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WORKER WAGE INCREASE AND THE FINANCIAL VIABILITY OF RUBBER PLANTATIONS; THE CUSHIONING IMPACT OF THE CARBON MARKET

E S Munasinghe and V H L Rodrigo

INTRODUCTION

Plantation crops like rubber play a significant role in Sri Lankan economy in terms of foreign exchange earning, employment generation and environmental protection. Obviously, rubber cultivation is a long term investment and once planted, trees are kept for *ca.* 30 years. Therefore, not only the amount and types of cost benefit components but also how they are spread out throughout the lifespan is important in business planning.

In particular, rubber is considered to be a labour intensive crop among the plantation crops in the country, second only to tea. On average, tea, rubber and coconut require *ca.* 1.25, 0.75 and 0.2 workers per hectare, respectively (personal communications with Dartonfield estate management and the Coconut Research Institute). In addition, seasonal demand for labour and speciality in labour use aggravate the issues in labour management. For instance, labour force in estates may not be sufficient during planting and rainguarding periods. Also, latex harvesting requires skilled workers. In order to tackle such labour issues, some measures have come forward though not be successful to the level of expectation. Use of heavy machinery (backhoe) for digging planting holes and low intensity harvesting systems are some of them.

Demands for wage increase are inevitable due to the continuous increase in cost of living. As for other sectors, it is same for the worker community in plantations. With the current extent of 122,000 hectares (Anon, 2008), the total number of work force engaged to rubber sector (including smallholdings) could be estimated *ca*. 92,000. Particularly the workers in large estates have strong voice even in politically demanding their needs through relevant trade unions. Despite of heavy resistance from plantation management, the wage increase never ends making labour management issues far more critical. On average, an annual basic wage increase rate of 13% has been recorded in the plantation sector during last 12 years (Anon, 2006). In particular, the wage increase in 2009 was huge with a value of 46% from the previous level.

There are no proper records on the worker wages in the smallholder sector, however that is highly subjective to the particular situations. In the intermediate zone, most of rubber growers are full time farmers and use their own/family labour in cultivation activities. However in the wet zone, only the limited number of smallholders use their own/family labour for rubber cultivation with the majority participate in off-farm activities. In support for this view, Stirling *et al.* (2002)

explained that the human capital which includes the labour is higher in the intermediate zone than the wet zone.

There should be a serious impact of labour wage increases on the overall profitability of plantations demanding an extensive investigation. Therefore, the present study was met to analyse the impact of the 2009 wage increase on overall profitability of rubber plantation through a detail financial analysis covering all cost and revenue components (including carbon) throughout its economic lifespan.

METHODOLOGY

In order to carry out financial analyses, all cost and revenue components were assessed considering their distribution throughout the lifespan of rubber cultivation. Being a plantation crop, quantities of cost components on field activities of rubber have been standardized and most estates adhere to same set of labour and material inputs. Hence for the cost calculations, quantities of input units for labour and material were obtained from the records of Dartonfield estate, Agalawatta (Estimates of Dartonfield Group, 2009). In order to assess the impact of wage rate increase, two standard wage rates *i.e.*, present (Rs.448/= per worker) and past (Rs.320/= per worker) were taken into consideration. These values consisted of all direct payments such as basic wage, attendance incentive, productivity incentive and contribution to employee's provident (12%) and trust (3%) funds. Material costs were calculated using the market prices prevailed in 2009. Costs involved in other general activities such as transportation and administration were also obtained from the records of Dartonfield Group in 2009.

Revenue from rubber latex during the lifespan of rubber was based on the yield curve developed before (Munasinghe *et al.,* 2008) and the average market price of latex in 2009, *i.e.* Rs.350,000/= per MT. Further, income from scrap rubber harvested was included in the revenue on the basis of 5 g per tree per tapping (*i.e.* average value for Dartonfield group) with the price Rs.150,000/= per MT. The tree value was included at the end of 30 year lifespan with a market price of Rs.1,750/=. The revenue per hectare from the sale of old trees was calculated using information on average tree density (Munasinghe, 2009). CO_2 fixed in the biomass of the whole tree was based on the allometric relationship developed before (Munasinghe *et al.*, 2008) and that in rubber produced from latex was taken as 91.5% carbon in raw rubber produce. The amount of CO_2 adding to the soil through annual litter fall was also taken in carbon estimations.
Market rate of carbon varies from US$ 5 to US$ 50 per MT CO_2 (www. ecobusinesslinks.com - Carbon Offset Survey) and the cost involved in developing a CDM project is in the rage of US$ 45,000-50,000. Assuming a CDM project with 5,000-10,000 ha of rubber (1.5-3 million MT CO_2), the cost per MT of CO_2 is only *ca*. US$ 0.03. Further, considering the less competitiveness of forestry projects in the market and ease in calculations, CO_2 was valued at a net rate of US$ 15 (Rs.1,635/=) per MT.

In the financial analyses, cost of production under present and past daily wage rates was compared. Further, financial analyses made with and without including carbon benefits. The measures of project worth of financial analyses were Net Present Value (NPV) at 10% discount rate, Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) at 10% discount rate (Discount rate of 10% is generally taken in most of financial analyses).

RESULTS

The total labour units (man days) required for the cultivation of one hectare of rubber for 30 year period have been 8421. Almost 91% of this was used in the mature phase of rubber cultivation *i.e*. from 7-30 years. Initial establishment required only 2.6% of the total whilst 6.4% of labour was utilized in the immature phase, *i.e*. from 1-6 years. In year wise distribution, the amount demanded during the first year for the establishment was 217. In rest of the immature phase, only 89 were required per year, however the mature phase required 320 per year (Fig. 1). The most labour demanding activity in the rubber cultivation was latex harvesting which comprised *ca*. 80% of the total (Fig. 2). Weeding occupied the second place at 11%, followed by other general maintenance activities (5%) such as maintaining fences, drains and silt pits, shoot cutting and census.

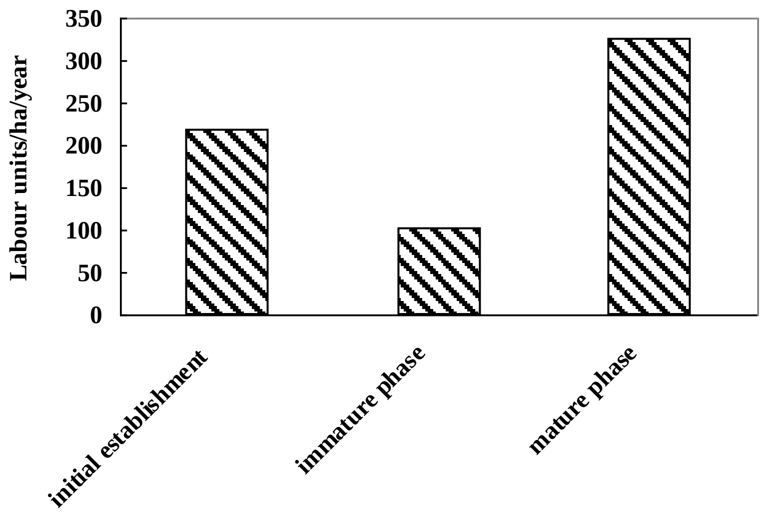


Fig. 1. Labour use distribution in different growth phases of rubber cultivation

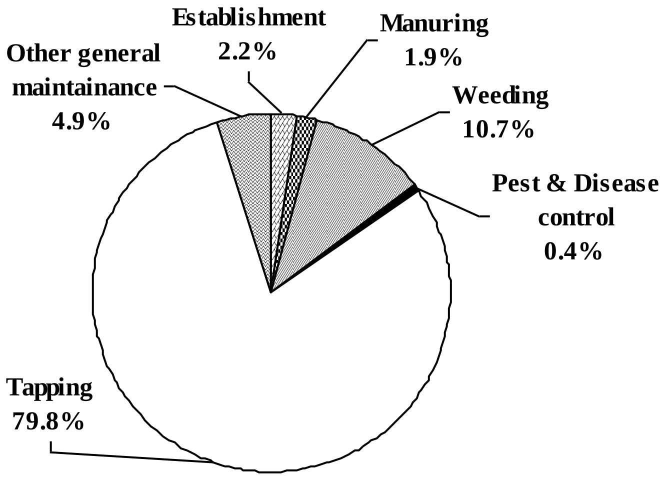


Fig. 2. Labour usage in different activities of rubber cultivation

The overall labour cost for the cultivation of one hectare of rubber land for 30 year period under the present wage rate of Rs.448/= was Rs.3.8 million. This was obviously 40% increase (Rs.1.1 million in absolute terms) over the value at the previous wage rate. For the mature phase, Rs.3.4 million was required for labour whilst under previous rate it was only Rs.2.5 million. Similarly, the labour cost involved in the six year immature phase was Rs.0.24 million under the new wage rate but only Rs.0.17 million under the previous rate. Labour cost distribution in different activities of rubber cultivation is shown in Figure 3. Among them, the most costly labour activity, harvesting which utilized Rs.89,600/= per year in the past, required additional Rs.35,840 per year to cope up with the wage increase.

The cost for cultivating one hectare of rubber land in 30 year period including labour, material and administration was Rs.5.12 million under the present wage rate (Fig. 4). In the case of cost per year, it varies from Rs.0.07 to 0.2 million. The present cost was an increase of Rs.1.1 million over the cost under previous wage rate. At present wage rate, the labour component comprised 74% of the total cost showing 10% increase over the proportion under previous rate. Under present wage rate the proportions of administration and material cost were 15% and 11% of the total, respectively. Consequently, the reductions of respective proportions were 21% and 19% from the previous values. The most costly activity, latex harvesting accounted 54% of the total cost with previous wage rate, however it increased up to 59% with the wage hike (Fig. 4). On this basis, the cost of production (COP) per 1 kg of latex rubber in plantation sector was Rs.134/= in the past. However, with the present wage hike it has increased up to Rs.171/= resulting in 27% increase in the overall COP.

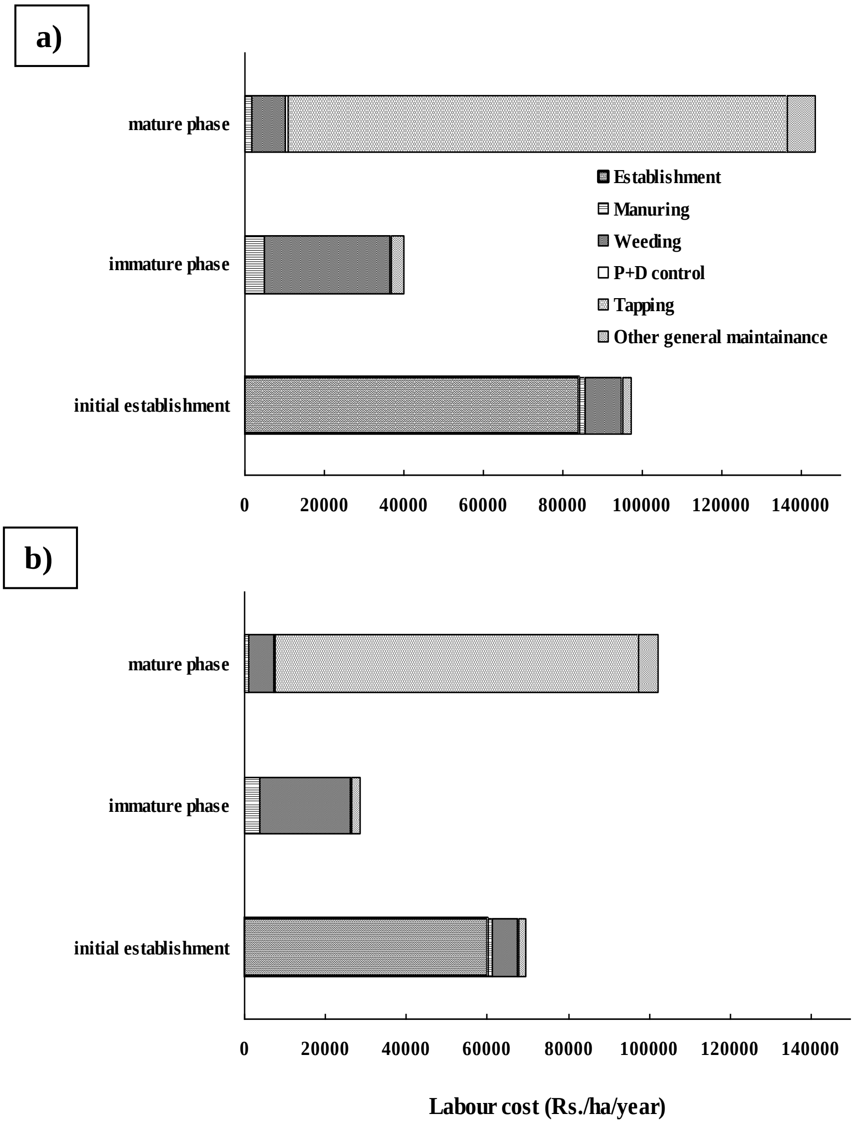
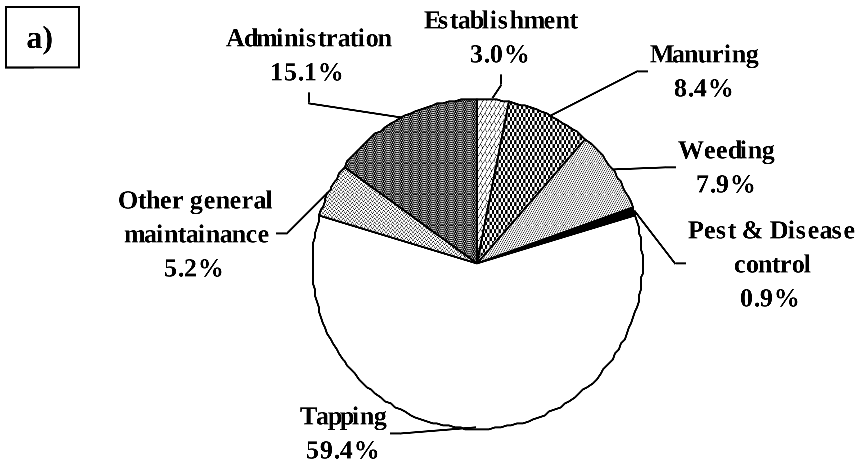


Fig. 3. Labour cost distribution in different activities of rubber cultivation. In (a) under present wage rate (Rs.448/=) and (b) under previous wage rate (Rs.320/=)



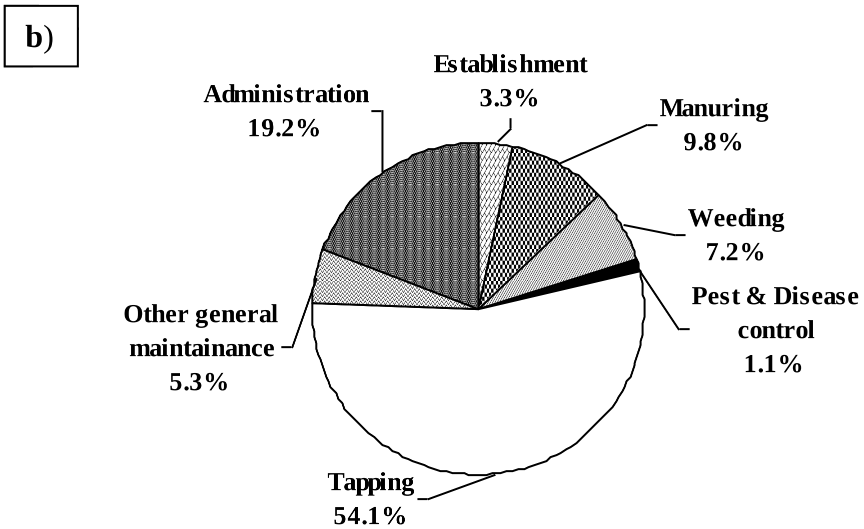


Fig. 4. Cost distribution in different activities of rubber cultivation at (a) present wage rate (Rs.448/=) and (b) previous wage rate (Rs.320/=).

