CHAPTER 5

INFLUENCE OF CUTTING CHARACTERISTICS ON STORAGE ROOT FORMATION AT INDIVIDUAL NODES

5.1 ABSTRACT

Little information is available on the contribution of individual subterranean nodes to storage root production. As this may affect productivity it was investigated in three pot experiments conducted on the Experimental Farm of the University of Pretoria. The objective was to determine the contribution of individual subterranean nodes to storage root formation on terminal, middle and basal vine cuttings, planted with three nodes below the soil surface. In Experiment 1 two types of stem cuttings (terminal and basal) with two orientations of planting (vertical and horizontal) were planted. In Experiment 2 two types of stem cutting (terminal and middle) with different numbers of leaves (0, 0.5, 1 and 2) were planted. In Experiment 3 three types of cuttings (terminal, middle and basal) with two orientations of planting (vertical and horizontal) were planted. Terminal cuttings were more productive than basal cuttings, and horizontal planting produced a higher storage root yield than vertical planting, but these treatments did not have a clear effect on the distribution of storage roots on the subterranean nodes.

Morphologically, the number of preformed root primordia, and thus the potential to produce storage roots, are similar for all nodes of a cutting. This was reflected in the results, and on average 3.7 storage roots were produced per cutting, with 33.2% of the storage roots formed on subterranean node 1, 30.0% on node 2 and 36.8% on node 3. However, in terms of fresh mass of

the storage roots node 1 contributed 45.4%, node 2 contributed 27.1% and node 3 contributed 27.4%. This distribution pattern may reflect the relative proximity of the nodes to the source of assimilates from the leaves.

5.2 INTRODUCTION

Cuttings from the shoot apex are often regarded as better planting material than basal or middle vine cuttings (Eronico *et al*., 1981; Choudhury *et al.*, 1986; Villamayor Jr & Perez, 1988; Schultheis *et al*., 1994). Apical cuttings may ensure better rooting and establishment and faster shoot growth and therefore early canopy closure for weed suppression (Eronico *et al*., 1981; Hall, 1987). The age of the source plant from which the cuttings are taken is important. Yield is significantly reduced when cuttings from older plants are used (Martin, 1984). Villamayor Jr & Perez (1988) reported that the basal cuttings of young sweet potato plants (2.5 months) produced a 19% lower storage root yield than the terminal cuttings. On the other hand, the basal cuttings from older sweet potato plants (4 months) produced a 56% lower root yield than the terminal cuttings of the same plants. The storage root mass obtained from the individual subterranean nodes of the cuttings, however, was not reported. The presence of leaves on vine cuttings greatly increased adventitious root production, presumably due to the presence of active endogenous root promoting substances (Fadl *et al*., 1977; Fadl *et al*., 1978). Ravindran & Mohankumar (1982, 1989) reported that storage root yield was significantly higher in plants from vine cuttings with foliage than in plants from cuttings without foliage. Contrary to this Villamayor Jr (1986) reported that the presence of leaves on vine cuttings did not influence storage root number and storage root mass.

The number of nodes on cuttings used as planting material may be an important aspect of yield variability. Lowe & Wilson (1975) reported that 80 to 100 % of the yield is produced at the first four nodes below the soil surface. An increase in the length of cuttings was reported to increase sweet potato yield (Jimenez-Tiamo, 1983). Choudhury *et al*. (1986) reported that the highest storage root yield of 63.5t ha^{-1} was achieved from 12-node cuttings when two types of vine cuttings (apical and middle) were planted. This was followed in decreasing order by cuttings having 9, 6 and 3 nodes respectively. However, none of the quoted sources reported on the contribution of the individual subterranean nodes to storage root yield. Du Plooy *et al*. (1992) conducted experiments to investigate storage root formation at individual nodes. They reported that the number of storage roots did not differ as they differentiated at lower nodes in vertically planted cuttings with three subterranean nodes. For the five subterranean nodes the first two produced more storage roots than the lower three. The results showed that the highest storage root mass was achieved from node 1. This was followed in decreasing order by the lower nodes.

