ROOT DEVELOPMENT IN SWEETPOTATO STEM CUTTINGS AS INFLUENCED BY PRE-PLANTING, PLANTING AND POST-PLANTING PRACTICES

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ABSTRACT

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The effect of selected cultural practices on the adventitious root development in the stem cuttings of sweetpotato [*Ipomoea batatas* (L.) Lam.] was investigated through pot experiments. Storing apical stem cuttings for at least 3 days under ambient condition markedly increased the number and total length of the adventitious roots (ARs) and the number of the first order lateral roots (LRs) per plant. Variety had no significant influence on the number and elongation of the ARs except that VSP-4 produced notably more first order LRs than VSP-2. The number of nodes buried in the soil at planting did not have significant effect on the production and elongation of the ARs and first order LRs. However, the results showed that the fewer the number of nodes buried at planting, the longer was the length of the ARs and the greater was the number of the first order LRs. Application of fertilizer had no positive effect on the same root system components while water application markedly influenced only the elongation of the ARs. Apical stem cuttings supported significantly greater AR elongation and first order LR formation than basal cuttings. Stem cuttings with leaves intact produced significantly greater number and length of ARs and number of first order LRs than cuttings in which the leaves were removed before planting.

KEYWORDS: Adventitious roots. Apical stem cuttings. First order lateral roots. Planting practices. Sweetpotato.

INTRODUCTION

Sweetpotato (*Ipomoea batatas*) is a root crop that is grown in many parts of the world primarily for its fleshy tubers which are used as fresh or processed food (Woolfe, 1992). In Asia, where about 80% of the world's sweetpotato is produced (Horton, 1989), propagation of the crop is commonly through the use of vine or stem cuttings (Holwerda and Ekanayake, 1991). Martin (1988) reported that the nature, physiological condition and treatment imposed on the cuttings before, during or after planting influence final yield of sweetpotato.

The subsequent establishment of sweetpotato cuttings in the field after planting depends on their ability to root well immediately, otherwise, their initial growth is delayed and results in low root tuber yields or extended growth duration. A well-developed root system during the early stages of growth is extremely important for the development of the shoot system as well as for the process of tuberization (Martin, 1988). Therefore, any factor in the rhizosphere, whether biotic or abiotic, that does not favor root development in sweetpotato stem cuttings could induce some degree of inhibition both in shoot growth and tuberization, consequently leading to poor yields.

Various factors which include the genetic background of the planting materials, the flow of photosynthates and hormones from the shoots and the nature of the soil are known to affect root formation (Rendig and Taylor, 1989). In sweetpotato, various practices have been designed to promote establishment of newly planted stem cuttings in the field. In some cases, these practices allow for practical handling of the planting materials. One such practice is the removal of leaves from the cuttings to lessen the weight and minimize moisture loss during long transport. The effect of this practice on the root development of sweetpotato stem cuttings is not well-understood. This study was conducted to determine the effects of this and other cultural practices that are usually done before (e.g., storage of cuttings), during and after (e.g., fertilizer application) planting sweetpotato stem cuttings on their root development.

MATERIALS AND METHODS

The experiments were made at the Philippine Root Crop Research and Training Center, ViSCA, Baybay, Leyte, Philippines using stem cuttings of local sweetpotato varieties. The rooting medium was sandy mixed soil containing less than 1% organic matter. The soil was made to pass a 1 mm^2 screen to remove organic debris and large particles before being filled into 16.5 cm x 14.0 cm pots. Except in Experiment 3 where fertilizer application was the variable factor, the soil in every pot was applied with 1.0 g of 14% N, P_2O_5, K_2O ground fertilizer before planting. Watering was done regularly except in Experiment 3 where the frequency of water application was also a variable factor. Each pot received 200 mL of water every time, i.e., at 2-3 days' interval.

All the plants were sampled for their root system at 12 days after planting except in Experiment 4 wherein sampling was done at 14 days after planting. The root systems were carefully removed by gently washing away the soil in the pot with a gentle stream of water. The roots were cleaned, tagged and brought to the laboratory for observation and measurements.

Experiment 1
Effect of length of storage of stem cuttings

Eight-node apical stem cuttings of variety VSP-2 with uniform internode length were taken from a propagation plot, bundled and kept under ambient condition for 10, 6 and 3 days. Together with freshly taken cuttings (i.e., stored for 0 day), the stored cuttings were planted in a randomized complete block design with 5 replications. Four-node planting was followed.

