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IDENTIFICATION OF LAND SUITABILITY FOR EXPANDING RUBBER CULTIVATION: A GIS BASED CASE STUDY IN EMBILIPITIYA AND KOLONNE AREAS IN RATNAPURA DISTRICT

L A T S Liyanaarachchi, B W Wijesuriya, J K S Sankalpa and M W H Gayan

SUMMARY

The declining of the traditional rubber growing area is aided by climate change and consequences of human development activities such as development activities. The changes of rainfall pattern and excess rainfall over the area is caused to disturb the tapping operation and reduce the tapping days which led the low natural rubber production. Therefore, the identification of suitable and potential lands to expand rubber beyond the boundary of traditional growing areas is an essential activity to expand the rubber cultivation when meeting global and local demand. Many of studies have been conducted to assess the land suitability of non-traditional rubber growing areas; such as Moneragala, Ampara, Vavuniya and Kilinochchi with the aid of Geographic Iinformation System (GIS) based technologies. Yet, some areas which are located in Ratnapaura district of the traditional rubber growing areas still have not been utilized for the rubber cultivation effectively. Thus, this study was conducted to assess the land suitability of Embilipitiya and Kolonne Divisional Secretariat Divisions (DSDs) *via* a GIS based model to investigate suitability of these areas to further expansion of rubber.

INTRODUCTION

As modern agriculture is aligning with novel technology to meet its targets by improving management approaches, a lot of decision making and supporting tools and platforms are highly contributing on it. Rapid and accurate decisions are highly aiding to protect crops and harvest and minimizing the risk of crop management. Majority of seasonal crops are aiding with such precision agricultural management approaches. Similarly, there are many of technological approaches which contribute to make precision agricultural management approaches for perennial crops throughout the world. Rubber is such a perennial plantation crop which has 0.2% contribution to the Gross Domestic Production (GDP) of Sri Lanka (Anon, 2019). Recently, rubber has met with different issues due to declining of rubber extent in the country. This is mainly because a considerable area in the Wet Zone where rubber is cultivated in Sri Lanka was replaced with other plantation crops such as oil palm and plantation forestry. Furthermore, traditional rubber growing lands were extensively used for other development activities to accommodate the increasing population. Further there are disturbances from the nature, especially change in the pattern of rainfall and occurrence of extreme events for the agronomic operations in the rubber sector.

To meet with national targets, the research scientists and policy makers are looking for alternative approaches, such as expanding rubber into other possible areas of the country to increase the production of the country together with productivity improvement possibilities. Though substantial work has been carried out to explore the possibility of expanding rubber to Eastern and Uva provinces, still there are marginal traditional lands to be considered for rubber farming.

Land suitability analysis and interpretation of results provide information to policy makers to develop a suitable management plan to expand rubber into non-traditional or unexposed areas. In development of land use management plans, Geographic Information System (GIS) plays a vital role where it acts as a decision support tool. The main advantage of the GIS approach is that it provides capability of Multi Criteria Evaluation (MCE), *viz.* to use a variety of digital data layers simultaneously and come-up with more realistic solutions (Buckety, 1997). Several studies have been carried out to assess the land suitability for rubber in Sri Lanka with the aid of GIS based models. One example is the study carried out by Karunaratne *et al.,* (2011), where they utilized MCE capabilities of GIS to develop a land use management plan for expansion of rubber within Moneragala district. In development of land use management plans, allocation of weights for variable considered (GIS layers) plays an important role. One particular approach commonly used to determine weights is through Analytical Hierarchical Process (AHP) (Jayathilaka *et al.,* 2011). It is a decision making tool to derive priorities through pair wise comparison of variables and where weights are determined based on a priority index (Saaty, 2008). Hence, this study aims to assess the land suitability of Embilipitiya and Kolonne DSDs by employing previous GIS based land suitability model applied to assess land suitability of Moneragala, Ampara and Vaunia districts by Karunaratne *et al.,* (2011), Sankalpa *et al.,* (2014) and Liyanaarachchi *et al.,* (2015) respectively.

METHODS

Study Area

The study was conducted for the Embilipitiya and Kolonne DSDs in Ratnapura district. Though Ratnapura district is considered as a traditional rubber growing district, these two DSDs are not traditional rubber growing areas except few smallholder cultivations in Kolonne DSD. The area belongs to the Low Country Wet Zone, Low Country Intermediate Zone and Low Country Dry Zone Categorized under DL1a, DL1b, IL1b, IL1c, IM2a, WM1a, WM1b and WU1, Agro-Ecological Regions (AERs).

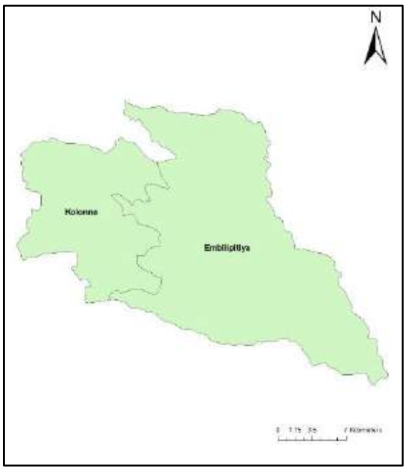


Fig 1. The study area - Embilipitiya and Kolonne DSDs

Acquisition of digital data and preparation of digital layers

Soil Data

Digital soil class map (1: 100,000) which comprises of the major soil groups of Sri Lanka was gathered from Natural Resource Management Centre, Department of Agriculture.

Climate data

Climate data which includes maximum temperature, minimum temperature, and annual cumulative rainfall data were gathered from WorldClim global climate database (https://www.worldclim.org/data/monthlywth.html). These climate data were available at 1 km spatial resolution.

Digital Elevation Model (DEM) data

NASA Shuttle Radar Topography Mission (SRTM) and Digital Elevation Model (DEM) data were gathered which are available at 90 m spatial resolution. Then, DEM was used to derive the slope map (as a percentage) which is considered as a primary terrain attribute.

Analysis of digital data layers was done at 100 m spatial resolutions which equal to 1 ha or 10000 m^2. Hence, prior to modeling, vector data layers namely soil map and land use data were converted to raster data format as weighted overlay analysis is done at raster environment. Finally, the following digital raster layers; annual cumulative rainfall, maximum temperature, minimum temperature, elevation (equivalent to filled DEM layer), slope, soil types were prepared as inputs to carry out the weighted overlay analysis in GIS environment.

Development of land suitability model

Land suitability index was derived for the study area with the aid of Equation [1]. Weighted overlay technique was used to carry out the analysis based on Liyanaarachchi *et al*., (2015).

$$Ri = \frac{\sum \; Wj \;\; . \;\;\; Xij}{100} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..[1]$$

Where, Ri is the capability value (land suitability) of a location/grid in the developed suitability map while Wj is the weight of the factor j. Xij is the ordinal rank capability of factor j in location/grid i.

Climatic and topographic factors which are important for growth and performance of the rubber tree were included as main variables. The weights allocation for main variables was done according to the influences to the growth and performance for rubber at Embilipitiya and Kolonne area. Priority levels of the main variables were determined by using Analytical Hierarchical Process (AHP). A discussion was conducted among researchers who are involved in the study and experts in the rubber sector. Derived priorities were then used to obtain the weights for digital layers considered and subsequently used to carry out weighted overlay analysis in GIS environment. Once weights were allocated for the main variables, ranks were allocated for the sub categories of respective variables based on Karunaratne *et al.,* (2011). However with the range of sub categories, ranking was carried out from 1 to 5, where rank 1 was allocated to most preferable while rank number 5 was given to the most unsuitable sub category (Annexure 1).

Finally, derived land suitability map using the Equation [1] was reclassified as; "Most suitable", "Suitable", "Moderately suitable", Slightly suitable" and "Not unsuitable". The "Most suitable" class has minimum limitations while "Not Suitable" class has maximum limitations with respect to expansion of rubber within the considered area. All the GIS analyses which includes data preparation and modeling were performed using ArcGIS 10.2 version software (ESRI, 2013).