Considering the importance of sweet potato as a food crop in many of the developing countries, the lack of knowledge on storage root formation is surprising. It is not clear whether storage root initiation differs among nodes, nor whether nodes differ as preferred assimilate sinks. Such information can affect production practices like length of cuttings, planting depth and ridging.

The objectives of this study were:

- to determine the contribution made by individual subterranean nodes of terminal, middle, and basal cuttings to storage root formation; and

- to determine the influence of cutting orientation, and presence or absence of leaves on the cuttings, on storage root formation at individual nodes.

5.3 MATERIALS AND METHODS

Three greenhouse experiments were conducted during 2002 on the Experimental Farm of the University of Pretoria, using the cultivar Atacama. Uniform terminal, middle and basal cuttings of 20 cm length and containing six nodes were obtained from plants grown in a greenhouse. Four cuttings per pot were planted with three nodes below the soil surface. For horizontally planted cuttings the three nodes were placed 5 cm below the soil surface with the top part of the cutting above the soil surface. The subterranean node closest to the soil surface was identified as node 1. The plastic pots (25 cm in diameter spaced 20 cm apart) filled with sandy soil were irrigated daily with a commercial nutrient solution. All three experiments were conducted under similar conditions during the autumn and winter of 2002. Plants were harvested ninety days after planting. Each plant was carefully uprooted from the sandy soil by submerging the pot in water to loosen the sand and minimize storage root breakage from the nodes. The roots were washed to remove the remaining sand. Only roots that could clearly be identified as storage roots were counted and weighed separately from each of the three nodes.

The experimental data were subjected to standard analyses of variance using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, Institute Inc. Cary, NC, USA 1989) to determine the effect of main factors and the interaction between them. Differences at the $P \leq 0.05$ level were used as a test of significance and means were separated using Tukey's t-test.

In **Experiment 1** two types of stem cuttings (terminal and basal) with two orientations of planting (horizontal and vertical) were planted. The experiment was a 2 x 2 factorial in a completely randomized design with ten replications.

In **Experiment 2** two types of stem cuttings (terminal and middle) with different numbers of leaves on the cuttings (0, 0.5, 1 or 2) were planted in a vertical position. The experiment was a 2 x 4 factorial in a completely randomized design with four replications.

In **Experiment 3** terminal, middle and basal cuttings with two orientations of planting (horizontal and vertical) were planted. The experiment was a 3 x 2 factorial in a completely randomized design with four replications.

5.4 RESULTS

Experiment 1

The total number and fresh mass of storage roots per plant obtained from terminal and basal cuttings planted in vertical and horizontal positions, and the contribution of individual nodes to storage root number and fresh mass are presented in Table 5.1. Due to the relatively high coefficient of variation only the main trends are discussed.

Terminal cuttings produced significantly more storage roots (2.75 per cutting) than basal cuttings (1.55). Vertical or horizontal planting of the cuttings did not affect the number of storage roots. Over all the treatment combinations on average 37.5% of the storage roots were formed on node 1, with 25.4% on node 2 and 37.2% on node three, indicating no clear node preference in the initiation of storage roots.

The terminal cuttings produced a larger mass of storage roots (151 g) than the basal cuttings (77 g). The orientation of the cuttings did not affect the storage root yield, although vertically planted cuttings tended to have higher yields than those planted horizontally. On average over the treatment combinations node 1 contributed 50.6% to the storage root mass, node 2 21.5% and node 3 27.9%.

None of the type x orientation of cutting interactions were statistically significant, indicating that for all the parameters evaluated the types of planting material reacted similarly to changes in the orientation of planting.

Table 5.1 Storage root number and yield produced per plant and per node from terminal and basal cuttings planted vertically and horizontally: Experiment 1