The revenue from the latex and scrap rubber during the whole harvesting period of 7-30 years was Rs.9.43 million per hectare. This would vary from Rs.0.3 to 0.5 million per year with an average of 0.4 million. Revenue earned at the end of the life cycle by selling rubber trees of a hectare of land was Rs.0.5 million. With that, the total revenue that can be earned by cultivating a hectare of land was Rs.9.93 million. When the value of carbon fixed in total biomass of the tree, rubber latex and litter fall were included to the revenue stream, the total revenue increased to Rs.10.5 million.

The total profit given by one hectare of rubber for 30 years under the present wage rate was Rs.4.8 million (without discounting). Accordingly, there was *ca.* 19% decline from the profit obtained under the previous wage rate. Time cause profit distribution in one hectare of rubber cultivation under two wage rates is illustrated in Figure 5. Whilst showing a similar pattern of distribution, only the values of cost and profit differ between two wage rates. This has resulted in increasing in the breakeven point up to 11 years in the present wage rate from 10 years from the previous case.

The Net Present Value (NPV) of rubber cultivation as a business as usual (including benefits of latex, scrap and the final value of the tree), was Rs.0.84 million at the discount rate of 10% under the previous wage rate (Table 1). As per the IRR, cultivating rubber under such wage rate was financially viable only up to 19.6% discount rate. The BCR was 1.67 at the discount rate of 10%. Nevertheless, NPV under the current wage rate decreased to Rs.0.54 million showing a 36% reduction from the previous value. Accordingly, BCR decreased by 0.32 at the same discount rate. Similarly, IRR declined by 3.6 with the recent wage hike (Table 1). When the carbon values were included in the benefit stream, NPV increased to Rs.0.6 million at 10% discount rate. Similarly, IRR increased to 16.5% whilst the BCR was 1.39 at 10% discount rate (Table 1).

Table 1. *Summary of financial analysis of the rubber cultivation under two different wage rates*

	Net present value (at 10% discount rate)	Internal rate of return	Benefit-cost ratio (at 10% discount rate)
Wage rate of Rs.320/=			
without carbon	Rs.837,958/=	19.6%	1.67
Wage rate of Rs.448/=			
without carbon	Rs.538,666/=	16.0%	1.35
with carbon	Rs.598,188/=	16.5%	1.39

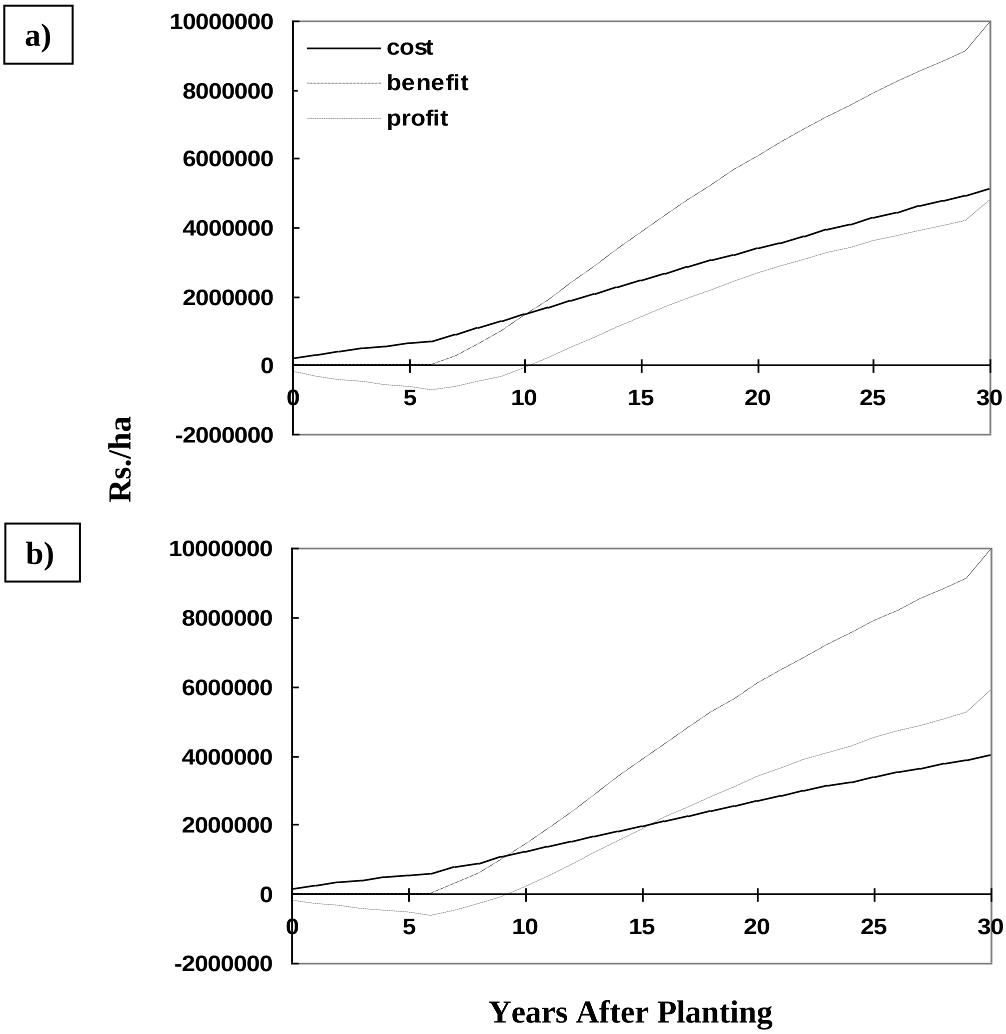


Fig. 5. An illustration on the cash flow of rubber cultivation under (a) present wage rate (Rs.448/=) and (b) previous wage rate (Rs.320/=). Cumulative values are given in each case

DISCUSSION

Rubber is one of the major plantation crops in Sri Lanka, that provides multiple advantages to the growers. The present study demonstrated the effect of recent wage increase on the financial viability of rubber cultivation using its direct benefits (*i.e.* rubber latex, timber/biomass produced, carbon fixed) (Table 1).

Although cultivating rubber under business as usual is financially viable at both wage rates, the present rate is not conducive for plantation companies as it reduces the NPV by Rs.0.3 million per hectare.

The IRR gives the discount rate where the NPV becomes zero. It should generally be above the market rate of interest for saving or otherwise above the money borrowing rate. Though 16% IRR is a reasonable level in financial analyses, it may not be sufficient under the fluctuating inflation rates (*e.g.* 22.6 in 2008 and 3.4 in 2009) in Sri Lanka (Anon, 2009). In particular, the decline in IRR by 3.6% with the wage increase has a serious effect on any money borrowing for rubber cultivation. However, in the present study, time cause price escalation was not considered and if considered, it would tend to enhance the face value of benefits more than the costs (as the former was greater always) resulting in higher level of financial viability. Further, some level of price change in labour has already been considered. Therefore in such situations, IRR and other financial indicators will improve making the project more worthwhile.

The labour cost in rubber cultivation could be analysed in two ways, *i.e.* cost per hectare and cost per a kilogram of rubber produced. On hectare basis, the labour accounts for *ca*. Rs.3.8 million. On the same basis, the proportional cost on labour increased to 74% of the total cost from the previous value of 67% with the wage increase. If the cost to produce a kilogram of rubber is considered, the share of labour is 74% amounting to Rs.127/= at the present rate. With the 40% increase in labour cost, the cost of production in terms of cost per 1 kg of rubber has increased by Rs.37/=. Respective proportionate increase was 28%. All these mean that labour plays a highly significant role in deciding the financial productivity of rubber plantations. Per unit increase in labour cost (Rs.1 per labour unit), cost of production per 1 kilogram of rubber increases by 30 cents. The cost per labour unit can never be reduced with the continuous demands for wage increases. Also, individuals cannot influence on rubber prices. If the wage rate increases over 50% of the recent level (*i.e.* above Rs.675/=per unit) whilst not changing output prices the viability of rubber cultivation would turn negative. Therefore, only two options are available, *i.e.* increasing the output per labour unit and overall land productivity. Incentive schemes are a short-term solution in both cases and this has seriously been considered in the present wage structure. A component of Rs.30/= has been assigned for the productivity. Nevertheless, effective utilization of this component has been limited to few activities. Particularly in latex harvesting, low frequency/intensity systems reduce the labour use and increase the worker output significantly (Rodrigo, 2009). Although the technologies have already been developed in this regard, few plantation companies in Sri Lanka are geared to this direction. Further, the use of rainguards will definitely increase the land productivity, but yet to be adopted in island wide. Use of quality planting material and high yielding clones, pest and disease management, increase in mature/immature ratio of rubber extent either by reducing the immature phase or increasing the mature phase and all other agro-management practices contribute towards healthy land productivity. Though costly or difficult at the moment with the technologies available, mechanisation plays a role in minimising labour costs or increasing the productivity in long-term.

Further expansion of rubber cultivation is possible mainly in drier areas with the participation of peasant community. In such instances, family and/or shared labour are mostly utilized (Stirling *et al*., 2002) and so, labour costs are not a great deal. However, effective utilization of worker time/labour is essential even in such smallholdings in order to enhance their overall land productivity which includes intercropping systems too. Therefore, techniques like Low Frequency Harvesting (LFH) systems are important in this regard. Even under hired labour conditions in smallholdings (this is particularly the case in the wet zone), LFH systems could effectively be implemented to minimise the labour use hence the cost. Perhaps, cluster systems operated by farmer societies are important here so that they can develop a system to share the latex harvesters among few smallholdings. Further, that could also be used as a pathway in technology transfer.

Instead of large scale plantations, development of out grower systems with the partnership between smallholders and latex manufacturers will also lead to reduce the labour costs. Moreover, it will reduce the administrative costs/general charges which has been the highest cost component in rubber cultivation.

Carbon trading is another option yet to be explored in rubber cultivation. Interestingly, inclusion of carbon values to the benefit stream would increase the NPV by Rs.60,000 per hectare than that of the business as usual (at 10% discount rate) under the present wage rate. Further, it improves IRR by 0.5% whilst BCR by 0.04 than those of the without carbon valuation. Therefore, a part of the labour cost increase could be compensated with carbon trading. Unfortunately, regulations do not allow existing plantations or replantings to claim for carbon credits. Only the new plantings (on the lands cleared before 1990) are eligible at the moment. However, it is expected to have the REDD (Reduce Emission from Deforestation and forest Degradation) programme coming to be effective after 2012. If so, all rubber plantations would be remunerated for its service to combat the greenhouse effect. Undoubtedly, this will help to ease the impact of increase in labour and other production costs.

REFERENCES

Anon (2006). Statistics Division, Department of Labour, Sri Lanka.

Anon (2008). Plantation Sector Statistical Pocket Book. Planning Unit of the Ministry of Plantation Industries, Colombo.

Anon (2009). Annual Report, Central Bank of Sri Lanka, Colombo, Sri Lanka.

Munasinghe, E S (2009). Growth, yield, carbon fixation and economics of rubber cultivation in Sri Lanka. *PhD Thesis*, University of Sri Jayewardenepura, Sri Lanka.

Munasinghe, E S, Rodrigo, V H L, Gunawardena, U A D P and Karunatilake, P K W (2008). Quantification of growth and economically important yield components of rubber plantations in wet and intermediate zones of Sri Lanka. *Proceedings of the Second Symposium on Plantation Crop Research*, Colombo, Sri Lanka, 299-306.

Rodrigo, V H L (2009). Exploitation methods to sustain high performance under changing scenarios. *Proceedings of the Centennial Rubber Conference*, Rubber Research Institute of Sri Lanka, 12-13 May 2009, Hilton, Colombo. P. 29-31.

Stirling, C M, Rodrigo, V H L, Sinclair, F L, Thennakoon, T M S P K and Senivirathna, A M W K (2002). Incorporating local and scientific knowledge in the adaptation of intercropping practice for smallholder rubber lands. *Final Technical Report*, Department for International Development Plant Science Programme, UK, pp 55.

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CINNAMON AS AN INTERCROP FOR RUBBER PLANTATIONS

P Seneviratne and M K P Perera

Cinnamon is an indigenous plant species and Sri Lanka is the largest producer of best quality cinnamon in the world. The Latin name *Cinnamom zeylancium* is derived from the Sri Lanka's former name Ceylon. Cinnamon belongs to the family Lauraceae and among many cinnamon species, Sri Lankan cinnamon is known as "true cinnamon" which has a very thin smooth bark with a light yellowish brown colour and a highly fragrant aroma. Cinnamon has been used as a spice for centuries and bark and oil is used in flavouring and perfumery and also as a source of eugenol. In addition cinnamon is also known for its anti-diabetic properties along with its ability to lower the cholesterol levels. Cinnamon is available in powder form and is being largely used in the preparation of kinds of desserts and savory dishes. Cinnamon bark is one of the few spices that can be consumed directly. However, European health agencies have recently warned against consuming high amounts of cinnamon powder of other species, due to a toxic component called coumarin. However, true Ceylon cinnamon has negligible amounts of coumarin and it is rich in anroixidents (Cinnamon tree).

Propagation of cinnamon is by seeds and therefore easy to produce plants and establish plantations. Cinnamon is harvested by coppicing plants grown over two years. Sri Lanka has the ideal climatic conditions for its growth. Cinnamon grown in rubber lands has increased the land productivity and also has helped to increase the cinnamon production in the country.

The immature period of rubber plantations, generally 5-6 years, generates no income but demands high inputs and this is considered as a problem. Intercropping during this period is one of the promising solutions. Rubber Research Institute of Sri Lanka has conducted trials to test the spatial arrangements and has come up with suitable systems for both small holdings and large plantations.

The rubber x cinnamon trials mentioned in this report were established in 1998 at Kuruwita Sub Station of RRISL and carried out by Mr L S S Pathiratne a former Botanist of the Plant Science Department of RRISL, who has contributed immensely on cultivation of cinnamon with rubber. The experiment consisted of 11 rubber inter row spacing treatments ranging from 7.2 to 18.0 m. The step wise increase in inter row space in the treatments was 1.2m, which is equivalent to the space between two cinnamon rows.

This report summarizes the observations made during the last five years. However, the number of rubber trees and cinnamon bushes under different spacing systems are reproduced in Table 1 from Pathiratne *et al*., (2004). The percentage of rubber trees and cinnamon bushes are also given with compared to sole crop condition of each species.

Table 1. *Spacing systems and number of rubber trees and cinnamon bushes under each spacing system with compared to sole crop condition*

Inter row space (m)	Rubber trees/ha	%	Cinnamon bushes/ha	%
Single rows				
7.2	579	115.8	9230	65.9
8.4	496	99.2	9940	71.0
9.6	434	86.8	10435	74.5
10.8	386	77.2	10815	77.3
12.0	347	69.4	11120	79.4
13.2	311	62.2	11368	81.2
Paired rows				
13.2	545	109.0	9800	70.0
14.4	505	101.0	10100	72.1
15.9	471	94.2	10303	73.6
16.8	441	88.2	10582	75.6
18.0	415	83.0	10779	77.0
Mono crop	500		14,000	

Generally height of cinnamon sticks are about 2.5 m at harvesting under sole crop conditions. Although similar observations were made in rubber x cinnamon during the first 5 years, cinnamon sticks tend to grow taller after about 7 years of planting due to the shade created by rubber canopies. Results from different spatial arrangements indicate that cinnamon needs at least 50% normal light levels in sole crop plantations to give a good yield (Pathiratne *et al*., 1998). The bark yield in all spacing treatments have been high in the first harvest and have declined after (Pathiratne *et al.*, 2004).

The growth of the rubber trees measured as the girth at the height at 120 cm from year 2005 to 2009 is shown in Figure 1. It can be seen that the girth has increased over the years, irrespective of the planting system which is comparable to mono-crop system.