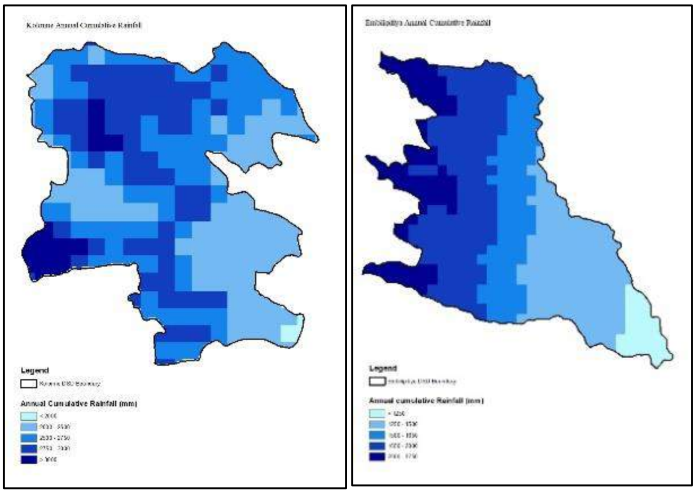
RESULTS AND DISCUSSION

Annual cumulative rainfall distribution pattern in Embilipitiya, Kolonne DSDs and allocation of weights

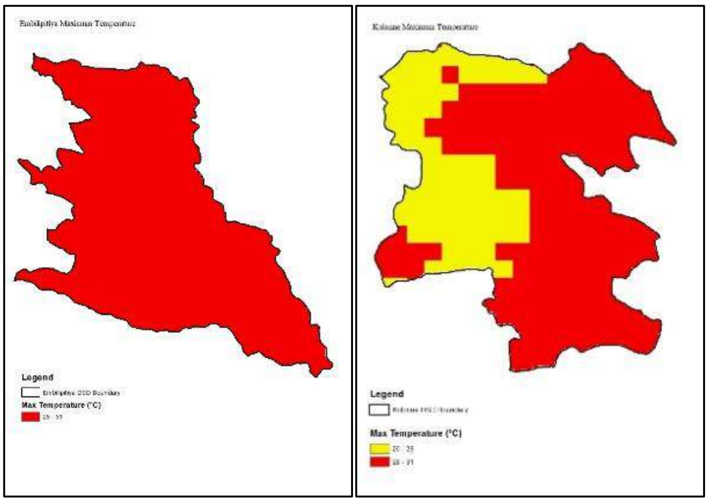
The AHP revealed that 35% weight allocation for the annual cumulative rainfall of the area. However, according to Yogaratnam (2001), the most suitable annual rainfall range for rubber cultivation is 1750 mm to 2000 mm. In this study rainfall vary between 1171 mm to 3305 mm given 5th and 3rd ranks respectively. Rank one (1) was allocated to the rainfall between 2000 – 2500 mm as Yogaratnam (2001) mentioned the limitation for the cultivation is higher at lower and excess rainfall. (Fig 2).

Maximum and minimum temperature distribution pattern in Embilipitiya, Kolonne DSDs and allocation of weights

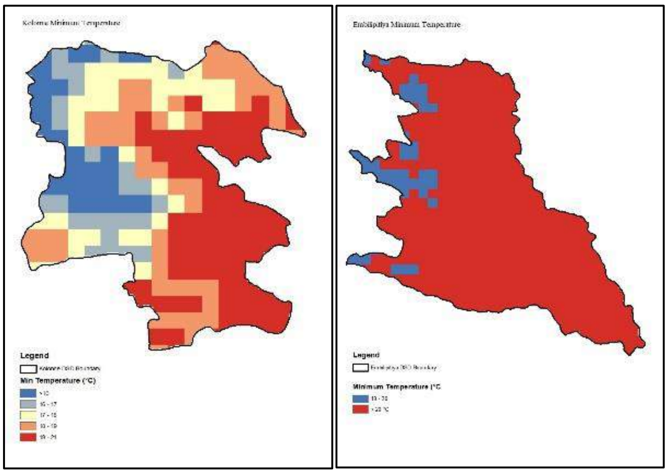
Respectively, 5% and 10% were allocated to the maximum and minimum temperatures for the area based on AHP. Yogaratnam (2001) reported that ideal daily maximum temperature range for rubber varies between 24 to 26 °C and 26 to 28 °C. Hence, ideal range for minimum temperature is 20 -24 °C (Yogaratnam, 2001) was ranked as 1. Maximum temperature of the area varies between 26 -31°C ranked as 1. The best rank of minimum temperature was assigned as 1 which more than 20 °C and lowest rank for minimum temperature assigned as 5 for temperature below 16 °C (Fig 2).



(a)



(b)



(c)

Fig 2. (a). Annual Cumulative Rainfall (mm), **(b).** Maximum Temperature and **(c).** Minimum Temperature Distribution of the Embilipitiya and Kolonne DSDs

Distribution of great soil groups in DSDs of Embilipitiya and Kolonne with weight allocation

The AHP allocated 25% for the great soil groups in Embilipitiya and Kolonne DSDs. This is a higher weight allocation than Karunaratne *et al.*, (2011) suggested for the Moneragala district. In the study area majority of soils consists of Reddish Brown Earth (RBE) soils and Red Yellow Podzolic (RYP) soils while river banks are covered with Alluvials. As RBE and RYP soils are provided desirable conditions to cultivate rubber, ranked with highest ranks while alluvial and erosional remnants assigned with lower ranks of 4 and 5, respectively.

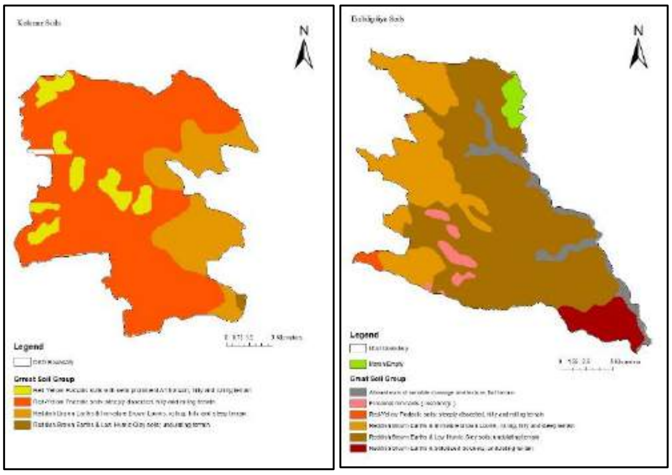


Fig 3. Great Soil Groups in Embilipitiya and Kolonne DSDs

Elevation and slope distribution of the area and weight allocation

Slope and Elevation of the area were weighted as 14% and 11%, respectively by AHP. The highest elevation of the area revealed as 1331 m while the lowest elevation was 23 m above mean sea level (amsl). Performance of the rubber tree in commercial scale is optimum in low altitudes, *viz* below 200 m amsl (Yogaratnam, 2001). Slope of the area varied between 0% to 102%. Therefore, slope was categorized as “less than 20 %” and “20 to 45 %”. The best rank was given to the category, “less than 20 %”. Rank 3 was given to the “20 to 45 %” category according to the Yogaratnam, (2001).

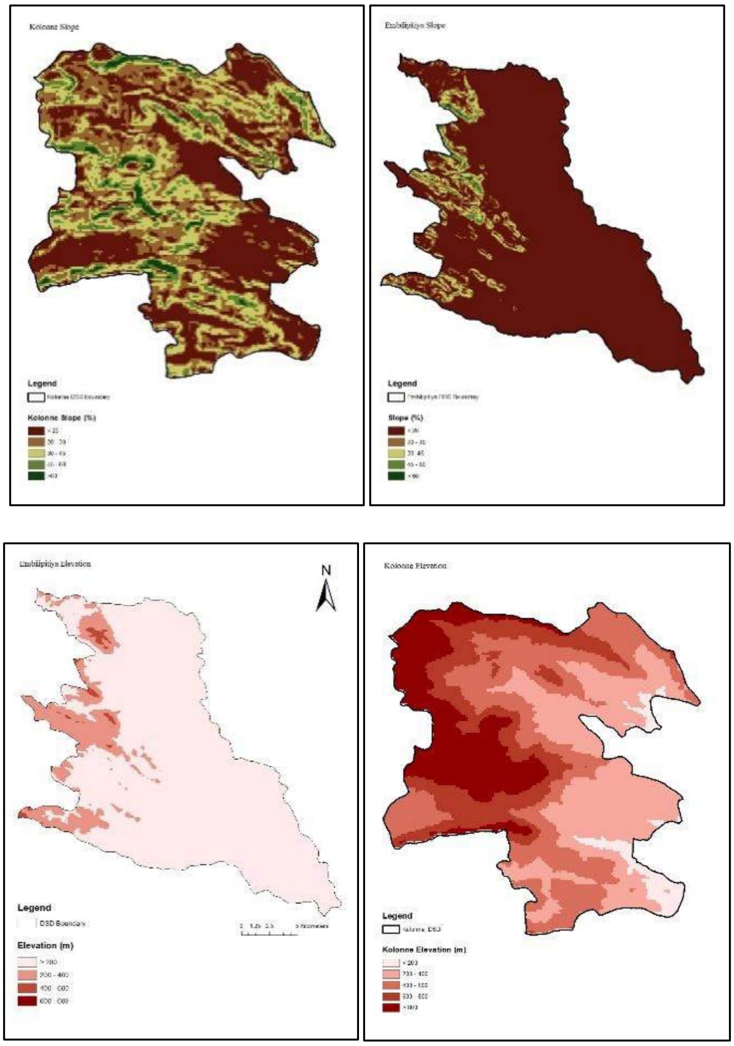


Fig 4. Slope and Elevation Distribution in Embilipitiya and Kolonne DSDs

Land suitability map for expanding rubber in Embilipitiya and Kolonne DSDs

According to the weighted overlay analysis done in ArcGIS, suitability classes of most suitable, suitable and slightly suitable were resulted. The considered study area (66.64%, 37848 ha) was consists with majority of "Suitable" suitability class and only 8.42% (4775 ha) of "Most Suitable" suitability class. Further there were 24.94% (14166 ha) land area where belongs to the "Slightly suitable" suitability class.

