takes 3-4 months to mature.

Apical, middle and basal stems were cut into 30 cm pieces. Cuttings from each of the position were planted on nine ridges per block. Cuttings were planted at a spacing of 30 cm along the ridge using looped planting orientation. Each ridge accommodated four cuttings leaving 15 cm on both ends. For every cutting, only three nodes were buried and both ends were left uncovered.

Vine pruning was done at 50 days after planting (DAP). Pruning was done at 0%, 25% and 50% levels respectively. To allow re-growth, vines were cut at 15 cm above ridge level. Vine pruning percentages were achieved through counting the number of stems per plant and number of leaves per stem. The number of stems to be cut was determined by the number of leaves per stem. Other standard agronomic practices for the crop were followed.

Data Collection

Vine weight was measured 50 DAP and at100 DAP. Storage root weight, length and diameter were measured at harvest. Vine and root weights were measured using a digital scale and expressed in tonnes per hectare. Storage root length was measured in cmusing a tape measure and a Vernier calliper was used to measure storage root diameter and expressed in cm/plant.

Data Analysis

The data was analyzed statistically using Analysis of Variance (ANOVA) technique with GenStat version 14 software. Comparison of treatment means was done using the Least Significance Difference (LSD), at 5% significance level.

RESULTS

Mean Length of Storage Roots

Data regarding length of storage root showed significant differences ($P<0.05$) for the vine cutting position (Figure 1). The mean shortest root length (11.98 cm) was observed from vines cut from the basal portion. The storage root length recorded from apical and middle cuttings treatments, 16.20 and 15.87 cm respectively, were however not significantly different (P>0.05) from each other.

There was no significant (P>0.05) influence of the vine pruning on the mean root length obtained at all pruning level treatments (0%, 25% and 50%). Also, data regarding cutting position and vine pruning level treatments also showed no significant interaction (P>0.05) to influence mean root length. Mean storage root length was 14.68 cm.

Mean Storage Root Diameter

As indicated in Table 1, there were significant differences (p<0.05) for cutting potion and vine pruning level treatment with regard to storage root diameter. Storage roots with the largest diameter (36.1 cm) were recorded from middle cuttings and 25% pruning level treatment while the smallest tuber diameter was recorded from a treatment of basal cuttings and 50% pruning level. There was significant interaction (p<0.05) between cutting positions and vine pruning level treatments on the storage root diameter. Mean storage root diameter was 29.99 cm.

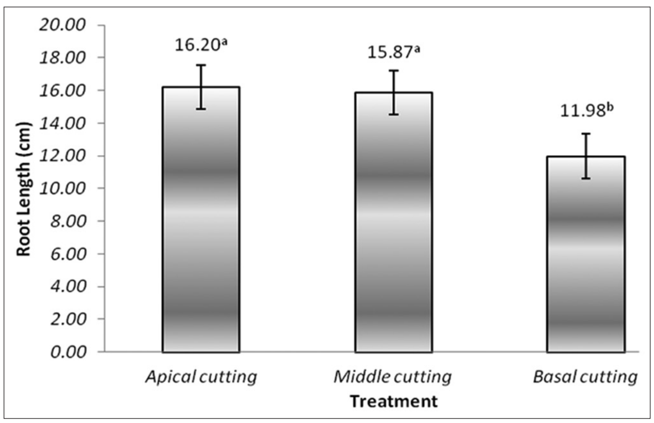

Figure 1. Mean storage root length

Table 1: Shows the means of root diameter, root weight and vine weight as affected by vine cutting position and vine pruning level

Treatment	Root diameter	Root weight	Vine weight
Cutting position(C)			
C apical	31.689b	29.533b	19.392b
C middle	32.378c	29786b	20.491c
C basal	25.911a	25.022a	18.811a
Significance	*	*	*
%Pruning level(P)			
P^{0}	32.889b	30.263b	15.036a
P^{25}	33.367b	30.396b	20.887b
P^{50}	23.722a	23.682a	22.771c
Mean	29.993	28.114	19.565
Significance	*	*	*
$LSD_{0.05}$	0.5094	0.3862	0.4772
CxP			
Significance	*	*	*
LSD	0.8823	0.6689	0.8265
CV%	10.7	6.7	5.2

*Denotes significance at P<0.05. ns denotes non-significance.