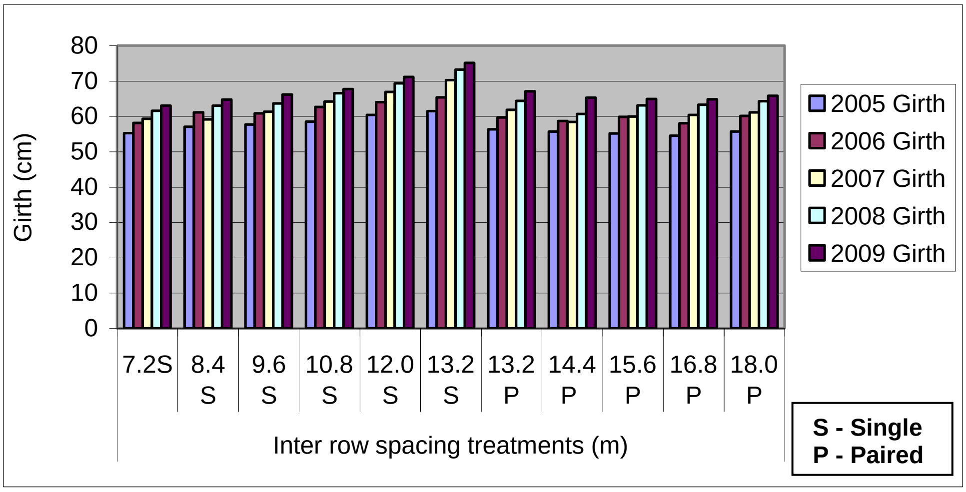

Fig. 1. Girth of rubber trees measured at 120 cm grown under different inter row spacings

Data collected up to now have shown no competition between the two crops for growth throughout the period of 11 years for all spacing systems.

The cinnamon bark yield grown under different spacing systems are as shown in Figure 2.

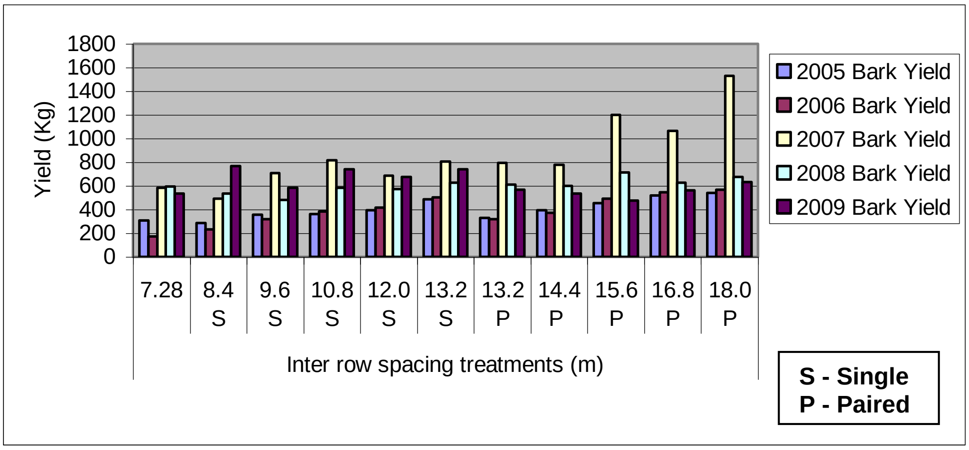

Fig. 2. Cinnamon bark yield kg/ha

Cinnamon bark yield too show the same trend as the growth of rubber trees. Wider single row systems give high bark yields. Paired rows too give high yields if the inter row spacing was above 15.6 m.

The yield of rubber measured as grams per tree per tapping are show in Figure 3. The rubber yield generally correlates to the girth of rubber trees. As shown in Figure 1, girth of rubber trees increases gradually but the same trend is not seen in the yield as shown in Figure 3.

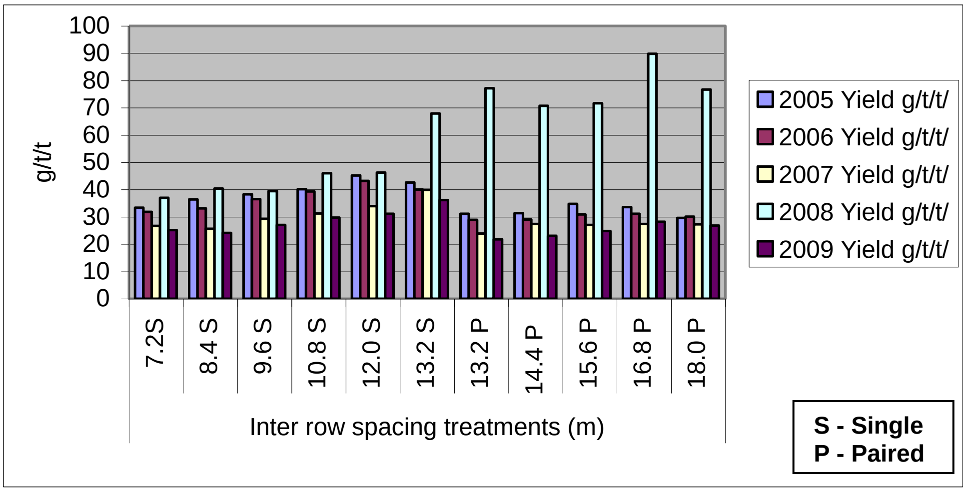

Fig. 3. The yield of rubber measured as g/t/t

If both cinnamon and rubber were established together, the first crop of cinnamon can be harvested after about 2½ years. During the first few years two harvests are possible per year as experienced in the trials conducted by us. A crop of about 700-800 kg could be harvested in our trial.

Performance of intercropping systems of cinnamon x rubber planted with different inter row spacing systems ranging from 7.2 m – 18.0 m have been published up to the 7th year of establishing (Pathiratne *et al*., 2004). It has been reported of insufficiency of narrow inter row spacing systems due to competition from rubber.

However, when cinnamon is planted as an intercrop, rubber should be planted with wider allies. If single rows are adopted rubber can be planted at 2.4 m x 9.6m (Fig. 4). With this spacing 10,435 cinnamon bushes can be accommodated. Though the cinnamon bark yield is low in this treatment when compared to paired row systems, small clearings cannot go for paired row systems and therefore this spacing gives reasonable return. But if paired rows are adopted, 2.4 m between the two rows of rubber planted triangularly and 14.4 m between the paired rows should be used (Fig. 5). A gap of about 1.4 m is sufficient between the rows of cinnamon while the first row of cinnamon should be planted at least 2.1 m away from rubber rows. Within the row cinnamon is planted at 0.6 m spacing.

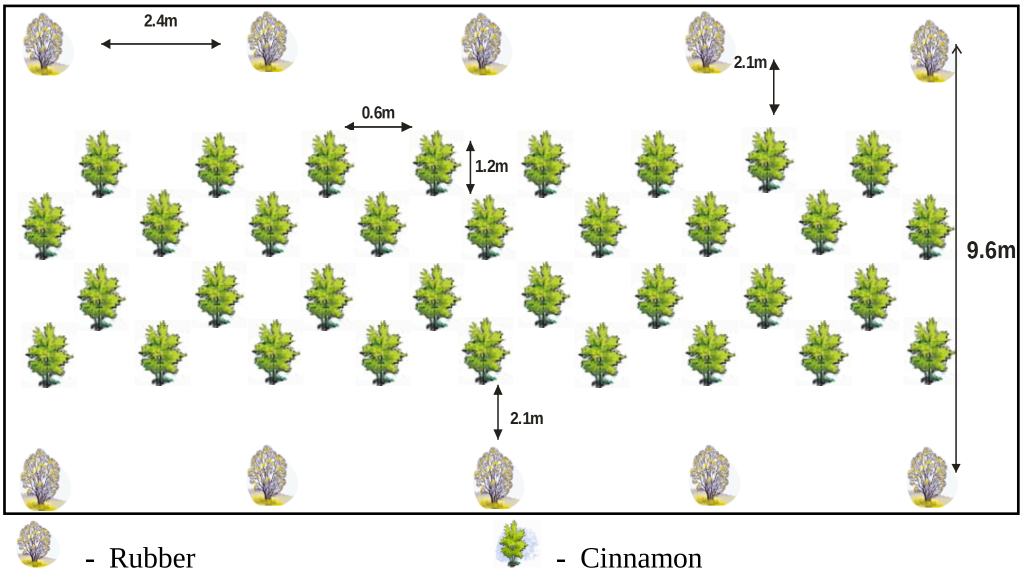

Fig. 4. Single row system for rubber x cinnamon planting

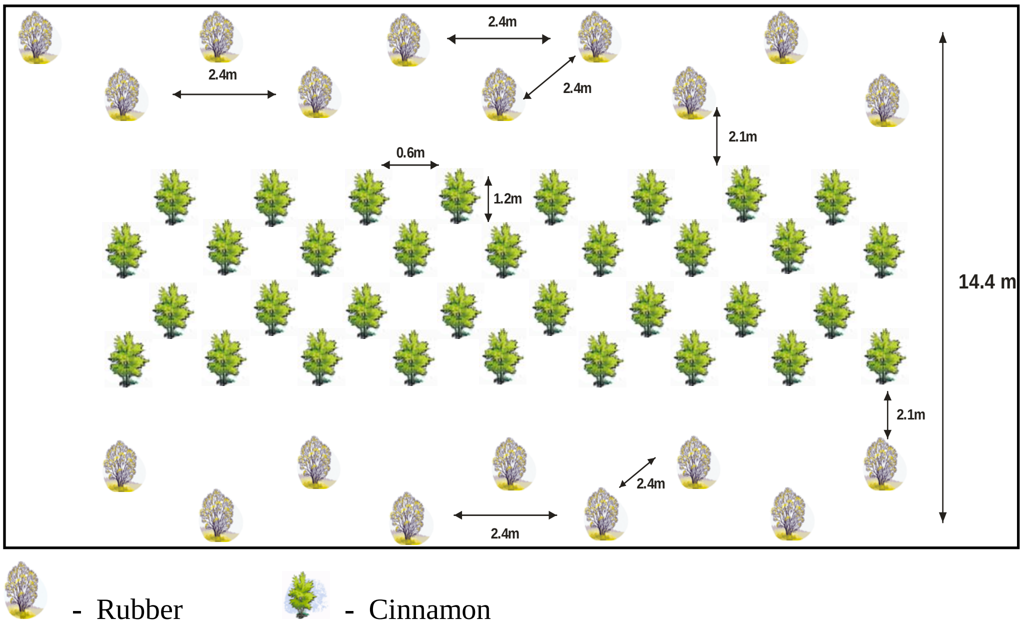

Fig. 5. Double row system

Grown as a sole crop, cinnamon sticks grow up to about 2.5 m. But when intercropped with rubber they tend to grow taller and thinner after about seven years. Data collected up to now have shown no competition between the two crops.

Ability to grow in all rubber growing regions and its tolerance to diseases including the deadly white root disease of rubber are positive factors for cinnamon to grow with rubber. Life span of cinnamon is 40-50 years this is an added advantage that both crops can be grown with minimum competition specially for the main crop.

As for many other recommended intercrops for rubber, the effect of the intercrop for the growth of the main crop *i.e.* rubber is found to be minimum in rubber x cinnamon system. After 10 years of the establishment of the clearing it seems the intercrop is affected by closed canopies and there by low light received. Yet, about 550-600 kg of cinnamon can be harvested from one hectare of rubber x cinnamon field. Approximately about 10-12 sticks make 1 kg of cinnamon, which is satisfactory.

REFERENCES

Cinnamon tree:http://pagead2.googlsyndication.com

Pathiratna, L S S and Perera M K P (1998). The effect of shade on the bark yield components of cinnamon *(Cinnamomum) verum J Pres.)* intercropped with rubber *(Hevea brasiliensis Muell. Arg). Journal of Plantation Crop* **26** (1), 58-62.

Pathiratna, L S S, Nugawela, A and Samarasekera, R K (1998). Shade effects of photosynthesis of cinnamon *(Cinnamomum verum J. Pres). Journal of the Rubber Research Institute of Sri Lanka* **81**, 29-37.

Pathiratna, L S S, Perera, M K P and Wijesuriya, B W (2004). Performance of cinnamon *(Cinnamomum verum J. Pres.)* intercropped at different spacings of rubber *(Hevea brasiliensis* Muell. Arg.) *Natural Rubber Research* **17** (2), 150-158.

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MICROBIAL BIOFILMS: NOVEL BIOFERTILIZERS FOR RUBBER PLANTATIONS

R P Hettiarachchi, R S Dharmakeerthi and G Seneviratne

INTRODUCTION

Continuous cultivation of rubber lands as a mono cultural cropping system has reduced soil fertility and land productivity. Erosion of top soil over more than 100 years and removal of large amounts of mineral nutrients in similar proportions through timber during replanting have mainly contributed to poor soil fertility.

In general the soils of rubber growing areas are gravelly, highly porous and lack in plant nutrients and therefore unsuitable for arable farming according to standard land classification (Dissanayake *et al.,* 1999). In order to enhance soil chemical fertility, it is essential to apply fertilizers. With only half of the applied fertilizers getting into the crop (Bockman *et al.*, 1990), there is a marked economic loss and environmental pollution. With the global fuel crisis, prices of inorganic fertilizers have risen sharply and will continue to rise in the future. Cost of inorganic fertilizers, low efficiency in fertilizer use and continuous use of large doses of inorganic fertilizers and their consequent negative repercussions have drawn attention to develop new approaches in fertilizer use.

Biofertilizers are ready to use live formulates of beneficial microorganisms which on application to soil, mobilize the availability of nutrients by their biological activity in particular, and help to build up micro flora and in turn improve the soil health, in general. Nitrogen-fixing biofertilizers harvest atmospheric nitrogen and convert into ammoniacal form, which will be available to the plants or is released in to the soil with time. Phosphorus biofertilizers solubilize fixed forms of phosphorus already present in the soil and make it available for the use of plants. Composting biofertilizers are used for hastening the process of composting and enriching its nutrient value.

In conventional inoculant technology of biofertilizers, a major problem yet to be addressed is the poor survival of introduced microorganisms in the soils due to various environmental stress factors (Seneviratne *et al*., 2008a). As such, a high level of microbial effect may not be achieved by the conventional practice of plant inoculation with monocultures or mixed cultures of effective microbes.

However, certain microbes can attach to the surfaces and differentiate to form complex multi-cellular communities called biofilms and they have the potential to be more effective biofertilizers than single cultures (Jayasinghearachchi and Seneviratne, 2004). A biofilm consists of microbial cells (algal, fungal, bacterial and/or other microbial) and extracellular biopolymers they produce. The extra cellular polymeric substances provide structure and protection to the community. Such communities can be found in medical, industrial and natural environments. However, the density of biofilms in the nature is not adequate to give sufficient beneficial effects and therefore needs to be produced and multiplied in the laborototy. Biofilms can also be engineered *in-vitro* for various biotechnological applications such as agricultural and environmental applications, enzyme technology, drug discovery studies and green energy research (Seneviratne, 2003; Seneviratne *et al*., 2008b).

Biofilm development

Formation of biofilms begins with the attachment of free-floating microorganisms to a surface. These surfaces could either be living or non living. If the colonists are not immediately separated from the surface, they can strongly anchor themselves onto the surface, almost permanently. The first colonists facilitate the arrival of other cells by providing more divers adhesion sites and ultimately to form a three-dimensional structure of cells encased in exopolysaccharides. There are three major types of biofilms that occur in the soil. They are bacterial, fungal and fungal-bacterial biofilms (FBBs). In fungal-bacterial biofilms, fungi act as a living surface to which the bacteria adhere (Fig. 1a and b).

Biofilm formation is thought to begin when bacteria sense environmental condition where they live. Environmental conditions that require triggering biofilm formation vary among organisms. For example, *Pseudomonas aeruginosa* will form biofilm under almost any condition that allow growth. On the other hand, some strains of *Escherichia coli* will not form biofilm in minimal medium unless supplemented with amino acids. In contrast, some strains of *E. coli* are reported to make a biofilm only in low-nutrient medium (Dewanti and Wong, 1995). In addition to the nutritional content of the medium, temperature, osmolarity, pH, iron and oxygen contents are some other environmental factors that can influence biofilm formation (Watnick and Kolter, 1999).