Experiment 2
Effect of variety and depth of planting

Eight-node apical stem cuttings of varieties VSP-2 and VSP-4 were planted in a split-plot design with 5 replications. The main plots were the two varieties [VSP-2 (bushy with serrated leaves) and VSP-4 (semi-bushy with entire leaves)] while the subplots were the number of nodes buried into the soil at planting (i.e., 2, 3 and 5 nodes).

Experiment 3
Effect of fertilizer and frequency of water application

This experiment was planted following a split plot design with 5 replications using apical stem cuttings of VSP-2. The main plots were fertilizer applications (with and without) at planting while the subplots were the frequency of water application [*viz*., two times daily (morning and afternoon), once daily, once every 2 days and once every 4 days].

Experiment 4
Effect of variety, kind of stem cuttings and leaf removal

This experiment was established following a split-plot design with 5 replications. The main plots were varieties (VSP-2 and VSP-4), the subplots kind of cuttings (apical and basal) and the sub-subplots the presence (intact or removed) of leaves in the cuttings. Planting was 4 nodes deep.

RESULTS AND DISCUSSION

Apical stem cuttings stored in ambient condition for 3 days produced significantly more ARs and first order LRs and had longer total length of ARs than the cuttings that were not stored and those stored for 6 and 10 days (Table 1). Although Nwinyi (1991) earlier reported that sweetpotato stem cuttings stored for 5 days at ambient

Table 1. Effect of length of storage of sweetpotato stem cuttings before planting on adventitious root and first order lateral root development.

Days of storage	No. of adventitious roots/cutting	Total length of adventitious roots/cutting, cm	No. of first order lateral roots/ cutting
0	17.40	259.96	388.20
3	29.80	447.20	562.20
6	15.00	335.72	328.60
10	15.80	217.82	292.20
LSD (5%)	10.90	148.50	181.40

condition produced yields that were doubled, and cuttings are wilted in East Africa to induce root initiation, no explanation of the practice has been presented so far.

Cuttings stored for 6 and 10 days produced ARs that grew to a considerable length, but most of these dried after some time due to the absence of growing medium and some of the remaining ARs were damaged in the process of planting. Cuttings stored for 3 days produced significantly more ARs and first order LRs after 12 days, probably because after 3 days of storage, only root primordia appeared in the lower nodes of the cuttings. These primordia developed into adventitious roots immediately after planting.

No significant difference was observed between VSP-2 and VSP-4 in terms of the number and total length of the ARs. However, in terms of the number of first order LRs the latter variety gave markedly higher number than the former (Table 2). The result could be due to the numerically greater number and total length of the ARs in VSP-4 and therefore, this may not be an inherent attribute of the variety. Nevertheless, an increased rate of rooting through the soil profile would enhance the capacity of the plant for water transport (McMichael et al., 1985).

Table 2. Effect of variety and number of nodes buried in the soil at planting on the adventitious root and first order lateral root development of sweetpotato stem cuttings.[1]

Factor	Number of adventitious roots/cutting	Total length of adventitious roots/cutting, cm	Number of first order lateral roots/cutting
Variety (A)	ns	ns	**
VSP-2	35.61	407.37	54.50
VSP-4	44.72	456.31	1059.72
Number of nodes buried (B)	ns	ns	ns
2	38.16	454.29	1104.50
3	41.58	431.32	916.92
5	40.75	409.90	699.92
A x B	ns	ns	ns

[1] ns and ** denote non-significant and significant at 1% level, respectively, based on F-test determined by ANOVA.

The number of nodes buried in the soil at planting, i.e., 2, 3 and 5, did not induce any marked difference in the number and length of ARs and the number of first order LRs. In fact, the total length of the ARs and the number of the first order LRs were higher in the 2-node than 3- and 5-node planting (Table 2). Holwerda and Ekanayake (1991) revealed that sweetpotato planted at a depth of 5 cm produced more roots per node compared to those planted at 10 or 15 cm deep. The present finding showed that the number of ARs was reduced in the 2-node planting but the fact that the total length and the number of first order laterals were numerically greater than in the 3- and 5-node planting suggests that the cuttings developed compensatory root growth. This growth enables plants with restricted growth in some of its root system components to maintain a steady increase in root volume through the enhanced growth of the other components (Crossett et al., 1975). This finding suggests that depth of planting of sweetpotato cuttings would not affect root establishment in the soil and the ability of the plant to withstand limited water. However, it is not known how tuber yield would be affected by the high density of ARs in a single node since every AR is a potential root tuber. It was observed in Experiment 2 that an average of 19 ARs was produced per node in the 2-node planting while there were only 14 and 8 ARs, respectively, in the 3- and 5-node planting.

