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Research Article

Influence of Vine Pruning Level and Varieties on Growth and Yield of Sweet potato (*Ipomoea batatas* L.) at Wondo Genet, Southern Ethiopia

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Abstract

The experiment was conducted during the 2021 and 2022 growing seasons at Wondo Genet Agricultural Research Center (WGARC). Four levels of vine pruning expressed by percentage (0, 25, 50, and 75) with two newly released varieties of orange fleshed sweet potato (Alamura and Kabode) were used. The experiment was arranged in a 2x4 factorial combination using randomized complete block design (RCBD) with three replications. All necessary data were collected and analyzed using SAS software version 9.4. The analysis of variance (ANOVA) showed that there was a highly significant (P≤0.01) interaction differences of varieties and pruning levels for plant height, root length, root weight per plant and root yield per hectare. The analysis of variance showed the presence of significant differences (p≤0.05) among tested varieties for plant height, root diameter, root yield per hectare, and root dry matter content. The highest root yield was obtained from Kabode (36.41 t ha^{-1}) variety pruned at 50% level, followed by Alamura variety (32.50 t ha^{-1}) at 50% pruning level while Alamura variety pruned at 75% level gave the lowest root yield of 21.33 t ha-1. On the other hand, the highest vine yield (25.38 t ha^{-1}) was recorded from Alamura variety pruned at 50% level, while the lowest vine yield (11.09 t ha^{-1}) was obtained from un pruned Kabode variety, which was not statistically different from the vine obtained from this variety pruned at 75% level. Therefore, for both varieties, vine pruning at 50% level was recommended for the highest root and vine yield as a dual-purpose crop.

Keywords: Dry matter content; Genetic variation; Photosynthesis; Root yield; Vine management; Vine yield

Introduction

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant belonging to the family Convolvulaceae [1]. Globally sweet potato is the 7th most important food crop after wheat, rice, maize, potato, barley and cassava (FAO, 2014). More than 140 million tons had been produced globally per year. The world average storage root yield had been estimated to be 14.8t ha^{-1} (FAO, 2014). Asia is the world's largest producing continent (129 M ton/annum) and China is the leading country (121 M ton/annum) which is 86% of world production. In Asia, it is primarily used for human consumption and animal feed. In Africa, sweet potato is the 2nd most important root crop after cassava and its production is concentrated in the East African and African great lake region countries [2,3]. It is one of the most important sources of carbohydrates for small holder farmers in Ethiopia [4] and the third root and tuber crop after Irish potato and cassava in quantity of consumption in tropical Africa [5]. Sweet potato yields are high per area [6] per unit of time [7]. Due to its higher productivity and drought tolerance, the crop can play vital role in achieving food self-sufficiency of the region [4]. This makes it an ideal sustainable crop for production in developing countries, where population growth has decreased the amount of arable land per person and increased the use of marginal land for food production [8]. Sweet potato provides household food security because the crop can be harvested within 3-6 months [9] and also can remain in the ground for "piece meal" harvesting, a common sweet potato "storage" practice in the tropics [5].

In Ethiopia sweet potato ranks the first in total production and the third in area coverage next to Irish potato and taro from root and tuber crops cultivated [10]. Its root is used as food and feed. As food, the root is usually consumed in boiled form. It is one of the cheapest sources of vitamin A. It is tolerant to adverse conditions like drought. It is an attractive food crop among farmers because it requires less care and input [11]. It is a popular food in many parts of Eastern Africa. It is drought resistant, hardy and can grow in marginal areas, thus contributing to improved food security.

When rainfall and temperature are favorable, sweet potato may grow vigorously and produces large quantities of vines in the expense of the storage roots [7]. As a result, part of the vine can be pruned and utilized as planting material, leaf vegetable or animal feed [7]. 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. Use of pruned sweet potato vines for feeding animals in developing countries may be beneficial due to gradual increase in prices of commercial feeds (Kebede et al., 2010). Moreover, Saraswati (2007) reported that young leaves which develop after re-growth are photosynthetically more efficient than older leaves.