Mean Storage Root Weight

The comparison of the treatment means regarding storage root weight was significant (P<0.05) for vine cutting position and pruning level (Table 1). The highest tuber yield (32.26 t ha^{-1}) was recorded from middle cuttings and 25% vine pruning level treatment. The treatment, basal cuttings and 50% pruning level, recorded the lowest tuber yield of 21.62 t ha^{-1}. The comparison of results also showed that there was significant interaction (P<0.05) between cutting positions and vine pruning level treatments on tuber weight. Mean total tuber weight was 28.11 t ha^{-1}.

Mean Total Vine Weight

Data pertaining to total vine weight revealed that there was significant (P<0.05) differences among the means for the treatments investigated (Table 1). The highest vine yield (23.55 t ha^{-1}) was recorded from middle cutting and 50% vine pruning level treatment, while the lowest yield (14.89 t ha^{-1}) was recorded from basal cutting and 0% vine pruning treatment. There was significant (P<0.05) interaction between cutting position and vine pruning level on total vine weight. Mean total vine weight was 19.57 t ha^{-1}.

DISCUSSION

Mean Storage Root Length

The significant difference (P<0.05) on average root length among cutting positions could be as a result of fast root establishment on apical cuttings. Unlike basal cuttings, apical cuttings have new and active cells which support the development of lateral roots through the supply of auxin from growing apical point. Apical cuttings supply the establishing roots with starch stored in the stem cells since they have higher starch level than lignin. The growing tip of the apical cutting also grow nippily and support growth of new shoots that in turn photosynthesize to supply roots with photosynthates. Also young nodes near the vine apex result in fast growing lateral roots that bulk to form storage roots [1]. Nedunchezhiyan *et al.* [4] argues that basal portion of the vine usually provide thick and woody cuttings which are characterised by poor root establishment and growth [4]. Apical cuttings probably developed longer lateral roots before root bulking. The length of lateral roots attained before root bulking is a determinant of storage root length since storage root bulking initiates with the accumulation of starch at the distal end of lateral root, proceeding upwards to the proximal end. Increase in the root length at distal end after first deposition of starch is only for water and nutrient uptake and not for bulking into storage root. The root stalk length is cultivar dependent; hence length of storage root is confined between the distal point of first starch deposition and the lower end of root stalk. Lewthwaite and Triggs in [7] attributes this to the bulking of sweet potato storage root that begins with deposition of carbohydrates near the root apex and the deposition continues upward to the lower end of storage root shoulder [17]. They also explained that the length of root stalk is a morphological cultivar descriptor.

Mean Storage Root Diameter

There was significant interaction between cutting positions and vine pruning levels on storage root diameter. Thickest roots were obtained from middle cuttings because of development of more stems as compared to apical and basal cuttings resulting in more leaves for photosynthesis and more apical shoots for auxin production. Higher level of auxin promotes elevated cell division, elongation and maintenance of meristematic state in cambial cells of growing roots after transport of auxin from apex of stem shoot. Unlike apical cutting, middle cutting has no growing tip resulting in complete suppression of apical dominance during cutting preparation and this enhances development of many shoots. These results are akin to those by Rasco and Amante who reported that middle cuttings can perform slightly better than the apical cutting especially in cultivars with fast growing vines resulting from apical dominance [18].

Basal cutting had the thinnest roots because of limited photosynthesis. Basal cuttings developed fewer and shorter vines as compared to middle and apical cuttings. Failure of the basal cutting to develop many and long vines might be a result of senescence and lignification of cells of the cutting. Basal cutting also developed fewer and shorter roots as compared to apical and middle cuttings. This might contributed to the reduction in storage root diameter due to limited water and nutrient uptake. Belehu in 2003 also stipulated that basal cutting has a poor root establishment [1].

For all cutting positions, vine pruning at 25% had highest root diameter, followed by 0% and the lowest diameter was recorded from 50%. This could be attributed to development of new and more stems due to partial suppression of apical dominance. International Potato Centre reported that vine pruning is normally done at 40-60 days after planning and it is a multiplicative tool for generating more and new shoots to enhance photosynthesis [19]. Saraswati in 2007 concluded that the photosynthetic ability of sweet potato leaves is affected by age, with higher rate of photosynthesis being found in young leaves [20].