Apical stem cuttings planted in a fertilized soil did not have a significant advantage over those planted in unfertilized soil in terms of the number and length of the ARs and the number of the first order LRs (Table 3). The absence of effects of fertilizer application on root development could be due to the fact that early root development, i.e., root initiation and initial elongation, was dependent on the stored food reserves in the stem cuttings.

Table 3. Effect of fertilization and frequency of water application on the adventitious root and first order lateral root development of sweetpotato stem cuttings.[1]

Factor	Number of adventitious roots/cutting	Total length of adventitious roots/cutting, cm	Number of first order lateral roots/cutting
Fertilization (A)	ns	ns	ns
With	28.06	417.23	1049.81
Without	27.19	424.72	998.50
Water application (B)	ns	**	**
Twice a day	31.38	483.75a	1260.38a
Once a day	28.00	475.33a	1199.50a
Once every 2 days	26.38	438.78a	1067.50a
Once every 4 days	24.75	286.03b	569.25b
A x B	ns	ns	ns

[1]ns and ** denote non-significant and significant at 1% level, respectively, based on F-test determined by ANOVA; In a column, numbers followed by the same letter are not significantly different based on DMRT (5%).

Water application had no effect on the number of ARs, but had a marked effect on total AR length (Table 3). However, significance could not be demonstrated between plants watered twice daily, once daily, and once every 2 days, but only between these plants and those watered once every 4 days. This result indicates that adequate moisture condition is necessary for rooting of stem cuttings. Under actual field condition, this may imply that sweetpotato should be planted when the soil has sufficient moisture so that good root establishment could be promoted.

Data (Table 4) showed that with apical stem cuttings elongation in ARs and formation of first order LRs were significantly greater than with basal stem cuttings both for varieties VSP-2 and VSP-4. When basal

Table 4. Effect of variety, kind of stem cutting and leaf removal on the adventitious root and first order lateral root development of sweetpotato stem cuttings.[1]

Factor	Number of adventitious roots/cutting	Total length of adventitious roots/cutting, cm	Number of first order lateral roots/cutting
Variety (A)	ns	ns	*
VSP-2	14.06	156.19	196.25
VSP-4	16.50	148.46	323.13
Kind of cutting (B)	ns	*	**
Apical	16.56	174.20	337.88
Basal	14.00	130.45	181.50
Leaf removal (C)	*	**	**
Intact	19.38	198.07	374.50
Removed	11.19	106.58	144.88
AxB	ns	ns	ns
AxC	ns	ns	ns
BxC	*	*	*
AxBxC	ns	ns	ns

[1]ns, * and ** denote non-significant, significant at 5% and significant at 1% level, respectively, based on F-test determined by ANOVA.

Table 5. Inhibition of adventitious root and first order root development in sweetpotato stem cuttings as affected by kind of cutting and leaf removal

Variety	Kind of cutting/ Leaf removal	Number of adventitious roots	Adventitious root length (cm)	Number of first order lateral roots
		% inhibition		
VSP-2	Apical			
	Leaves intact	0	0	0
	Leaves removed	39	47	73
	Basal			
	Leaves intact	15	9	50
	Leaves removed	34	47	80
VSP-4	Apical			
	Leaves intact	0	0	0
	Leaves removed	52	56	61
	Basal			
	Leaves intact	28	34	49
	Leaves removed	60	67	77

stem cuttings were used as planting materials, inhibition in the number and length of the different root system components were observed in both varieties (Table 5).

The presence of leaves in the cuttings at planting had positive effects on the formation and elongation of ARs and the first order LRs of both apical and basal stem cuttings (Table 5).

Further investigations are required to explain possible reasons of improved root development reported here, e.g., assimilate- or hormone-induced process at the organ/cellular and sub-cellular levels.

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