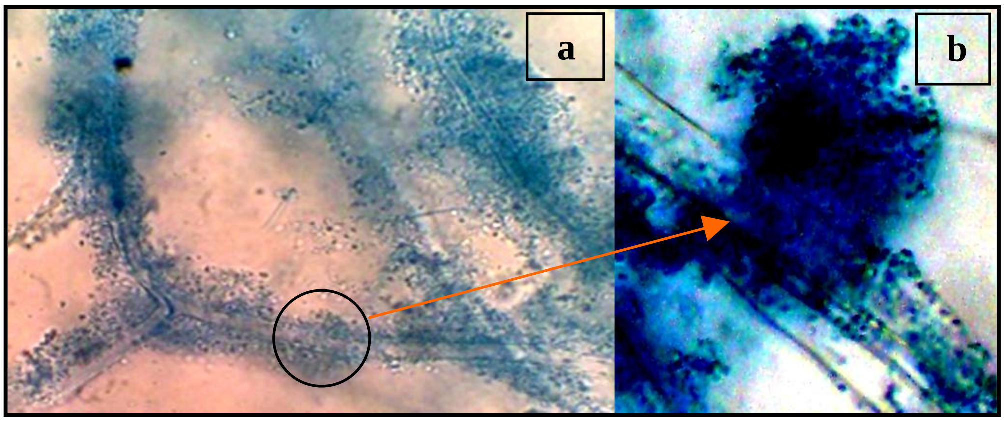

Fig.1. A microscopic view of bacterial cells attached to a fungal filament forming a fungal-bacterial biofilm (a) and a close-up of the biofilm (b).

Properties of biofilms

The biofilms are held together and protected by a matrix of excreted polymeric-compounds called exopolysaccharide. This matrix provides protection from variety of environmental stresses and facilitates communication among themselves through biochemical signals (Flemming, 1993). Biofilms have a unique pattern of gene expression which is different from their non-biofilm forming stages.

Advantages and disadvantages of biofilms

Biofilm communities are present in the rhizosphere (the root surface and the region immediately surrounding a root) and bacteria attached to roots then produce exopolysaccharides. This not only provides many advantages to bacterial cells, but also enhances soil aggregation by cementing particles together and leads to marked improvement of soil structure and helps plants avoid water stress (Amellal *et al*., 1998). Microorganisms living in rhizosphere biofilms enhance cycling of nutrients and help biocontrol of pest and diseases, resulting in improved agricultural productivity (Seneviratne, 2003).

Interactions between common soil fungi and Rhizobia have formed fungal-rhizobial biofilm and these interactions have fixed N_2 biologically. This was not appeared when the *Rhizobium* spp. was grown as a monoculture (Jayasinghearachchi and Seneviratne, 2004). The fungal-bacterial biofilms of beneficial endophytes have been observed to produce high acidity and plant-growth promoting hormones (Bandara *et al*., 2006). The higher acidity is generally important for pathogen suppression and enhanced weathering of the mineral substrates (Jayasinghearachchi and Seneviratne, 2006; Seneviratne and Indrasena, 2006).

The ability of bacteria to form films on living and non living surfaces could also create problems in plant and animal life. They sometimes can be harmful or pathogenic. Furthermore some pathogenic bacteria in biofilms can be more resistant to antibiotics and unfavorable environmental factors such as, extreme temperatures, pH values and osmolarity than when they are free living (Costerton *et al*., 1987).

Application in agriculture

The conventional practices of plant inoculation with effective microbes may not provide substantial benefits. It has now been invented biofilmed inocula developed *in vitro*, which give improved microbial action, compared to conventional biofertilizers (Seneviratne *et al*., 2008a). The knowledge gained through numerous recent studies has shown a promising trend in the application of biofilm-based biofertilizers known as biofilmed biofertilizers (BFBFs) in diverse crops.

The plant growth-promoting effects of BFBFs have been observed in rice (*Oryza sativa*), tea (*Camellia sinensis*), wheat (*Triticum aestivum*) and anthurium (*Anthurium andraeanum*) (Seneviratne *et al*., 2009). Apart from their growth promoting effect, biofilms help to increase soil carbon accumulation as well one of the most important fertility promoters in the soils (Jayasekara *et al*., 2008).

Recently, it has been found that chemical fertilizer application can be cut down by half when BFBFs are applied into tea plantations (Zavahir *et al*., 2009). However, this valuable technology has not still been tested in rubber growing soils, but experiments are underway to develop BFBFs using microorganisms isolated from rubber growing areas in Sri Lanka.

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REFERENCES

Amellal, N G, Burtin, F, Bartoli and Heulin, T (1998). Colonization of wheat root by an exopolysaccharide producing *Pantoea agglomerans* strain and its effect on rhizosphere soil aggregation. *Applied Environmental Microbiology* **64**, 3740-3747.

Bandara, W M M S, Seneviratne, G and Kulasooriya, S A (2006). Interactions among endophytic bacteria and fungi: effects and potentials. *Journal of Bioscience* **3**, 645-658.

Bockman, O C, Kaarstad, O, Lie, O H and Richards, I (1990). Agriculture and fertilizers. *Agricultural Crops*, New Delhi, India, 9-30.

Costerton, J W, Geesy, G G and Cheng, J J (1987). Bacterial biofilm in the nature and disease. *Annual Review of Microbiol*ogy **41**, 435-464.

Dewanti, R and Wong, A C L (1995). Influence of culture condition on biofilm formation by *Escherichia coli*. *Int. J. Food Microbiol*. 26, 147-164.

Dissanayake, S T B, Wijewardena, J D H and Samarappuli, L (1999). Management of the wet zone soils. In: *Soils of the Wet Zone of Sri Lanka*. pp. 160-175 (Eds. R B Mapa, S Somasiri and S Nagarajah), Soil Science Society of Sri Lanka.

Flemming, H C (1993). Biofilm and environmental protection. *Water Science Technology* 27, 1-10.

Jayasinghearachchi, H S and Seneviratne, G (2004). Can mushrooms fix atmospheric nitrogen. *Journal of Bioscience* **23**, 293-296.

Jayasinghearachchi, H S and Seneviratne, G (2006). Fungal solubilization of rock phosphate is enhanced by forming fungal-rhizobial biofilms. *Soil Biology and Biochemistry* **38**, 405-408.

Jayasekara, A P D A, Seneviratne, G, De Silva, M S D L, Jayasinghe, L A S P and Premathunga, P (2008). Preliminary investigations of the potential application of biofilmed biofertilizers for tea nurseries. In: *Proceeding of the second symposium of the plantation crop research-export competitiveness through quality improvements.* pp. 170-175 (Eds. N P A D Nainanayake and J M D T Everard), Coconut Research Institute of Sri Lanka.

Seneviratne, G (2003). Development of eco-friendly, beneficial microbial biofilms. *Current Science* **85**, 1395-1396.

Seneviratne, G and Indrasena, I K (2006). Nitrogen fixation in lickens is important for improved rock weathering. *Journal of Bioscience* **31**, 639-643.

Seneviratne, G, Kecskes, M L and Kennedy, I R (2008a). Biofilmed biofertilizers: novel inoculants for efficient nutrient use in plants. In: *Efficient nutrient use in rice production in Vietnam achieved using inoculant biofertilizers*. pp. 126-130 (Eds. I R Kennedy, A T M A Choudhury, M L Kecskes and M T Rose), *Proceedings of a Project (SMCN/2002/073)* Workshop held in Hanoi, Vietnam.

Seneviratne, G, Zavahir, J S, Bandara, W M M S and Weerasekara, M L M A W (2008b). Fungal-bacterial biofilms: Their development for novel biotechnological applications. *World Journal Microbiology Biotechnology* **24**, 739-743.

Watnick, P L and Kolter, K (1999). Steps in the development of a Vibro cholerae El Tor biofilm. *Molecular Microbiology* **34**, 586-595.

Zavahir, J S, Jayasekara, A P D A, Seneviratne, G and De Silva, M S D L (2008). Potential application of biofilms: A new approach for tea gardens. *Bulletin of the Tea Research Institute of Sri Lanka* **20**, 1-6.

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TERMITE ATTACKS ON RUBBER PLANTATIONS: METHODS FOR PREVENTION

T H P S Fernando, C K Jayasinghe and C Wijeratna

Termites are known to cause considerable problems in agriculture, forestry and housing. They are a group of insects (Isoptera) consisting of more than 2500 species of which 300 species are considered as pests. These insects usually attack plants in stress conditions and they have nests underground, others in woods and some build mounds. Termites are small and variable in colour from white to brownish black. They have three main body parts; head, thorax and abdomen and consists of six legs and live in colonies of thousands. They have different looking individuals living together in the colony. Colonies are built up in castes: workers, soldiers and reproductives. Workers and soldiers are blind, wingless and soft bodied while reproductives can be winged or wingless. The largest individual is the queen. Her job is to lay eggs, sometimes thousands in a single day. A king is always by her side. Soldiers defend the nest, having large heads and powerful jaws. Majority of the termites in the colony are workers. They maintain the nest, system of tunnels, and shelter tubes, gather food and feed the young. Termites are attacked by a wide range of natural enemies. Despite the large number of predators termites are able to maintain high populations by means of mass reproduction.

The most troublesome termites in agriculture are the ones that feed on dead organic material such as crop residues, mulches and organic matter. However, when these organic matters are not freely available they attack live plant materials too. They attack plants at the base of the stem by ring barking or cutting them completely. Some termites eat into the tap roots of young plants immediately below the soil surface destroying the root portions and filling the cavities with soil. Damaged plants wilt and may die within a few days particularly under drought conditions.

Bark eating termites attack a wide range of crops including rubber. They cover tree trunks or plant stems with tunnels built of soil. More frequently termites gain access through the dead ends of pruned stems or stumps from which they may invade the tissues. Termites feed on dead plant materials such as wood, leaf litter, roots or humus. Some termites are able to digest wood with the assistance of symbiotic bacteria or fungi in the gut.

Termite attacks on annual and perennial crops are greater during the dry periods or droughts than periods of regular rainfall. With regard to the rubber cultivation, currently the plantations have moved to intermediate and dry zones of Sri Lanka too. During the recent past many growers are reported to have faced the termite attack in their plantations, especially in Moneragala, Badalkumbura and Padiyathalawa areas. The recent reports were associated with the termite invasions on dead parts of the plant and examination of such fields have shown that the cause for the death of the plants was not the termite attack. The plants at young stages may die due to various reasons and consequently, termites may colonize these dead tissues. However, Extension Officers and growers must be vigilant to note such damaging termite attacks.

Symptoms

The first sign of termite attack in plant roots is wilting. Eventually young plants fall over. Pull out the affected plants and examine the roots or lower stems for live termites. Plant roots and stems may be completely hallowed out and be soil filled.

Sometimes plants are covered with soil runways. Under which termites can be found. Better to examine in the early morning or late evenings as termites may move deeper in to the soil when the temperature is comparatively high.

Termites can attack plants at any stage of development from the seed to the mature plant. Termite attack normally begins in an area of dead wood resulted by pruning or other damage. Deficiency or excess of water may stress plants and encourage termite attack. In general, attack on plantations grown in drier areas and during dry periods is greater. Application of fertilizer at right time enhances plant vigour hence the ability to withstand the termite attack will be less. All the cultural practices should aim at maintaining or enhancing plant vigour as much as possible. The use of good quality planting materials, and appropriate planting practices are more likely to reduce termite attacks.

Management strategies

Before any control measures are adopted, identification of the causative pest is a must. The level of control depends on the knowledge of pest, and the climatic condition. Methods of chemical control are more effective if used in combination with cultural and biological methods.

Cultural practices/Biological control/Chemical control

- Adopt correct recommendations to promote healthy plants growing, to prevent termite damage as normally they attack dead, water stressed or weak plants.
- Avoid unnecessary injuries to the plant as they may facilitate the entry of termites.
- Destroy termite nests to expose them to predators.
- Remove plant debris, especially moist and decaying woods contacting the plants.
- Remove termite affected plants or plant parts as early as possible.
- Increase organic matter of the soil by mulching which will improve food resources for the termites. This will improve micro bacterial activity and ensure

adequate soil aeration too. But they should be well away from the base of the plant.

- Termites live on dried material. Healthy plants are the last food option for termites so maintain healthy plants.

- If there are any dead plants remove them from the field as soon as possible.

- Neem products are reported to have a repellent effect.

- Heaping wood ash around the base of the tree trunk is also effective though it shows very short term activity.

- Use of persistent insecticides in the soil around the colar region prevents damage to plants. Insecticides such as organophosphates (chlorpyrifos), carbamates (carbofuran) and pyrethroids (permethrin) have been used for efficient control.

Despite the negative impacts, the termites are also very beneficial insects to the environment. They improve the soil fertility by decomposing organic matter and aeration of the soil. Termites provide shelter and food to associated organisms and also reported to fix nitrogen through micro-organisms. Chemical control measures should be applied only when the pest status reach a damaging level. Hence, growers should focus on prevention of the attacks through cultural practices and in case of an unusual spread of the colonies, seek advice from the Rubber Research Institute.

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THE GROWTH PATTERN OF RUBBER TREE TO IMPROVE THE PERFORMANCE OF CLEARINGS

P Seneviratne and G A S Wijesekara

Rubber (*Hevea brasiliensis*) is a woody perennial tree with a life span of over hundred years in the rain forests. However, in plantations, the rubber trees are uprooted after 30 years or so due to gradual decline in yield, making it economically not viable.

At the beginning of the plantations, the planting material for rubber was seeds collected from mature trees during the short seed fall every year. This method of propagation was gradually replaced by bud grafting technique which is a vegetative propagation method. Yet, the involvement of the seedling remained unchanged as bud grafting required seedling root stocks to graft. Therefore, though grafted with a bud harvested from clonal bud wood plants, growth pattern in both seedling and budded plants is more or less the same. But, the growth pattern of the budded plant can be influenced by the quality of the grafted bud and the age of the seedling.

The normal growth pattern of rubber is episodic as seen in many other perennials such as coffee and cocoa (Pierik, 1990 and Seneviratne, 1996). The growth during the immature period is clearly visible as it occurs in flushes. Also, there are two distinct growth phases namely juvenile or immature and mature. These two growth phases are also found in many other perennial trees. All other woody perennials in general have a long immature phase. Juvenile phase of rubber is about five years for seedlings as well as for budded plants. In tamarind it is said to be about 16 years. During the immature phase, all genes that are active or switched on in the plant towards the vegetative growth of the plant, gradually become inactive or getting switched off as the tree enters the mature phase (Pierik, 1990). Once a tree enters the mature phase, it remains in that phase until it dies. However, it is the mature tree which produces seeds which are fully juvenile. Though the length of the juvenile phase is unique for the plant species (Bonga, 1982), it can be influenced by external factors such as physiological condition of the gafted bud and the age of the seedling in bud grafted plants (Bonga, 1982; Borchert, 1976). In other words, though the seedling is fully juvenile or immature at the time of grafting, the age and the physiological condition of the bud can influence the length of the juvenile phase by entering the mature phase earlier. This is considered as a problematical situation in rubber, as growth rate of the rubber plant is positively and significantly correlates with the growth phase. Rubber trees can girth at a faster or higher rate only during the immature phase of growth, *i.e*. during the first five years. This is a common phenomenon but as most of the other tree species welcome the entering in to mature phase earlier to obtain fruits and it is considered an advantage.

Therefore, it is extremely important to maintain the budwood plants from which the buds are harvested, to be as juvenile as possible. Accordingly, guide lines given for the maintenance of budwood nurseries are mainly to preserve the quality of the buds so as to prevent the budded plants entering the mature phase earlier than normally expected five years. For instance, budwood plants are recommended to be pollarded once or twice every year throughout their life span of 10 years. Every time a tree is pollarded it reverses its growth phase *i.e*. moves towards juvenility.

Also budwood nursery plants are recommended to be pollarded close to the root system of the tree. First cut is made 30 cm above the graft union and the second cut onwards they are made 15 cm away from the previous cut (Fig. 1). The reason for this is to get the advantage of high degree of juvenility present in the root system. Juvenility reduces gradually along the tree from the root system towards the apex. Therefore, the closer the origin of the shoots to the roots, the more juvenile they are. This can be shown diagrammatically as in Figure 2, and this phenomena is seen in rubber trees as well as in budwood plants.