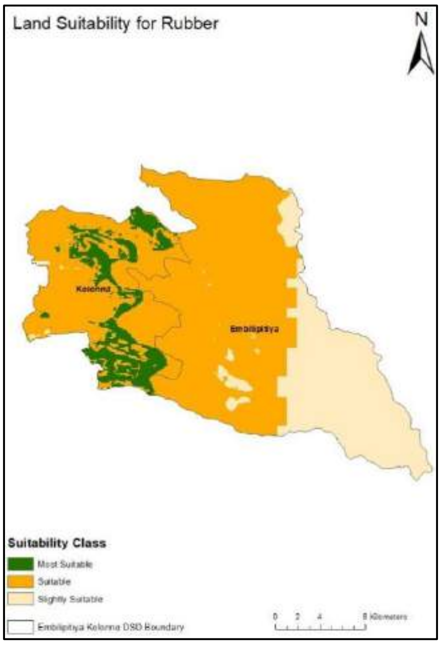


Fig 5. Land suitability map for rubber in Embilipitiya and Kolonne DSDs

Table 1. *Land Extents under Different Suitability Classes*

Suitability Class	Area (ha)	Percentage (%)
Most Suitable	4775	8.42
Suitable	37848	66.64
Slightly Suitable	14166	24.94

Table 2. *Distribution of Land Suitability Class with Respect to DS Divisions*

	Land Extent (ha)		
DS Division	**Most Suitable**	**Suitable**	**Slightly Suitable**
Kolonne	4505	12495	89
Embilipitiya	270	25353	14079

The Majority of most suitable areas have been distributed in Kolonne DSD while majority of slightly suitable areas are distributed in Embilipitiya DSD. Hence, Kolonne DSD consists with WU1, WM1a, WM1b and IM2a which have high rainfall compare to the Embilipitiya DSD where consists with DL1a, DL1b, IL1c and IL1b AERs have less rainfall (Fig. 6). Though Kolonne DSD has more “most suitable” lands compare to the Embilipitiya DSD, areas where belongs to the WU1, WM1a, WM1b have less amount as there are high slopes.

Fig 6. AERs of Embilipitiya and Kolonne DSDs

CONCLUSIONS

Total number of 4775 ha of lands are categorized as “Most suitable” lands for expand rubber in the study area. However, as remaining lands have not categorized as “Not Suitable” those areas are suitable to cultivate rubber with some amendments and special management practices. As the study provide only land suitability output for the area, potential land suitability evaluated with updated land use map. Investigators are expected to carried out further analysis of potential land suitability of the area with recently satellite image which having more updated land use rather than previously surveyed digital maps. Use of more realistic climate data instead of remotely captured grid data will be provide more accurate model. Hence, use of rubber growing soil series as soil data may provide more contribution to assess land suitability than great soil groups. However, this kind of studies provide preliminary data for the land suitability assessment and ground level investigation should be done at site specific level when cultivating rubber. This is more helpful to extract suitable lands to expand rubber out of huge areas like DSDs, Districts, and Provinces for policy makers.

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Annexure 1. Weights and ranks allocated for main variables and sub categories respectively

Main Variable	Contribution Percentage	Sub Category	Rank
Great Soil group	25%	Reddish Brown Earths & Low Humic Gley soils; undulating terrain	3
		Alluvial soils of variable drainage and texture; flat terrain	4
		Erosional remnants (Inselbergs)	5
		Reddish Brown Earths & Solodized Solonetz; undulating terrain	3
		Reddish Brown Earths & Immature Brown Looms; rolling, hilly and steep terrain	3
		Red-Yellow Podzolic soils with semi-prominent A1 horizon; hilly and rolling terrain	1
		Red-Yellow Podzolic soils; steeply dissected, hilly and rolling terrain	1
		Marsh	5
Annual Cumulative Rainfall	35%	> 1250 mm	5
		1250- 1499 mm	4
		1500 - 1650 mm	3
		1650 – 2000 mm	2
		2000 – 2500 mm	1
		2500 – 2750 mm	1
		2750 – 3000 mm	1
		>3000 mm	3
Minimum Temperature	10%	< 16 °C	5
		16 – 17 °C	5
		17 – 18 °C	4
		19 – 20 °C	3
		> 20 °C	2
Maximum Temperature	5%	26 – 28 °C	1
		28 – 31 °C	1
Elevation	11%	< 200 m	1
		200 – 400 m	2
		400 – 600 m	3
		600 – 800 m	4
		> 800 m	5
Slope	14%	0 – 20	1
		20 – 30	2
		30 – 45	3
		45 - 60	4
		> 60	5

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CLIMATE-SMART AGRICULTURE: AN APPROACH FOR ADAPTING AND BUILDING RESILIENCE TO CLIMATE CHANGE

S A Nakandala

Climate-Smart Agriculture (CSA) is an approach to guide actions to transform and reorient agricultural systems to achieve sustainable agricultural development for food security under climate change. The CSA approach is designed to identify and operationalize sustainable agricultural development in a changing climate. The concept of CSA is first defined by the Food and Agriculture Organization of the United Nations (FAO) at the Hague Conference on Agriculture, Food Security and Climate Change in 2010 (FAO, 2013). The aim of CSA is to improve food security, help communities to adapt to climate change that contributes to resilience. It has three main objectives *i.e.* 1. increasing agricultural productivity and income; 2. adapting and building resilience to climate change; 3. reducing and/or removing greenhouse gases emissions (FAO, 2013). In Sri Lanka, many practices in agriculture are related to this CSA concept and are already used by farmers to different degrees in order to mitigate the climatic risks. Mainstreaming CSA requires promising agricultural production systems and institutional and financial assistance (World Bank, 2019).

This paper discusses how the agriculture sector can benefit by the concept of Climate-Smart Agriculture in Sri Lanka with the experience gained by the author while engaging the world bank project under the title of "Climate Adaptation and Resilient project for South Asia" (CARE for South Asia project). CARE for South Asia project is funded by the World Bank Group and implemented by the Asian Disaster Preparedness Centre (ADPC), Bangkok, Thailand. The project aims to create an enabling environment for climate resilience policies through enhanced regional cooperation and knowledge exchange for climate resilience and adaptation (World Bank, 2020). This paper further discusses; how current practices of the rubber sector can be improved as through Climate-Smart Agriculture in order to mitigate adverse climate conditions when introducing rubber to the non-traditional rubber growing areas in Sri Lanka.

Impact of climate change on agriculture

Sri Lanka has three main agricultural production systems *ie;* food crops, plantation crops and dairy industry. The most important food crops are rice, maize, pulses, and vegetables. Plantation crops include tea, rubber, coconut and sugarcane which are mainly focused on domestic and export earnings. Intensive and mono-cropping techniques are common for plantation crops. Agriculture is the most vulnerable sector which is totally dependent on climatic factors like temperature, rainfall, light intensity, radiation and sunshine duration. Therefore, climate change has significantly impacted on agriculture and food production. Changes in rainfall pattern, increase of mean temperature and decrease in soil water availability are considered extreme weather events. Droughts will be exaggerated with low availability of soil water and temperature increment in a range of 1-2°C (IPCC, 2014). In exposure to temperatures of over 33 °C during the flowering stage of paddy cultivation significantly reduces productivity. Root and tuber production are reduced with the change of diurnal temperature range in the highlands which will likely negatively impact the crop productivity (Punyawardena, 2011). Excessive rainfall may happen flooding and waterlogging conditions that also lead to crop loss. Higher intensity of rainfall and low drainage capacity of soil would increase the frequency of such devastating floods. Prolonged floods would result in significant loss of potential food production.

Considering all the direct and induced adverse effects of climate change on agriculture, Climate-Smart Agriculture (CSA) concept aims to improve the integration of agriculture development, resilience and climate responsiveness.

CSA technologies and practices

Climate-Smart agricultural practices and technologies present opportunities for addressing climate change challenges, as well as for promoting economic growth and development of the agriculture sector. According to the country report on CSA published by World Bank in 2019, hundreds of technologies and approaches around the country are under the heading of CSA. For example, reservoirs for collecting and saving rainwater for irrigation and human and animal consumption as a means of mitigating climate variability, is one of the best CSA practices has been adapted since ancient times. These reservoirs continue to support modern agriculture to date. In the Sri Lankan agriculture system, there are many co- existent traditional and modern climate adaptation strategies. CSA practices, such as conservation of genetic diversity and indigenous crop and livestock varieties, the introduction of high-quality, genetically improved varieties, adaptation of planting times, water and soil conservation techniques, intercropping and agroforestry, shade management, mulching, manure production and organic fertilization, crop diversification, and home gardening are considered to adapt for increasing food security and productivity under climate change (Fig. 1).

