

Agronomic and economic viability of rubber (*Hevea brasiliensis* Muell. Arg.)/cinnamon (*Cinnamomum verum* J Pres.) intercropping systems involving wider inter-row spacing in rubber plantations

L S S Pathiratna* and J C Edirisinghe*

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Abstract

Agronomic and economic viability of rubber/cinnamon intercropping under 10 inter-row spacing systems of rubber ranging from 8.4m to 18.0m were tested. Spacing treatments with 8.4m-13.2m had single rows and those between 13.2m and 18.0m had paired rows of rubber. The total dry matter of harvested shoots, bark yield and the percentage dry matter in bark remained unaffected even at the third harvest in wider inter row spacing systems, viz: 12.0m and 13.2m single row and 14.4m-18.0m paired row systems. Pay back period for systems involving 10.8m, 12.0m, 13.2 single row and 15.6m, 16.8m and 18.0m paired rows was 5 years i.e., after three harvests of cinnamon compared to 11 years for sole crop rubber. Pay back in 5 years in systems involving 10.8m –13.2m single rows was the result of low expenditure on rubber due to its reduced density. In systems involving 15.6m-18.0m this was mainly due to the sustained higher yields from cinnamon. Though the reduced rubber densities incur considerable losses of income from rubber in the long run, the excess income obtained from cinnamon in the 5th year was almost sufficient to cover this loss and all the costs in the system involving 15.6m. In the 13.2m paired row system where the rubber density was higher than the standard, low pay back is due to both reduced income from cinnamon and greater expenditure on rubber. Suitability of rubber inter-row spacings involving 14.4m, 15.6m and 16.8m paired rows for viable rubber/cinnamon intercropping systems is evident at this stage.

Key words: Cinnamon, intercropping, rubber, viability

Introduction

Intercropping under rubber is a useful practice to overcome some of the major problems faced by the growers. Price fluctuations of raw rubber, high cost of production, long unproductive immature period and loss of tapping days due to rain are some of the problems that affect the growers,

particularly the small holders (Jayasena and Herath 1986). Additional income that can be obtained during both immature and mature stages of rubber would improve their level of subsistence. Either short-term full sunlight requiring crops such as banana, passionfruit or vegetables and shade

* Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka

tolerant perennial intercrops such as coffee, cocoa, pepper or cardamom are planted as inter crops (Rodrigo, 2001).

However, the agronomic viability of these intercropping systems are decided mainly by the level of interference from the tree component of the system (Conner, 1983). Shade (Goringer *et al.*, 1996) and competition from invading roots (Ong *et al.*, 1991, Rao *et al.*, 1991, van Noordwijk & Purnomoshidi, 1995) retard the growth and yield of intercrops and becomes uneconomical. Consequently, crops suitable for growing under immature rubber (Rodrigo, 2001) can be grown only for about 4 years. Those crops that are considered suitable for growing under mature rubber are mostly shade tolerant species and are expected to give sustainable yields as perennial intercrops. But interference from rubber becomes severe after about 5 years in systems where rubber is planted with standard inter-row spacings (8.1m or less) (Pathiratna & Perera 2004).

One way of reducing the adverse influence from rubber to the intercrop is by increasing the space between the rubber rows. Reducing the standard 500 trees/ha rubber density by increasing the inter row space to accommodate intercrops can lead to loss of per ha yield of rubber, the cumulative effect of which will be very large in the long run depending on the number of trees reduced and the market price of rubber. Another possibility is by arranging rubber rows in an east west direction, which is also ineffective after

about 5 years under standard inter row spacings (8.1m) (Pathiratna & Perera 2004). Therefore, it is necessary to strike a balance between densities of the component crops so that the system becomes viable both agronomically and economically. Adjusting the tree spacings combined with spatial arrangements to maintain wider inter-rows while maintaining the standard rubber tree densities is a possibility and the data subjected to this analysis are from an experiment where wide inter-row spacings were tested for their suitability for intercropping cinnamon as a perennial intercrop (Pathiratna *et al.*, 2004).

Materials and Methods

Experimental

The experiment was established in the RRISL Sub-Station at Kuruwita in the Ratnapura district. The land is almost flat and the soil is acidic (pH 4.8) and belongs to the order Ultisol. The mean annual rainfall is about 3000 cm and is well distributed during most part of the year. Further details of this experiment are available elsewhere (Pathiratna *et al.*, 2004).