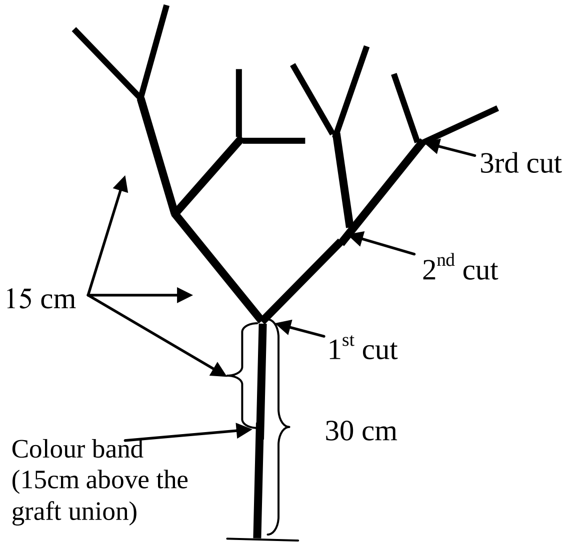

Fig. 1. Harvesting budwood while maintaining the frame

Furthermore, the life span of a budwood nursery is restricted to be 10 years even with annual pollarding. Budwood plants should not show any mature characteristics such as flowering and wintering even at the age of 10 years. However, though the maturity in budwood trees is not strong enough to show them externally, there is an accumulation of mature characteristics within the tree. Therefore, use of budwood from budwood plants older than 10 years is not recommended. Further, using buds from immature clearings even if they are less than 10 years of age is not recommended because the continuous growth for 5 years makes the trees to enter the mature phase and therefore to posses mature characteristics.

What is emphasized here is that the influence of the physiological condition of the grafted bud on the growth of the budded plants which determines directly the growth and therefore the productivity of the clearing. As far as the long life span, *i.e*. about 30 years, rubber plantations is concerned, use of quality plants with high growth rate within them is very important.

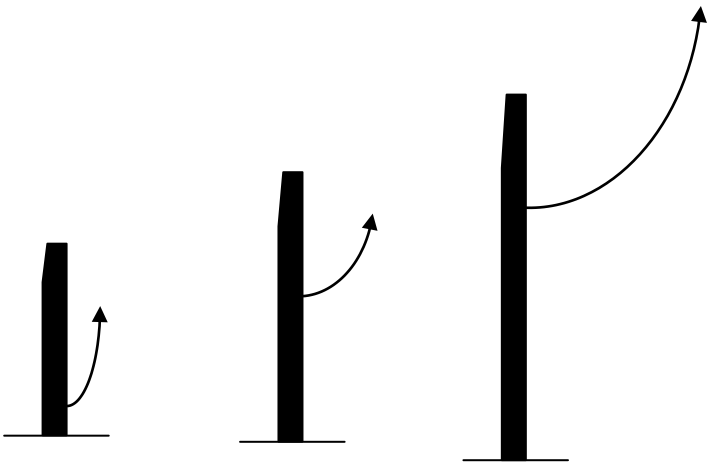

Fig. 2. When the pollarding height increased, then the angle between the stock plant and the shoot also increase

As we all have seen, rubber seedlings grow straight and the colour is copper brown which is also unique to the juvenile growth phase. When a budded tree is cut very close to the root system, similar growth is seen in resulting shoots. However, the budded plants will never grow as straight as seedlings and also will be light green in colour (Fig. 3). The angle of the shoot to the main shoot is another valuable indication to learn about the juvenility in the plant; the higher the angle the mature the plant. Further, the internodal length is highest in seedlings and this also reduces gradually as the tree ages. This can also be used to identify good quality plants as far as juvenility is concerned.

It should also be highlighted that even the best quality plants will find it difficult to perform according to their ability if other agro-management practices such as weeding and manuring are neglected. But, even under the best agro-management, the plants will not grow if the quality is poor. Therefore, every attempt should be made to produce the budded plants with high juvenility and also to maintain the agromanagement practices at level best during the first five years. It is an established fact that the potential of a particular clone is shown if only the plants from that clone is produced in such a way that they are high quality, specially as juvenile as possible. Then only the trees will possess the potential growth rate unique to the clone and attain the required growth that is 50 cm measured at 120 cm height within 4-5 years and finally give the potential yield which is the ultimate objective of planting rubber. When the trees are in the mature phase, then the growth rate becomes very slow and thus to reach the tappable girth sometimes they need about 10 years.

Fig. 3. Growth of immature bud parallel to the seedling stock plant

One of the main reasons to impose a ban on the usage of bare root budded stumps in 2004 was also this. It takes about one and a half years for the bare root plants to get grafted. Then they are grown in bags for another 6-7 months until they grow up to 2-3 leaf whorl stage. When 2-2½ years old bare root plants are planted in the field, they enter the mature phase in another 2½ to 3 years and after that, the growth becomes very slow. This is witnessed by annual wintering. Another problem faced here is forming shoots along the main trunk (Fig. 4). All these shoots appear below the height of 8 feet need to be removed in order to have a clear trunk of about 8 feet to tap.

In conclusion, in order to get an economically viable rubber plantations established, the following factors are important.

- Budded plants should be planted in the field as young as possible. Young budding plants are about 10 months at planting. This is practiced in almost all estates under RPCs but the government rubber nurseries are not yet up to this standard required.
- Budwood nursery plants should be pollarded annually and uprooted after 10 years.
- Vigorous and good quality budded plants should only be planted in fields.
- Agromanagement practices such as weeding and manuaring should be maintained to the level best during the early years. First five years from the field establishment is a critical period for the rubber tree.
- Under no circumstances should mature budwood be used.
- If a budded plant grows straight parallel to the stock shoot, then it is considered juvenile and good quality.
- If a tree enters the mature phase earlier than 5 years it shows through early wintering and (Fig. 4) such a clearing may need about 10 years to be exploited.

- When plants having immature qualities are planted and maintained under optimum agro-management practices, then they reach tappable girth in 4-5 years (Fig. 5).

Fig. 4. Early wintering and branch formation in trees of a clearing of about 3 years

Fig. 5. A clearing planted with high quality plants and maintained well reaching tappable girth in 4-5 years

REFERENCES

Bonga, J M (1982). Vegetative propagation in relation to juvenility, maturity and rejuvenation. In: *Tissue Culture in Forestry*. pp.387-412 (Eds. J.M. Bonga and D.J. Durzan), Martinus Nijhoff/ Dr.W. Jank Publishers).

Borchert, R (1976). The concept of juvenility in woody plants: *Acta Horticulturae* **56**, 21-36.

Pierik, R L M (1990). Rejuvenation and micropropagation In: *Current Plant Science and Biotechnology in Agriculture*. *Progress in Plant Cellular and Molecular Biology*. pp.91-101. Kluwer Academic Publishers.

Seneviratne, Priyani (1996). The growth, phase change and rejuvenation of trees with special reference to *Hevea brasiliensis* (Muell. Arg). *Journal of the Rubber Research Institute of Sri Lanka* **78**, 1-14.

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PLANTING RUBBER AT LOW DENSITIES IN HOME GARDENS TO SUSTAIN RURAL LIVELIHOOD

P Seneviratne, Shasika Nakandala, K A G B Amaratunga, T U K Silva, R P Karunasena, R K Samarasekera, M K P Perera, M Alwis, L Zoysa, P D Pathirana, W Karunathilaka and R Handapangoda

Hevea brasiliensis (Muell Arg.) is one of the eight species of the genus *Hevea* and it is said in the legends that even Sir Henry Wickham who collected the seeds of *Hevea brasiliensis* was not aware of the fact that only *Hevea brasiliensis* is capable of giving high amounts of latex through a single cut made on the bark.

Once the *Hevea brasiliensis* seeds were established as plantations the planters soon discovered the variation among seedlings for growth as well as for yield. However, propagation through bud grafting could alleviate this variation considerably but, this method still demands thorough selection process to get rid of the weak plants. The main reason for growth and yield variation in budded plants is the variation created by the unselected rootstocks (Senanayake, 1975). Accordingly, all weak seedlings should be culled as recommended by the Rubber Research Institute of Sri Lanka at various stages. Among the main selection steps (i) collecting seeds from the early seed fall, (ii) harvesting only less than 50% of the germinated seeds selected as early germinates, (iii) discarding all weak seedlings during the first 2-3 months and (iv) discarding at least 20% of the budded plants at the 2nd leaf whorl stage which have not grown up to the expected growth of the budded plants, are very important.

The growth condition of the bud patch which is grafted on to the seedling is equally important for the growth of the budded plant, and for the yield as the yield partially depends on the growth condition or the size of the tree. Even, when the best rootstocks selected are grafted with high quality bud patches, the growth of the plants can still be influenced by many other factors.

Among some important factors are the micro environment and the agro-management practices such as weed control and proper application of manure specially up to the first three to four years of the immature phase. Another important factor which affects the growth is the competition from the surrounding plants or the planting density. Until early 1980's the recommended stand was 180 trees per acre (450 trees per ha.). The planting material used during this period was bare root budded stumps and the casualty rate and the variation in growth were very high resulting in a significantly low number of productive trees during tapping. With the objective of having a higher number of productive plants at maturity, the planting density was increased up to 200 trees per acre (500 plants per ha.). In 2010, this was again revised to have 515-520 plants per hectare and it was also recommended not to consider the spacing system in order to qualify for the subsidy. Accordingly, spacing systems were adjusted to be 4.3m x 4.5m, 3.5m x 5.5m and 2.5m x 7.25m.

However, RRISL has conducted trials with both lower and higher densities. Lower densities started from 350 trees per ha. whilst higher densities have up to 900 plants per hectare. General observations of the two trials indicated that lower densities had better girth. The growth and other parameters which contribute the yield directly such as girth and bark thickness were found to decrease with the increasing density from 500 up to 900 gradually.

Further, though the number of trees grown in a unit land area was different, the amount of latex and volume of timber that could be harvested from them were rather comparable and the higher number of trees does not seem to do the justice as far as the crop is considered. Yet, the interest of the grower is always to increase the density and as on one hand the estates managed by Regional Plantation Companies do not depend on the government subsidy to plant rubber and on the other hand they do believe in having 500 trees at tapping if about 600 trees were planted. Therefore, use of different densities and spatial arrangements without getting much of a return for the investment is seen in many places.

Though the potential yield is a clonal characteristic, there are so many other factors which influence the potential yield. Growth condition or the size of the tree is one of the most important factors. Rarely, we see individual trees giving very encouraging yields as high as one liter of latex volume per tapping. This is equivalent to about 300 g of dry rubber per tree per tapping and the total yield per hectare having such trees only, is beyond imagination. However, we should not forget the fact that the growers of the first seedling generation in Sri Lanka who were achieving only 250-300 kg of dry rubber per hectare per year wouldn't have dreamt of today's yields from the same species. Therefore, the potential does not seem to have limits, thus ways and means to increase the potential yield seem to be worth trying.

The main message the author wants to convey through this writing, is that the yield potential of rubber tree has plenty of room to be explored. Therefore, the rubber growers, or rather the policy makers engaged in making decisions with regard to rubber cultivation in Sri Lanka, must take every possible step to make sure that the rubber trees planted are given the optimum conditions for the growth, so that the tree can pay back the best to the growers.

One area which has shown a clear effect on the growth of the rubber tree is the planting density. As stated earlier, when the planting density is low, the trees tend to grow bigger and very high yields per tree are achieved. Growth and yield of low density and high density trials conducted by RRISL are reproduced in Tables 1 & 2 for easy reference (Annual Reviews 2009 & 2010).

A few old trees grown individually in one location in the Moneragala district are still giving around one liter per tree per tapping and this indicates that even a few trees grown with sufficient space can yield significantly higher volumes through out (personal communications) and thus have become sustainable units.

Therefore, if a family owns 10-15 of such trees, a good income is guaranteed for a long period of around 25 years. Under the circumstance, having a few such trees in the home garden would be a kind of an insurance scheme for the family as the crop can be obtained when we need only, and if necessary after retirement. In other words, rubber is one of the privileged trees which can store the crop within, for the farmer to utilize when he is in need of it. Contrary to tea or coconut, the rubber tree can wait for even 50 years to be harvested without an additional cost of maintenance. Further, tapping of 10-15 trees require minimum labour and even an unemployed house wife, a retired person or old farmer can attend to it even at the age of around 65-70 years.

Thus this concept of having a few rubber trees in the home garden is looking at the same old rubber plantations from different perspective and this would be food for thought for those who are really interested in helping the poor to improve the lively hood in a long term way. The perennial nature of the tree will help the farmer the same way. Country like Sri Lanka, having ideal climatic conditions for growth of rubber trees in about 2/3 of the area, will sure to be benefited through such projects in many ways including poverty alleviation.

RRISL has already initiated trials to grow rubber at low density in Moneragala district. Each farmer was supplied with 5-10 plants, and we have come across of very devoted farmers among the 1500 farmers who own miniature clearings. The field establishment rate was very satisfactory, mainly owing to the planting at the correct time and also due to sufficient attention given to the small number of trees in their vicinity. An establishment rate of over 90% was achieved in this exercise. The average plant establishment rate in the Moneragala and Ampara districts remain very low due to many reasons including severe dry period which follows the main planting season in November – December period. Though the number of plants given to each house hold had to be restricted to 10 due to very high demand from the farmers in Moneragala district, it would have been ideal if plots of different sizes such as with 10, 20. 30 and 40 trees were established as land is available to establish even bigger size plots at low density.

Table 1. *Effect of planting density on growth and yield parameters of rubber*

	RRIC 100				**RRIC 121**				**RRIC 133**				**PB 260**			
Density	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**
350	91.8	49.5	7.92	2772	90.1	54.8	8.76	3066	94	50.8	8.12	2842	85.7	43.5	6.96	2436
425	84.8	47.7	7.63	3242	84.7	48.9	7.82	3323	85.1	47.6	7.61	3234	80	40.7	6.51	2766
500	80.9	42.3	6.8	3386	80.4	43.8	7	3500	83.7	40.4	6.46	3230	73.3	37.1	5.94	2970
575	74.3	37.2	5.92	3421	78.3	38.9	6.2	3565	81.5	35.9	5.74	3300	72.8	33.2	5.31	3053

Estimated tapping days per year - 320
Tapping system - ½ S d/2
(Source: Annual Review, 2009)

Table 2. *Effect of planting density on growth and yield parameters of rubber. In (a) plant girth (cm), bark thickness (mm) at 150cm height and trees in tapping, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100				RRIC 121			
	Girth (cm)	**BT (mm)**	**% Trees in tapping**	**Tappable trees/ha**	**Girth (cm)**	**BT (mm)**	**% Trees in tapping**	**Tappable trees/ha**
500	68.69	8.01	70.68	353	78.2	7.61	70.01	350
600	67.15	7.86	68.91	413	74.38	7.21	68.01	408
700	62.07	7.63	68.08	477	71.27	6.98	70.84	496
800	62.05	7.24	74.08	593	69.22	6.87	76.6	613

(b)

	RRIC 100		**RRIC 121**	
Density (tree/ha)	**Yield (g/t/t)**	**Yield (kg/ha/yr)**	**Yield (g/t/t)**	**Yield (kg/ha/yr)**
500	18.43	1104	34.82	2002
600	21.24	1451	33.13	2201
700	16.83	1365	29.32	2486
800	14.47	1455	24.36	2496

(Source: Annual Review, 2010)

REFERENCES

Annual Reviews of Rubber Research Institute of Sri Lanka (2009). *Review of the Plant Science Department*, pp.28-63.

Annual Reviews of Rubber Research Institute of Sri Lanka (2010). *Review of the Plant Science Department*, pp.33-68.

Senanayake, Y D A (1975). Yield variability in clonal rubber (*Hevea brasiliensis* Muell, Arg.) *Journal of Plantation Crops* **3**, 73-76.

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DIAGNOSIS AND MANAGEMENT OF PATCH CANKER OF *HEVEA BRASILIENSIS*

K M S Tennakoon and E A D N Nishantha

INTRODUCTION

During recent years there have been frequent reports to Rubber Research Institute on the incidence of abnormal bark cracking in the collar region of trees together with the oozing of latex. This malady has now been identified as "patch canker" and the causative organism was reported to be a fungal pathogen *Pythium* spp. (Silva and Nishantha, 2007). The disease is distributed in several districts namely: Kalutara, Rathnapura, Colombo and Galle. As patch canker is spreading fast in rubber plantations in Sri Lanka the aim of this article is to educate the stakeholders on the early diagnosis and efficient management of the disease.

