SURVIVAL OF SELF-ROOTED ROSE *(ROSA HYBRIDA)* AS AFFECTED BY HARVEST STAGE, CULTIVAR AND STORAGE PERIOD OF BUDWOOD WOOD

M. A. Otiende[1], J. O. Nyabundi[2], M. O. A. Onyango[3] and K. Ngamau[4]
[1,2] Botany and Horticulture Department, Maseno University
[3,4]Horticulture Department, Jomo Kenyatta University of Agriculture and Technology, Nairobi

ABSTRACT

Roses are the leading cut flower produced in Kenya contributing 70% of total cut flower revenue. Roses may be offered as gifts during occasions such as valentines', Christmas, and Mothers' Day. They can also be used for decoration of houses and wedding ceremonies. Low percentage survival rates (less than 50%) of self-rooted cuttings of highly demanded cut rose cultivars ('Milva' and 'Shocking Vasila') adversely affect their production. This results in increased cost of production and shortage of planting materials consequently delaying planting during the peak periods when export demand is high. In an effort to further understand factors affecting percentage survival in these cultivars, the bud wood development stage and cold storage period of cut wood and their relationship to survival of the two *Rosa hybrida*, cultivars were evaluated. The bud wood was harvested at flower bud initiation, tight flower bud and full bloom stages and then stored for 0, 3 or 7 days at 2 – 4°C. The treatments were arranged in a completely randomised design with three replications. Bud wood harvested at full bloom stage exhibited significantly ($p < 0.05$ higher percentage survival than bud wood harvested at flower bud initiation stage in 'Milva'. Percentage survival of bud wood from tight flower bud and full bloom stages were not significantly different from each other in 'Shocking Vasila' though survival from full bloom stage was higher. Storage for 7 days yielded significantly higher percentage survival than 0 days storage in 'Milva'. Non-storage produced significantly lower percentage survival than 3 and 7 days storage in 'Shocking Vasila'. Results suggest that the cut wood of the two cultivars should be harvested at full bloom stage and stored for 7 days to achieve higher percentage survival. The cultivars differed significantly in their ability to root. 'Shocking Vasila' was found to be an easy to root cultivar compared to 'Milva' as more than 70% survival was achieved. 'Milva' exhibited less than 45% survival hence difficult root cultivar. In order to improve percentage survival in this cultivar, other methods of propagation such as top grafting and tissue culture should be employed. In addition the effects of exogenous auxin and carbohydrate concentrations on percentage survival of this cultivar should be examined.

Key words: Rose, cultivar, harvest, storage, period, self-rooted, budwood, period

1.0 INTRODUCTION

The low percentage survival of self-rooted cuttings of highly demanded cut rose cultivars adversely affects the cut flower value and production. This results in increased cost of production and shortage of planting materials, consequently delaying planting during the peak periods when both export and domestic demand is high. Rooting and survival of stem cuttings may be adversely affected by a number of variables such as physiological age, genetic composition, treatment of cuttings, nutritional status and environmental factors (Hartmann *et al., 1997).*

The physiological age of the cutting influences survival of stem cuttings through carbohydrate content (Rauveni and Raviv, 1981), endogenous auxin (Caboche *et al*., 1987; Eriksen, 1974) and rooting co-factors (Davies and Hartmann, 1988). The inflorescences are strong sinks of photoassimilates and compete for metabolites necessary for rooting (Johnson, 1970) and also produce inhibitors to root initiation (Edmund, 1977). Pertwee, (1995) reported that cuttings from full bloom flowering shoots should be used in propagating roses to ensure that they produce flowers that are true-to-type.

A successful storage of cuttings minimises growth and development during storage and sustains photosynthetic and regrowth potential (Nihal *et al.,* 1996). Low temperature has been used to slow metabolic processes of horticultural produce such as cut roses, to reduce bud break, to enhance callus formation at the base of the cuttings (Davies and Potter, 1985) and to allow accumulation of large quantities of cuttings for rooting and planting at the same time (Hartmann *et al.,* 1997; Cram and Landquist (1989) revealed that dormant cuttings allow more time for the cuttings to produce roots before energy is diverted to leaf production. Delayed bud break reduces resource allocation conflicts between the root system and elongating shoot (Christopher *et al.,* 2004).