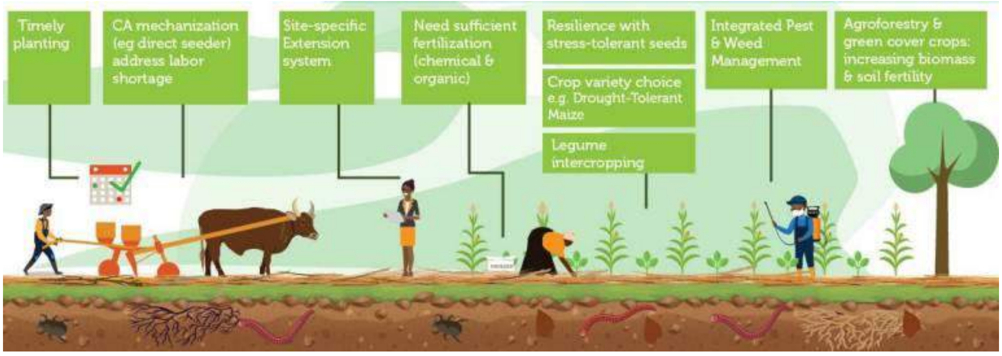

Fig. 1. Strategies of Climate-Smart Agriculture (*Source: Smart digital farming in agriculture: Status and prospects for Sri Lanka, Lankagreenhouse.lk*)

Further to that, farmers have adopted many CSA practices aimed at water conservation, such as the use of short-duration and drought-resistant varieties, shared cultivation, zero tillage, rainwater harvesting and micro-irrigation. Institutional support needs to be strengthened to build climate adaptation and resilience at all levels in water conservation. Water harvesting, inter-basin transfers, enhancing water use efficiencies and reuse, as well as groundwater development, can all be adopted for the sustainable development of the water sector (Sharma, 2021). Soil conservation practices include the introduction of salt-tolerant varieties, construction of ditches, contour planting, mulching, manure harvesting, and use of cover crops. However, insufficient resources and limited marketing options are some of the barriers to adoption of CSA (World Bank, 2019). Therefore, the government intervention is needed compulsorily to have a significant impact on CSA implementation in Sri Lanka. The state protection and guaranteed price schemes, particularly in food production, have the potential to encourage the adoption of Climate-Smart strategies.

Is CSA a new concept in rubber cultivation?

The answer is No. Even though the term CSA is somewhat new to the rubber industry, many adaptation strategies that have been taken so far are falling to CSA technology. Expansion of rubber cultivation to non-traditional areas in the Intermediate and Dry zones of the country is one of the appropriate initiatives to increase national rubber production in the country. Prolonged drought periods experienced every year are considered as the major impediment that limits plant growth and development in those areas. Drought could elevate abiotic stress to plants, leading to an intolerable physiological and metabolic effect that primarily reduce plant growth. The impact of drought stress on young rubber plantations including rubber nurseries and immature rubber plantings would be more severe compared to mature rubber plantations. Water scarcity leading to drought conditions in those areas decrease the productivity of planting material production in rubber nurseries. Similarly, severe growth reduction and longer immaturity periods due to drought stress have also been experienced in immature rubber plantings under long dry spells.

However, with the immense contribution of the researchers in RRISL towards R & D, greater success was achieved in rubber cultivation in non-traditional areas. As a CSA implementation, RRISL focuses on promoting suitable operational and management techniques for nursery management by introducing young budding plants to develop improved preparedness of the Sri Lankan rubber sector to minimize the impact of climate change (Seneviratne, 2005). For large scaled rubber nurseries in drought-prone areas *ie;* the Intermediate and Dry Zones of the country, RRISL has introduced sprinkler irrigation systems as one of the convenient and efficient micro-irrigation systems to mitigate drought stress to young rubber plants. The introduction of sprinkler irrigation system as a modern irrigation technology is very important for improving productivity through enhancing water-use efficiencies of large-scale rubber nurseries under climate change (Nakandala, 2018).

Recommendations of climate-smart agronomic practices such as correct time of planting at the beginning of rainy seasons, mulching immature plants to conserve soil moisture and efficient nutrient and cover crop management (Samarappuli *et al.*, 2005), intercropping young rubber with variety of short- and long-term crops like banana, pineapple, cinnamon, tea and etc. which gives partial shading are considered as strategic management practices for improving productivity in varying climatic conditions.

An imposing of rain guards to rubber cultivation in the wet zone is also a convenient method of CSA to adapt to climate change in rainy seasons. Germplasm improvement for resistance to climate change and higher yields is the key area of enhancing the resilience of the rubber against abiotic stress. Breeding of new clones includes multiplication, establishment and scientific evaluation of the *Hevea* germplasm, molecular level screening to identify drought-tolerant clones (Wijesuriya, 2020).

As such, rubber cultivation satisfies the objectives of CSA in a deeper investigation. The rubber industry is ready to take over its third objective *i.e.* mitigation GHGs resulting from agricultural production systems. Lands utilized for rubber cultivation in the Intermediate and Dry Zones of the country permits to trade carbon fixed or emission reduction. The Clean Development Mechanism (CDM) is the concept developed by the Kiyoto protocol that allows participation in new econo mic ventures for carbon trading. In this context, attempts are taken to expand and to gain the potential of rubber cultivation in carbon trading for the mitigation of climate change (Iqbal *et al.*, 2010).

In summary, the Climate-smart agriculture concept reflects the objective to integrate–agriculture development and climate responsiveness and to achieve its multiple objectives. CSA promotes the application and scaling up of proven practices and approaches and CSA adaptation strategies should be accompanied with mitigation practices that support soil and water conservation and address GHGs emissions. Many of the beneficial agronomic practices on Rubber in order to reduce the abiotic stress of rubber plantations due to climate change are being identified as acceptable methods of CSA.

Acknowledgments

The author gratefully acknowledged all RRISL Scientists who have dedicated to R&D towards the recent development of climate-smart activities for the sustainability of rubber cultivation in the country and wish to give her deepest gratitude to Prof. K D N Weerasinghe, Emeritus Professor, Faculty of Agriculture, University of Ruhuna and Dr. Seneka Basnayake, Director, Climate Resilience Department, ADPC, Thailand for giving the opportunity to join the CARE project for South Asia where she could earn experiences on Climate-smart agriculture.

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BREEDERS OF RUBBER SEEK GROWER PARTICIPATION IN CLONAL SCREENING

S P Withanage

ABSTRACT

Being a perennial nature of Rubber (*Hevea brasiliensis*), the conventional breeding excise is a laborious and time-consuming event. The clone recommendation, it has been taken attempt to maintain a rich clone basket for growers where always top-up more than thirty-five clones; especially for estate plantation sector where have a wide range of choice. The results of surveys conducted in past and recently on local clonal composition showed that very poor clonal balance and the industry has been dominated by one to three clones, driving the whole rubber industry in a danger. Because the stakeholders have not been developed the faith /confidence on other clones as they have insufficient experience and evidence on the performance of those clones. This situation arises mainly due to the poor use of clones in groups II and III. Due to this vicious cycle on poor usage of clones by stakeholders, many clones have missed the ladder of upgrading although they have stayed long period in the recommendation. To overcome this situation, it needs the active involvement of growers, including appropriate number of new clones into their yearly replanting programe. The breeders have to provide necessary bud woods of new clones continuously to encourage the expansion of their bud wood nurseries. Strengthen of this collaboration of breeders and stakeholders, will help to breakdown the vicious cycle of clone usage and drive the industry into healthy clonal balance and sustainable rubber cultivation in the country.

INTRODUCTION

The history of *Hevea* breeding in Sri Lanka goes back to the 1930s with the genetic improvement of planting material through the hybridization process was started. There has been tremendous improvement in *Hevea* planting material in the last few decades. In the conventional breeding procedure, it takes nearly 20-25 years to recommend a clone, commencing from hybridization followed by evaluation and selection. After selecting a genetically improved genotype from the breeders' evaluation process, it is introduced into group III of the clone recommendation under Rubber Research Institute of Sri Lanka (earlier as Rubber Research Institute of Ceylon) prefix by proving the authenticity of the country. The clonal development programme is gradually progressed in the last few decades starting from Mill 3/2, up to RRISL 2100 series today.

Clone recommendation is the basic package given by RRISL to growers to maximize the productivity of rubber lands by maintaining the genetic diversity in the industry. It comprises a wide variety of clones with guidelines on their usage. The promising clones from group III are gradually elevated to higher groups; *viz.* as group II and then finally to group I which consists of clones with proven track records for large-scale planting. However, this clonal evaluation process needs contributions from both the breeders and stakeholders (Fig. 1), because it is a very difficult task to produce a high-yielding and vigorous clone with all other secondary characters up to a satisfactory level by only a single step of the breeding process. Although recommended clones perform well in terms of yield and girth, but may be susceptible to some diseases whilst tolerating other diseases. Also, some clones perform differently in different agro-climatic regions. Therefore, in a long-term crop like rubber, it is of utmost importance that evaluates over a long period in the field by establishing a sufficient extent of land. It is a known fact that the breeding process is a difficult task and breeders alone cannot reach the ultimate goal of producing a good clone without the cooperation of stakeholders. Because, once release the clone, the breeders have limited capacity to involve in the development of industrial confidence on clones. However, both breeders and stakeholders are responsible for the clonal screening process.

Nevertheless, it seems that the stakeholders have not taken their fullest responsibility in the clone evaluation process although they have thirty-six clones in recommendation compared to the smallholders who provided very few options (Fig. 2). Therefore, the estate plantation sector should contribute more to this commercial evaluation process (Fig. 1).