Disease spread

The causative agent, *Pythium* species prevail in various crops and under diverse conditions. Some species can be devastating while many others are not fatal. Land without proper drainage, mechanical damages and stress conditions of the plant can be considered as the main factors that enhance the pathogen growth and disease spread. This pathogen is widely distributed and spores can be found everywhere in nature; in soils, water and in plant roots. Presence of *Pythium* does not necessarily mean it will harm the plants. Sometimes these spores do not germinate; even when they germinate they are not always capable of penetrating the healthy plant tissues. The severity of the disease depends on the *Pythium* species and conditions that satisfy the pathogen penetration. When soil is moist and heavily infested with the pathogen it will easily enter through the damaged tissues (cracks or wounds) of the tree. These cracks and wounds may be caused by mechanical means (heavy winds) or biological agents (bark feeding caterpillar, fungi, bacteria, nematodes *etc*.). Ultimate result will be the slow growth and deterioration of the plant. *Pythium* takes the advantage of the weakness of the host especially when small wounds are presence. Spread of the disease is severe during the rainy season as wet conditions provide a favorable environment for the growth of the pathogen (Agriose, 1988). Further, incidence of patch canker is observed to be higher in areas prone to wind.

During the dry seasons experienced in Indonesia and in Sri Lanka the disease automatically cease to spread, or only spread very slowly. Under a protected dry weather period, the affected bark patches dry out and are scaled off by the action of the undamaged cambium beneath (Sharples, 1936).

Diagnosis

The exudation of the latex at the collar region is the most conspicuous symptom of this malady. At the latter stage, the latex between the bark and the wood coagulates under the bark forming a pad which emits a foul smell (Fig. 1).

In most cases, a patch canker infection could be detected before it has fully penetrated through the cortex to the cambium, but if left alone when the disease reaches to the advance stage, it damages the cortex and move towards the cambium thus extend over a large area of the bark and make tissues feeble, ultimate result will be the breakage of trees during heavy winds.

Fig. 1. Symptoms of patch canker (a) Abnormal bark cracking in the collar region, (b) Exudation of the latex from the collar region (the typical symptom of the disease), (c) Rotten tissues and latex pads in the collar region (d) Removed latex pad from the collar region

Disease management

When plants are damaged by pests or mechanical means, especially when collar region and underneath portions are damaged, growers must initiate control measures, which will help to reduce *Pythium* at the same time. If the rubber trees are prone to heavy wind, wind barriers must be established in order to prevent the damage to the trees. There are chemical controls available for treatment of *Pythium* infestations. Before starting the treatment, the disease affected portions of the trees should be cleaned carefully without damaging the bark of the tree or the root system, damaging to the tissues may enhance the further spreading of the disease. Affected portion should be exposed by removing the latex pads and rotten tissues. A fungicide containing Mancozeb (80%) can be used for the treatment (Dissolve 15 g of fungicide in 3 liters of water). Initially 2 liters should be poured in to the collar region. Then, Candarsan should be applied only to the area where surgical treatment has been done to avoid the washing off the fungicide. Subsequently, the collar region of the affected trees should be covered with the soil. Finally, remaining portion of the dissolved fungicide (one liter) should be poured to the soil which covers the collar region.

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REFERENCES

Agriose, N (1988). *Plant Pathology*. United Kingdom Academic Press, London, 294-297.

Petch, T (1921). Plant pests and diseases in Ceylon. *Tropical Agriculture* **57,** 192-194.

Sharples, A (1936). *Diseases and Pests of the Rubber tree*. Macmillan & Co. Ltd, London, 255-258.

Silva, W P K and Nishantha, N (2007). Bark cracking disorder. *Annual Review of Rubber Research Institute of Sri Lanka* 69.

Zeng, H C, Ho, H H and Zheng, F C (2005). *Pythium vaxans* causing patch canker of rubber rubber trees on Hainan Island, China. *Mycopathologia* **159,** 601-606.

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BEE-KEEPING IN RUBBER BASED AGRO-ECOSYSTEMS

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Rubber is a multipurpose plant. However, it is mainly used for the extraction of latex. Rubber wood is used in the manufacture of furniture and also as a source of fire wood. Apart from theses direct uses of the rubber plant, it is also a good source of nectar during its flowering period for the honeybees for the production of honey which is beneficial for the rubber growers as a supplementary source of income.

Indigenous honeybee *Apis cerana indica* (Hymenoptera: Apidae) can be effectively utilized in rubber based farming systems if rubber growers possess an effective understanding on the behaviour of this honeybee along with the seasonal changes of the rubber plant. To support the proper exploitation of nectar secretion in rubber, several studies have been undertaken during the past few years at the Kuruwita Sub-station of the RRI.

The nectar in rubber is mainly produced from the nectar glands or nectaries that are situated at the distal end of the leaf petiole where the three leaflets join. The rubber plants above the age of four years are able to produce nectar that can be transformed into honey by the honey bee. These glands become active during re-foliation in January to March. The nectar collected by the honey bee is transformed to the honey inside their body and stored in the honey combs. The annual pattern of production of nectar, its volume and sugar content differ from clone to clone. The date of the commencement and the period of nectar flow are different between the clones. Similarly the prevailing weather condition is also important in this process (Table 1).

Table 1. *Nectar flow (No. of days) in some RRIC clones in the past 4 years*

Clone/Year	2006	2007	2008	2009
RRIC 100	12	27	38	33
RRIC 102	---	13	01	43
RRIC 121	12	24	10	39

The longest nectar flow period of 43 days was recorded in clone RRIC102 in 2009. However, this particular clone has had no nectar flow in 2006 and only one day of flow in 2008 showing the year to year variability of nectar flow. Despite such variability within a clone, a mixture of clones is capable of providing lengthy period of nectar flow. For instance, the mixture of clones tested in the present study was capable of providing 12-47 days of nectar flow (Table 2).

Table 2. *Length of the nectar flow in a mixed plantation of clones RRIC 100, RRIC 102 and RRIC 121*

Year	2006	2007	2008	2009
No. of days	12	47	40	45
Duration	19.03.2006 to 30.03.2006	07.02.2007 to 25.03.2007	23.02.2008 to 02.04.2008	18.02.2009 to 02.04.2009

Nectar flow and the effect of weather

During the nectar flow period of the year, the secretion of nectar from the nectar glands located at the distal end of the leaf petiole where the leaflets join, start between 16:00hrs to 16:30hrs in the mature rubber tree. It was observed that nectar flow continued for nearly 12hours and ceased before the sun rise. The nectar secreted from the gland was seen as a clear drop or spread over the leaflets in the following morning. The glands reactivate again in the evening to secrete nectar throughout the nectar flow period.

Usually, the Asian honey bee forages within a radius of 300 meters from its hive or nest (Punchihewa, 1994). So apiary or the Bee yard should be kept very close or within this foraging radius of 300 meters to the rubber plantation.

Rainfall during the nectar flow period was an obvious major barrier that could affect the honey production under rubber. This was detrimental in two ways, first by preventing bee from flying and secondly by washing away the nectar that get collected on top of the exposed nectar gland. The effect of rain during the nectar flow period at the Kuruwita Sub-station of Rubber Research Institute is given in Table 3.

Table 3. *Honey yield and the rainfall during the nectar flow period (Feb. - April) of rubber during the years 2006 to 2010*

Year	2006	2007	2008	2009	2010
Rainy days	5	9	28	22	9
Rainfall (mm)	123.8	149.3	460.1	385.0	114.8
Honey yield per colony (ml)	127.5	1395.0	1014.0	735.0	3453.0

The number of honey harvests that could be obtained under rubber was dependent on the rainfall conditions and in good productive years honey could be harvested 3 to 4 times. In Sri Lanka about 1-3 kg of honey yield per bee hive could be extracted. During the year 2010, a yield of 4.5kg honey per hive was recorded owing to a favourable weather conditions during the nectar flow period. Other factors that affect apiary honey production in rubber based agro-ecosystems are described below.

Finding bee colonies

Wild or natural honey bee colonies are not freely available in most of the home gardens or agricultural lands in Sri Lanka. Usually they are found in places like crevices in rocks or terraces, hollow trees or holes in the ground. Bees may also nest in termite hills and inside hollow walls and roof cavities of houses.

These natural colonies of bees that grow large, strong and overcrowded will send out one or more reproductive swarms during the honey flow season. These swarms cluster on a tree or a bush nearby. These swarming bee colonies prefer to settle down in hives such as clay pots, barrels, hollow log hives that are made of *Kithul* trees (*Caryota urens*) and in cement flower pots. One of these hives could be placed on a low or a reachable crotch of a tree or a suitable place. All of these hollow devices can become hives or natural nesting sites as well and can be easily available honey bee colonies for beginners in beekeeping. Traditional cylindrical split log hive (*eg*: *Kithul* logs) can be placed on a branch of a tree or suspended from a strong branch. These fixed comb hives could be later transferred into standard wooden movable comb hives for effective management.

To obtain best results, transferring of colonies to the standard wooden movable comb hives, should be carried out in November or December. If the process is delayed, beekeeper may not have sufficient time to fill in the super frames with combs for storing honey resulting in decrease of honey crop during the nectar-flow season. When 6 combs are build in the brood box of the standard 8 brood comb hive, gradual transferring of older brood combs to fill the honey frames should be started. One mature comb is cut into appropriate size for filling two honey frames (Punchihewa, 1994). It is important to preserve the super honey combs in as they would be needed for the next year honey season. If properly managed, unnecessary honey storage will not take place in the brood box that can be collected in the honey boxes placed on top of the brood box. It is also important to know how to manage the bees so that the honey is not stored in brood combs inside the brood box. Undue congestion in the brood box will lead to excessive swarming causing lower honey yields. To harvest the honey by using a mechanical (centrifugal) extractor during the rubber nectar flow season, it is important to transfer the bee colonies from the fixed comb hives (pots, logs and *etc*.) to the standard wooden box at the correct time. When the wild swarms are not occupying the empty containers or logs for a long period, a bee colony can be obtained from a reputed beekeeper to start beekeeping.

Absconding

The main problem faced by the rubber based beekeeper is absconding of bee colonies from the movable comb hives. There are several reasons for the tendency to vacate from the manmade wooden bee boxes or hives. Some major reasons for absconding of bee colonies in the rubber regions are given below.

a. Food shortages during off season/adverse weather conditions
b. Red Ants (*Dimiya* or Weaver ants) attacking beehives.
c. Wasps or hornets attacking bee hives.
d. *Kanawe* bees or Trigona bees occupying bee hives.
e. Wax moth: many beekeepers tend to think wax moth as a major problem because they find wax moth larva infested combs in absconded empty hives.

a. Food shortage/adverse weather conditions

Generally the apiaries maintained near the rubber plantations have access for foraging from the rubber trees from early February to early April (Table 2). Commencement and seize of nectar from the rubber tree and the length of the nectar flow period are different from year to year.

The nectar collected form rubber leaves are converted to honey and stored in honey supers by the worker bees. When rain interferes with foraging of bees they consume the stored honey as they are unable to fly outside the hive. There is no nectar is present in the rubber tree after the short nectar flow period of the year (January to April). During the long dearth period of April to January, the foraging worker bees have to fly for other flowering species to collect nectar. Therefore it is an advantage to have forest or home gardens near the apiaries maintained in rubber plantations.

The Asian honey bee, *Apis cerana* has the maximum flying distance (foraging distance) of about 700 meters radius. But the average foraging distance is only about half this distance. If sufficient numbers of flowers are not present within the foraging distance, they have to abscond from the site and find a new nesting place in the forest or any other suitable place where the flowers are abundant.

To avoid this, an artificial feeding with sugar dissolved in boiled water 1:1 can be introduced into the hive at the rate of 200ml/bee colony. Ample amounts of pollen are available in coconut flowers. Therefore, it is important to have a few coconut trees too close to the apiary.

b. Red ant (Dimiya) or Weaver ant

Red ant (*Dimiya*) or Weaver ant (*Oecophylla samaragmida*) attacks the honey bees. If they intrude the nest the honey bees will escape by performing an emergency absconding process where all adult bees abscond leaving the brood and food stores behind. To control this, grass could be grown around the stand of the bee colony. Also a layer of grease or used engine oil can be applied around the hive stand as a temporary solution. It may also practical to keep the hive away from the foraging area of the Red ant. *Dimiya* ants are general scavengers and they go for all kinds of food and they become commoner in unclean home gardens where garbage is carelessly disposed. Under such uncongenial conditions *Dimiya* can turn out to be predators of honey bee colonies.

c. Wasp or Hornet attack

Wasp is a carnivorous insect that can attack honeybee for food. This is a major problem faced by the beekeeper in the rubber plantations. Wasp usually attacks inside and outside the bee hive. If the attack is intensified, the honeybees abscond from the existing hive. When the nesting sites of the wasp are around the bee apiary, it is not possible to carry out beekeeping. The wasp nests present in the vicinity should be removed for the existence of honeybees. When a 5 litre plastic can filled with diesel is hanged over the wasp nest and let the drops of diesel to fall onto the nest through a tiny hole at the bottom. (**Caution:** This should be done only in the night when they can not fly). Wasps will then vacate the site after collapse of the nest in a few days. This method should be carried out very carefully as they attack human beings aggressively. Also some kind of foliage that prevent direct exposure of the hive entrance can discourage wasps (Punchihewa, 1994).

d. Kanawe bees or *Trigona* bees

Kanawe bee (*Trigona irripedis*) is a sting – less, small honey bee species. These also nest in a cave or a hole. They prefer to enter into *Apies cerana* bee hives and establish without any problem. When *Kanawe* bee expands the colony together in the same hive, *Apis cerana* bees vacate their nest in a few days. Only way is to remove them from the hive as soon as the bee-keeper observe them occupying hives.

e. Wax moth

This is the commonest problem in bee-keeping. Wax moth (*Gallaria mellonella* and *Achroia grisella*) fly into the bee hives at night and lay eggs on the floor board or on empty combs. The larvae travel within the brood combs while eating wax. Usually weak colonies or recently divided colonies are prone to wax moth attack. When all the brood combs are attacked the bees have to abscond to a suitable site. To overcome this situation during the dearth period empty combs have to be removed and stored in sealed polythene to be used in next honey flow period.

One of the most effective ways to prevent wax moths entering combs will be by providing supplementary feeding for the bees during dearth periods. Non starving bees can effectively remove the wax moth larvae.

The other difficulty that the beekeepers face is stinging, which is very painful. Honey-bee cannot be tamed like some other animals but their aggressive habit of stinging while rearing can be minimized by the use of smoke. A smoker is used for this purpose. Mild smoke generated from burning coconut husks can be an effective safeguard when one is opening bee hives.

For those who are interested, a piece of mosquito netting could be stitched to a suitable hat for making a bee veil for protection of eyes, face and neck from stinging of bees. Beekeeper should cover the body as a precaution before opening hives. While the beekeeper is engaged in transferring, division, examination, harvesting, feeding and all other related work in beekeeping, he or she must use smoke throughout to minimise possibility of stinging. Those who are not having a smoker can generate smoke by burning the stripped thick edge of a dry coconut husk as a temporary arrangement.

CONCLUSION

Main objective of this paper is to encourage the rubber growers to engage in beekeeping which requires a relatively small investment. The difficulties faced by the beginner beekeepers in and around the rubber plantations, and the solutions for them are briefly discussed. It is not practical to employ labourers in beekeeping. Successful approach is to “do it yourself” with a proper understanding about bees. This definitely is a productive leisure time activity.

REFERENCES

Punchihewa, R W K (1994). *Beekeeping for honey production in Sri Lanka*. Department of Agriculture, Peradeniya.

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SOUTH AMERICAN LEAF BLIGHT OF RUBBER; A THREAT FOR NATURAL RUBBER PLANTATION INDUSTRY

T H P S Fernando, G de Silva and C Wijeratne

Hevea brasiliensis is a member of the family Euphorbiaceae and natural rubber is an important commodity to the economy of Sri Lanka. Further, the natural rubber plantation industry makes export earnings and provides livelihood to over thousands of people. Rubber plantations supplement thousands of hectares to the forest cover and provide many other socio-economical and ecological benefits. The Asian rubber growing countries produce more than 90% of the world's natural rubber. This important industry is under the threat from the deadly disease, South American Leaf Blight (SALB) and this disease, SALB is of great historical interest since it is the factor which is hindering the development of natural rubber plantation industry in its region of origin.