Post storage performance of propagules is closely related to the carbohydrate content of the cutting at the time of harvest (Nell *et al.,* 1990). Therefore harvesting bud wood at physiological age with optimal levels of photosynthates and phytohormones and cold storage for a particular period may play a significant role in subsequent field establishment of rooted cuttings. Cultivars 'Milva' and 'Shocking Vasila' are among the highly demanded cut rose cultivars in the large-sized, long-stemmed range with excellent stem quality and extremely long vase life of 14-15 days, excellent shippability and production of 140-220 stems/m^2/year. Low percentage survival (less than 50%) adversely affects production of these cultivars. In an effort to further understand the factors influencing percentage survival of self-rooted rose cuttings, the objective of the present study was to evaluate the effects of bud wood stage and cold storage period on survival of the two cut rose cultivars.

2.0 MATERIALS AND METHODS

Bud wood of two (2) rose cultivars, namely, 'Milva*'* and 'Shocking Vasila' were obtained from James Finlay Flowers Company Limited, Kenya for rooting in pots under greenhouse conditions at James Finlay Flowers during the months of May to

September 2004. The bud wood of the two cultivars were harvested at three flower bud development stages: flower bud initiation (visible bud stage), tight flower bud and full bloom and then subjected to 3 cold storage periods of 0, 3 and 7 days. The bud woods were 5-7 cm long, 0.6 cm thick with one node obtained from where 5-7 leaflets occur. The bud wood to be stored for 7 days was harvested first followed 4 days later by 3 days storage and finally the 0 day (non-stored) on the day of planting. Storage was done in cold store at 2-4^{o}C. The 18 treatments were factorially combined, replicated 3 times and arranged in a completely randomized design. Planting was done in pots (7cm by 7cm by 6.2cm) filled with the cocos medium.

The pots were arranged in suitable trays at a rate of 10 pots per tray at a spacing of 14 cm by 14 cm then placed on greenhouse benches and irrigated to potting capacity before planting. After planting, relative humidity greater than 90%, temperature of 26-30^{o}C (daytime) and 22–24^{o}C (night time) and misting cycles of 10-30 minutes (daytime) and 1-2 hours (night time) were maintained in the first two weeks then gradually reduced to harden the plants. There were 40 potted plants per treatment. 10 plants per plot were sampled for shoot height and leaf number. Five plants per plot were sampled for leaf surface area, fresh shoot weight, root number and fresh root weight. Shoot height and fresh shoot weight were obtained 28 days and 34 days after planting, respectively. Leaf surface area was obtained by grid line intercept approach as described by Nye and Tinker, (1977) 34 days after planting.

The root measurements were obtained 35 days after planting. The roots were gently released from the medium, washed under running tap water, scrapped from the stem using a sterilised budding knife and then wiped with tissue paper to absorb surface moisture before measurements were taken. Root surface area was obtained by the grid line intercept approach. Fresh root weight and Root number were also obtained. Percentage survival was obtained by determining the plants with shoots and roots 35 days after planting. Data collected were subjected to analysis of variance using MODSTAT as a statistical package. Duncans' Multiple Range test was used to separate the means at 5% level (Gomez and Gomez, 1984; Steel and Torrie, 1980). Percentage survival data were transformed using $\log_{10}$ before being subjected to ANOVA.

3.0 RESULTS AND DISCUSSION

3.1 Influence of Storage Period,Bud wood Stage and Cultivation on Shoot Height

The interaction of bud wood stage, storage period and variety significantly ($p<0.05$) influenced shoot height (Table 1). Increasing storage period and bud wood stage significantly increased the shoot heights in 'Shocking Vasila'. In 'Milva' storage period had no significant effect on its shoot heights. However, taller shoots were obtained from bud wood stored for 7 days. In both cultivars bud wood harvested at full bloom and tight flower bud stages were significantly taller than those from flower bud initiation stage though shoot heights from the former two stages had no significant difference in their shoot heights. In 'Shocking Vasila' produced significantly taller shoots than 'Milva'The total shoot length of a lateral shoot is a function of both length of each internode, number of internodes present as well as the condition of the root system (Mastalerz, 1997). The shoot depends entirely on roots for supply of water, minerals, nutrients and synthesis of gibberellins and cytokinins (Salisbury and Cleon, 1991). Cytokinins have been implicated in control of shoot growth through regulating cell division and elongation. The vigorously growing taller shoots observed showed that there was faster shoot elongation in these treatments.