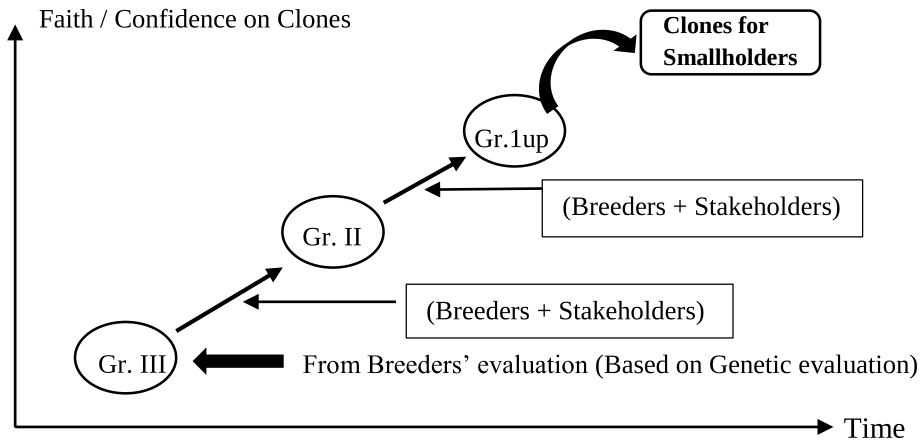

Fig. 1. Clonal progress with time in the Industry. After introducing into Group III (Gr. III) it should gradually upgrade to Group II (Gr. II) and finally to Group I (Gr. I) with breeders and stakeholders experiences. The most confident clones in Group I, recommend for Smallholders also.

1. ***Clone Recommendation for the Plantation Sector*** **(below 300 m altitude)**

Group I

Each clone to be planted up to a maximum of 10% of the total extent of the plantation to minimize the risk on sudden outbreak of diseases (e.g. Corynespora leaf fall)

RRIC 102, RRIC 121, RRIC 130*, RRISL 203, PB 260*

Group II

Each clone to be planted up to 3% of the total extent of the Plantation.

RRIC 133	RRISL 201	RRISL 2001	BPM 24
	RRISL 205	RRISL 2003	PB 217*
	RRISL 206*		PB 235*
	RRISL 210		PB 28/59*
	RRISL 211*		
	RRISL 217		
	RRISL 219		

Group III

Each clone to be planted up to two hectares in a plantation. (Estate/RRI collaborative clone trials)

RRISL 208	RRISL Centennial 1	PB 255
RRISL 2000	RRISL Centennial 2	PR 255
RRISL 2002	RRISL Centennial 3	PR 305
RRISL 2004	RRISL Centennial 4	RRII 105
RRISL 2005	RRISL Centennial 5	RRIM 712
RRISL 2006		
RRISL 2100		

* Clones to be tapped at 67%, i.e. S/2d3

Fig. 2. Recommended clones under Group I, II, and III for the Plantation Sector of Sri Lanka (From Clone Recommendation revised 2013, Genetics and Plant Breeding Department, Rubber Research Institute Substation, Nivitigalakele, Matugama, Sri Lanka).

The planting strategy provides in the clone recommendation is to tell the growers (Planters) to use a wide variety of clones, but each to a smaller extent, to widen the genetic diversity of rubber lands. It is advised to limit the planting of any single clone from group I up to a maximum of 10% of the total extent in group II, a single clone can be planted up to 3% of the total extent and whereas in group III each clone can be planted in an extent up to 2 ha. However, when using many clones, growers have to be careful in maintaining pure stands for each clone (Fig. 2). Further, the experiences of stakeholders in every aspect of the performance of a clone are required and shared with the breeders to develop the faith and confidence to progress the promising clones along the ladder (Fig. 3). The breeders' responsibility lies with considering the feedback of stakeholders and involve with experimental large-scale evaluation and revising the clone recommendation in time. In this revision, it needs to take firm decisions, on the position of the clones, whether they should be upgraded, downgraded, withdrawn, or kept for further evaluation. Yet, unfortunately, due to the poor interest and response of growers for the new clones, it is very hard to find a satisfactory level of information, data, and facts at the commercial level to assess those clones. Therefore, most of the promising clones do stagnate without developing faith or confidence among growers. This vicious cycle further drives to underuse of these clones (Fig. 3). The growers focus more on Group I clones and as a result, the underused ones never very rarely get a chance for expanding further. Most of the time, the smallholders' recommendation is enriched from the group I clones and it is also badly affected by this poor clonal progress (Fig. 3). Ultimately, this unbalanced clonal composition affects the whole rubber industry in the country adversely. According to a survey done in 2009-2010, nearly 99% of the clonal composition is represented by three clones; namely, RRIC 100, RRIC 121, and PB 86 (Seneviratne and Zoysa 2010) subsequently. According to the survey done in 2020, it showed a reduction in extents of RRIC 100 and PB 86 by 8% and 2%, respectively whilst the extent under RRIC 121 has risen to 73%. However, all other clones represent 11% of the composition but are still not at a satisfactory level (Seneviratne *et al*., 2020). Although the Breeders wish to have disease-free or tolerant clones as one of their main objectives. There is no guaranty of 100% risk avoidance in a sudden disease outbreak. Also, it resulted in narrowing genetic diversity, lower productivity, and lack of clones for smallholders, and wastage of breeding cost and effort. Not only for Breeders, Pathologists and Chemists also facing difficulties in the strengthening of the clonal screening process.

This poor rate of clonal adaptation might be due to various reasons. It may be the low level of awareness and perception of newly recommended clones among stakeholders. From the side of Breeders, when a clone is released by adding to the recommendation, there is no systematic propaganda or service carried out to promote the new promising clones. In addition, the stakeholders also give a very loose perception of clone recommendations and are reluctant to change their minds from already known familiar clones. The higher time duration of renewal of bud wood nurseries is too limited to the adding of new clones to their multiplication programme.

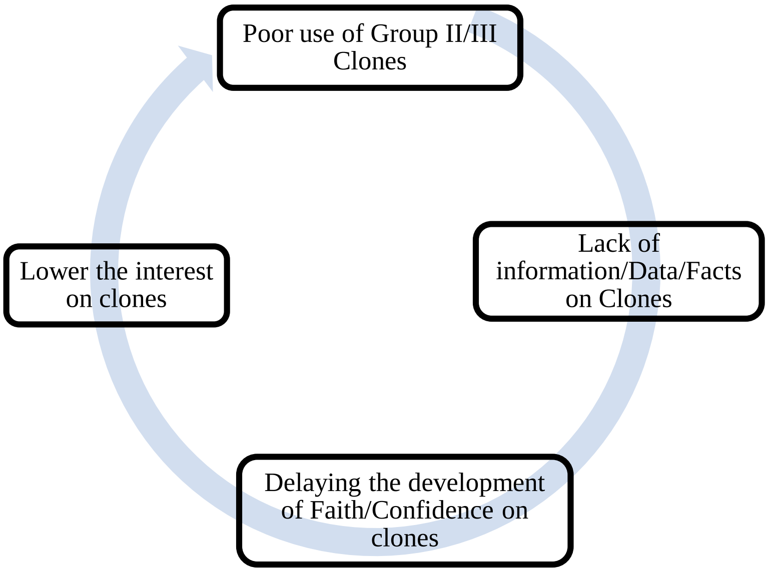

Fig. 3. The Vicious Cycle on poor usage of Group II/III recommended clones by the Plantation Sector in Sri Lanka

To overcome this unfavorable situation both Breeders and stakeholders should pay attention to their responsibilities and need to take proper measures (Table 1).

Table 1. *The Breeders and Stakeholders responsibilities to be carried out for succeeding the clonal screening process for sustainable rubber cultivation in Sri Lanka.*

Breeders Responsibility	Stakeholders Responsibility
• Provide awareness and Small-scale clonal and available large-scale experimental performances. • Information on locations.	• Keep interested and attention to clone recommendation. • Select the appropriate number of new clones to the replanting list every year.
• Continuously provide the bud woods for bud wood nurseries and for multiplication based on early requests and availability of bud woods	• Made prior request for bud woods • Expansion of own bud wood nurseries with promising clones
• Collaboration with Stakeholders throughout the evaluation process	• Keep on collaborating with RRISL. • Provide feedback and support for data collection
• Provide the status of a clone frequently/ update the status	

Therefore, it is a very important and urgent need for active collaboration of stakeholders for the clonal screening process to maintain the healthy clonal balance and sustainable rubber cultivation in the country.

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EFFECTIVE NURSERY DISEASE MANAGEMENT: A REQUIREMENT FOR A SUSTAINABLE RUBBER PLANTATION INDUSTRY

T H P S Fernando, A Mallikarachchi and D Siriwardena

INTRODUCTION

Health of the nursery plants is one of the key indicators of vigorous growth and high productivity of rubber cultivations. Benefits of healthy planting materials are always long-term as far as rubber is concerned. Rubber (*Hevea brasiliensis*) plantations are normally raised from high yielding clonal materials propagated by bud grafting. Ploy-bag plants of rubber are raised in nurseries for around six months before transplanting in to the field. Though there is a marked variation in field susceptibility to common diseases depending on the type of the clone, all poly-bag rubber plants regardless of the clone succumb to almost all the economically important foliar diseases under nursery conditions. In view of issuing healthy plants for the growers, Rubber Research Institute of Sri Lanka recommends the prophylactic application of fungicides to protect these plants from diseases.

