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Effect of Vine Length and Leaf Removal on Growth and Yield of Sweet Potato [*Ipomoea batatas* (L.)] in the Wet Middleveld of Eswatini

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Sweet potato (*Ipomoea batatas* L.) is an economically important food crop in Eswatini. Since its introduction, numerous agronomic research activities were carried out in agricultural research centers, non-governmental organizations, and universities. However, information on the correct vine length for planting to improve sweet potato root yield in Eswatini is scanty. Therefore, this study aimed at helping farmers with the correct vine length to be used for improved growth and yield of sweet potatoes. A field experiment was conducted at the Luyengo campus, crop production farm during the 2019/2020 crops season. It was laid in a Randomized Complete Block Design (RCBD) in a factorial arrangement with three replicates. The treatments were vines planted with or without leaves and different vine lengths; 25 cm, 30 cm, and 35 cm. Kenya white variety was used. Data were collected on growth and yield parameters. Results showed that leaf removal yielded significantly ($P<0.05$) lower than non-leaf removal. This may be attributed to delayed photosynthetic activity in the former. The Vine length had no significant effect on yield. It is concluded that vines with leaves be used as planting material, and the length of vines to be used for planting should be 25 to 30 cm.

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Keywords: Sweet potato; Kenya white variety; leaf removal; vine lengths.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a herbaceous dicotyledonous plant with creeping, perennial vines, and adventitious roots. It belongs to the family *Convolvulaceae* and is usually considered the only Ipomoea species of economic importance [1]. The crop is regarded as the most important root or tuber of the tropics because of flexibility in planting and harvesting schedules in frost-free areas, short cropping season, use of non-edible parts for planting, non-trellising habit, and low requirement for soil nutrients [2]. Sweet potato is one of the world's most important, underexploited food crops as well as amongst the versatile crops. Its annual production is more than 133 million tons in the world and is ranked as the fifth most important food crop in developing countries in terms of fresh weight basis after rice, wheat, maize, and cassava [3]. Sweet potato is recognized as an ideal crop for food security. The yellow and orange-fleshed sweet potato varieties are also known as a good source of vitamin A that is frequently lacking in the diets of most African farming communities [4]. However, most varieties in subSaharan Africa are white-fleshed, low-yielding, and lacking beta-carotene, the precursor of vitamin A that was found vital to pregnant women and children. In Eswatini, sweet potato is produced exclusively by peasant farmers. Consequently, the potential contribution of this crop toward food security in Eswatini is underestimated as there is a huge gap between potential yield and the yield of peasant farmers [5 and 3]. However, ignorance on the appropriate method of preparing the planting materials for better growth and yield is one major limiting factor for increasing sweet potato yield in Sub-Saharan Africa [6]. In Eswatini, farmers use any type of cuttings that are available and convenient to handle with no distinctive manner of preparing them. Some farmers plant short cuttings because they are easy to handle and more economical while others use very long cuttings obtained from already established fields [3]. Vine management is done through indigenous knowledge systems. Some farmers prune vines at different levels depending on the purpose of pruning while others do not practice pruning. The use of sweet potato shoots as a vegetable, planting material, or forage promotes shoot removal and this is expected to decrease the supply of photosynthates to the growing storage roots [7]. However, the use of pruned sweet potato vines for feeding animals in developing countries may be beneficial due to the gradual increase in prices of commercial feeds [8]. Planting of stem cuttings of different lengths and pruning of vines before planting has resulted in yield variations among farmers. It is, therefore, urgently necessary to identify the best methods of vine preparation for sweet potato cultivation. Therefore, this study was conducted to determine the appropriate vine cutting length and leaf removal that will increase the growth and yield of sweet potato in the wet middle-veld of Eswatini.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The field study was carried out at the University of Eswatini, Faculty of Agriculture at Luyengo. Luyengo is in the Middle-veld agro-ecological zone of Eswatini and is located at 26.34º S and 31.10º E at an altitude of 732 m above sea level. The mean annual temperature is 18ºC and the annual rainfall is between 800 mm to 1000 mm. The average winter temperature is about 15 °C while for summer it is about 27 °C. The soil type of the experimental site is the Malkerns M set soil series clay loam to sandy loam Oxisols mostly with acidic soil pH [9].