Table 1: Effects of storage period, bud wood stage and cultivar on shoot height (cm) of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivar	Budwood stage	Storage period (s) in days			Stage means	Variety means	Grand Stage means
		0	3	7			
'Milva'	Flower bud initiation	0.19	0.19	0.20	0.19 *		Flower-bud initiation 0.86*
	Tight flower bud	0.51	0.30	0.78	0.53 ns		
	Full bloom	0.33	0.88	0.48	0.56 ns		Tight flower bud 1.63 ns
Storage means		0.34 ns	0.46 ns	0.49 ns		0.43 *	
'Shocking Vasila'	Flower bud initiation	1.04	1.95	1.56	1.52*		
	Tight flower bud	2.31	2.8	3.20	2.73 ns		
	Full bloom	1.85	3.44	4.32	3.23 ns		Full bloom 1.90 ns
	Storage means	2.60 ns	2.73 ns	3.16*		2.74 *	
Grand Storage means		1.47 ns	1.57 ns	1.83*			

Ns,* Non significant or significant at 0.05
0 day (control)

3.2 Influence of Storage Period, Bud wood Stage and Cultivar on Leaf Surface Area

Bud wood harvested at full bloom stage produced larger leaf surface area than the other two stages in both varieties (Table 2). In 'Milva' significantly lower leaf surface area resulted from bud wood harvested at flower bud initiation stage. In 'Shocking Vasila' bud wood harvested at the three stages were significantly different from each other. Highest leaf surface area resulted from bud wood harvested at full bloom stage. Storage period significantly influenced the leaf surface area of both cultivars. In 'Milva' bud wood stored for 7 days produced significantly higher leaf surface area than the 0 and 3 days storage. In 'Shocking Vasila' the unstored bud wood produced significantly lower leaf surface area than the stored. 'Shocking Vasila' had significantly larger leaf surface area than 'Milva'.

A correlation between shoot stem length and shoot leaf area has been established in the apple cultivars (Johnson and Lakso, 1985) making stem length a useful tool for estimating leaf area. Leaves on cuttings act as a source of assimilates, minerals, hormones and rooting co-factors (Hartmann *et al.*, 1997). The greater leaf surface area observed showed that there was faster cell division and expansion and possibly cytokinins was involved. Endogenous cytokinins frequently produce broad, fleshy leaves though the effect is relatively small.

Table 2: Effects of storage period, bud wood stage and cultivar on leaf surface area (cm^2) of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivar 'Milva'	Budwood stage	Storage period (s) in days 0	3	7	Stage mean	Variety mean	Overall Stage mean
Storage means	Flower bud initiation	1 84	3 83	1 94	2 54'		Flower bud initiation 17 64'
	Tight flower bud	4 42	3 88	8 54	5 05''		
	Full bloom	4 23	6 24	9 30	6 59''		Tight flower bud 24 37'
Storage means		3 53'	4 66''	6 59'		4 93'	
'Shocking Vasila'	Flower bud initiation	18 46	40 58	30 15	32 73'		
	Tight flower bud	35 98	40 73	52 57	43 08'		
	Full bloom	58 92	55 80	60 83	58 52'		
	Storage means	37 79'	45 70''	50 83''		44 78'	Full bloom 32 35'
Overall Storage means		20 66''	25 18''	28 7''			

Ns, ' Non significant or significant at 0 05
0 day (control)

3.3 Influence of Storage Period,Budwood Stage and Cultivar on Fresh Shoot weight

Significant differences in fresh shoot weight were observed in bud wood at the different stages and the different storage treatments (Table 3). In 'Milva' bud wood from flower bud initiation stage produced significantly lower fresh shoot weight than from tight and full bloom stages. Fresh shoot weight from bud wood harvested at full bloom stage was higher than from tight flower bud stage. In 'Shocking vasila', bud wood harvested at full bloom stage produced significantly higher fresh shoot weight than that from flower bud initiation stage. Fresh shoot weight from bud wood harvested at tight flower bud stage was significantly (pd<0.05) different from those harvested at flower bud initiation stage and full bloom stage. Stored bud wood produced significantly higher fresh shoot weight than unstored in both cultivars. Bud wood stored for 7 days had the highest fresh shoot weight. 'Milva' had significantly lower fresh shoot weight (0.18g) than 'Shocking Vasila' (1.03g). Due to short internodes in 'Milva' probably more of the total carbohydrates translocated by the larger leaf area were exported to the rest of the plant and smaller percentages to the stem and perhaps this led to the lower fresh shoot weight observed in 'Milva.' Most of its cuttings did not form roots and possibly shoot growth resources from the roots were inhibited.