Identification of diseases

Correct disease identification is critical in recommending effective disease management practices. This saves plants, time, money and the environment. The diagnosis depends on basic knowledge of the disease, their symptoms and the season they appear. Descriptive illustrations are also helpful in the disease identification. The advices of Extension staff in the diagnosis will also be helpful or the suspected samples can be sent directly to the RRISL, laboratories of Plant Pathology & Microbiology for disease identification.

Table 1. *Important leaf diseases of rubber – under nursery conditions & the causative agents*

Plant Part	Disease	Causative agent
LEAF DISEASES	Powdery mildew	*Oidium heveae*
	Colletotichum leaf disease	*Colletotichum* spp.
	Corynespora leaf fall disease	*Corynespora cassiicola*
	Phytopthora	*Phytophthoro* spp.
	Bird's eye spot disease	*Drechslera heveae*
	Target leaf spot	*Thanateporus cuumeris*
STEM DISEASES	Secondary die-backs	Multiple Organism attacks
	Collar rot condition	*Phythium* spp.
ROOT DISEASES	Collar &hypocolyl rots	*Sclerotium rolfsii*
	Geotrichumassosiations	*Geotrichum* spp.
	While root disease	*Rigidoporus microporus*
	Sudden wilt	*Nattrassia mangiferae*

Powdery mildew
Caused by *Oidium heveae*

Powdery mildew disease is evident during the refoliation season. With the build up of the fungus in the rubber plantations, the disease is spread to the nurseries. The disease is caused by an obligate parasite. The growth of the fungus on the tender leaves appear as white powdery spots on both surfaces. Severely infected leaflets shrivel and fall off (Fig. 1) leaving the petioles for some time. The pathogen attacks tender leaflets and due to the favourable micro-climatic conditions in nurseries, disease may be very severe if chemically unprotected.

Colletotrichum leaf disease
Caused by *Colletotrichum* spp.

Colletotrichum leaf disease is commonly called Gloeosporium leaf disease among the growers. This disease is caused by many *Colletotrichum* species. This disease occurs throughout the year but it is severe during the monsoon periods and in the presence of tender leaves. The tender expanding leaves formed in poly bag plants are highly susceptible in the presence of rainy weather. This pathogen can infect any green tissue such as green shoots causing them to die-back. Copper brown leaves get discoloured, shrivel and fall off and apple green leaves show tip dieback. Mature leaves are resistant to the infection and the raised symptom ‘blisters’ are observed (Fig. 2). In seedlings the anthracnose symptom with concentric zones are also noted.

Corynespora leaf fall disease
Caused by *Corynespora cassiicola*

Corynespora leaf fall disease can be very serious under nursery conditions. The disease is caused by the fungus *Corynespora cassiicola*. A unique feature of the pathogen is the capability in producing a wide variety of symptoms making identification of the disease complicated.The most characteristic symptom is the railway track lesion (Fig 3). Hence if there seems to be any confusing symptoms it would be advisable to get the assistance from the Plant Pathology & Microbiology Department of RRISL to confirm your diagnosis. Affected leaves gradually take a characteristic yellow or orange colouration.

Bird’s Eye Spots Disease

Birds Eye Spots Frequently found during the dry months of the year. The disease is also more prevalent in seedlings and caused by the fungus *Helminthosporium heveae (Drechslera heveae)*. Disease is identified by the presence of circular lesions with reddish brown margin. The central area is silvery white and later falls off giving a shot-hole appearance (Fig. 4).

Phytophthora Leaf Disease

At the time of pod set, Phytophthora diseases prevail in the nearby rubber fields spreads in to nursery plants too. Under nursery conditions, the disease spreads rapidly as the micro-environmental conditions are highly favourable for the disease. First, the fungus attacks petioles and then spreads to leaves and green stems of nursery plants. The symptoms appear as dark brown to black coloured lesions with a drop of coagulated latex on petioles (Fig.5) and leaf lamina are also infected and the leaves will get characteristic colouration finally showing necrotic lesions in the stems.

Target Leaf Spots
Caused by *Thanatephorus cucumeris*

A disease declared as quarantine importance to Asia and Africa. Pathogen affects the young leaves during prolonged wet weather. Crowded conditions, shade and overgrown weeds predispose the plants to infection. Symptoms appear on young leaves during prolonged wet weather as tiny circular spots which later develop into irregular water soaked patches. These lesions are much lighter in colour than the surrounding unaffected area and are translucent if viewed against the light (Fig. 6).

Secondary Die-Back

Secondary die-back condition of nursery plants (Fig.7) is a common incidence during rainy weather seasons. Any pathogen causing diseases such as *Colletotrichum*, *Corynespora* or more commonly *Phytophthora* may lead its symptom to a die-back condition. Many secondary organisms such as *Botrodiploidea* sp., *Fusarium* sp. or bacteria may play a role here. Management of the primary cause at early stages may prevent any die- back conditions.

Foot Canker and Sudden Wilt
Caused by *Nattrassia mangiferae*

A disease prevalent in young budding plants or in seedlings at the collar region. The causative fungus is a weak parasite. The pathogen enters the host at the collar region and spreads internally developing a canker. Hot sunny weather provides ideal conditions for the disease development. Disease spreads under extremely dry weather destroying young budded plants or seedlings in polybags. Subsequently, leaves of the affected plants become brownish and fall off resulting in death of the plants. The most reliable diagnostic feature of the disease is the development of longitudinal cracks on the bark at the collar region.

Collar and Hypocotyl Rots
Caused by *Sclerotium rolfsii*

The disease is restricted to germinating seeds. The causative fungus is a facultative parasite capable of extensive saprophytic growth within the surface layers of soil. A wet rot is developed on the hypocotyl of the germinating seeds. As the infection progresses, network of whitish mycelial strands develop on the affected tissue and the hypocotyl is completely destroyed inhibiting the emergence of seedlings.

White Root Disease

Caused by *Rigidoporusmicroporus*

The disease can be identified by whitish fungal growth and on further examination, presence of rhizomorphs, thick mycelial aggregated on the roots (Fig. 8). Geotrichum is a harmless fungus but under certain circumstances the growth might cause a considerable damage to young plants. Growers misidentify the friendly Geotrichum growth as white root disease and hence this should be avoided. We should be considerate to select healthy planting materials at the time of planting. Any nursery site, should be strictly free from white root disease fungus as otherwise the plants may spread the disease to new areas as well. The poly bags after kept in nursery beds may act as a polythene mulch so that the hidden fungus may rapidly grow out. This method is being used as an early detection technique for the disease

Pest Attacks

Pest attacks can also be observed in rubber plants especially under nursery conditions. Correct agronomic practices will normally keep insect pests away. In nurseries pests such as mites, mealy bugs, scale insects, cockchafer grubs or slugs may be harmful. But when the infestations are serious chemical controlling should be adopted. Seek the advices from the Plant Pathology department of RRISL for any pest management advice.

Monitoring of disease - Disease Calendar

The success of disease controlling process in rubber nurseries is the prevention and timely application of management practices. The best way to accomplish this is the careful monitoring of the occurrence of the diseases in the nursery and also of the adjoining fields. As continuous fungicidal sprays are required to protect the leaves which are susceptible, irrespective of the clonea good knowledge on the background information is required. That way the nursery manager can make the the disease management more cost effective and efficient (Table 2). Corynesporaleaf fall disease, Colletotrichum leaf disease and insect attacks play a significant role in the disease management as they prevail in a nursery throughout the year. Powdery mildew is seen only during the refoliation period and bird’s eye spots and foot canker are normally observed during the dry weather. Phytophthora diseases and collar & hypocotyl rots start with the pod – set and spreads in the presence of rainy weather.

Table 2. *Calendar for the appearance of foliar diseases in nurseries*

Disease	Prevailing period
Corynespora leaf fall disease Colletotrichum leaf disease Different insect attacks Root Diseases	Throughout the year
Oidium leaf disease	At the time of refoliation
Bird's eye spots Foot canker & sudden wilt	Dry months of the year
Phytophthora leaf fall disease Target leaf spot Secondary die-backs Geotrichum associations	Pod set / Monsoons
pest attack White root disease	Throughout the year

Nursery Managers should have a disease calendar to suit their rubber growing areas. Even though there is a possibility to control individual diseases, RRISL recommends a chemical control protocol to suit all the commonly seen diseases in nurseries.

Practices such as weeding, manuring, watering *etc.* at right time to avoid diseases as much as possible will be very important. However as fungal diseases dominate in rubber nurseries fungicides are an important component of nursery disease management. It is important to remember that chemical use should be integrated with all the other appropriate agronomic practices. Information regarding the common diseases, their calendar, and mode of action of different fungicides will help to decide timing of fungicide applications. Based on the mode of action the fungicides can be classified into protective and curative nature. Chemical control is the most reliable and quick way to protect the plants. The chemicals should be used at recommended rates and the frequency of application is very important in disease management programmes. Furthermore, selection of the most efficient material, properly calibrated equipments and knowledge on appropriate application technology are equally important for the efficiency in disease control.

RRISL Recommendation for Nursery Disease Management

Rubber Research Institute of Sri Lanka recommends the prophylactic application of fungicides for nurseries.