According to Shumbusha et al. [12], the dual purpose of sweet potato varieties are ones which have combinations of high root yields and vine production. Sweet potato has the capabilities to produce a large number of vines as a feed source, aside from the yields of storage roots. Mulungu et al. (2006) also reported that both the storage roots and vines are essential resources for human and animal consumption. However, the information about dual-purpose (contemporary food and fodder producing) attributes of different sweet potato varieties and vine pruning levels to optimize yield of fodder without disturbing root yield is limited. Consequently, pruning of vines at different levels might have resulted in yield variations among sweet potato varieties. Therefore, this experiment was conducted to determine the effects of vine pruning level and varieties on sweet potato production to meet high and reliable yield of both the storage roots and vines and to identify optimum level of vine pruning with maximum root yield of sweet potato.

Materials and Methods

Description of experimental site

The experiment was conducted at Wondo Genet Agricultural Research Center (WGARC), located in Sidama region at the elevation of 1780 meter above sea level with the minimum and maximum temperature of 12.02^{0}C-26.72^{0}C respectively. The site receives an average rainfall of 1128 mm. The soil category of the area is a sandy loam type, which is favorable for sweet potato production.

Treatments and experimental design

The experiment was consisted of four levels of vine pruning expressed by percentage (0, 25, 50, and 75) with two newly released varieties of orange fleshed sweet potato (Alamura and Kabode). The experiment was arranged in a 3x4 factorial combination using randomized complete block design (RCBD) with three replications. Thus, there was 8 treatment combinations in triplicates. The treatments were randomly allotted to each plot. The experimental plot had an area of 9 m^2 (3m width x 3m length). The space between replications and plots was 1.5 m and 1 m, respectively. The space between rows and plants was 60cm and 30cm, respectively. A total of 50 cuttings were planted at each plot. Plants in the three middle rows out of the five rows per plot constituted the net plot used as the sampling unit. Ten plants from the middle rows were taken for sampling and data analysis (Table 1).

Table 1: Treatment description.

Number of Treatments	Treatment Combinations
1	Kabode * non prune (control)
2	Kabode * 25% of vine pruning
3	Kabode * 50% of vine pruning
4	Kabode * 75% of vine pruning
5	Alamura * non prune (control)
6	Alamura* 25% of vine pruning
7	Alamura * 50% of vine pruning
8	Alamura * 75% of vine pruning

Vine pruning

Vine pruning was done at 70-80 days after planting (at vegetative stage). Each of the varieties (Kabode and Alamura) received four treatments of vine pruning levels (0, 25 and 50 and 75%). To allow re-growth, vines were cut at 15 cm above ridge level. Vine pruning percentages was made through counting the number of stems per plant and number of leaves per stem. Hence, the number of stems to be cut was determined by the number of leaves per stem.

Data analysis

Collected data were subjected to analysis of variance using SAS package (SAS 9.4). The least significance differences (LSD) were

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made to compare the treatments following the procedures of Gomez and Gomez (1984).

Result and Discussions

The analysis of variance (ANOVA) showed that there was a highly significant (P≤0.01) interaction differences among the varieties and pruning levels for plant height, root length, root weight per plant and root yield per hectare, which could be attributed to the genetic potential of the varieties and the variation of their degree of response to pruning. For instance, the tallest plant height (148.33cm) was recorded from unpruned Alamura which was statistically similar with this variety pruned at 25 and 50% level and the shortest (82.12cm) was Kabode variety pruned at 75% level. As far as root length is concerned, the maximum root length (15.10cm) was obtained from the Kabode variety pruned at 25% level which was statistically similar to the value obtained from the unpruned Kabode variety (14.94cm) while the shortest (11.07cm) was from the Kabode variety pruned at 75% level, statistically similar with Alamura variety when pruned at 50% level. The differences in plant height, root length among the sweet potato varieties might be due to the inherent characters of the varieties and the differences in the level of pruning. This could be a result of development of new and more stems due to partial suppression of apical dominance for generating more and new shoots to enhance photosynthesis. The present study results are in agreement with the result obtained by Munetsi (2015). Belehu (2003) also found that pruning had significantly affected the growth characters of the sweet potato plant.