Table 3: Effects of storage period, bud wood age and cultivar on fresh shoot weight (g) of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivars	Budwood stage	Storage period (s) in days			Stage means	Variety means	Grand Stage means
		0	3	7			
'Milva'	Flower bud initiation	0.01	0.07	0.14	0.07*		Flower bud initiation 0.33*
	Tight flower bud	0.13	0.29	0.28	0.23-		
	Full bloom	0.13	0.30	0.30	0.24-		
Storage means		0.09*	0.22 -	0.24 ..		0.18*	Tight flower bud 0.43..
'Shocking Vasila'	Flower bud initiation	0.69	1.20	0.89	0.93*		
	Tight flower bud	0.80	1.05	1.37	1.07*		Full bloom 0.53..
	Full bloom	1.34	1.21	1.46	1.34*		
	Storage means	0.70*	1.15 -	1.24 ..		1.03*	
Grand Storage means		0.70 ..	0.69 -	0.74 ..			

3.4 Influence of Storage Period, Bud wood Stage and Cultivar on Root Number

Significant differences were noted between cultivars (Table 4). Root number ranged from 17.95 in 'Shocking Vasila' to 6.19 in 'Milva'. Storage period and bud wood stage significantly affected the average root number in both cultivars. Harvesting bud wood at full bloom stage resulted in significantly more roots in both cultivars. Storing bud wood for 7 days resulted in significantly higher root number in 'Milva' than 'Shocking Vasila'. No significant differences were noted in root number among storage treatments in 'Shocking Vasila'.

The physiological age of the cutting influences root initiation and development through carbohydrate content (Rauveni and Raviv, 1981), endogenous auxin (Caboche *et al*., 1987; Eriksen, 1974) and rooting co-factors (Davies and Hartmann, 1988). The bud wood harvested at full bloom stage possibly had more cutting resources required for root initiation, growth and development compared to the other stages. Root tips are sites of synthesis of gibberellin-like and cytokinin-like hormones (Wilkins, 1990). Cytokinins have been implicated in control of shoot growth by regulating cell division and elongation, leaf protein metabolism and auxiliary shoot growth (Moore, 1979). The higher root number (Table 4) had a positive effect on subsequent shoot growth (Table 1) and cuttings that had more roots had many sites of cytokinin synthesis thus promoting shoot growth in bud wood harvested at full bloom stage and stored for 7 days in both cultivars. Ooyoma and Toyoshima (1965) associated increase in root number and subsequent growth height. Large numbers of roots in *Betula, Prunus, Malus* and *Viti*s enhanced transplant survival (Burd and Dirr, 1977). The greater root number (Table 4) was associated with higher percentage survival in both cultivars (Table 7). Cold storage of cuttings enhances callus formation at the base of the cuttings of leafy cuttings of carnations, and 'Karume type' Azalea, (Hartmann *et al*., 1997), Chrysanthemums (Van de Pol, 1988), Rhododendron (Davies and Potter, 1985) and Poinsettias (Hentig and Knosel, 2005). Callusing is a prerequisite to the formation of root initials in stem cuttings. From the study it is likely that stored bud wood formed callus earlier than unstored bud wood after planting and possibly root initiation occurred earlier before bud break thus reducing resource allocation conflicts between the roots and shoots. Cram and Landquist (1989) revealed that dormant cuttings allow for the cuttings to produce roots before energy is diverted to leaf production. Lack of bud break reduces resource allocation conflicts between the root system and elongating shoots (Christopher *et al.,* 2004).

Cultivar difference was observed in root number. 'Shocking Vasila' had more roots than 'Milva'. Most cuttings of 'Milva' were observed to form only thick callus at the base of cuttings that did not form roots and perhaps cutting resources were diverted from root formation as shown by fewer roots (Table 4). Similar observations were made in Fraser fir cuttings (Christopher *et al.,* 2004).