Group I

mancozeb / ridomyl / captan / propineb / copper containing

fungicides – cobox (3g per liter)

Group II

carbendazim (1.0g – 2.0 per liter) - (Systemic fungicide)

hexaconazole (2.0 ml liter) - (Systemic fungicide)

- Spray one fungicide from each group alternatively at weekly intervals.
- Under wet weather, as the contact fungicides may easily get washed off, one of the systemic fungicides should be applied. If the disease severity is high, use the carbendazim at a concentration of 2.0g / liter. * - Systemic fungicide.
- If the circular leaf spot disease (Pesta) incidence is comparatively high, apply the fungicides from group II alternatively
- Application of sulphur containing fungicide at a concentration of 3g per liter is recommended only during the Powdery mildew season.
- There is no blanket recommendation for the frequency of fungicide application. The Nursery Manager should decide the time duration after careful monitoring of the diseases; based on weather conditions, stage of the plant and other economic considerations.
- Regarding any insect attack or uncommon disease situation, Please Contact the Plant Pathology & Microbiology Department.

Acknowledgement

Authors are thankful to Ms. Madushani Lanka for word processing.

Fig. 1. Severely infected leaflets shrivel and fall off

Fig. 2. Spots are circular and appear as raised blisters

Fig. 3. Characteristic symptom is the railway track lesion

Fig. 4. Silvery white and later falls off giving a shot-hole appearance

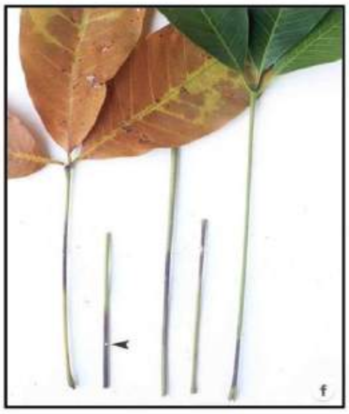

Fig. 5. Symptoms appear as dark brown to black coloured lesions with a drop of coagulated latex on petioles

Fig. 6. Lesions are much lighter in colour than the surrounding unaffected area and are translucent if viewed against the light

Fig. 7. Secondary die-back condition nursery plants

Fig. 8. Presence of rhizomorphs, thick mycelial aggregated on the roots

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BIOPESTICIDES FOR SUSTAINABLE AGRICULTURE

T H P S Fernando, N A D D Nishantha and N Aberathna

Over the next two decades, the increase in crop production will be essential to meet the rising needs of the world. Measures should be adopted without causing much harm to the agricultural sector and the environment. Hence plant protection approaches should be developed to suit the future prospects making the processes more environmental friendly. The government of Sri Lanka has banned the use of chemical pesticides and therefore needs to identify alternative methods to manage harmful disease conditions of economically important agricultural crops. For the sustainability of agriculture, biopesticides play an important role to be used in integrated pest management system.

Generally biopesticides are found in nature and are made of living rganisms. Biopesticides make less risk to the environment than the chemical pesticides. Currently, biopesticides fulfill approx. 5% share of the global chemical pesticide market. The use of biopesticides is hindered mainly by the high cost, slow action and short supply. Their biodegradable nature and low toxicity levels make them important. They are also specific in action, causing less pest resistance issues. Use of biopesticides in sustainable agriculture provides social acceptability, sustainable economic productivity and facilitating environmental stewardship. At the same time, sudden changes in the protection products from chemical pesticides to biopesticides may have implications short-term or long-term. Intensive agricultural programmes that have been conducted for long periods have influenced the naturally inhabiting microbe populations in nature especially in agricultural soils. Most of our agricultural soils are "sick" in nature due to many reasons. Hence the rehabilitation process of the beneficial soil micro flora should be undertaken slowly reducing the chemical usage and promoting the application of biological agents. In biological agricultural systems, the short-term benefits are always less than the long-term benefits.

Biopesticides consists of naturally occurring organisms or compounds that suppress the growth of pests. They are classified into three main groups;

- Microbial biopesticides
- Biochemical biopesticides
- Plant incorporated protectants (PIPs)

Microbial biopestices

Micro-organisms like bacteria, fungi, viruses and protozoa are generally used as biopesticides. They are more targeted (for the crop and the disease) in action. Some common microbial biopesticides are entamopathogenic fungi, *Beauveria bassiana* or *Trichoderma species*. These biopesticides are targeted for plant pathogenic bacteria, fungi, insects and weeds. The most widely used microbial biopesticide is the insect pathogenic bacteria - *Bacillus thuringiensis* (Bt). There are other entamopathogenic Baculoviruses and fungi. At least 170 different biopesticide products based on entomopathogenic fungi like *Beauveria bassiana* or *Metarhizium anisopliae* have been developed. Microbial biopesticides based on different *Trichoderma* spp. are active against *Rhizoctonia*, *Pythium*, *Fusarium*, *Rigidoporus* and other soil-borne pathogens while specific strains of *Bacillus subtilis*, *Pseudomonas fluorescens* and *Pseudomonas aureofaciens* are being used against a range of plant pathogens including damping-off and soft rots. Microbial antagonists, including yeasts, filamentous fungi and bacteria are also used as control agents of post-harvest diseases. On the other hand, plant pathogens are being used as microbial herbicides. Two products, 'Collego' (*Colletotrichum gloeosporioides*) and 'DeVine' (*Phytophthora palmivora*) are already used in the USA.

Biochemical biopesticides

Biochemical biopesticides include plant materials like essential oils, semiochemicals, plant growth promoting regulators, insect growth regulators. They tend to control pests without killing them. For example, they may repel pests, disturb their mating or growth secondary metabolites, natural minerals. Plants produce a wide variety of secondary metabolites that prevent herbivores from feeding on them. Some have been identified to be used as biopesticides. The most widely used botanical compound is neem oil, an insecticidal chemical extracted from seeds of *Azadirachta indica.* A semiochemical is a chemical signal produced by one organism that causes a behavioural change in an individual of the same or a different species. The most widely used semiochemicals for crop protection are insect sex pheromones, some of which can now be synthesized and are used for monitoring or pest control by mass trapping.

Plant incorporated protectants (PIPs)

PIPs are transgenic plants. The genes are introduced into plants by genetic engineering so that they are capable in protecting themselves from pests.

Advantages of biopesticides

Biopesticides have a range of attractive properties that make them good components of disease controlling. Most are selective, produce little or no toxic residue, and development costs are significantly lower than those of conventional synthetic chemical pesticides. Biopesticides can be applied with farmers' existing spray equipment and many biopesticidesare suitable for local scale production.

- Chances of developing resistance is less compared to the chemical pesticides due to their multiple modes of actions against targeted pests
- The environmental negative impacts like pesticide related pollutions, bioaccumulation of chemicals, biodiversity losses, insurgence of secondary pests and elimination of natural beneficial enemies are less with the use of biopesticides
- With the prohibitive restrictions towards the synthetic pesticides, biopesticed have become beneficial
- Low toxicity properties
- Little or no negative impacts on non-target organisms or humans

- Biodegradability
- No postharvest contaminations
- Stability against abiotic stresses
- Compatibility in integrated pest management (IPM)

Limitations of biopesticides

The disadvantages of biopesticides include a slower rate of controlling compared with the conventional chemical pesticides, shorter persistence in the environment and susceptibility to unfavourable environmental conditions. Because most of the biopesticides are not as efficacious as conventional chemical pesticides and also they are not suited for use as stand-alone treatments.

- High cost of refined commercial products
- Inability to meet market demand
- High specificity which may require an exact identification of the pest/pathogen and the use of multiple products to be used; although this can be an advantage in that the biopesticide is less likely to harm species other than the target
- Susceptibility towards environmental factors often variable efficacy due to the influences of various biotic and abiotic factors (since some biopesticides are living organisms, which bring about pest/pathogen control by multiplying within or nearby the target pest/pathogen)
- Slow action - Often slow speed of action (thus making them unsuitable if a pest outbreak is an immediate threat to a crop)
- Studies have found broad spectrum biopesticides having effects on beneficial organsisms
- Users need more knowledge to use biopesticides effectively.

Prospects of Biopesticides

An IPM is a pest-control option, equivalent to an effective multi-faceted approach involving the combination of cultural practices and other suitable control tactics into one management program to achieve a long-lasting reduction of pest population and associated problems**.** Positive externalities that go along with biopesticides besides significant pest population reduction are social acceptability, economic viability, and environmental stewardship, the three-domain concept of sustainable development. The limitations are to be addressed through research breakthroughs in the coming years as research and developmental activities related to biopesticides have received more attention during the recent past

Challenges and opportunities for Integrated Pest Management (IPM)

Integrated pest management tool is the most efficient disease controlling strategy in the world. IPM is regarded to methods such as chemical, biological, physical integrated for disease management in crop cultivation based on a principle of optimum rather than maximum pest control included. The chemical controlling methods are very popular among the growers and the other agronomic practices and physical methods are too familiar among the growers. Use of biopesticides in the management of diseases have been restricted only to laboratory or protected house conditions in many countries. Improvement of productivity levels is of importance for the sustainability of the agriculture and one way to increase is to effective management of pests. There are around 67,000 different crop pest species in the world and it has been estimated that together they cause about 40% reduction in the world's crop yields, even though improved plant varieties, plant protection, plant nutrition, and other stimulants have increased the yields by nearly 70%. The use of synthetic pesticides has increased significantly during the recent past owing to,

- Injudicious use of broad spectrum pesticides affecting human and environment health
- Prophylactic use of pesticides excessively poses the development of heritable resistance. For example worldwide, over 500 species of arthropod pests have shown resistance to one or more insecticides, while there are about 200 species of herbicide-resistant weeds.
- Further pressures on pesticide use arise from concerns expressed by consumers and pressure groups about the safety of pesticide residues in food. These concerns are voiced despite the fact that pesticides are among the most heavily regulated of all chemicals.