2.2 Treatments and Experimental Design

The trial was set up as a 2 × 3 factorial experiment with treatments arranged in Randomised Complete Block Design (RCBD) replicated three times. Vine cutting length (25, 30 and 35 cm) and vines (with leaves and those without leaves) were the studied factors. Each plot was 4 m by 3.6 m with an inter-row spacing of 90 cm and 25 cm between rows. The variety used was Kenya White.

2.3. Land Preparation, Planting, Fertilization and Trial Management

The experimental field was ploughed, disked, and ridged with a tractor. There were four ridges per plot and a space of 1 m between plots. Secateurs were used for vine cutting and pruning. The vines were of three different lengths (25 cm, 30 cm, and 35 cm). Other vines had leaves and others were without leaves (leaves were pruned before planting). The middle parts of the vine were used as planting materials. Two-thirds of each vine with four to six nodes were planted horizontally into the soil at depth of 15 to 20 cm and leaving two to three nodes above the ground on the 5th of December 2019. Fertilizer application of 350 kg/ha of N: P: K [2:3:2 (22)] was done based on the recommendations of Ossom [5]. Fertilizer was applied as a single dosage one week after planting. Weeding and reshaping of ridges were carried out at 4 and 6 weeks after planting. The sweet potato was grown under rain-fed conditions. Harvesting of the two middle rows was done on the 4th of April 2020.

2.4 Data Collected

Vine length, the number of branches per plant, and the number of leaves were determined at 4, 6, 8, 10, and 12 weeks after planting from five randomly selected plants in each plot. The vine length was measured using a 5 m AIYI tape measure and the average of the five plants was recorded. Both the number of branches and the number of leaves were counted manually, and averages were recorded.
At harvesting, the number of storage roots, mass of storage roots (g), storage root diameter (cm), length of storage roots (cm), and storage root yield (tonnes/ha) were determined. The number of storage roots was determined by using five plants randomly selected from the net plot. Then from the total number of storage roots of each plot, the average number of storage roots per plant of each plot was determined.

The mass of storage roots was determined from the already randomly selected five plants of the sweet potato from each plot. It was done using a 6 kg Contech high precision balance to determine the average mass of sweet potato storage roots per plant for each plot.

The length of storage roots was determined on the five plants used for the determination of tuber diameter using a 300 mm ruler. The length of all storage roots from the five plants was measured and from that, the average length per root was determined. The storage root yield was weighed immediately after harvest using a digital scale and the yield was converted to tonnes/ha.

3. RESULTS

3.1 Number of Branches/Plant

There was a significant difference (P < 0.05) in the number of branches/plant at four to six WAP when comparing vines with and without leaves. However, from eight to 12 WAP no significant differences were observed. Data trends showed that leaf removal reduced the number of branches/plant throughout the experiment. There was no significant difference in the number of branches/plant when vine cutting lengths were compared throughout the experiment. A closer look at the results showed that the highest number (18.1) of branches/plant recorded when 25 cm vines were planted at 12 WAP and the lowest recorded at four WAP when 30 cm vines were used, though not significant (Table 1).

3.2 Vine Length (cm)

Table 2 shows the effects of vine length and the presence or absence of leaves on vine length. It is interesting to note that removing the vine leaves at planting reduced the vine length

Table 1. Number of branches per plant of sweet potato in response to leaf removal and vine cutting length at 4, 6, 8, 10, and 12 weeks after planting (WAP)

Treatments	Weeks after planting				
	4	6	8	10	12
Leaf removal					
Leaves	5.6a	9.13a	11.91	15.44	16.69
No leaves	2.53b	4.82b	10.07	14.89	15.49
LSD (0.05)	1.00	0.93	ns	ns	Ns
Vine length (cm)					
25	4.37	7.10	10.40	17.50	18.10
30	3.73	7.10	11.17	13.67	14.87
35	4.10	6.73	11.40	14.33	15.30
LSD (0.05)	ns	ns	ns	ns	Ns
CV (%)	23.4	12.7	17	18.8	18.4

ns = non-significant at P = 0.05; Means in columns followed by different letters are significantly different to each other at P = 0.05 according to Least Significance Difference (LSD) test; CV = Coefficient of variation throughout the experiment. Vine lengths were significantly different (P<0.05) at four to 10 WAP, after which no significant differences were observed at 12 WAP. The longest vines of 88.2 cm were obtained at 12 WAP where vines had their leaves present at planting. Nevertheless, the different vine lengths at planting did not yield any significant differences in vine length during the entire experiment. However, the results showed that the longest vines were recorded at 12 WAP where 35 cm vines were planted. A closer look at Table 2 showed that using vines of length 35 cm at planting gave rise to longer vines throughout the experiment.