Table 4: Effects of storage period, bud wood stage and cultivar on root number of self- rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivars	Bud wood stage	Storage period (S) in days			Stage means	Variety means	Overall Stage means
		0	3	7			
'Milva'	Flower bud unopen	4.17	4.07	5.9	4.91a		Flower bud unopen 10.84a
	Tight flower bud	4.00	3.00	6.37	5.23a		
	Full bloom	6.20	7.40	16.23	9.94b		
Storage means		5.01a	5.02ab	9.50b		6.19b	Tight flower bud 10.78a
'Shocking Vasila'	Flower bud unopen	17.53	16.13	16.63	16.77a		
	Tight flower bud	13.07	13.13	22.23	16.34a		
	Full bloom	20.37	25.43	16.43	20.74b		
	Storage means	17.10ab	18.2ab	18.43ab		17.95b	
Overall Storage means		11.06a	11.61a	13.97a			Full bloom 15.34b

Ns, b Mean significantly significant at 0.05
0 day control

3.5 Influence of Storage Period, Bud Wood Stage and Cultivar on Root Surface Area

The root surface area was significantly affected by the cultivar and storage period. 'Shocking Vasila' produced significantly higher root surface area than 'Milva' (Table 5). Storing bud wood of both cultivars for 7 days yielded significantly higher root surface area than the non-stored bud wood. However, root surface area from bud wood stored for 3 days was not significantly different from those stored for 0 and 7days.

Cultivars with greater root surface usually have a relatively greater water and nutrient uptake capacity, higher yield stability and drought tolerant (Zhang, 1995). The greater root surface area observed in bud wood stored for 7 days and in 'Shocking Vasila' greatly influenced the survival of the cutting during the hardening off period. The rooted cuttings with greater root surface area and root number were observed to be more vigorous in growth during the hardening off period. Though bud wood from 'Milva' remained green before the onset of hardening off period due to short interval misting cycle (10 – 30 mins), high relative humidity (greater than 85% within the first two weeks after planting), with gradual exposure to the hardening condition, most of its cuttings lost their leaves possibly because of the fewer and poorly developed roots or failure of some cuttings to form roots.

Table 5: Effects of storage period, bud wood stage and cultivar on root surface area (cm^2) of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'.

Cultivars	Bud wood stage	Storage period (s) in days			Stage means	Variety means	Grand Stage means
		0	3	7			
'Milva'	Flower bud initiation	12 07	11 74	18 51	14 31 ■		Flower bud initiation 59 06″
	Tight flower bud	6 36	16 48	13 30	12 01 ■		Tight flower bud 41 76″
	Full bloom	10 50	16 30	23 08	16 63 ■		
Storage means		9 84'	14 84 ″	18 26'		14 32'	
'Shocking Vasila'	Flower bud initiation	18 10	27 19	30 73	25 34 ■		
	Tight flower bud	19 93	29 34	40 55	29 94 ■		Full bloom 46 76″
	Full bloom	25 15	31 70	33 50	30 12 ■		
	Storage means	21 06'	29 41 ″	34 93'		28 47'	
Grand Storage means		30 90'	44 26'	53 20'			

Ns' Non significant at significance at 0.05
0 day (control)

Significant storage period and bud wood stage effects were noted on root fresh weight (Table 6). 'Milva' and 'Shocking Vasila' were significantly (pd<0.05) affected by stage stage of bud wood. At harvest harvesting bud wood at full bloom stage resulted in significantly higher fresh root weight than the flower bud initiation stage. In 'Shocking Vasila', fresh root weight from bud wood harvested at tight flower stage was not significantly different from that harvested at flower bud initiation and full bloom stages. Fresh root weight from bud wood harvested at flower bud initiation and tight flower bud stage were not significantly different from each other in 'Milva'. Storing bud wood for 7 days resulted in higher fresh root weight than 0 and 3 days storage though fresh root weight from the latter periods were not significantly different from each other in 'Shocking Vasila'. Though fresh root weight in 'Milva' was not significantly affected by storage period, highest root weight resulted from bud wood stored for 7 days.

The increase in fresh root weight with increase in storage period and at later stages of bud wood development could be due to high dry matter accumulation in the roots. The vigorously growing shoots from full bloom stage had greater fresh root weight in both cultivars and possibly the greater leaf surface area observed had promotive effect on root growth as it trapped more light for photoassimilate production. Rauveni and Raviv (1981) reported a positive correlation between carbohydrates translocated from the leaves to root formation in stem cuttings of Avocado. Post storage performance of propagules is closely related to the carbohydrate content of the cutting at the time of harvest (Nell *et al.,* 1990). Possibly the bud wood harvested at full bloom stage had more carbohydrate content and a greater portion of it was translocated to the base of cutting for root growth and development. The fresh root weight is related to number of roots and root surface area. The treatments that had more roots and greater root surface area produced greater fresh root weight in this study.