The thinnest roots from vine pruning at 50% could be an indication that over-pruning negatively affects root growth. Storage root growth might have been suppressed either through extremely reduction in photosynthesis just after pruning, development of excess vines after re-growth or overproduction of auxin by new shoots. Development of excess vines causes imbalances in distribution of photosynthates between storage roots and the tops. Overproduction of auxin also causes imbalances in the auxin to cytokinin ratio in the storage roots after transport of auxin from vine tips and this disturbs cell division and elongation [21].

Mean Storage Root Weight

The highest root yield was obtained from the middle cuttings because of development of more stems on the middle cutting as compared to apical cutting which is affected by apical dominance. Apical dominance is excluded from middle cutting during cutting preparation by removal of apical tip; hence more stem shoots develop enhancing photosynthesis and auxin production. Although the apical tip was removed during the preparation of basal cutting, it had the lowest root yield because of the failure to develop many stems as a result of senescence and lignification. Belehu also noted that basal stem cuttings are not preferred by farmers since they result in very low root yield [1].

For all cutting positions, pruning vines at 25% resulted in the highest storage root yield due to partial suppression of apical dominance for the development of many new shoots which are favourable for photosynthesis and auxin synthesis. Pruning vines at 50% has resulted in the lowest root yield due to extremely reduced photosynthesis just after pruning, imbalance in auxin to cytokinin ratio due to over-production of auxin after regrowth or imbalances in distribution of photosynthates between roots and the aboveground parts after re-growth. Increase in storage root size is a result of increase in the number of cells in which photosynthates are deposited to increase the root weight [22].

Total Vine Weight

There was significant interaction between cutting positions and vine pruning levels on total vine weight. The highest vine yield was recorded from middle cuttings as a result of development of more secondary stems due to partial suppression of apical dominance during cutting preparation as well as higher level of starch stored in the cutting. Rasco and Amante also reported that middle cutting can grow better than the apical cutting particularly in cultivars which develop long stems [18]. Basal cuttings had the lowest vine yield due to highly lignified cells of the cutting that probably resulted in poor root system for water and nutrient uptake to support vine growth.

Among all cutting positions, vine pruning at 50% resulted in highest vine yield as a result of tremendous suppression of apical dominance to promote the development of more secondary stems as compared to 25% and 0% pruning levels. Un-pruned plots had lowest vine yield due to apical dominance and shedding of lower leaves owing to senescence.

CONCLSION

Apical stem cutting had the longest storage roots as compared to middle and basal cuttings. Middle stem cutting had highest storage root diameter, storage root weight and vine weight than apical and basal cuttings. Pruning vines at 25% resulted in highest storage root diameter and storage root weight as compared to 0% and 50%. Vine pruning at 50% resulted in highest vine weight as compared to 25% and 0%.

Based on the results, farmers should plant both apical and middle stem cuttings since they are both high yielding in terms of storage roots and vines. Farmers should also prune 25% of vines to improve the contemporary storage root and vine production attributes especially for cultivars which develop long vines such as German 2. Further research should be done using

25% vine pruning regime in other cultivars as a way of selecting dual-purpose cultivars. Effect of different vine harvesting regimes in sweet potato nurseries on the future performance of nurseries needs to be evaluated through empirical study.

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AUTHOR'S CONTRIBUTION

All authors contributed equality in carrying out the research study and the development of this paper.