3.3 Number of Leaves/Plant

Vines planted with leaves produced more leaves than vines planted without leaves throughout the experiment though significant differences were only observed at six and eight weeks after planting (Table 3). The number of leaves/plant for vines with leaves was in the range 32.76 to 204.00, while for vines without leaves ranged from 15.13 to 186.40. However, no significant differences were observed for the effects of vine length on the number of leaves/plant throughout the experiment. Data trends showed that the highest number (200.90) of leaves/plant was recorded at 12 WAP when 25 cm vines were planted. The lowest number of leaves/plant of 23.43 was recorded when 35 cm vines were planted, though not significant (Table 3).

3.4 Number of Tubers/Plant

Data on the number of tubers/plant is shown in Table 4. There was a significant difference (P<0.05) in the number of tubers/plant when leaves were present or absent at planting. The results showed that the presence of leaves gave rise to more tubers/plant than when leaves were removed. However, no significant differences were observed for the effects of vine length at

Table 2. Vine length (cm) of sweet potato as affected by the vine cutting lengths (25, 30 and 35 cm) and presence or absence of leaves at 4, 6, 8, 10, and 12 weeks after planting

Treatments	Weeks after planting				
	4	**6**	**8**	**10**	**12**
Leaf removal					
Leaves	14.14a	27.6a	51.0a	75.7a	88.4
No leaves	7.09b	16.5b	43.4b	64.3b	81.2
LSD (0.05)	2.42	10	5.65	9.42	ns
Vine length (cm)					
25	10.28	20.4	44.3	69.7	87.4
30	11.27	23.5	48.6	65.5	77.6
35	10.30	22.1	48.7	74.8	89.4
LSD (0.05)	ns	n	ns	ns	ns
CV (%)	21.7	22.2	11.4	12.8	11.7

ns = non-significant at P = 0.05; Means in columns followed by different letters are significantly different to each other at P = 0.05 according to Least Significance Difference (LSD) test; CV = Coefficient of variation

Table 3. Number of leaves/plant as affected by vine cutting length and presence and absence of leaves at 4, 6, 8, 10, and 12 weeks after planting

Treatments	Weeks after planting				
	4	**6**	**8**	**10**	**12**
Leaf removal					
Leaves	32.76	72.00a	122.00a	184.30	204.00
No leaves	15.13	40.20b	96.00b	161.70	186.40
LSD	ns	9.25	20.15	ns	ns
Vine length (cm)					
25	24.60	52.90	103.40	179.60	200.90
30	23.80	58.70	106.30	163.50	192.5
35	23.43	56.70	117.30	175.8	192.10
LSD	ns	ns	Ns	ns	ns
CV%	9.2	15.7	17.6	15.8	14.1

ns = non-significant at P = 0.05; Means in columns followed by different letters are significantly different to each other at P = 0.05 according to Least Significance Difference (LSD) test; CV = Coefficient of variation

Table 4. Effects of vine cutting length and vines with and without leaves on yield components and yield of sweet potato

Treatments	Number of tubers/plant	Length of tuber (cm)	Mass of tubers/plant (g)	Tuber yield (tonnes/ha)
Leaf removal				
Leaves	5.27a	22.03a	1244a	10.7
No leaves	4.13b	19.38b	951b	7.60
LSD	1.03	11.10	267.3	ns
Vine length (cm)				
25	4.87	19.54	1090	9.63
30	4.23	20.38	1162	8.81
35	5.00	22.19	1039	9.17
LSD	ns	ns	ns	ns
CV%	5.92	5.79	9.17	11.05

ns = non-significant at P = 0.05; Means in columns followed by different letters are significantly different to each other at P = 0.05 according to Least Significance Difference (LSD) test; CV = Coefficient of variation

planting on the number of tubers/plant. The highest number of tubers/plant was recorded (5.00) where vines of length 35 cm were planted and the lowest was observed (4.23) where 25 cm long vines were planted (Table 4), though not significant.

3.5 Tuber Length (cm)

The results of tuber length of sweet potato as affected by presence or absence of leaves at planting and vine length are presented in Table 4. Like other growth attributes, the presence or absence of leaves at planting was significant ($P < 0.05$) for tuber length (Table 4). The longest tuber of 22.03 cm was obtained where vines had their leaves present at planting, whilst the shortest tuber of 19.38 cm was obtained where leafless vines were planted. Nevertheless, vine length at planting was also not significant ($P > 0.05$) for tuber length (Table 4).