Kabode variety pruned at 50% level gave the highest root yield (36.41tha^{-1}) followed by Alamura variety pruned at 50% level (32.50tha^{-1}) and the lowest (21.33tha^{-1}) was from Alamura variety pruned at 75% level, which was statistically similar with the yield obtained from unpruned Alamura variety (24.44 tha^{-1}). For both varieties, the highest root yield was obtained at 50% pruning but the yield became decreased when the pruning level increased from 50% to 75%, probably due to partial suppression of apical dominance for the development of many new shoots which are favorable for photosynthesis and auxin synthesis resulted in root yield. Munetsi (2015) also found that sweet potato pruning made at 50% level resulted the highest toot yield than the unpruned one. As the level of pruning increased the root yield was increased up to 50% level of pruning, might be due to the supply of photosynthesis was reduced. The result is in harmony with Saraswati (2007) who reported that vine pruning results in eventual root yield reduction due to over removal of active leaves which is response for supply of photosynthates (Table 2).

Table 2: Interaction effect of varieties and pruning level on plant height, root length, root weight/plant and root yield/ha of sweet potato at Wondo Gent in 2021/2022.

Treatments	Plant Height (cm)	Root Length (cm)	Root Weight/Plant (kg)	Root Yield/ha(tha^{-1})
Unpruned Alamura	148.33^{a}	13.45^{bc}	0.62^{e}	24.44^{cd}
Alamura*25	143.13^{a}	13.87^{ab}	0.77^{bcd}	28.96^{bc}
Alamura*50	140.65^{ab}	12.28^{c}	0.86^{bc}	32.50^{b}
Alamura*75	131.60^{b}	13.76^{b}	0.69^{ed}	21.33^{d}
Unpruned Kabode	108.67^{c}	14.94^{ab}	0.89^{ab}	28.63^{bc}
Kabode*25	102.14^{cd}	15.10^{a}	1.01^{a}	31.29^{b}
Kabode*50	95.60^{d}	13.53^{b}	1.02^{a}	36.41^{a}
Kabode*75	82.12^{e}	11.70^{c}	0.74^{cde}	26.11^{c}
CV	8.17	9.61	8.82	12.39
LSD	8.54	1.25	0.13	4.29

Means followed by the same letters within the same column are statistically non- significant at p<0.05 according to the least significant difference (LSD) test, CV= Coefficient of Variation.

There was no significant interaction (p>0.05) between varieties and vine pruning levels on root number, root diameter and root dry matter content but significant differences were observed among varieties. Therefore, the maximum numbers of roots per plant, thickest root and highest dry matter content were obtained from Kabode variety and the lowest was from Alamura, which might be due the presence of substantial differences among the varieties. The presence of highly significant differences among sweet potato varieties might be due to the presence of genetic differences used in the development of these varieties. Damtew, et al. [13] and Bililign [14] also reported that tested sweet potato varieties had a significance difference with respect to different traits. Moreover, Habtamu et al. [13] also reported a similar result in which significance differences among potato varieties was found probably due to genetic variability presented.

On the other hand, the maximum root number (52.79), the thickest (12.16cm) root and the highest dry matter content (34.82) were resulted from vine pruning done at 50% while the minimum root number, the thinnest root and the lowest dry matter content was from unpruned one followed by vine pruning done at 75% level. This could be an indication that 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. Moreover, over-pruning also negatively affects root growth, might have been suppressed either through extremely reduction in photosynthesis just after pruning that leads to root development reduction. Stoller et al. (2012) who reported that growth of roots occurs at a certain ratio of auxin to cytokinin (Table 3).

Table 3: Main effect of varieties and pruning level on root number, root diameter and root dry matter content of sweet potato at Wondo Gent in 2021/2022.