This experiment consisted of 11 rubber inter-row spacing treatments ranging from 7.2m – 18.0m. The stepwise increase of the inter-row space in each treatment was 1.2m which is equivalent to the space between two cinnamon rows and there was a corresponding increase in the number of cinnamon rows in each treatment. The density of rubber trees/ha was low when

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the inter-row spacing was more than 12.0m and to rectify this 2.4m triangularly spaced rubber trees in paired rows were included. Rubber treatments with the same spacings without the cinnamon intercrop and cinnamon only plots served as controls. The 7.2m spacing treatment was omitted from this analysis (Table 1).

Six-month old polybagged plants of rubber, clone RRIC 121 and cinnamon seedlings of the same age were used for planting. Spacing for cinnamon was 1.2 m × 0.61 m in the inter row space leaving a gap of 1.8m to the rubber row. The crops in the experiment was fertilized and managed according to the standard practices (Pathiratna *et al.*, 2004).

Measurements

Cinnamon was harvested annually, beginning in the 3rd year after

planting. Mature sticks from three bushes from each row were sampled. bark was peeled and the yield was determined. Percentage dry matter (PDM) in bark was calculated as the percentage of the total dry matter of harvested shoots. Growth of rubber was measured as girth of trees at a height of 90cm from the graft union.

Economic analysis

Cash flow in rubber/cinnamon intercropping systems

Cash flow in rubber/cinnamon intercropping under different inter-row spacing systems were calculated for the three harvests of cinnamon. Income from rubber is excluded from this analysis as harvesting of rubber has not commenced at this stage and the following items were used for this analysis.

Table 1. Density of rubber and cinnamon under different inter row spacing treatments and the number of cinnamon rows in the inter-row space under different treatments

	Inter-row space (m) Single row treatments					Inter-row space (m) Paired row treatments				
	8.4	9.6	10.8	12.0	13.2	13.2	14.4	15.6	16.8	18.0
Rubber trees/ha*	496 (-4)	434 (-66)	386 (-114)	347 (-153)	331 (-169)	545 (+45)	505 (+5)	471 (-29)	441 (-59)	415 (-85)
Cinn.bus hes/ha	9940	10435	10815	11120	11368	9800	10100	10303	10582	10779
No. of cinn. rows	5	6	7	8	9	9	10	11	12	13

(*Figures in parenthesis in row 2 are the number of trees less or more than the standard)

(1) Expenditure on planting and upkeep of rubber for the 1st five years; (2) Expenditure on planting and upkeep of cinnamon for the first five years; (3) Expenditure on the harvesting and processing of cinnamon, taken as 40% of the income from cinnamon; (4) Income from cinnamon obtained in the three harvests (value of remaining cinnamon sticks after peeling as fuel wood and of leaves that can be used for extracting oil were not accounted). This was calculated using the per bush yield and the number of cinnamon bushes/ha for each inter row spacing treatment; (5) Selling price of cinnamon taken as Rs.350/ kg of dried bark.

Effect of changing the rubber plant density

The following assumptions and criteria were considered when calculating the present value of revenue forgone and benefits accrued from rubber due to the reduction or increase of plant density of rubber (Table 1). (1) The number of trees available in a hectare reduces annually due to various reasons and the average yield/ ha also changes. Consequently, the average annual yields per ha for RRIC121 used for this calculation were, 639.5kg, 855.9kg, 1010.0kg, 1104.5kg, 1149.3kg and 1156.8kg for 7th, 8th, 9th, 10th, 11th and 12th years respectively. (2) Any long-term interaction effects on the yield of

rubber due to increase or decrease in rubber trees are ignored. (3) Rubber starts to give an income after the 6th year and any loss or addition of income could occur after this. (4) Discount factor was at 10% interest rate. The present rubber price was taken as Rs.110/kg.