SALB Endemic countries (Fig. 1)

1. Belize	8. El Salvador	15. Nicaragua
2. Bolivia	9. French Guiana	16. Panama
3. Brazil	10. Guatemala	17. Paraguay
4. Colombia	11. Guyana	18. Peru
5. Costa Rica	12. Haiti	19. Surinam
6. Dominican Republic	13. Honduras	20. Trinidad & Tobago
7. Ecuador	14. Mexico	21. Venezuela

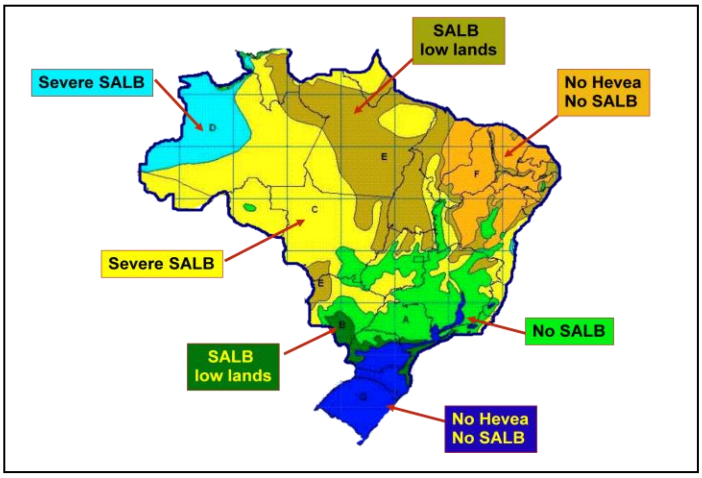

Fig 1. SALB endemic countries (source: Protection Against SALB of Rubber in Asia & the Pacific Region, volume ii)

The pathogen

South American Leaf Blight is caused by the fungus *Microcyclus ulei* (P. Henn.) V. Arx. It is an obligate parasite. This fungus was previously known as *Dothidella ulei, Melanopsammopsis ulei, Fusicladium macrospores and Aposphearis ulei.*

M. ulei is in the group Ascomycetes. The fungus provides sexual and asexual stages both on rubber leaves and three types of spores namely conidia, pycnospores & ascospores (Fig. 2) are produced. It has been shown that conidia & ascospores are responsible for spread of the disease (Chee, 1976). The conidia and pycnospores are produced during asexual stages while ascospores during the sexual stage. Conidia are mainly two-celled with a broad proximal cell and a tapered distal cell. The characteristic feature of the conidia is that they are twisted. The conidia sometimes have only one cell and they are more common during dry weather conditions and in laboratory cultures. The pycnospores are dumbbell shaped and comparatively small. Ascospores are oblong in shape and are made up of two cells of unequal size (Chee, 1976).

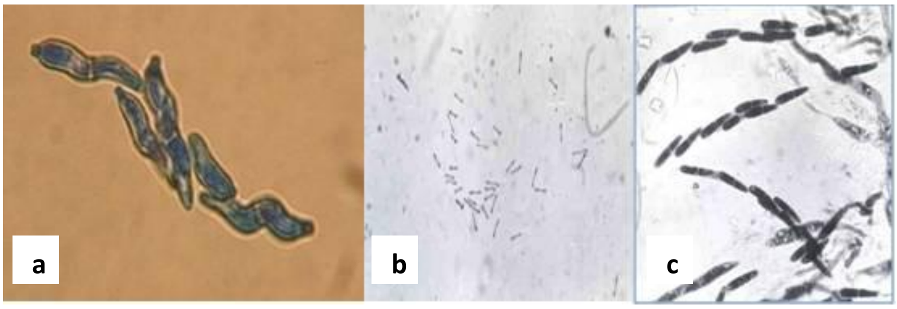

Fig 2. *Microcyclus ulei*, the cause of SALB produces three types of spores a) conidia b) pycnospores and c) ascospores

Symptoms

Very young leaves of the rubber plant are the most susceptible to SALB. The types of symptoms produced on leaves are influenced mainly by the age of the leaves at the time of infection, susceptibility level of the clone and the prevailing weather conditions.

Shortly after the infection of young rubber leaflets, the distortion in the shape is noted (Fig. 3a). A few days after the infection, irregular-shaped disease lesions develop and on the lesions abundant conidia appearing in dark to olive green in colour are observed (Fig. 3b). Severely infected copper brown leaves during wet weather causes the leaves shrivel, turn black and fall off leaving the petioles intact (Fig. 3c).

When the infection occurs on semi-mature leaves, the leaflets will not drop immediately. The characteristic dull velvety lesions which are olive green in colour are developed and later small round black raised structures called pycnidia are formed (Fig. 3d). The pycnidia produce pycnospores.

Subsequently, (several weeks later) the round dark raised structures enlarged and form more prominent raised bodies called perethecia. They are located epecially around the edges of the disease lesions (Fig. 3e). These perethecia bear ascospores. As the leaf ages, the leaf tissues of the centre of the lesions die, turn papery white and tear off leaving shot-holes in the leaf. *M. ulei* also infects the other parts of plant such as inflorescence, petiole, stem and young fruits, When shoot tips are infected, eventually they may cause tip die-back (Fig. 3g). Severe SALB infections cause poor canopy densities with dead branches ultimately leading the plants to death.

Fig. 3. **(a)**The first signs of infection; deformation of young leaflets **(b)** Irregular shaped disease lesions developed on the young leaflets; dark to olive green in colour **(c)** Severely infected leaflets shrivel, turn black and drop off; the petioles remain on the stem **(d)** Small round black raised structures; pycnedia **(e)** Round dark raised structures enlarge and form perethecia

Economic importance

SALB is the most serious disease of the rubber plant. Due to the fact that rubber plantation industry is playing a major role in the economy of our country, safeguarding our plantations from this deadly disease has become vitally important. Several renowned Plant Pathologists predicted that SALB would be devastating in South East Asia as the weather conditions in this region are similar to those found in the SALB endemic areas in Brazil (Chee, 1980, Silva 2007). Furthermore, the rubber clones planted in Asia are susceptible to SALB. Therefore, an outbreak on SALB would destroy the rubber plantation industry in South East Asia within a short period of time. Richard Evans Shultes, a well known rubber Botanist, predicted that if SALB reaches the South and South East Asian region, within 5 years, the rubber industry in South East Asia would be compromised (Davis, 1997).

SALB is most damaging when it infects the tender leaves and young shoots developing after the annual wintering. Severely infected leaves fall off and the repeated cycle of infection and defoliation results in trees with poor canopy throughout the year. Therefore the growth of young rubber plants is affected. As a consequence, the immature period is elongated. In Sri Lanka, it is common that the rubber plants reach the tappable girth within six years or earlier under good agro-management practices. In the SALB endemic countries the immature period may be as long as 13 years. The latex yield of the SALB infected trees is also reduced. The loss of yield couples with the extra management costs and extra agronomic inputs on disease control affects the economic viability of rubber cultivation.

Quarantine measures

The first line of defence against this unwanted pest is the quarantine legislation. SALB is always a threat to the rubber cultivation in Asia and Africa. Due to the expansion of rubber cultivation to new countries and also the increased travel and transport between SALB endemic countries with the Asia and African rubber growing countries, the threat has increased. The threat of SALB to Asian countries was realized since 1950's (Altson, 1955; Hilton, 1955; Rao, 1973) and therefore the introduction of quarantine measures was prompted. As a result, establishment of the Asia and Pacific Plant Protection Agreement (APPPC) had been launched in 1955 (Lieberei, 2007; Thurston, 1973). This agreement clearly stipulated measures to deal with SALB especially to regulate the importation of rubber planting materials (promulgation of article IV and appendix B to the agreement). This obliged the members to prohibit the import of any plants or plant parts from SALB endemic areas (Fig 1) into the countries unless certain stringent phyto-sanitory import requirements were met. This agreement was revised in 1999 to bring it in line with the World Trade Organization (WTO) Agreement on the application of sanitary and phyto-sanitory measures as the 1956 provisions relating to SALB were found to be inconsistent. Therefore, APPPC decided that a pest risk analysis (PRA) on SALB should be developed by the member countries. The PRA for SALB has been completed and accepted at the 25th session of the APPPC. The PRA is the guideline used to develop the standards on SALB. These standards provide a guide for APPPC member countries that grow rubber to prevent the entry, spread and establishment of SALB.

In Sri Lanka the Plant Protection Ordinance No.10 of 1924 provides the access for the prevention of entry of unwanted exotic pests and the control and eradication of them in Sri Lanka. SALB has been gazetted as a dangerous pest under this Act (Gazette Extra Ordinary of the Democratic Socialist Republic of Sri Lanka

No. 165/2). Under the Act, The Director General of the Department of Agriculture is empowered to provide general supervision of all matters for purposes of executing the provisions of the Act. The Director General of the Department of Agriculture is empowered to request for the assistance of any other organization to provide necessary assistance. Rubber Research Institute Sri Lanka is responsible for implementing all actions and measures to avoid the entry of the pathogen under the guidance of the Department of Agriculture.

Public vigilance

Even though SALB is presently confined to Central & South America, the chance of its spreading beyond the American continent has greatly increased due to rapid increase in air travel. Increased trade and movement of tourists and businessmen between American tropics and Asian countries can possibly introduce SALB in to our territory.

Hence, the role of plant quarantine is important in order to manage and prevent the entry of this alien species by regulating the import of agricultural commodities. Policy makers, Scientists, Plant Pathologists, Quarantine Officers and Custom Officers are to regulate the import regulations sticking firmly to the commodity import conditions. Importers and general public should understand the importance of such regulations as it is our duty to enhance, the capacity and capability of our country's readiness in detecting, preventing and managing the introduction of SALB.

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References

Altoson, R A (1955). South American Leaf Blight. *Journal of the Rubber Research Institute of Malaysia* **14,** 338-354.

Chee, K H (1976). South American leaf blight of *Hevea brasiliensis*: spore behaviour and screening for disease resistance. *Proceedings International Rubber Conference* 1975, Kuala Lumpur **Vol. 3,** 228-235.

Chee, K H (1980). The status and future prospects of rubber diseases in tropical America. *Plant Pathology* **59**, 541-548.

Davis, W (1997). The rubber industry's biological nightmare. *Fortune*, August 4, p. 36-46.

Hilton, R N (1955). South American leaf blight. A review of the literature relating to its depredations in South America, its threat to the Far East and the methods available for its control. *Journal Rubber Research Institute Malaysia* **14,** 287-337.

Lieberei, R (2007). South American leaf blight of the rubber (*Hevea* spp.) tree: New steps in plant domestication using physiological techniques and molecular markers. *Annals of Botany* **100,** 1125-1142.

Rao, B S (1973). Potential threat of South American leaf blight to the plantation rubber industry in the South East Asia and Pacific region**.** *F.A.O. Plant Protection Bulletin* **21,** 107-113.

Silva, L G C (2007). Zoneamento do risco de occurrencia do mal das folhas da seringueira com base em sistemas de informacoes geograficas (Mapping risk of occurrence of SALB of rubber using GIS) *MSc Thesis*, Universidade Federal de Vicosa, Brasil, 38 pp.

Thurston, D H (1973). Threatening plant diseases. *Annual Review Phytopathology* **11**, 27-52.

Bulletin of the Rubber Research Institute of Sri Lanka, (2011) **52**, 50-60

A GUIDE TO EXPLORE STATISTICAL INFORMATION ON THE SRI LANKAN RUBBER SECTOR

Wasana Wijesuriya

INTRODUCTION

Data and information on rubber industry are needed for the stakeholders in the rubber sector for their routine decision making processes throughout the planting cycle and this need extends further to the production process, marketing and value addition. On the other hand the Government also requires data and information for formulating and implementation of policies. Hence, accurate and timely information is a basic and essential requirement for effective decision making which is crucial for rubber sector development.

The issue of timely and accurate data and information in the rubber sector has been raised regularly and discussed frequently in many forums. Absence of reliable and timely information in both plantation and industry sectors of rubber has been pointed out in many occasions. Further, it is not possible to access these data with ease as they are not integrated for easy access. Hence, this article is prepared with the intention of making aware the data users in the rubber sector on the availability of statistics which are found in various sources.

The current system of data and information collection

The state sector is mainly involved in data collection in the rubber sector. Figure 1 depicts the current system of data collection by Rubber Development Department (RDD) & Ministry of Plantation Industries (MPI). MPI coordinates the activities of 3 institutions under its authority; namely, RDD, Rubber Research Institute of Sri Lanka (RRISL) and *Thurusaviya* fund[1]. A separate division named 'Plantation Management & Monitoring Division' (PMMD) is also in operation under MPI which facilitates data collection from Regional Plantation Companies (RPCs). Among these institutions, RDD has the mandate for data and information collection in the rubber sector. The main data providers are depicted in Figure 1. Several other institutions also collect and disseminate information on rubber and will be discussed in the following sections.

[1] This has been established under the Act No. 23 of 2000 with the aim of uplifting the living standards of rubber smallholders by facilitating the production of quality rubber sheets and ensuring fair price for their products.

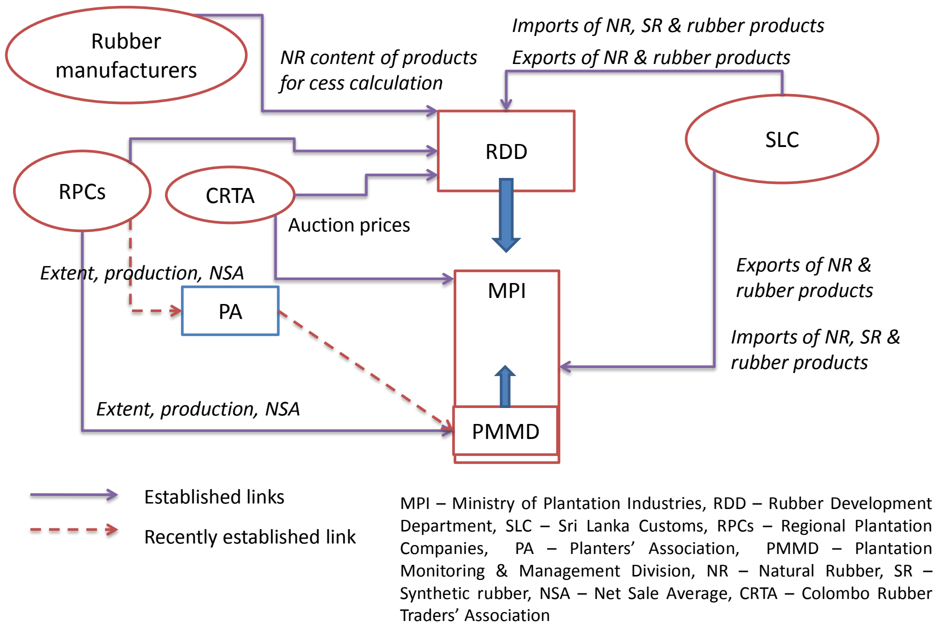


Fig. 1. Current system of data collection by Rubber Development Department (RDD) & Ministry of Plantation Industries (MPI)

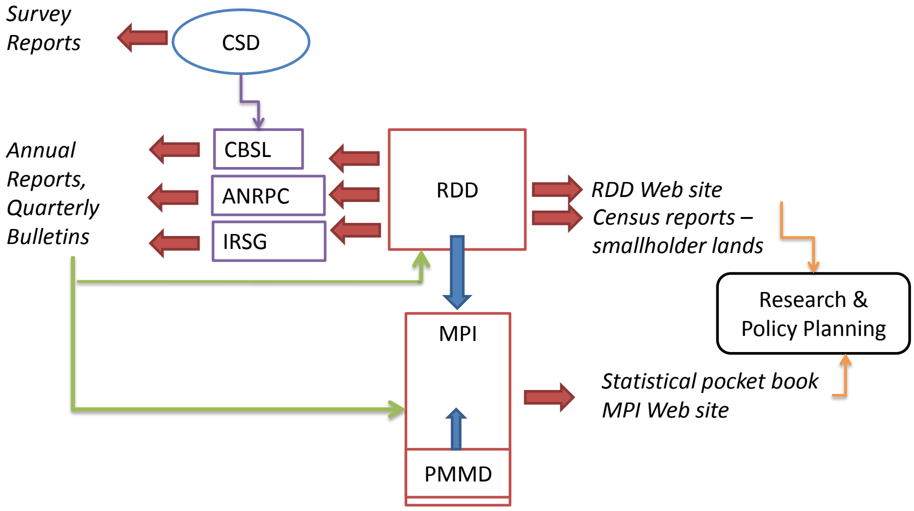
The information generated is distributed to the local and international communities through websites and various reports and also receive information from other sources as depicted in Figure 2.