Treatment	Total	Node Position		
		Node 1	Node 2	Node 3
Storage root numbers				
Type of cutting				
Terminal	2.75 (100%)	1.20 (43.6%)	0.75 (27.3%)	0.80 (29.1%)
Basal	1.55 (100%)	0.45 (29.0%)	0.35 (22.6%)	0.75 (48.4%)
LSD_T	0.84	0.54	0.50	0.55
Orientation of cutting				
Vertical	2.3 (100%)	0.80 (34.8%)	0.55 (24.0%)	0.95 (41.3%)
Horizontal	2.0 (100%)	0.85 (42.5%)	0.55 (27.5%)	0.60 (30%)
LSD_T	0.84	0.54	0.50	0.56
Mean	2.15 (100%)	0.83 (37.5%)	0.55 (25.4%)	0.77 (37.2%)
CV%	60.0			
Storage root yield (g)				
Type of cutting				
Terminal	151 (100%)	91.7 (60.8%)	39.9 (26.4%)	19.3 (12.8%)
Basal	77.3 (100%)	28.4 (36.7%)	10.9 (14.1%)	38.1 (49.0%)
LSD_T	55.17	46.12	27.27	32.10
Orientation of cutting				
Vertical	122 (100%)	66.6 (54.5%)	21.1 (17.3%)	34.4 (28.2%)
Horizontal	106 (100%)	53.5 (50.4%)	29.7 (28.0%)	22.9 (21.6%)
LSD_T	55.2	46.12	27.27	32.10
Mean	114 (100%)	60.0 (50.6%)	25.4 (21.5%)	28.7 (27.9%)
CV%	75.0			

Experiment 2

The contribution of individual nodes to total number and fresh mass of storage roots obtained from terminal and middle cuttings with and without leaves are presented in Table 5.2. Due to the relatively high coefficient of variation only the main trends are discussed. There was no difference in the number of storage roots produced by terminal and middle cuttings. However, the presence or absence of leaves on the cuttings affected storage root number, with significantly less storage roots (3.6) formed on cuttings without leaves, compared to approximately 5.4 on cuttings with leaves. The number of leaves present on a cutting did not have an effect on storage root numbers. On average over the treatment combinations the contribution of individual nodes to storage root numbers was similar, with node 1 bearing 34%, node 2 35%, and node 3 31% of the storage roots.

The terminal cuttings produced a larger mass of storage roots (250 g per plant) than did the middle cuttings (197 g). The presence or the absence of leaves on the original cutting did not affect storage root mass. On average over the treatment combinations the contribution of individual nodes to storage root mass decreased from 103 g (47%) on node 1 to 69 g (31%) on node 2 and to 50 g (22%) on node 3.

The type of cutting x presence or absence of leaves on cutting interactions were statistically significant for storage root number at node 1 (Figure 5.1) and at node 2 (Figure 5.2). Middle cuttings with one leaf produced more storage roots on node 1 and 2 than terminal cuttings with one leaf. With 0, 0.5 or 2 leaves per cutting there were no differences between terminal and middle cuttings. No physiological explanation for this phenomenon can be offered.

Table 5.2 Storage root number and yield produced per plant and per node from terminal and middle cuttings planted with and without leaves: Experiment 2

Treatment	Total	Node Position: Node 1	Node 2	Node 3
Storage root numbers				
Type of cutting				
Terminal	4.66 (100%)	1.50 (32.2%)	1.72 (37.0%)	1.44 (30.9%)
Middle	5.25 (100%)	1.84 (35.1%)	1.75 (33.3%)	1.66 (31.6%)
LSD_T	1.02	0.44	0.56	0.54
Leaf number				
0	3.62 (100%)	1.31 (36.2%)	1.25 (34.5%)	1.06 (29.3%)
½	5.50 (100%)	1.81 (32.9%)	1.94 (35.3%)	1.75 (31.8%)
1	5.37 (100%)	2.12 (39.5%)	1.69 (31.5%)	1.56 (29.0%)
2	5.31 (100%)	1.44 (27.1%)	2.06 (38.8%)	1.81 (34.1%)
LSD_T	1.44	0.63	0.79	0.76
Mean	4.95 (100%)	1.67 (33.8%)	1.73 (35.0%)	1.55 (31.1%)
CV%	28			
Storage root yield (g)				
Type of cutting				
Terminal	250 (100%)	115 (46.0%)	82.8 (33.2%)	52.0 (20.8%)
Middle	197 (100%)	92.4 (46.9%)	55.7 (28.3%)	48.8 (24.8%)
LSD_T	45.27	32.71	33.7	31.1
Leaf number				
0	207 (100%)	104 (50.1%)	67.5 (32.6%)	35.8 (17.3%)
½	199 (100%)	106 (53.0%)	56.5 (28.3%)	37.1 (18.6%)
1	251 (100%)	111 (44.3%)	78.4 (31.2%)	61.5 (24.5%)
2	235 (100%)	93.3(39.7%)	74.5 (31.7%)	67.2 (28.6%)
LSD_T	64.02	46.26	47.7	44.03
Mean	223 (100%)	103 (46.7%)	69.2 (30.9%)	50.4 (22.4%)
CV%	27.8			