Results

Growth and yield of cinnamon

Yield of cinnamon

The bark yield of cinnamon in all treatments and in control plots declined over the harvests. The control plots yielded 113.3 g/bush, 92.2 g/bush and 63.9g/bush respectively at three harvests and the percentage reductions were 18.6 and 43.6 at the 2nd and 3rd harvests compared to that of the first harvest. The yield in spacing treatments also showed a similar trend and the average yields were 83.3 g/bush, 71.9g/bush and 48.2g/bush respectively at the three harvests. Thus the percentage reductions in yield at the 2nd and 3rd harvests were 13.7 and 42.1 compared to that of the 1st harvest irrespective of treatment effects. Therefore, the g/bush bark yield data of treatments for each harvest was considered as a percentage of the yield of cinnamon in control plots (Fig 1).

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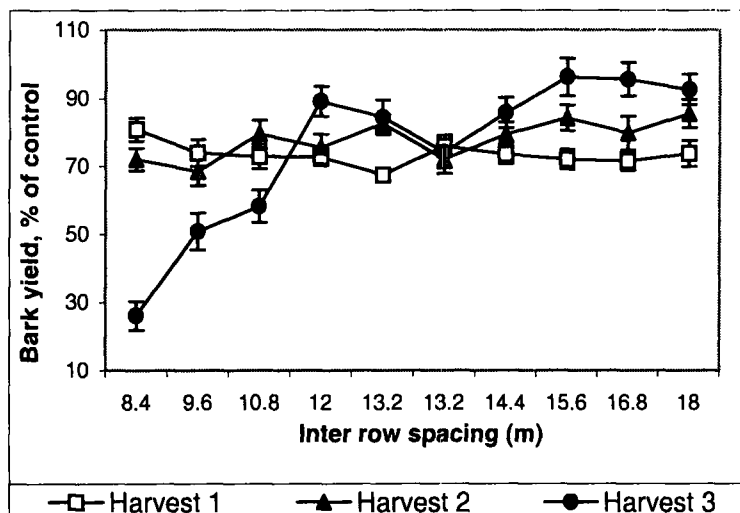


Fig. 1. Effect of inter row spacing on bark yield at the three harvests presented as percentage of cinnamon monocrop control. First five treatments (spacings 8.4m-13.2m) are inter-row spacing treatments with single rows of rubber. Next five treatments (spacings 13.2m-18.0m) are inter-row spacing treatments with paired rows of rubber.

In the first harvest, 8.4m spacing treatment had significantly higher bark yield compared to all other single row treatments. No significant differences were observed in other treatments. In the second harvest bark yield was significantly reduced in the 8.4m and 9.6m single row treatments but these did not differ from those of the 12.0m single row or 13.2 m paired row treatment. Other treatments did not show significant differences in bark yield.

In the 3rd harvest bark yield of treatment with the 8.4m inter row space was significantly lower than all other treatments. Significant reductions were seen in the 9.6m and 10.8 treatments too. Among paired row treatments the

13.2m treatment had significantly lower yield while other four paired row treatments did not show significant differences (Fig 1).

Total plant dry matter

Total plant dry matter (DM) yield of harvested sticks of cinnamon is also considered as a percentage of the control. In the first harvest, the single row treatments with 8.4m, 9.6m and 10.6m had the highest total DM. The yields in all other treatments remained similar.

In the second harvest, DM production in all single row treatments ranging from 8.4m-12.0m and of the 13.2 paired row treatment was similar while the yield of 13.2m single row and

all paired row treatments from 14.4m – 18.0m did not differ significantly.

In the 3rd harvest, the DM yield of 8.4m, 9.6m, and 10.6m single rows and 13.2 paired rows were the lowest and these treatments also differed significantly from each other. Other two single row treatments (12.0m and 13.2m) gave similar yields. Among the paired row treatments, 13.2m treatment had the lowest DM while the other four treatments had similar yields among them (Fig. 2).

Percentage dry matter in bark

In the first harvest, the 9.6 m

treatment had the lowest PDM in bark, but did not significantly differ from other single row treatments. Paired row treatments with 15.6m, 16.8m and 18.0m spacings had a higher PDM than the 14.4m treatment.

In the second harvest, there were no significant differences in PDM among both single row or paired row treatments. But in the 3rd harvest, 8.4m treatment had the lowest PDM in bark while other single row treatments were similar. PDM in bark of the paired row treatments were also similar (Fig. 3).