REFERENCES

1. Belehu T. *Agronomical and physiological factors affecting growth, development and yield of sweet potato in Ethiopia*. (Doctoral dissertation, University of Pretoria). *2003.*
2. Belehu T, Hammes PS. Effect of temperature, soil moisture content and type of cutting on establishment of sweet potato cuttings. South African Journal of Plant and Soil. 2004 21(2):85-9.
3. Chagonda I, Mapfeka RF, Chitata T. Effect of tillage systems and vine orientation on yield of sweet potato (*Ipomoea batatas* L.). American Journal of Plant Sciences. 2014;5:3159-3165.
4. Nedunchezhiyan M, Gangadharan B, Susantha K. Sweet Potato Agronomy. Fruit, vegetable, cereal science and biotechnology. Global Science Books. 2012;6(1):1-10.
5. Mutandwa E. Performance of tissue-cultured sweet potatoes among smallholder farmers in Zimbabwe. The Journal of Agrobiotechnology Management and Economics. 2008;11(1)5:48-57.
6. Toshome-Abdissa M, Nigussie-Dechassa R. Yield and yield component of sweet potato as affected by farmyard manure and phosphorus application: in the case of Adami Tulu District, Central Rift Valley of Ethiopia. Basic Research Journal of Agricultre Science and Review. 2012;1(2):31-42.
7. Mutasa W, Gasura E, Mabsa S, Masekesa RT, Masvodza DR. Does 2,4-dichlophenoxyacetic Acid Induce Flowering in Sweet Potato. African Journal of Biotechnology. 2013;12(51):7057-7062.
8. Mutandwa E, Gadzirai CT. Comparative assessment of indigenous methods of sweet potato preservation among smallholder farmers: Case of grass, ash and soil based approaches in Zimbabwe. African Studies Quarterly. 2007;9(3):85-98.
9. Mukunyadzi M. Sweet potato postharvest handling and marketing in Chiweshe (Mazowe District) in Zimbabwe. MSc thesis, Larenstein University, Wageningen. 2009.
10. Agronomy Research Institute. Simplified production fact sheets on selected field crops grown in Zimbabwe. Department of Agricultural Research and Extension (AREX) publication. Ministry of Lands, Agriculture and Rural Settlement. Harare, Zimbabwe. 2002:72.
11. Mulungu LS, Mwailana DJ, Reuben SSOW, Tarimo JPA, Massawe AW, Makundi RH. Evaluation on the effects of topping frequency on yield of two contrasting sweet potato (*Ipomoea batatas* L.) Genotypes. Journal of Applied Sciences. 2006;6:1132-1137.
12. Etela I, Kalio GA. Yields components and 48-h rumen dry matter degradation of three sweet potato varieties in N'dama Steers as influenced by date of harvesting. Journal of Agriculture and Social Research. 2011;11(2):15-21.
13. Low J, Lynam J, Lemaga B, Crissman C, Barker I, Thiele G, Namanda S, Wheately C, Andrade M. The sweet potato: Sweet potato in Sub-Sahara Africa. International Potato Center, Sub-Sahara Africa. 2009:359-390.
14. Kebede T, Gutu T, Lemma T, Tadesse E, Guru M. Feed intake, growth performance and economic efficiency of browsing Arsi-bale goats fed increasing proportions of sweet potato (*Ipomoea batatas* L) vines as a replacement for concentrate. World Journal of Agricultural Sciences. 2010;6(1):44-55.
15. Niyireba TN, Ebong C, Agili S, Low J, Lukuyu B, Kirui J, Ndirigwe J, Uwimana G, Kahundiye L, Mutimura M, Gahakwa D, Gachauri CK. Evaluation of dual-purpose sweet potato (*Ipomoea batatas* L. Lam) cultivars for root and fodder production in Eastern Province, Rwanda. Agricultural Journal. 2013;8(5):242-247.
16. Nyamapfeni K. The soils of Zimbabwe. Nehanda Publishers. Harare. Zimbabwe. 1991:179.
17. Lewthwaite SL, Triggs CM. Preliminary study of the spatial distribution of sweet potato storage roots. Agronomy New Zealand. 2009;(39):111-122.
18. Rasco ET, Amante V. Sweet potato in tropical Asia. Sapprad-Pcarrd. 2000.
19. International Potato Centre. Sweet potato seed systems: Training manual for farmers. SHASHA Project, Western Kenya. 2009.
20. Saraswati P. Physiological and growth responses of selected sweet potato (*Ipomoea batatas* (L.) Lam.) cultivars to water stress. PhD thesis. James Cook University. 2007.
21. Stoller JH, Leclere S, Liptay A. Controlling the ratio of auxin to cytokinin in the root mass of a potato plant; limiting excessive growth of vines. USPTO. 2012.
22. Ravi V, Naskar SK, Makeshkumar T, Babu B, Krishnan BPS. Molecular physiology of storage root formation and development in sweet potato (*Ipomoea batatas* (L.) Lam.). Journal of Root Crops. 2009;35(1):1-27.