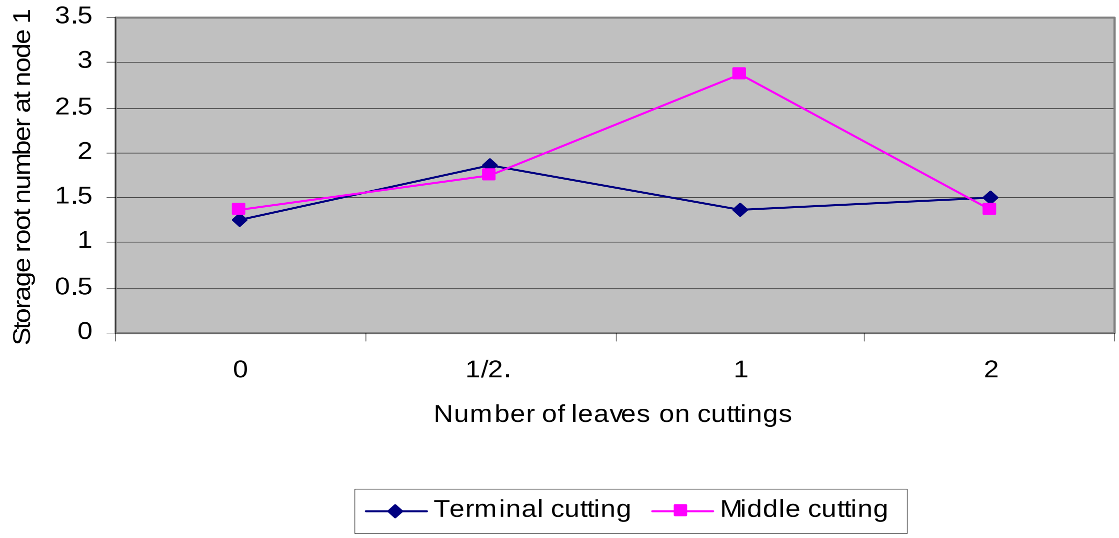

Figure 5.1 Interaction between type of planting material and number of leaves on cuttings on storage root number at node 1 Experiment 2