Rubber Development Department (RDD)

RDD is functional under Ministry of Plantation Industries (MPI) which holds the authority of collecting important data in the rubber sector. In terms of a Cabinet Decision, the Rubber Control Department which was established under the Ordinance No.06 of 1934 was converted to RDD since year 1994. A complete list of services rendered by RDD to its stakeholders, is available in their website[2] and among them there are several activities that generate data and some requires data from other sources (Table 1). Except for activities listed under 1, 12, 13 & 14, all others generate data while No. 9 requires international market information and No. 10 need data retrieval from foreign sources while providing those organizations with local information in the rubber sector. As can be seen from the services/activities of RDD, the data and information which are collected by them can provide the basic platform

[2] Rubber Development Department. http://www. rubberdev.gov.lk/

for the information management system of the rubber sector if properly integrated in the up-stream of the rubber supply chain.



MPI – Ministry of Plantation Industries, RDD – Rubber Development Department, PMMD – Plantation Monitoring & Management Division, CBSL – Central Bank of Sri Lanka, CSD – Census & Statistics Dept., IRSG – International Rubber Study Group, ANRPC – Assoc. for Natural Rubber Producing Countries

Fig. 2. Data and information outputs of data providers and their users in the rubber sector

A census of rubber lands was conducted during the latter part of 2010 by RDD which covered 135 Divisional Secretariat (DS) divisions within 15 administrative districts. In addition to the extents of rubber under different ages, clones and geographical distributions, several other information, *viz.* marketing channels, grades of rubber produced and socio-economic variables of smallholders are also available in this report[3]. The questionnaire includes several other important areas such as, yields obtained and information on rubber traders in different geographical locations. This available information needs to be further explored to collect baseline information in the smallholder rubber sector. Although data and information are generated while rendering services to the stakeholders, very little information is available to the stakeholders through their website and no attempt has been made to automate the applications for subsidies and industry registrations yet.

[3] RDD (2012). *Census of rubber lands – 2010/2011*. Department of Rubber Development, Ministry of Plantation Industries, Sri Lanka.

Ministry of Plantation Industries (MPI)

MPI publishes the Statistical Pocket Book[4] for all plantation crops and their performance every year. The data and information for these publications are acquired mainly from RDD. There are certain instances where data is obtained from Regional Plantation Companies (RPCs), IFAD-SPEnDP[5] project, Export Development Board (EDB), Sri Lanka Customs (SLC)and Colombo Rubber Traders' Association (CRTA). MPI does not receive any information on industries directly from CSD or Ministry of Industries & Commerce (MOIC). Further, the statistical pocket book does not contain any methodologies adopted in the estimation of production and local consumption of rubber which is a routine activity conducted by RDD. Information on international scenario is presented employing the data from International Rubber Study Group (IRSG) and Association for Natural Rubber Producing Countries (ANRPC). This publication serves as one of the main sources of information in printed format which contains information on the rubber industry. Chapter 6 of this publication focuses on the estate sector based on information collected at the start of every year from the plantation companies.

Sri Lanka Customs (SLC)

Statistics Department of the SLC provides data on exports and imports of raw rubber and rubber products to several institutions including, RDD, MPI and Central Bank of Sri Lanka (CBSL). Statistics Department of SLC provides reliable statistics as they carryout screening of information they acquire from the Automated Data Processing (ADP) department. HS codes and related tax structures are available in the website[6] for different raw rubber and finished rubber products. Monthly breakdown on imports and exports of raw rubber and finished products are available with them and can be obtained on request for analysis of the performance of the rubber sector. These data are used by RDD to calculate revenue generation and in the process of estimating the Natural Rubber (NR) production.

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[4] Ministry of Plantation Industries. 2011. *Statistical Pocket Book Plantation Sector*. Ministry of Plantation Industries, Colombo, Sri Lanka

[5] Smallholder Plantation Entrepreneurship Development Programme funded by International Fund for Agricultural Development (*IFAD*)

[6] Sri Lanka Customs. http://www.customs.gov.lk/

Table 1. *Services and activities rendered by RDD and data generation under each activity*

	Service/Activity	Data generation
1	Implementation of the powers vested under principal statutes and legal sources	Not relevant
2	Registration of rubber lands and their owners through the Regional offices, issuance of licenses, and the provision of planting material, fertilizer and subsidies	Registry of rubber lands with planting material requirement & (fertilizer issues)[1] in each planting season
3	Administration of the system of subsidies for new planting and re-planting, and the distribution of subsidies through the District offices	Replanting & new planting extents in each district with subsidy issues
4	Production of high quality rubber plants in government and private rubber plant nurseries, and provision of subsidies and instructions to the private sector for the production of plants	Information on nurseries, their capacity and subsidies provided
5	Issuance of licenses for sale of rubber, manufacture of rubber based products and export of rubber	Information on rubber dealers, geographical distribution, types of rubber purchased & their forward links
6	Provision of subsidies for the modernization of factories for the manufacture of rubber	Details of factories, subsidies given and expected improvements in quality & quantity
7	Collection of important data and information in respect of the rubber cultivated lands, production, local consumption and exports	Information on rubber extent, production, local consumption & exports
8	Provision of advisory services for the cultivators and transportation of their agricultural inputs to augment progress of the rubber cultivation	Information on needs and supplies
9	Make rubber smallholders aware of the available markets	Information on foreign markets and trends
10	Interaction with international organizations in the spheres of production, consumption and trade in natural rubber	Information retrieval from international sources and providing them data on local situation
11	Collection and administration of Cess funds	Information on cess collection for raw rubber & rubber products
12	Motivation the smallholders in respect of the phases of rubber cultivation and production	Not relevant
13	Organization and implementation of activities for the economic uplift of the smallholders	Not relevant
14	Implementation of state policy aimed at the expansion of productivity and production in the sphere of rubber and act as the leading institution for that purpose	Not relevant
15	Estimation, collection and accounting of government revenue	Information on revenue through different sectors of rubber

Census and Statistics Department (CSD)

The Department of Census & Statistics[7] continues to conduct the Annual Survey of Industries (ASI) which commenced in 1984, replacing the Annual Survey of manufacturing industries and covers all activities categorized under the 3 industrial divisions; namely Mining & Quarrying, Manufacturing and Generation & Distribution Electricity, Gas and water. This survey report provides estimates for industrial indicators in respect of all the industrial establishments which had been included in the register of industrial establishments. Information pertaining to rubber sector is found in this report up to the 4-digit level of Industry Standard Industrial Classification (ISIC) as given below (Table 2). This report contains methodologies adopted and metadata which facilitates the data users to get an idea about the quality of data[8]. Information on different industrial aspects pertaining to the rubber industry under establishments with less than 25 persons and with more than 25 persons is available in this report. The relevant tables appear in the industry report are listed in Table 3.

Ministry of Industries and Commerce (MOIC)

There is a possibility of registering Companies through the website[9] of the Ministry of Industries and Commerce. A database is available on registered companies for different rubber products. The unavailability of the date of registration is a weakness in this database as it hinders analysis on the industry performance. As pointed out by the work group members, registration of companies can be done at present at regional level and no proper mechanism is available to transfer the information to the Ministry of Industries and commerce.

Table 2. *Industry Standard Industrial Classification (ISIC) classification of rubber products*

Level			**Description**
2-digit	**3-digit**	**4-digit**	
25			Rubber & Plastic products
	251		Rubber products
		2511	Rubber tyres & tubes, rebuilding of rubber tyres
		2512	Rubber gloves & condoms
		2513	Products from Natural Rubber
		2514	Articles of rubber
		2519	Rubber products (not classified elsewhere)

[7] Department of Census & Statistics. http://www.statistics.gov.lk/
[8] Department of Census & Statistics. 2010. *Annual survey of industries.* Department of Census & Statistics, Sri Lanka.
[9] http://www.industry.gov.lk

Table 3. *Information available in the report of Annual Survey of Industries pertaining to the rubber sector for establishments with 25 or more employees and less than 25 employees*

Table No.	Information
Table 9 & 10	Value of output & output components classified by industry
Table 11 & 12	Value of input & input components classified by industry
Table 13 & 14	Value of electricity & type of fuel classified by industry
Table 15 & 16	Employment by nature of employment & sex classified by industry
Table 17 & 18	Categories of employees by nature of employment classified by industry
Table 19 & 20	Earning of employees by nature of employment classified by industry
Table 21	Salaries per employee by nature of employment & industry class
Table 22 & 23	Persons engaged by nature of employment classified by industry division
Table 24 & 25	Value of assets (at the beginning of the year) classified by industry
Table 26 & 27	Value of gross additions to the fixed assets during the year classified by industry
Table 28 & 29	Economic indicators of industrial activity classified by industry class
Table 30 & 31	Principal indicators of industrial activity classified by investment size class

Central Bank of Sri Lanka (CBSL)

Central Bank in its annual report publishes data and information on rubber industry. These include data on plantation, manufacture, trade, wage rates, imports and exports (Table 4). This publication is available to the public usually by May/June in each year. The annual survey of industrial production by the Economic Research Department of CBSL provides data on various aspects based on a questionnaire.

Export Development Board (EDB)

Data on export performance of rubber is available in the EDB website prepared from the sources, CBSL and SLC. This site also includes analysis of policy implications which are of relevance to the rubber sector as well, specially focusing the budget proposals. Other publications relevant to the rubber sector by EDB are listed below.

1) Sri Lanka Directory of Exporters - (CD Version)
2) Expo News - Fortnightly Bulletin for Exporters
3) *'Apanayana Puwath'* - Monthly Bulletin for Exporters

Under the 'trade directory' in the website[10], information can be obtained for Companies that produce various types of rubber products with contact details. Trade statistics are also available in this website for the subscribers.

[10] http://www.srilankabusiness.com

Board of Investment (BOI)

The BOI website[11] mainly consists of policy related publications such as tax incentives for Foreign Direct Investments (FDI) policy in Sri Lanka and norms and guidelines related to environment, buildings, labour and employee standards. Information is available from BOI on industries related to rubber sector together with investments and number of employees on request.

Industrial Development Board (IDB)

IDB was established under the Industrial Development Act No. 36 of 1969, for encouragement, promotion and development of industries in Sri Lanka[12]. It provides services to promote and develop Micro, Small and Medium Enterprises (MSMEs) in Sri Lanka. The Rubber Products Development and Services Centre (RPD & SC) of IDB was established in 1982 to cater to the needs of the rubber industry. Hence, RPD & SC generates data and information through their services especially to the SME rubber sector and can be regarded as a key point of data generation. They also publish a directory of rubber manufacturers occasionally and the latest available being published in 2009[13].

International Rubber Study Group (IRSG)

The International Rubber Study Group (IRSG) is an inter-governmental organization composed of rubber producing and consuming stakeholders. Located in Singapore, IRSG was established in 1944. In order to facilitate the interaction between the industry and the Group, a Panel of Associates with members of organizations involved in the rubber industry has been established. As of 1st June 2012, IRSG currently has 35 member countries and 120 industry members[14]. The Member Governments are; Republic of Cameroon, Cote d'Ivoire, The European Union (27 Member States), India, Japan, Nigeria, Russian Federation, Singapore and Sri Lanka.

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[11] http://*www.investsrilanka.com*
[12] http://www.idb.gov.lk
[13] IDB. 2009. *Directory of Rubber Manufacturers*, Industrial Development Board of Ceylon
[14] http://*www.rubberstudy.com*

Table 4. *Information on the rubber industry available in the annual report of Central Bank of Sri Lanka*

Table No.	Title	Information/Source
Chapter 2 – National output & Expenditure		
2.1	Sector Composition and Increase in Gross Domestic Product by Industrial Origin at Constant (2002) Prices	Rate of Change, Contribution to Change, Share of GDP – Source: Census & Statistics Dept.
2.2	Agriculture Production Index	Source: Central Bank of Sri Lanka
2.3	Trends in Principal Agricultural Crops	Plantation Companies, Sri Lanka Customs, Central Bank of Sri Lanka, Department of Census and Statistics
2.7	Industrial Production Index (IPI)	Source: Central Bank of Sri Lanka
Statistical Appendix		
1	Gross National Product by Industrial Origin at Current Prices of Major Economic Activities	Source: Department of Census and Statistics
2	Gross National Product by Industrial Origin at Constant (2002) Prices of Major Economic Activities	Source: Department of Census and Statistics
12	Real National Income	Sources: Department of Census and Statistics, Central Bank of Sri Lanka
13	Trends in Principal Agricultural Crops	Sources: Plantation Companies, Sri Lanka Customs, Central Bank of Sri Lanka, Department of Census and Statistics
14	Production of Tea, Rubber, Coconut and Export Agriculture Crops	Source:Rubber Development department
29	Industrial Production Index of Major Divisions	Source: Central Bank of Sri Lanka
30	Industrial Production Index (2010=100)	Source: Central Bank of Sri Lanka
46	Average Daily Wages in the Informal Sector	Source: Central Bank of Sri Lanka
47	Average Daily Wages of Informal Sector by Province	Source: Central Bank of Sri Lanka
59	Central Bank Trade Indices – Value	Source: Central Bank of Sri Lanka
60	Central Bank Trade Indices – Volume	Source: Central Bank of Sri Lanka
61	Central Bank Trade Indices – Unit Value	Source: Central Bank of Sri Lanka
63	Exports	Sources: Sri Lanka Customs Central Bank of Sri Lanka

Table No.	Title	Information/Source
67	Rubber Exports and Prices	Sources : Colombo Rubber Traders' Association, Sri Lanka Customs, World Bank, Central Bank of Sri Lanka
68	Major Rubber Export Destinations	Source: Sri Lanka Customs
72	Selected Industrial and Mineral Exports	Sources : Sri Lanka Customs Central Bank of Sri Lanka
73	Imports by Major Categories	Sources: Sri Lanka Customs Central Bank of Sri Lanka
75	Imports and Exports of Major Commodities	Sources: Sri Lanka Customs Central Bank of Sri Lanka

The Group is served by a small Secretariat, with the Secretary-General, who is responsible to the Group, as its Executive Head. The rest of the group consists of two senior Economists, an Economist & Statistician, an Administrative Manager, a Finance Manager and an IT manager. IRSG Secretariat is the authoritative source of rubber statistics. Data on production, consumption, trade and prices (both natural rubber and synthetic rubber) are published on a quarterly basis in the Secretariat's Rubber Statistical Bulletin. An analysis of the statistics is given in the quarterly Rubber Industry Report. The Secretariat also prepares forecasts of rubber production and consumption, and undertakes statistical studies, where appropriate, on specific aspects of the industry. Short-term forecasts (current year and subsequent years) are also presented in the Rubber Industry Report, while longer-term forecasts are given in the semi-annual report the World Rubber Industry Outlook. IRSG is a very good example of an agency catering to the needs of the rubber stakeholders.

Association for Natural rubber processing countries (ANRPC)

ANRPC is an inter-governmental organization established in 1970. The membership is open to the governments of countries producing NR. As on 30 June 2010, the ANRPC has 11 Members; governments of Cambodia, China, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. These 11 countries accounted for about 92 per cent of the global production of natural rubber during 2010. NR trends and statistics, quarterly NR market review and market news updates are the major publications of ANRPC. Daily prices are available (except for Singapore & Sri Lanka) in the ANRPC website[15].

In addition, there are several other Associations relevant to the rubber sector as identified in Figure 01 which provides data and information. Colombo Rubber

[15] http://*www.anrpc.org*

Traders' Association[16] is one such institution which provides auction prices through their website.

A thought for the future

Stakeholder participation is in a poor status with respect to data and information management and not explored properly the possibility of their involvement in the current system yet. There is a basic necessity to design a more effective data and information management system for the rubber industry through stakeholder participation to facilitate more informed decisions relevant to strategies and policies needed for sustenance of the rubber industry. Timely and reliable information delivered *via* outputs of different nature are of paramount importance to all the stakeholders in the rubber sector for policy making, research and development activities, broadening the knowledge base, market intelligence and competitiveness. More informed decisions will lead to a sustainable rubber industry in Sri Lanka.

[16] http://crta.org