3.6 Mass of Tubers/Plant (g)

The cuttings with leaves produced significantly ($P<0.05$) higher root mass/plant (1244 g) than the cuttings without leaves (951 g). However, the mass of tubers/plant was not significantly affected by the vine lengths 25, 30, and 35 cm (Table 4).

3.7 Tuber Yield (kg/ha)

Results for the influence of different vine lengths and the presence or absence of leaves on sweet potato root yield per hectare are presented in Table 4. Sweet potato responded non-significantly to both presence and absence and different vine lengths at planting. The highest (10.7) non-significant yield (t/ha) was obtained where leaves were present at planting than when leaves were removed (7.60). Planting vines of length 25 cm produced a more non-significantly yield of sweet potato (9.63 t/ha), followed by 35 cm long vines (9.17 t/ha) and lastly 30 cm long vines (8.81 t/ha) (Table 4).

3.8 Correlation Coefficients

The correlation coefficient matrix is shown in Table 5 below. The data shows that there was a negative relationship between vine length and tuber length. Another negative relationship was recorded for tuber yield and the number of branches. However, these relationships were not significant. There was a weak positive relationship between tuber yield and vine length and also with tuber length. A significantly positive relationship was recorded for tuber yield and dry mass. The coefficient of determination (R^2) was ($0.6821^2 \times 100$) 46.5 % indicating that 46.5 % of the differences in yield may be attributed to dry matter.

4. DISCUSSION

4.1 Number of Branches/Plant

Vines with leaves at planting had a significantly ($P<0.05$) higher number of branches from four to 10 WAP than vines without leaves. This was due to the mere fact that the experiment was planted on a rainy day, thus the old leaves did not drop. According to [10]. Kenya white vine cuttings are

Table 5. Correlation coefficient matrix

Tuber diameter							
Dry matter	0.0004ns						
Mass of tubers	0.2949ns	0.3327ns					
No. of branches	0.3238ns	0.0119ns	0.2741ns				
No of tubers	-0.4349ns	0.3249ns	0.2299ns	-0.4971ns			
Tuber yield	-0.1479ns	0.6821*	0.4378ns	-0.0808ns	0.5503ns		
Vine length	-0.4897ns	0.4946ns	0.1909ns	-0.1940ns	0.6183ns	0.5247ns	
Tuber length	0.0984ns	-0.1157ns	0.0090ns	0.3135ns	-0.1199ns	0.0991ns	-0.0823ns
	Tuber diameter	Dry matter	Mass of tubers	No of branches	No of tubers	Tuber yield	Vine length

*ns = non-significant at P = 0.05; * significant at P = 0.05* usually thick and woody, sometimes fail to establish and may rot. This was the case with some of the vines planted without leaves, thus few branches were established as compared to vines planted with leaves. However, vines of length 25 cm had a non-significantly higher number of leaves than 30 and 35 cm long vines. Nevertheless, [11] found that there were significantly more branches on plants derived from 30 cm than 15 and 22.5 cm-long cuttings. [12] indicated that cuttings of greater length than 25 cm tend to be wasteful of planting material, while shorter cuttings establish more slowly, and give poorer yields. Similar results were recorded by [13], in Nigeria where plants were sawn with 30 cm vine length perform better. Factors such as the genetic potential of variety, number of available sprouts at planting, and sprout damage may affect branching. Differences in the number of branches/plant can be attributed to vine length because branch formation depends mostly on the vine length of the plant [14].

4.2 Number of Leaves/Plant

Vines planted with leaves produced more leaves than vines planted without leaves and significant differences were observed at 6 and 8 WAP. This can be due to those vines planted without leaves did not easily establish and some got rotten thus a lot of gap filling was done, which affected growth. The number of leaves is believed to depend on the number of branches and internode length [14]. [11] stated that a higher number of leaves could also be due to the greater number of nodes which might have enhanced the development of more roots, better and early cuttings were established differently, rapid vine development, more branches, and more leaf production. There were no significant differences amongst the effects of vine length on the number of leaves/plant. Variation in the number of leaves/plant is a genetic character.

