DOI: http://doi.org/10.4038/jrrisl.v97i0.1880

Effect of method of transplanting young budded plants on growth of rubber tree (*Hevea brasiliensis* Muell. Arg.)

P Seneviratne*, S A Nakandala* U S Weerakoon and R Handapangoda***

* *Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka*
** *367/3, Jinasena Mawatha, Mahara, Kadawata, Sri Lanka*

Abstract

Planting materials used for the establishment of new rubber fields in Sri Lanka are young buddings. At planting, it is recommended to remove the polythene bag fully. This is a high labour demanding exercise and has inherited shortcomings of lateral root systems getting damaged when making the vertical cut along the sidewall to remove the bag. Attempts were made to transplant the young budding plants with the bag and four other methods together with the currently recommended method as the control. Treatments tested were, planting with the whole bag intact, planting with the bag but without the base of the bag, four slits made on the sides of the base removed bag and with the whole bag intact and only four slits made on the sides of the bag. Two whorled young budding plants of clone RRIC 121 were used. The experiment was carried out according to a Complete Randomize Design (CRD). Each treatment had twenty replicates.

The growth data up to six years from planting revealed that girth values are not significantly different. The field establishment rates were 100% with all treatments. The labour requirement is low when the plants are transplanted with the bag, which guarantees that the root system is not disturbed or damaged and hence no casualties. Also, when large extents are planted it is extremely difficult to follow the correct step by step procedure to remove the polybag and a certain percentage of casualties are expected and reported. The differences in the growth and the timber volume were not significant among treatments 20 years after planting. It was found in this study that planting without the base of the polythene is equally effective as removing the whole bag.

Key words: field planting, *Hevea*, rubber, planting with the bag, RRIC 121, young buddings

Introduction

The extent under rubber (*Hevea brasiliensis* Muell. Arg.) is 130,000 ha (Anon, 2017) in Sri Lanka, and in order to maintain this area under the prevalent 30 year replanting cycle around three percent of this extent needs to be replanted annually. Accordingly, at a rate of 516 trees per hectare of land, about 2.2 million rubber plants are used and about 3,960 ha are expected to be replanted annually. In addition, new planting also takes place in non-traditional areas but to a lesser extent. Until the beginning of the 20th century, rubber tree was propagated with seeds and since the perfection of the bud grafting technique for rubber in 1917 by Van Helton, rubber plantations were established with bud-grafted plants raised in nurseries. Bud-grafted plants can be introduced to the field in various forms such as bare-root budded stumps, polybag plants young buddings, stumped buddings, *etc*. Since 2003, the recommended planting material for rubber is young buddings. In traditional rubber growing areas, seedling nurseries are established with the onset of seed fall in August and the young budding plants with two leaf whorls are ready for planting with the onset of the southwest monsoon rains in the following year which is the longest for those areas. In non-traditional rubber growing areas of the country such as in Moneragala and Ampara districts planting is done in October with Northeast monsoon rains.

The main advantage of using young budding in poly bags is the age of the plant, which is less than one year and, a well-established root system of young buddings which helps in the continuous growth in the field especially under unfavorable weather and climatic conditions. Also, the cost of young budded plants is comparable to bare-root budded stumps due to less nursery time involved in producing them. The high field establishment rate of young buddings is partially due to the well-established root system in the bag at planting. Uniform growth in the field is achieved mainly because of the vigorous culling of less vigorous plants and also due to less or no casualties in the field (Seneviratne and Nugawela, 1996).

Accordingly, one hundred percent success in field establishment and uniform growth of plants can be obtained if planted with the onset of the monsoon rains and with great care at planting by paying attention to every plant transplanted to the field. Preparation of the plants for field planting by tailing the taproot about 10 days before field planting date and minimizing watering during this period to keep the soil inside the bag hard which minimizes root disturbance. Though the establishment of rubber plantations with two whorled young buddings has proved advantages over bare-root budded stumps, in commercial plantations, casualties are reported due to dieback of the shoot. This happens when the root system is damaged and also the weather condition becomes dry soon after field planting. Hansethsuk (2003) has recommended fixing a split bamboo stick to the stem of the plant with leaves to prevent any damage from strong winds. It will prevent damages due to animals such as birds perching on the tender shoot. This is practiced by smallholder farmers in Sri Lanka too but very rarely in the estate sector.