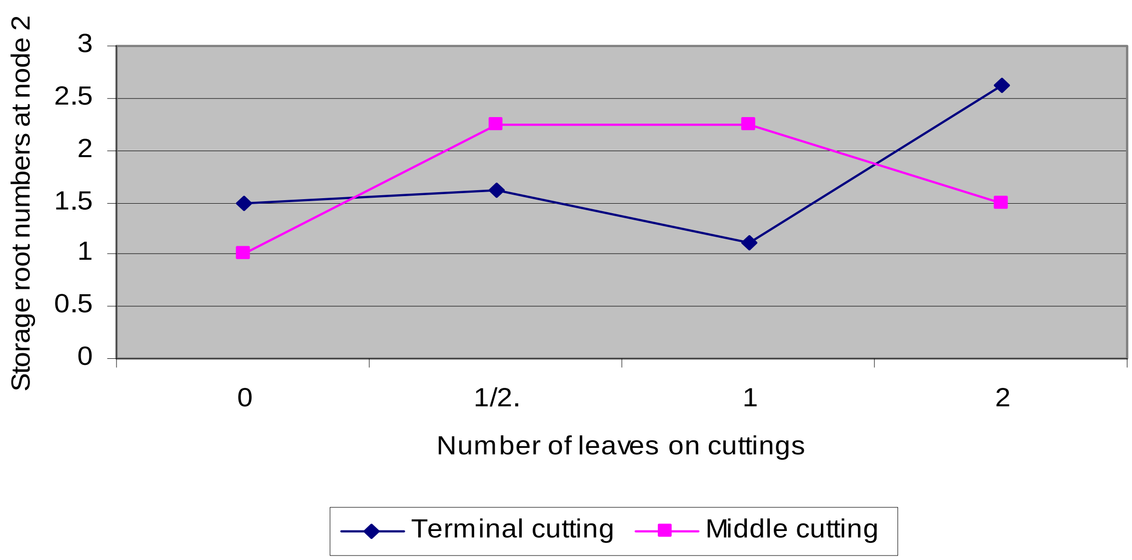

Figure 5.2 Interaction between type of planting material and number of leaves on cuttings on storage root number at node 2 Experiment 2

Experiment 3

The total number and fresh mass of storage roots per plant obtained from terminal, middle and basal cuttings planted in vertical and horizontal positions, and the contribution of individual nodes to storage root number and fresh mass are presented in Table 5.3. Considering the relatively high coefficient of variation only the main trends are discussed. Terminal cuttings produced significantly more storage roots (4.8 per cutting) than middle cuttings (3.4). Vertical or horizontal planting of the cuttings did not affect the number of storage roots produced. On average over all the treatment combinations 31.6% of the storage roots were formed on node 1, 30.5% on node 2 and 37.8% on node three.

The terminal and middle cuttings produced a larger mass of storage roots (184 g and 186 g per plant respectively) than the basal cuttings (71 g). Horizontal planting of the cuttings resulted in a larger total storage root yield than vertical planting. On average over all the treatment combinations 43.5% of the storage root fresh mass was formed on node 1, 29.3% on node 2 and 27.1% on node three.

None of the type x orientation of cutting interactions were statistically significant indicating that for all the parameters evaluated the three types of cutting reacted similarly to changes in planting orientation.

Table 5.3 Storage root number and yield produced per plant and per node from terminal middle and basal cuttings planted vertically and horizontally: Experiment 3

		Node Position		
Treatment	**Total**	**Node 1**	**Node 2**	**Node 3**
Storage root numbers				
Type of cutting				
Terminal	4.8 (100%)	1.6 (32.2)	1.5 (31.4)	1.8 (36.2)
Middle	3.4 (100%)	1.3 (38.9)	1.0 (29.7)	1.1 (31.5)
Basal	4.1 (100%)	1.0 (24.3)	1.3 (30.3)	1.9 (45.4)
LSD_T	1.07	0.60	0.49	0.94
Orientation of cutting				
Vertical	4.0 (100%)	1.3 (31.6)	1.2 (29.4)	1.5 (39.0)
Horizontal	4.3 (100%)	1.3 (31.2)	1.4 (31.9)	1.6 (37.0)
LSD_T	0.87	0.49	0.40	0.77
Mean	4.1 (100%)	1.3 (31.6)	1.3 (30.5)	1.6 (37.8)
CV%	24.8			
Storage root yield (g)				
Type of cutting				
Terminal	184 (100%)	82.0 (44.6)	57.6 (31.3)	44.2 (24.0)
Middle	186 (100%)	100 (54.0)	51.1 (27.5)	34.4 (18.5)
Basal	71 (100%)	19.0 (26.9)	21.0 (29.8)	30.6 (43.3)
LSD_T	49.94	41.22	28.01	25.00
Orientation of cutting				
Vertical	124 (100%)	59.4 (48.1)	31.8 (25.8)	32.3 (26.1)
Horizontal	170 (100%)	74.9 (44.0)	54.7 (32.1)	40.5 (23.8)
LSD_T	40.78	33.66	22.87	20.41
Mean	146.8 (100%)	67.2 (43.5)	43.2 (29.3)	36.4 (27.1)
CV%	32.4			