4.3 Vine Length (cm)

The longest vines which were obtained on planting material with leaves can be attributed to more photosynthetic activity on the leaves and their subsequent partitioning to plant parts. However; [15] noted that sweet potato early vine growth does not differ significantly but only at its mid and late stages. He argued that this difference at later stages after planting might be due to the different adaptive growth rates as the cuttings were established differently in the various treatments. The longest vines where planting vines of 30 and 35 cm were used could be due to a greater number of nodes which might have enhanced the development of more roots, better and early establishment of cuttings [11].

4.4 Number of Tubers/Plant

Vines planted with leaves produced significantly more tubers per plant than vines planted without leaves. These correlated with [16] who reported that the high number of leaves present in the sweet potato plants results in more tubers due to the high photosynthesis rate and subsequent dry matter partitioning to the harvestable roots. The higher number of tubers at 35 cm vine length could be explained by the higher number of nodes on the 35 cm cuttings which were buried and provided more points for tuber root initiation. According to [11], tuber initiation and bulking begin earlier on cuttings with more nodes than those with fewer nodes as a result of the early rapid growth which translated into higher roots yield and greater marketable yields.

4.5 Mass of Tubers/Plant

Results showed the highest significant($P<0.05$) mass of tubers/plant was obtained where sweet potato vines were planted with leaves than without leaves and this could be attributed to differences in source-sink relationships [14]. However, vine length did not significantly increase the mass of tubers/plant, though 30 cm long vines produced the highest mass of tubers/plant. The higher mass of tubers/plant at 30 cm vine length could be explained by the higher number of nodes on the 30 cm cuttings which were buried and provided more points for tuber root initiation. According to [11], tuber initiation and bulking begin earlier on cuttings with more nodes than those with fewer nodes as a result of the early rapid growth which translated into higher roots yield and greater marketable yields.

4.6 Tuber Length

There was a significant ($P<0.05$) difference between vines with leaves and without leaves. Longer tubers were obtained were sweet potato vines had leaves and this could be due to more leaves implying the photosynthesis rate was high leading to more sugars for the storage roots hence their growth length [14]. Vine cutting length did not significantly increase the length of tubers. However, sweet potato harvested from 35 cm long vines had the longest tubers compared to 25 and 30 cm vines. [11] stated that tuber initiation and bulking begin earlier on cuttings with more nodes than those with fewer nodes as a result of the early rapid growth which translated into higher roots yield and greater marketable yields.

4.7 Tuber yield (kg/ha)

There was no significant difference between vines planted with or without leaves, different vine lengths. However, vines planted with leaves had the highest yield compared to those without leaves. [15] stated that root yield in sweet potato was positively and significantly ($P<0.05$) correlated to root diameter, average root weight, and the number of roots per plant. [17] stipulated that, there is a close relation between root yield and the number of leaves per plant. The use of sweet potato shoots as a vegetable, planting material, or forage promotes shoot removal and this is expected to decrease the supply of photosynthates to the growing storage roots [7]. [12] indicated that tuber yield tends to increase with an increase in the length of the vine cutting used and a length of about 30 cm is recommended. Cuttings of greater length than this tend to be wasteful of planting material, while shorter cuttings establish more slowly, and give poor yields. Nevertheless, the results from this study revealed that when comparing the vine lengths, the shortest vines (25 cm) gave the highest tuber yield than 30 and 35 cm long vines.

4.8 Correlations

The negative relation between tuber yield and number of branches means that increasing number of branches compromises tuber yield as those resources may have been used for tuber development. These results are consistent with those of [18] who reported that the number of branches did not have an influence on the tuber yield of sweet potato. A positive relationship between tuber yield and dry matter was expected because the tuber is the storage organ for sweet potatoes. The was a weak positive relationship between tuber yield and vine length. However, this still implies that longer vine lengths are preferred for increased tuber yield.

5. CONCLUSION

According to the results of this study, leaf removal significantly ($P<0.05$) reduced sweet potato yield but did not significantly influence the growth performance of the crop. In addition, sweet potato yield and its components were not significantly affected by the vine cutting length (25, 30, and 35 cm) at planting hence producing a positive net return in sweet potato production. Amongst the presence and absence of leaves, marginally higher growth and yield were observed for the presence of leaves. It is recommended that a leafy vine length of 25 cm be used to increase sweet potato production in Eswatini. It is also recommended that since the results obtained from this study were from one growing season, further studies are recommended to confirm these findings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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