The current recommendation for field establishment of young buddings is by removing the whole bag. The bottom of the poly bag is completely removed using a sharp knife and the bag along with the plant is then placed in the planting hole. A vertical cut is made starting from the bottom of the polythene bag, taking care not to damage the roots. Soil is filled up to that level and then the cut is continued up to the brim and the planting hole is filled with soil so that the cylinder of soil inside the polythene bag is undisturbed and the piece of polythene is carefully pulled out. Finally, the soil is packed firmly around the plant without pressing the soil core. As can be well understood, all these steps to safeguard the root system in the bag are not always adopted by the general workers who undertake this task of transplanting bag plants. Moreover, they are not aware of the importance of all these steps and they sometimes take the whole bag out before placing the plant inside the hole. Some recommendations such as keeping the soil in the bag dry are not possible in rainy weather. When the soil is soaked with water, damages to the roots is unavoidable. Having all the steps done carefully, one may press the soil around the plant with the foot which breaks or detach lateral roots. The whole purpose of having a good root system is lost under such conditions. However, if planting is done with the onset of the rains, the plant can withstand this until new roots are formed in 2-3 weeks. But, under unfavourable weather conditions, loss of water from plant tissues can affect the survival rate.

The objective of the study was to find out an effective and ergonomically viable method of transplanting young buddings safely to avoid casualties at planting while reducing the cost and preventing a set back on the growth.

Materials and Methods

Location and season

The experiment was carried out in one of the substations of the Rubber Research Institute of Sri Lanka, located at Nivithigalakale of Kaluthara district. Planting was carried out in May during the South West monsoon rainy season in 1999.

Planting materials

Young budding plants used for the study were of clone RRIC 121, grown up to two whorls in 7"x18" (15x45 cm), gauge 500, black polythene bags with bottom half perforated. Only plants with a harden top whorl were used. The tap root tailing was done using a pair of secateurs two weeks before planting.

Treatments

T1 - Planting with the poly bag intact

T2 - Planting with the bag of which base is removed

T3 - Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife

T4 - Planting with the bag intact (T1) but four slits made on the wall of the polybag with a sharp knife

T5 - Whole bag removed (Current recommendation)

Method of planting and after care

The size of the planting holes was 2'x 2'x2½' (60 x 60 x75 cm) and they were cut one month in advance, refilled and allowed to settle naturally. No fertilizer was incorporated to planting holes as recommended. Prior to planting a hole was dug using a mamoty to suit with the height of the bag. The graft union was positioned 4-5 centimetres below the ground level.

All plants were inspected at weekly intervals for any mechanical damages or dying due to planting shock. Weeding and manuaring cycles were done according to the recommendation.

Experimental design and data collection

The experiment was carried out according to a Complete Randomize Design (CRD). Each treatment had twenty replicate plants.

Diameter values were measured at 6" (15 cm) above the graft union monthly during the first year using a Vernier calliper and they were converted to girth for comparison. After the first year girth was measured using a tape annually at 3' (90 cm) from the graft union throughout the experimental period.

Standard Error of Mean (SEM) was calculated for the monthly data collected and the annual girth data were analyzed using SAS Statistical package.

Estimation of timber volume

Tree diameter was calculated using girth values taken at the height of 1.5m using following equation.

$D = G/\pi$

Where,

D = Diameter of the tree (m) at the height of 1.5m

G = Girth of the tree (m)

π = constant

Total tree height was estimated using formula (1) (Munasinghe *et al*., 2013).

$$TH_{wz} = -15.13 + 40.28 \Big/ \left(1 + \exp\left(-.13(YAP - 1.03)\right)\right) \quad \text{----------------} \quad (1)$$

Where,

TH_{wz}= Total tree height for Wet Zone (m)

YAP = Years after planting

Total timber log volume was estimated using formula (2) (Munasinghe *et al*., 2013).

$$TV_{tt} = -0.02 + 0.394 * Diameter^2 * Height^2 \quad \text{------------------} \quad (2)$$

TV_{tt} = Total timber log volume (m^3)

Diameter = Diameter of the tree at the height of 1.5m (m)

Height = Estimated height using formula (1) (m)

Results

Field establishment rate recorded up to 12 months was 100% for all treatments. Shoot growth assessed by diameter measurements and converted to girth are given in Figure 1. Though the girth values for five treatments show differences, they are not significantly different. However, the treatments 1 and 4, those planted with the base of the bag and base plus slits made on the wall, respectively show slightly lower girth values in the first year after planting. But, the girth values of all treatments are in acceptable levels, more than 12 cm average girth at the end of 13 months.