Treatments	Root Number	Root Diameter (cm)	Root Dry Matter Content (%)
Varieties			
Kabode	46.84[a]	9.67[a]	32.23[a]
Alamura	40.92[b]	7.90[b]	26.47[b]
LSD (0.05)	2.52	0.65	4.32
Pruning Level (%)			
0	31.05[d]	4.64[d]	21.08[c]
25	47.42[b]	11.33[b]	26.24[bc]
50	52.79[a]	12.16[a]	34.82[a]
75	38.18[c]	6.58[c]	28.88[b]
LSD (0.05)	2.92	0.75	5.61
CV (%)	7.04	9.1	8.9

Means followed by the same letter in the same column are not significantly different at 5% level of probability. LSD= Least significant difference, CV= Coefficient of variation.

The analysis of variance showed that the main effects of pruning and varieties and their interaction exerted a very highly significant (P=0.0001) influence on vine yield/ha of sweet potato. The highest vine yield /ha (25.38 tha^{-1}) was harvested from variety Alamura pruned at 50% level, followed by the same variety pruned at 75% level (Table 4). On the other hand, significantly the lowest vine yield (11.09 tha^{-1}) was obtained from unpruned Kabode variety, which was not statistically different from the vine obtained from this variety pruned at 75% level. Among both varieties, vine pruning at 50% resulted in highest vine yield. This could be due to tremendous suppression of apical dominance to promote the development of more secondary stems as compared to 25%, 75% and 0% pruning levels. Un-pruned (0% pruning) plots had lowest vine yield and this could be due to apical dominance. Shedding of lower leaves on un-pruned plots due to senescence might also contributed to the results. These results in harmony with the report made by International Potato Centre (2009) which stipulated that vine pruning is a multiplicative tool for generating more vine. Similarly, Niyireba et al. [15] found that pruning could increase vine yields of sweet potato. Increasing the level of vine harvests increased the partitioning of assimilates to vines [16], resulted in production of more vines [17-21].

Table 4: Interaction effect of Pruning and Varieties on Vine yield (t/ha) of sweet potato at Wondo Genet in 2021/2022.

Varieties	Pruning Levels (%)			
	0	**25**	**50**	**75**
Kabode	11.09[d]	16.52[c]	18.50[bc]	13.41[d]
Alamura	17.23[c]	20.32[b]	25.38[a]	22.43[b]
LSD (0.05) = 2.51	CV (%) = 11.79			

Means followed by the same letter in the same column and row are not significantly different at 5% level of probability. LSD= Least significant difference, CV= Coefficient of variation.

Conclusion

Sweet potato is a dual-purpose crop which could produce for food and animal feed. The vine pruning prior to storage root harvesting was intended to increase the quantity and quality of fresh forage for animal feed. Therefore, this study was aimed with the objective of determine the effect of vine pruning on root and vine yield of sweet potato varieties. The analysis of variance (ANOVA) showed that there was a significant (P≤0.01) interaction differences of varieties and pruning for plant height, root length, root weight per plant, root and vine yield. For instance, the highest root yield was obtained from Kabode (36.41 tha^{-1}) variety pruned at 50% level, followed by Alamura variety (32.50 tha^{-1}) at 50% pruning level and Alamura variety pruned at 75% level gave the lowest root yield of 21.33 tha^{-1}. On the other hand, the highest vine yield (25.38 tha^{-1}) w

as harvested from Alamura variety pruned at 50% level, while the lowest vine yield (11.09 tha^{-1}) was obtained from un pruned Kabode variety, which was not statistically different from the vine obtained from this variety pruned at 75% level. For both varieties, vine pruning at 50% level was recommended for the highest root and vine yield as a dual-purpose crop. Generally, for both varieties, vine pruning done at 50% level will be recommended for producers to obtain the highest root and vine yield. Therefore, from this experiment, we can conclude that, pruning of more profitable for maximizing storage root yield and production of vines also increased that farmers can able to obtain additional incomes for animal feed without disturbing the storage root yield.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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