Table 6: Effect of storage period, bud wood stage and cultivar on fresh root weight (g) of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivars	Budwood stage	Storage period (t) in days 0	3	7	Stage means	Variety Mean	Overall Stage means
'Milva'	Flower bud initiation	0.82	0.54	0.65	0.67a		Flower bud initiation 0.64b
	Tight flower bud	0.66	0.77	1.03	0.82a		
	Full bloom	1.15	1.20	1.13	1.16b		
Storage means		0.88ab	0.84ab	0.94a		0.83a	
'Shocking Vasila'	Flower bud initiation	0.17	0.37	1.28	0.61b		Tight flower bud 0.89a
	Tight flower bud	0.48	0.72	1.65	0.95a		
	Full bloom	1.18	0.46	1.86	1.17b		
	Storage means	0.61ab	0.52ab	1.00b		0.91a	
Overall Storage means		0.74a	0.68ab	1.29b			Full bloom 1.17b

Ms, b Mean significant at significant at 0.05
0 day = control

significantly higher percentage survival than at flower bud initiation stage in both cultivars. Storage resulted in significantly higher percentage survival than no storage in both cultivars.

Percentage take was measured on the basis of presence of shoots and roots on the cutting. Shoot and root growth are closely related. Mastalerz (1977) revealed that maximum shoot growth could be obtained only when the roots are growing vigorously and functioning normally. The shoots entirely depend on the root system for supply of water, nutrients and some hormones such as cytokinin and gibberellins. Cytokinins have been implicated in control of cell division and elongation, leaf protein metabolism and axillary shoot growth (Moore, 1979). The carbohydrates translocated from the leaves were found to positively correlate to rooting (Rauveni and Raviv, 1981) in avocado stem cuttings. The cuttings that had better shoot growth were found to produce better roots and therefore higher percentages survival in both cultivars. The cultivar 'Shocking Vasila' produced a greater number of roots and gave higher percentage survival (79.82%) compared to 'Milva' (29.96%) (Table 7). Most of the cuttings from 'Milva' were observed to produce only thick callus mass at the base of the cutting that did not form roots. Perhaps cutting resources such as mineral, nutrients, and carbohydrates were diverted from root formation as shown by lowered rooting percentage, fewer and shorter roots. Due to fewer and lack of roots in some cuttings, the shoot growth resources from the roots were inhibited, thus most of its cuttings died during hardening off period. From the results 'Milva' appeared to be a difficult to root

cultivar and possibly its stem cuttings had more of the growth inhibitors, lowered nutrients, rooting co-factors or lacked sensitivity to auxin. Lack of competency in difficult to root species may be due to lack of sensitivity to auxin rather than the sub-optimal levels of endogenous auxins as opposed to easy to root species (Caboche *et al.,* 1987). High concentration of exogenous auxin inhibits rooting and may induce ethylene that may lead to loss of cutting leaves and inhibition of bud break (Robert *et al.,* (2001). It has been found that auxin is required for initiation of adventitious roots on stems and divisions of the first root initials depend upon endogenous and exogenous levels of auxin (Eriksen, 1974). From this study it is therefore important to determine the levels of endogenous auxin in 'Milva' before deciding on concentration of exogenous auxin to be used, rooting co-factors and carbohydrates content of the cutting before deciding on the storage duration. In addition, other methods of vegetative propagation can be employed to overcome the problems associated with lowered percentage take in 'Milva' such as top grafting and tissue culture.

Table 7: Effects of storage period, bud wood stage and cultivar on percentage survival of self-rooted cuttings of Roses 'Milva' and 'Shocking Vasila'

Cultivars	Budwood stage	Storage period (s) in days 0	3	7	Stage means	Variety means	Overall Stage means
'Milva'	Flower bud initiation	1 29	1 28	1 39	1 32 (21 00)		Flower bud initiation 1 66 (45 55)
	Tight flower bud	1 43	1 04	1 69	1 40 (29 00)		
	Full bloom	1 37	1 69	1 68	1 60 (39 89)		
Storage means		1 37 (23 22)	1 42 (26 22)	1 61 (40 44)		1 46 (29 96)	Tight flower bud 1 75 (55 95)
'Shocking Vasila'	Flower bud initiation	1 75	1 89	1 88	1 85 (70 11)		Full bloom 1 80 (63 17)
	Tight flower bud	1 88	1 93	1 94	1 92 (82 89)		
	Full bloom	1 91	1 96	1 94	1 92 (86 89)		
	Storage means	1 85 (70 89)	1 92 (84 00)	1 92 (84 00)		1 90 (79 82)	
Overall Storage means		1 67 (47 06)	1 74 (55 30)	1 79 (62 22)			