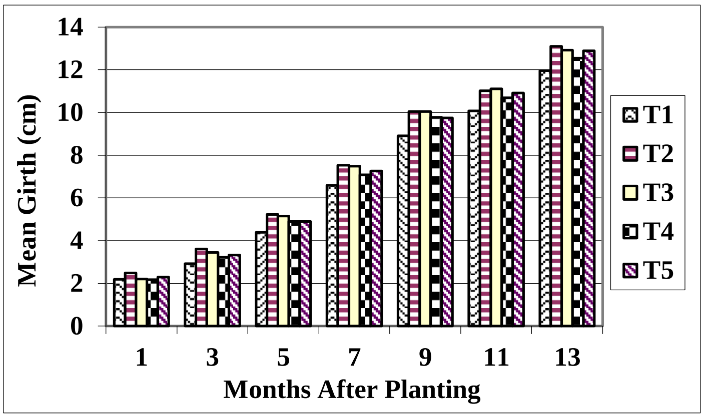

Fig. 1. Mean girth of plants measured at 6” (15 cm) above the graft union of the five treatments,

T1-Planting with the poly bag intact, T2-Planting with the bag of which base is removed, T3-Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife, T4-Planting with the bag intact (T1) and four slits made on the wall of the polybag with a sharp knife and T5-Whole bag removed (Current recommendation).

Plants were not sampled to see the root growth, as there were only 20 replicate plants and also as the diameter or the girth was taken monthly during the first year and then annually to determine the growth. However, root growth of one of the plants planted with the bag without the base or any slits made on the wall (Treatment 2) is shown in Plate 1. This was taken after one year of field planting and by exposing the root system carefully from one side. Generally, the girth of the shoot and the tap root is similar and in Figure 2, collar region shows the girth of the taproot and the bag broken into strips when the tap root and the laterals grow.

.

Fig. 2. Root growth of a plant planted with the bag but without the base or any slits made on the wall of the bag (Treatment 2) after one year of field planting

Mean annual girth (cm) of the young budded plants of five treatments up to six years of planting are given in Table 1. The lowest girth is shown by the plants planted with the base of the bag, throughout the first year followed by the plants planted with the base of the bag and the slits made on the wall. Though both treatments had the base of the bag intact, Treatment 4 had slits on the bag. However, the treatment effects had disappeared with the completion of one year after planting and hence the set back due to the presence of the bag seems temporary. The growth of the plant is partly determined by fertilizer absorption, which is the only important criterion.

Mean girth of the plants at the end of six years are shown in Figure 3. The lowest value of 51.4 cm was apparent in treatment planted with the base of the bag and with no slits cut.

Table 1. *Annual mean girth of plants of the five treatments*

Treatment	Year after planting					
	1	**2**	**3**	**4**	**5**	**6**
T1	11.90[b]	16.22[a]	20.88[a]	34.60[a]	46.00[a]	51.54[a]
T2	13.00[a]	17.00[a]	21.35[a]	33.94[a]	45.90[a]	51.73[a]
T3	12.90[ab]	16.96[a]	21.28[a]	34.87[a]	46.52[a]	52.98[a]
T4	12.50[ab]	17.00[a]	21.83[a]	35.46[a]	47.26[a]	53.69[a]
T5	12.80[ab]	17.68[a]	22.61[a]	36.48[a]	48.20[a]	54.01[a]

Means with same letter along the columns are not significantly different.

T1 - Planting with the poly bag intact, T2 - Planting with the bag of which base is removed, T3 - Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife, T4 - Planting with the bag intact (T1) but four slits made on the wall of the polybag with a sharp knife and T5 - Whole bag removed (Current recommendation).

As it can be seen from Figure 3, variation within the treatment and among treatments is low in the girth and therefore, the differences are not significant among treatments. The annual girth increment (cm) of plants of five treatments are shown in Figure 4.

The timber volumes calculated based on the girth values taken after 20 years from planting are shown in Table 3. As it can be seen from Table 2, there is no significant difference among treatments for the volume of timber produced by the plants transplanted under different treatments.