5.5 DISCUSSIONS AND CONCLUSION

Number of storage roots

The three experiments resulted in a clear picture regarding the contribution of individual nodes to storage root production. The mean number of storage roots produced by the three types of cuttings was similar. On average over the three experiments 3.7 storage roots were produced per cutting, with 33.2% of the storage roots formed on subterranean node 1, 29.9% on node 2 and 36.8% on node 3, indicating no clear node differences (Table 5.4). It should be noted that on average only 1.27 storage roots were actually initiated per node, although typically four or more preformed root primordial (potential storage roots) are present on each node. Contrary to this Du Plooy *et al.* (1992) observed that with three subterranean nodes the number of storage roots did not differ significantly, but tended to decrease from 2.6 roots at node 1, to 2.4 roots at node 2 and to 2.2 roots at node 3. For the five subterranean nodes the storage roots decreased significantly from 2.1 roots at node 1, to 1.9 roots at node 2, to 1.4 roots at node 3, to 1.1 roots at node 4, to 0.9 roots at node 5. The three subterranean nodes produced a total of 7.2 storage roots per cutting while the five subterranean nodes produced 7.4, compared to the 3.7 storage roots per cuttings obtained in our experiments. Lowe & Wilson (1975) reported that node 1 contributed 27%, node 2 contributed 30%, node 3 contributed 24% and node 4 contributed 18% of the total number of storage roots per cutting.

Preformed root primordia on the basal part of the vine are more aged and exposed to damage over a longer period than primordia on the terminal part of the vine. This may partly explain the phenomenon that terminal cuttings are more productive than the basal cuttings. The extent of damage to root primordia can affect the results obtained from experiments to determine the contribution of individual subterranean nodes to storage root formation. It is important that cuttings should be handled properly to avoid possible damage to preformed root primordia.

Fresh mass of storage roots

On average over the three experiments node 1 contributed 45.4%, node 2 contributed 27.1% and node 3 contributed 27.4% of the storage root fresh mass (Table 5.5). This distribution pattern probably reflects the relative proximity of the nodes to the source of assimilates from the leaves. The results corroborate those of Du Plooy *et al*., (1992) who reported that node 1 of three subterranean nodes contributed the highest storage root mass of 140 g, node 2 contributed 90 g and node 3 contributed 41 g. With five subterranean nodes, node 1 contributed the highest storage root mass of 136 g, node 2 contributed 92 g, node 3 51 g, node 4 35 g and node 5 28 g. Lowe & Wilson (1975) observed that the mean storage root yield of node 1 was 85 g, node 2 116 g, node 3 64 g and node 4 54 g for six cultivars. The explanation for the differences between the results of Du Plooy *et al* (1992), Lowe & Wilson (1975) and the experiments conducted at University of Pretoria is not clear, but it reflects the high degree of variability in sweet potato research pointed by Lowe & Wilson (1975).

No clear information yet exists on the contribution of individual subterranean nodes to the number and mass of storage roots produced. This is the subject which deserves more research attention. The pot experiments reported here contribute towards a better understanding of this topic and clearly indicated that a similar number of storage roots formed at each of the three subterranean nodes, reflecting the fact that the number of preformed root primordia (potential storage root) was the same for all the nodes (Chapter 3). Only a few of the adventitious roots developing from preformed root primordia actually develop into storage roots. Factors determining whether a potential storage root develops into storage root remain unclear and deserve more attention.

Table 5.4 Mean storage root number per node of the three experiments

Type of cutting	Storage root number (Percentage contribution in bracket)			
	Total	Node 1	Node 2	Node 3
Terminal	4.08	1.42 (36.0)	1.33 (31.9)	1.33 (32.0)
Middle	4.31	1.57 (37.0)	1.37 (31.5)	1.36 (31.5)
Basal	2.83	0.72 (26.7)	0.80 (26.5)	1.31 (46.9)
Mean	3.74	1.24 (33.2)	1.17 (29.9)	1.33 (36.8)

Table 5.5 Mean storage root mass per node of the three experiments

Type of cutting	Storage root mass (Percentage contribution in bracket)			
	Total	Node 1	Node 2	Node 3
Terminal	194.75	96.2 (48.1)	60.1 (29.4)	38.50 (22.4)
Middle	191.48	96.5 (50.5)	53.4 (27.8)	41.61 (21.6)
Basal	73.98	23.7 (37.7)	16.0 (24.2)	34.31 (38.1)
Mean	153.40	72.1 (45.4)	43.2 (27.1)	38.14 (27.4)

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