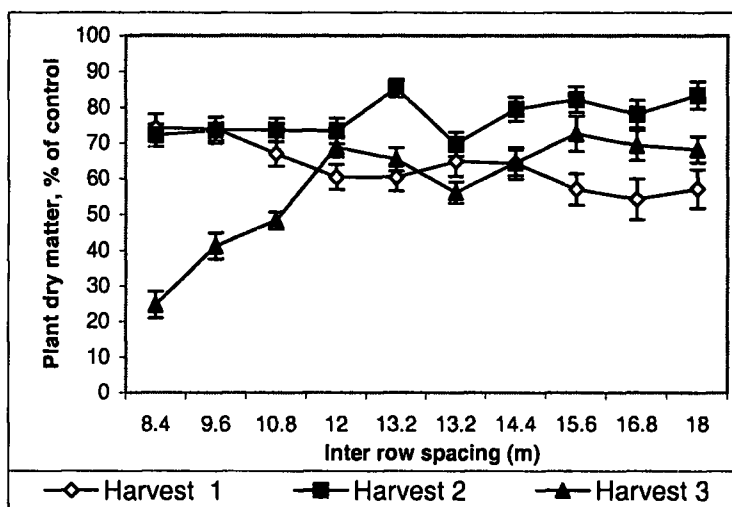


Fig. 2. Effect of inter row spacing on the total dry matter yield of harvested shoots at the three harvests presented as a percentage of the cinnamon monocrop control. First five treatments (spacings 8.4m-13.2m) are inter row spacing treatments with single rows of rubber. Next five treatments (spacings 13.2m-18.0m) are inter-row spacing treatments with paired rows of rubber.

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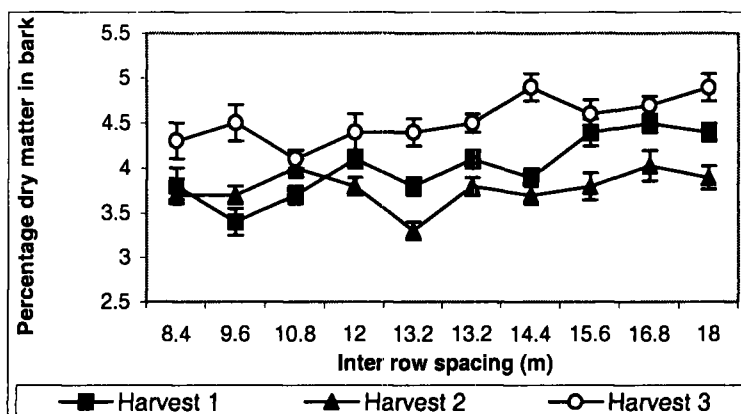


Fig. 3. The effect of inter-row spacing on the percentage dry matter (PDM) in bark at the three harvests First five treatments (spacings 8.4m-13.2m) are inter-row spacing treatments with single rows of rubber. Next five treatments (spacings 13.2m-18.0m) are inter-row spacing treatments with paired rows of rubber

Growth of rubber

The inter-row spacing similar to the standard used for inter cropping (8.1m) in this experiment is 8.4m and the growth in girth of rubber of none of the treatments differ significantly from this (Table 2).

Economic benefits

Cash flow in the rubber/cinnamon intercropping systems

The discounted net cash flow showed that there was no recovery of

expenses in any of the treatments in the first two years. In the 3rd, 4th and 5th years all treatments except the treatment with the 8.4m inter row spacing in the 5th year, showed excess of income over expenditure. When the total for the five years were considered, the treatments with the 8.4m, 9.6m single row, 13.2m and 14.4 paired row treatments showed a deficit while all other spacing treatments showed excess of income over expenditure (Fig 4).