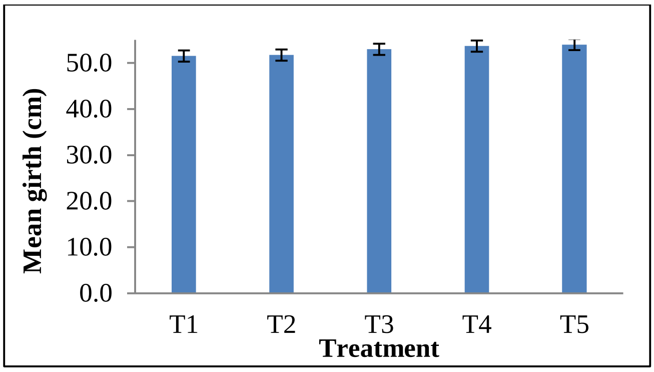

Fig. 3. Mean girth (cm) of the plants of the five treatments at the end of six years

T1 - Planting with the poly bag intact, T2 - Planting with the bag of which base is removed, T3 - Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife, T4 - Planting with the bag intact (T1) but four slits made on the wall of the polybag with a sharp knife and T5 - Whole bag removed (Current recommendation). Bars show SEM values.

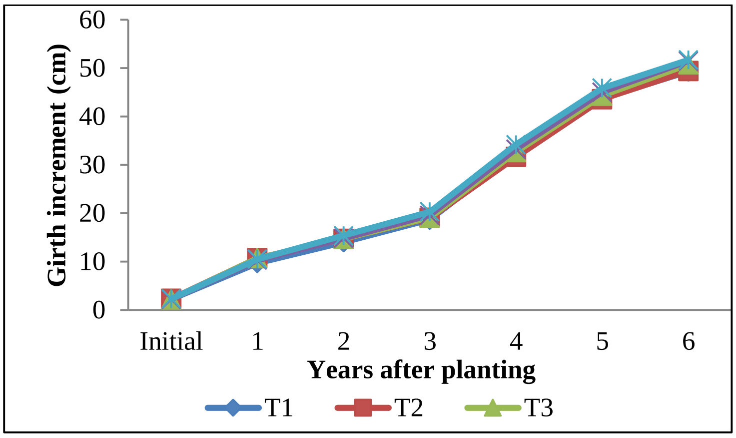

Fig. 4. Annual girth increment (cm) of the plants of five treatments

T1 - Planting with the poly bag intact, T2 - Planting with the bag of which base is removed, T3 - Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife, T4 - Planting with the bag intact (T1) but four slits made on the wall of the polybag with a sharp knife and T5 - Whole bag removed (Current recommendation).

Table 3. *The timber volume calculated based on the girth values taken after 20 years of planting*

Treatment	Mean girth (cm)	Timber volume (m^3)
T1	78.39[a]	0.59[a]
T2	82.23[a]	0.64[a]
T3	81.60[a]	0.63[a]
T4	83.07[a]	0.66[a]
T5	80.32[a]	0.60[a]

T1 - Planting with the poly bag intact, T2 - Planting with the bag of which base is removed, T3 - Planting with the bag of which base is removed (T2) and four slits made on the wall of the polybag with a sharp knife, T4 - Planting with the bag intact (T1) but four slits made on the wall of the polybag with a sharp knife and T5 - Whole bag removed (Current recommendation).

Discussion

The root system of a plant is responsible for up-taking nutrients and water from the soil. Therefore, the growth and development of above-ground parts of a tree depend on the performance of the roots to a greater extent. The root architecture is important for perennial trees for anchorage when the tree is fully grown specially to withstand strong wind under heavy showers generally prevailing during monsoonal rainy periods.

The propagation of rubber is through bud grafted plants where the rootstock comes from a seed and the bud is from an authentic clone raised in a bud wood nursery for harvesting buds. A thorough selection process is adopted to select vigorous rootstocks for bud grafting, starting from collecting seeds from the early seed fall as the vigour of the root system has a key role to play in the growth of the scion (Anon, 2016/09). There is a significant positive correlation between the time taken for germination and the vigour of the plant and effective usage of the germination bed is therefore recommended for rubber nurseries. During field establishment, care must be taken not to disturb the root system, mainly not to introduce a set back to the growth of the plant. More importantly, if the roots are damaged in a plant with foliage on it, the plant often cannot survive due to the shock followed by dieback of the shoot. The extent to which the root system gets damaged during field establishment could influence the setback period, but it will soon grow roots when the plant has leaves which in turn produce and transport cytokinins to promote root growth. Similarly, when the plant has a profuse, vigorous, and undisturbed root system, it supports the growth of the areal part by absorbing water, nutrients and synthesizing auxins for the shoot growth.