Ns, '
Means with same letters are not significant at 0.05
0 day = control

l that
antly

higher percentage take in both cultivar than the other treatments and also 'Shocking Vasila' had significantly higher (79.82%) percentage survival than 'Milva' (29.5%). It is clear from the study that 'Milva' is a difficult to root cultivar as lower percentage survival was obtained. A study is therefore recommended to determine the effects of exogenous auxin and carbohydrate concentration on rooting of this cultivar as most of its cutting only formed callus at the base of cuttings.

Most of the cuttings from 'Milva' did not form shoots even after 7 days of cold storage. This shows the buds still remained dormant and a study should be done to determine the effect of longer storage duration on rooting and bud break in these cuttings. It is also important to determine the carbohydrate content of these cuttings before deciding on the storage duration. In addition, other methods of vegetative propagation such as top grafting and tissue culture can be employed to overcome the problems associated with lowered percentage survival.

ACKNOWLEDGEMENTS

We express sincere appreciation to Mr. Francis Maimba, Head of Propagation Department James Finlays Flowers Company Limited, Kericho, Kenya. Special thanks are extended to USAID project for sponsoring this project and Finlays Flowers Company for providing the rooting resources for the research.

REFERENCES

Burd S. M. and M. Dirr (1977) Propagation of selected Malus taxa from softwood cutting. *Proc. Intl. Plant Propagation Society*.

Caboche M., J.F. Muller F. Chanut G. Aranda and S. Cirako glu. (1987). Comparison of the growth promoting activities of various auxin analogs on rooting on cells derived from wild type and a mutant tobacco. *Plant Phys*., **83**, pp 795-800.

Christopher L. R., J. Rampton, B. Goldfarb F. A. Blazich and F. C. Wise (2004). Growth stage, Auxin type and concentration influence rooting of stem cuttings of Fraser fir. *Hort. Sci*., **39**(6), pp1397 – 1402.

Cram W. H. and Linquist C. H. (1989). Refrigerated storage of Hard wood cuttings of willow and poplar, *Tree planter Notes,* **33**(4), pp. 3-5

Davies F. T., Jr., and H.T. Hartmann. (1988). The physiological basis of adventitious root formation. *Acta. Hort*., **227**, pp 113-20.

Davies T. D., and T. R. Potter.(1985). Carbohydrates, water potential and subsequent rooting of stored rhododendron cuttings. *Hortscience*, **20,** pp 292-293.

Edmund J. B. (1977). *Fundamentals of Horticulture*. 3rd edition. McGraw-Hill Bk. Company. New York.

Eriksen E. N. (1974). Root formation in Pea cuttings. 11. The influence of indole 3-acetic acid at different development stages. *Phys. Plan,* **30,** pp 153- 162.

Gomez K. A. and Gomez A.A. (1984). *Statistical procedure for Agricultural research*. John Wiley and Sons Inc. New York.PP

Hartmann. H, T Dale E. Kester, Fred T. Davies Jr., Robert L.G. (1997). *Plant propagation: Principles and practices*. 6th edition, prentice Hall International Inc. London.

Hentig W. U. v and K. Knosel (2005) Storage of poinsettia cuttings. IISHS *Acta Horticulture,* **181**.

Johnson C. R. (1970). The nature of flower bud influence on root regeneration in the Rhododendron shoot. Ph.D. dissertation Oregon State Univ. Carvallis, Oreg. Pre-rooting storage in the dark. *Acta.hort*.**, 226,** pp 519-524

Johnson R. S. and A.N. Lakso (1985). Relationships between stem length, leaf area, stem weight and accumulated growing degree days in Apple shoots. *J. Amer. Soc. Hort. Sci.,* **110**(4), pp 586 – 590

Mastalerz J. W. (1977). *The greenhouse environment*. John Willey and SonsInc.Moore T. C. (1979). *Biochemistry and physiology of plant growth hormones*, Springer – Verlag, N.Y.

Nell T.A., R.T. Leonard, and J.E. Barret. (1990). *Production and postproduction irradiance effects acclimatization and longevity of potted chrysanthemum and poinsettia*.