Table 2. The effect of inter row spacing on the girth of rubber in the 5th year

Girth(cm) *	Inter-row spacing treatments (m)									
	8.4	9.6	10.8	12.0	13.2	13.2	14.4	15.6	16.8	18.0
Intercropping	49.0	49.0	50.1	51.4	51.9	48.2	48.9	47.8	46.5	48.1
	abcd	abcd	abc	ab	a	bcd	abcd	cd	d	bcd
Rubber only	44.8	48.1	43.1	48.6	47.1	46.4	46.5	44.5	44.3	49.5

*Values with the same letter are not significantly different

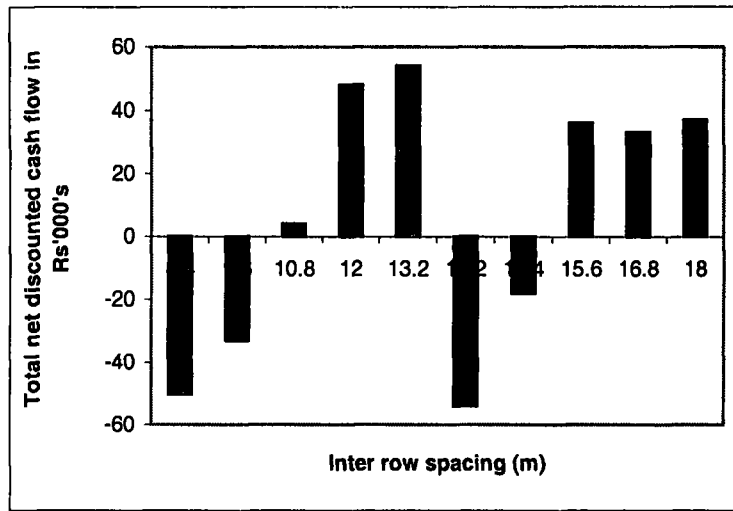


Fig. 4. Total net discounted cash flow up to the 5th year of rubber/cinnamon intercropping systems under different inter-row spacings of rubber. First five treatments (spacings 8.4m-13.2m) are inter-row spacing treatments with single rows of rubber. Next five treatments (spacings 13.2m-18.0m) are inter-row spacing treatments with paired rows of rubber. (There was no income from rubber at this stage. Only the income from cinnamon was considered).

Effect of changing the plant density of rubber

Increasing the inter row space of rubber reduced the number rubber trees/ha. The long term effects of this, up to 30 years were estimated and are presented in fig. 5. This shows that when the rubber density was reduced there is a large loss of income from the 7th year onwards depending on the number trees reduced compared to a standard of 500 trees/ha. When there were more trees than in the standard, (only in the 13.2m and 14.4m paired row systems) corresponding financial benefits were also seen.

Discussion

The agronomic advantages of having wider inter row spacings are

clearly seen in the main indicators tested viz: total plant dry matter yield of harvested cinnamon shoots, bark yield and the PDM in cinnamon bark after the 2nd harvest. The growth and yield of cinnamon under rubber with narrow inter row spacings (8.4m-10.8m) was greatly affected particularly after the 2nd harvest by the shade from the expanding canopy and the competition from the invading roots into the inter row (Ong *et al.*, 1991, Rao *et al.*, 1993, Goringer *et al.*, 1996 Pathiratna & Perera 2002). Although cinnamon is known to grow and yield satisfactorily under moderate shade (Pathiratna & Perera 1998 and Pathiratna *et al.*, 1998) the shade and competition from rubber seems to be severe under these spacings.

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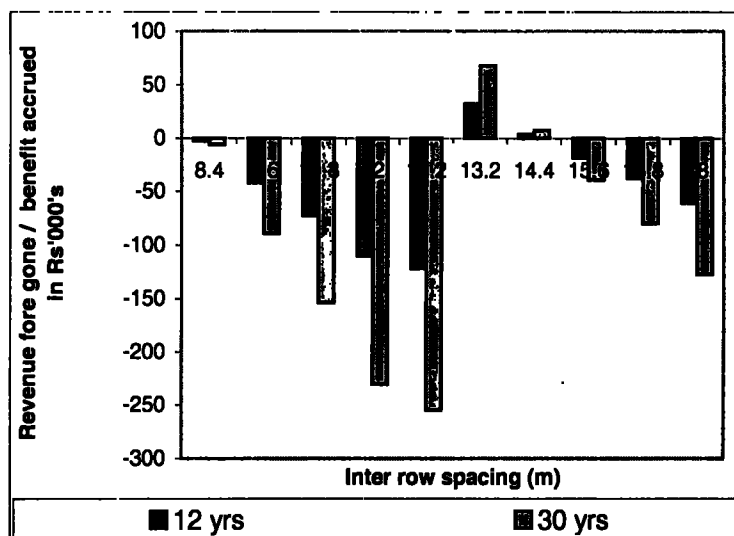


Fig. 5. The total present value of revenue forgone and benefits accrued from rubber due to the reduction or increase of plant density under different inter row spacing systems of rubber (Table 1) for 12 and 30 years.