The annual growth increment of young budded plants is generally 10 cm and rubber plantations are tapped after five years of planting. The requirement for a tree to be opened for tapping is 50 cm girth measured at 120 cm above the ground level or the graft union. However, growth rate depends mainly on the quality of the plants and the immature upkeep specially the application of fertilizer. Climatic conditions as well as microclimate, terrain and the soil condition too affect the growth of plants. The growth phase of budded plants is generally five years and the rate drastically reduces as the trees enter the mature phase where annual flowering and wintering is observed.

According to the diameter measurements of field planted plants, a significant difference among treatments could be observed only during the first year. The highest mean value given by T2, *i.e.*, plants transplanted without the base of the polybag, must be due to not getting the lateral roots disturbed during slitting of the bag in all treatments except for treatment 1 where the plants were transplanted with the bag intact. The lowest mean value given by T4, in which the plants were planted with the base of the bag intact and with only four slits on the bag can also be explained by the damage that occurs during making slits on the wall of the bag. When planting with the polybag intact, the lateral roots which generally grow geotropically, may find it difficult to penetrate the bag and thus take a little longer to start growing. But, all polybags had perforation at the bottom half of the bag and as seen in Figure 2, the lateral roots had naturally grown out from those holes though the base is blocked.

This could be a reason for the plants transplanted without the base to show a little higher girth during the initial months, though not significant. Another reason for the higher growth in plants transplanted with only the base removed could be that the lateral roots not getting damaged due to absence of slits on the wall. Generally, in young buddings when the stock plant is cut back after four weeks of the grafting date most of the lateral roots tend to die. This takes place to maintain correct shoot to root ratio (Dharmakeerthi *et al*., 2008). The size of the scion shoot depends on the food reserves of the rootstock. This statement is partly supported by the observation of bigger rootstocks given rise to thicker scion shoots (Seneviratne, *et al.*, 1996). However, as the scion shoot grows and develops further, the apex of the scion synthesizes auxins and is transported down to promote root growth as explained earlier. The increased root growth supports the scion to grow. The lateral roots inside the bag tends to form a network around the soil bole if kept in nurseries for a longer duration. Therefore, it is simply not possible to make a slit on the sidewall of the poly bag without harming at least part of the lateral roots, as there is no gap between the bag and the soil core (Fig. 5). Therefore, until the plant regenerates its lateral roots even with the recommended method of removing the bag. There will be a setback in the growth. The planting hole is 30” deep but the height of the bag is only 18” and therefore, inside the hole below the base of the bag the loose soil is available for the roots to start growing without any barrier when the base is removed as in treatments 2 and 4.

Fig. 5. The lateral root growth of young budding plants showing circular growth on the root bole.

The lowest mean girth values observed in plants transplanted with four slits on the sides could be again due to the damage to laterals. The growth of the taproot cannot be stopped by the layer of polythene of the base and only an aluminium sheet inserted to the base of the bag before soil filling could stop the penetration of the taproot which coiled inside at the base (Review of Plant Science Department, Annual Review 2001). As the taproot coiling at the base of the polythene bag often retards the growth of the seedling before bud grafting and also as it delays bud grafting unnecessarily, an experiment has been conducted to see whether the growth of the seedling improves if a central hole is made at the base of the bag in addition to the normally recommended perforation at the bottom half of the bag (Review of Plant Science Department, Annual Review 2001). As expected the growth was better and the morphology of the taproot was improved with no bending or coiling at the base before penetrating to the soil.

In the present experiment, any growth difference among treatments should gradually seize once the root growth starts. The data on the girth of the plants of different treatments is in accordance with the fact that once the roots grow out of the bag then the effect of the bag type, whether the base was present or whether the cuts were made on the sidewall would be immaterial.

Different methods practiced to transplant the bagged plants to the field can affect the growth and the morphological development of the root system and thus the growth of the whole plant. Rubber tree develops a strong taproot and extensive lateral roots. The whole root system accounts for about 15% of the total dry weight of a mature tree. It is reported that in three year old rubber trees the taproots are about 1.5 m long and the laterals about 6-9 m long (Priyadarshan, 2011). Growth of the main roots seem to regulate the development of the lateral branches of plant. Laterals are more numerous (Wightman and Thimann, 1980) and major lateral roots arise from the taproot and they grow in horizontal direction to the soil surface or grow slightly downwards. Laterals that arise at the bottom of the taproots do not extend horizontally as those nearer to the soil surface. The ultimate product of lateral roots is yellow-brownish, un-suberized feeder roots having around 1mm thickness. These roots are mainly responsible for the uptake of water and nutrients (Soong, 1976, Samarappuli *et al.,* 1996). It is found that feeder root density is significantly differs with the distance from the base of the rubber plant. The amount of feeder roots in the surface layer of soil is more than 75% of the total feeder roots.

The method of fertilizer application to rubber plants in the field is explained in the (Anon, 2016/4, Fertilizer to Rubber). Fertilizer is applied to four holes of 6-8" depth made around base of plant by forking. With the rain, the dissolved fertilizer is leached down and the feeder roots established there can absorb them. The establishment of the root system well below the ground level is advantages to protect the trees from wind damages when they are fully grown.

However, the development of a root system has a general pattern though it can be influenced by the soil type, mode of fertilizer application, soil moisture content and aeration, nature of the ground cover and cultivation practices, *etc.* Growth and distribution of the root system has a greater influence on nutrition and water uptake and thereby the yield of rubber tree providing a major pathway for the flow of nutrients. Root systems of young rubber plants are restricted to the soil environment within the polybag. After field establishment, they have the ability to develop and extend within the soil profile.

As observed in the present study, the method of transplanting the polybag plants can affect the growth of the root system, during the initial period until the new roots are generated. The girth or the growth of the areal part of the tree is the best indicator to assess the root growth and the nutrient uptake. Study reveals that planting with the bag with the base removed is so much ergonomically viable and also cost effective while guaranteeing no damage to the lateral roots in the bag.

References

Anon (2016/09). Production of Budded Plants. Plant Science Department, Rubber Research Institute of Sri Lanka.

Anon (2016/04). Fertilizer to Rubber. Soils and Plant Nutrition Department, Rubber Research Institute of Sri Lanka.

Anon (2017). Statistical Information of Plantation Crops. Ministry of Plantation Industries.

Dharmakeerthi, R S and Seneviratne, A M W K, Edirimanna, V U and Chandrasiri, J A S (2008). Effect of stock pruning on shoot and root growth of budded polybag plants of *Hevea brasiliensis. Natural Rubber Research* **21**(1 &2), 24-31.

Hansethuk, J (2003). *Techniques for planting and management of immature rubber plantations*. Retrieved 06 15, 2016, available in http//www.agnet.org/ htmlarefile/liberary/ 20110720151748.

Leong, S K, Yoon, P K and P'Ng, T C (1986). Use of young buddings for improved *Hevea* cultivation. In: *Proceedings of International Rubber Conference,* 1986, Kuala Lumpur, Malaysia, pp. 555-577.

Munasinghe, E S, Rodrigo, V H L and Gunawardena, U A D P (2014). Modus operandi in assessing biomass and carbon in rubber plantations under varying climatic conditions. *Experimental Agriculture* **50** (1), pp 40-58.

Priyadarshan, P M (2011). Biology of *Hevea* Rubber. London: MPG Book Group.

Samarappuli, L, Yogaratnam, N, Karunadasa, P and Mitrasena, U (1996). Root development of *Hevea brasiliensis* in relation to management practices. *Journal of the Rubber Research Institute of Sri Lanka* **77**, 93-111.

Seneviratne, P and Nugawela, A (1996). Use of young buddings as a planting material in Sri Lanka. *Proceedings of the International Rubber Research and Development Board Conference*, Beruwala Sri Lanka, 1-7.

Seneviratne, P, Nugawela, A and Ramawickrama, D (1996). The importance of selecting plants at nursery stage. *Bulletin of the Rubber Research Institute of Sri Lanka* **33**, 34-44.

Seneviratne, P (2001). Review of the Plant Science Department. Annual Review of the Rubber Research Institute of Sri Lanka. pp.30-31.

Soong, N K (1976). Feeder root development of *Hevea brasiliensis* in relation to clones and environment. *Journal of Rubber Research Institute of Malaysia* **24**, 283-298.

Wightman, F and Thimann, K V (1980). Hormonal factors controlling the initiation and development of lateral roots. I. Sources of primordia-inducing substances in the primary root of pea seedlings. *Physiologia Plantarum* **49**, 13-20.

Address for correspondence: Dr (Mrs) P Seneviratne, Deputy Director Research - Biology, Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka.
e-mail*: ddrbiorrisl@gmail.com*.