However, the higher bark yield seen in the 8.4m treatment or the higher total DM seen in both 8.4m and 9.6m treatments in the first harvest could not be due to any effect of rubber as the rubber trees were small at this stage. But may be due to the fewer number of cinnamon rows (5 and 6) compared to the large number of cinnamon rows in other treatments (up to 13). In the 2nd harvest, the effect of rubber on cinnamon was evident as reduced DM and bark yields of treatments with narrow inter row spacings (8.4m-12.0m single rows). The 13.2 paired row treatment behaved differently possibly due to the larger number of trees (double the number) influencing the 13.2m inter row area compared to the 13.2m single row treatment. These

treatments (8.4m-12.0m single row and 13.2m paired row) were affected more in the third harvest (5th year after establishment) further reducing the DM and bark yields showing the inadequacy of these inter row spacings. On the other hand the 14.4m spacing treatment and those beyond, clearly showed the advantage of wider inter rows. Higher plant DM and bark yields and higher PDM in bark of cinnamon in these treatments even in the 3rd harvest was probably due to the avoidance of the adverse influences from rubber.

Tapping rubber trees in this experiment did not commence in the 5th year and any income from rubber is excluded from this analysis. But cinnamon was harvested annually commencing in the 3rd year. All costs of

planting rubber and cinnamon, upkeep of both crops and cost of harvesting and processing cinnamon were considered and the discounted net cash flow in systems under different inter row spacings for the 1st five years shows recovery of costs in treatments involving inter row spacings of 10.8m, 12.0m and 13.2 single row systems. This was mainly due to the low expenditure on rubber as the number of trees was less in these systems. In the 15.6m, 16.8m and 18.0m paired row systems recovery of costs by the 5th year is mainly due to the higher income from cinnamon particularly after the 1st harvest. The deficit shown in the 8.4m, 9.6m single row systems at the end of the 5th year is the result of increased expenditure on the greater number of rubber trees and the low bark yield from cinnamon after the 2nd harvest. The deficits shown by the 13.2m and 14.4m paired row systems are also due to the same reason. Had the value of remaining sticks and leaves that can be used for fuel wood and for extraction oil respectively been estimated and included in this calculation, the deficits could have been reduced further particularly in the 14.4m treatment.

At this stage it becomes important to consider the long term effects of changing the rubber tree density on the yield of rubber. Lowering the number of rubber trees/ha compared to the 500 tree standard results in the reduction of the kg/ha yield of rubber and is a disadvantage when rubber productivity is concerned even if there

is no loss of net income/ha. This is the case with the 10.8m, 12.0m and 13.2m single row treatments and also with the 18.0m paired row treatment that gave higher bark yields sufficient to recover all expenses in 5 years. But the revenue foregone from rubber is estimated to be high in such treatments. The revenue foregone from rubber in the 15.6m and 16.8m system even for the 30 year period is low compared to the above and the expected cinnamon income from the 4th harvest in the 6th year can easily surpass these deficits. On the other hand the 13.2m and 14.4m paired row treatments gave additional income by having more rubber trees. This shows that the treatment with the 14.4m paired rows of rubber, although had a small deficit at the end of 5 years has a greater potential as a suitable spacing system. Those with 15.6m and 16.8m paired rows also show the potential with the possibility of recovering the deficit shown in the 4th harvest in the 6th year. Therefore these wider inter row spacing treatments have greater advantages both agronomically and economically for viable rubber/cinnamon intercropping systems.

These findings also show the pay back period for rubber/cinnamon intercropping systems involving wider inter row spacings with paired rows will be about 6 years. Under monocrop conditions rubber takes about 5-6 years to commence tapping and it takes a further 5-6 years to recover the cost of planting and upkeep. The estimates of the pay back period made recently shows that this period is 11 years for

sole crop rubber (RRIC 121) (Edirisinghe, 2004).

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Address for correspondence: Mr L S S Pathiratna, Botanist, Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka.
E-mail: dirrri@tradenetsl.lk