There is an urgent requirement for alternative methods for the sustainability of crop protection. Hence IPM is promoted as the best way forward as different crop protection practices are combined with careful monitoring. Therefore the shortcomings of individual methods are reduced. The overall aim would be to not to eradicate pest problems but managing them below levels that cause economic damage. Some of the approaches are given below;

- Use of synthetic chemical pesticides
- Use of resistant cultivars
- Crop practices such as crop rotation, intercropping
- Physical methods
- Natural products like plant extracts
- Biological control measures

In contrast, biological control plays a central role in the production of many greenhouse crops.

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INTRODUCTION OF NEW FOREIGN CLONES FOR OUR RUBBER INDUSTRY

S P Withanage and T B Dissanayake

The history of the cultivation of rubber in Sri Lanka goes back more than 100 years when under – British colonization. As we know rubber is not our native crop but was introduced from the Amazon zone of Brazil. However, Sri Lanka is considered a center for distributing Rubber to South Asian countries. Today, 122.076 Million rupees of foreign income (Anon, 2018) and value-added as 0.3 percent of Gross Domestic Product (Anon, 2018). It covers around 0.137 Million hectares (Anon, 2018) and support a significant amount of livelihoods in the country. Around 65% of the growers are represented by smallholders and the rest is shared by the plantation companies. The rubber planting material is referred to as rubber "clones" which are labeled in numbers, earlier under RRIC (Rubber Research Institute of Ceylon) and now as RRISL (Rubber Research Institute of Sri Lanka) are familiar with the growers.

All clones which growers can use with reference to their category are compiled in the clone recommendation, the other way is the planting package given to the industry. It instructs you, how to select a clone(s) and to what extent you can use it in your land because the selection of a clone is very important as it stays a long period with you due to its perennial nature. The current clone recommendation is comprised of thirty-seven clones and out of them, five clones are recommended for smallholders (Revised clone recommendation 2013 RRISL).

However, the story behind the development of this clone package is pretty laborious, time taken, and the costly process runs to achieve three main goals such as the increment of productivity, improvement of the quality, and maintenance of a wide genetic diversity in the Rubber plantations. The breeding, evaluation, and selection process mainly takes around 25-30 years where clones are passed through the comprehensive evaluation/testing steps in many aspects as high yield, vigorous (open for tapping earlier), disease resistant/tolerant timber values, latex quality, adaptability, etc.

Rubber growing countries all over the world have their own breeding programs, caring to develop more and more genetically improved clones. And they are practicing the exchange of their planting materials between other Rubber growing countries. Sri Lanka has experienced several bi and multi-lateral clone exchanges during the past hundred years. There is evidence, even in the current clone recommendation that it got 10 foreign clones from different countries such as India, Malaysia, and Indonesia.

Recently under the guidance and monitoring of IRRDB (International Rubber Research and Development Board), a Memorandum of Understanding has been signed by Rubber growing countries to exchange 49 Rubber clones between them. At the beginning 12 countries; Philippines, Cambodia, CIRAD (France), Cote d'Ivoire, China, Guatemala, Indonesia, Cameroon, Malaysia, Myanmar, India, Nigeria, Thailand, and

Sri Lanka. In the year 2018, Bangladesh too signed as a new Rubber growing country. Cambodia and Cameroon are not offering clones to other countries but are recipients due to the threat of the presence of SALB (South American Leaf Blight) disease in their countries. Although France is at the threat of SALB, they transfer the clones via Ghana ensuring the planting material is not contaminated with SALB. Bangladesh is also only a receiver but does not offer clones as it is a new Rubber growing country. All other countries offer around two to five clones to the exchange pool. Sri Lanka offers five clones; RRISL 203, RRISL 208, RRISL 211, RRISL 219, and RRISL 2001.

The objective of this programme is to promote international cooperation and capacity building in the IRRDB member countries for the betterment of the Natural Rubber industry and evaluate the performance of all the exchange clones in the different agro-climatic conditions in the member countries.

Under this memorandum, the donor party (sender of clones) should ensure compliance with the quarantine requirement of the receiving country, meet the cost of packing and transporting the Bud Woods to the receiving country as well as should ensure all necessary approvals and requirements of the law are met before transporting the Bud Wood to the receiving country. Similarly, the recipient party also comply with prevailing quarantine regulation in their country once the Bud Wood reaches the destination (Fig. 1). Any recipient country can transfer their material to a third party (to any party not listed above) with the written concepts of the donor party. The recipient country should use their original names.

The memorandum of understanding will remain in for 15 years from the year started. All countries should submit their program report of foreign clone trials annually to the IRRDB.

As an extension of their memorandum, all parties agreed to authorize the Rubber Research Institute of Thailand to share all the clone exchanges with the government of Peru in place of Peru allowing IRRDB to collect wild accessions of *Hevea bresiliensis* and other *Hevea* species from its territory.

So far we have received 17 clones from India (5 clones), Thailand (5 clones), Cote d'Ivoire (five clones), and two clones from Myanmar (Table 1). All these received clones are already established in the Bud Wood nursery of the breeding garden at Neuchatle estate in Kalutara district (Fig. 2).

Table 1. *Details of clones received from Thailand, India, Myanmar, and Cote d'Ivoire*

Country	Thailand	India	Myanmar	Cote d'Ivoire
Clones received	RRIT 251	RRII 414	ARCPC 24/4	IRCA 41
	RRIT 3904	RRII 417	ARCPC 6/22	IRCA 230
	RRIT 3604	RRII 422		IRCA 317
	RRIT 226	RRII 429		IRCA 331
	RRIT 408	RRII 438		IRCA 825

The testing of adaptability of foreign clones

For the continuous establishment of adaptability trials, the multiplication programme will be carried out every year until it completes the establishment of all agro-climatic regions of the country. The adaptability trials will be assessed under the estate/RRI collaborative manner. Twelve clones received from India, Myanmar, and Thailand were multiplied and established as the first adaptation testing trials at the Neuchatle Estate, Dickhena Division, Millaniya, Kalutara belongs to the low country wet zone in the year 2021. The second adaptability trial was established at Galewatta division, Dartonfield group of RRISL with the same twelve foreign clones in October 2021(Fig. 3a and 3b). It is expected to establish an equal amount of plants from each clone in a complete randomized layout in every agro-climatic region. Due to difficulties in preparing planting material at the beginning, the first and second adaptability trials were established with approximately 25 and 100 plants from each clone respectively. As now it has been expanded the bud wood nurseries, it is planned to establish each clone in one tapping task (approximately 250). Growth, yield, and other performances, especially disease prevalence will be monitored continuously with the collaboration of other research departments to ensure their adaptability for local conditions. It is expected to establish two more adaptability trials in the year 2022. Also, it is planned to establish RRI/smallholder collaborative trials to test the selected foreign clones for their suitability for smallholders. Screening of the suitability of these clones for the marginal areas will be commenced along with the molecular application.

The clone exchange programe is continuing successfully although there was a two-year delay due to the COVID -19 pandemic. However, it is planned to accelerate the exchanging program to receive all clones as soon as possible to strengthen the local breeding pool.

Fig. 1. Received Bud woods under strong quarantine process

Fig. 2. Bud wood nurseries of foreign clones established at Neuchatle Estate, Dickhena Division, Millaniya, Kalutara, Sri Lanka.

Fig. 3a. Bud grafting of received clones at Breeding garden, RRISL, Neuchatle Estate, Dickhena Division, Millaniya, Kalutara, Sri Lanka

Fig. 3b. Multiplied foreign clones at Breeding garden, RRISL, Neuchatle Estate, Dickhena Division, Millaniya, Kalutara, Sri Lanka, ready to establish adaptability trials.

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AN ASSESSMENT OF THE WORKFORCE OF LATEX HARVESTERS IN MEDIUM SCALE RUBBER HOLDINGS: A CASE STUDY IN COLOMBO DISTRICT

P K K S Gunarathne and K K I Jayasundara

INTRODUCTION

The Medium-scale Rubber Smallholder Sector (MRSS) which extends between 10 to 50 acres plays a key role in rubber production and in creating job opportunities for the smallholder rubber sector (Dissanayake, *et al*., 2014). MRSS has been facing a serious problem of due to workforce unavailability for the latex harvesting in the last two decades. This situation is very crucial in the Colombo District as it represents 38% of medium-scale rubber holdings in the country (MPI, 2019). Finally, there will be a national issue created in the rubber sector on this matter. This article is based on a study that attempted to carry out a workforce assessment in Latex Harvesters (LHs) of MRSS in Colombo District and it was the objective of this study. It will provide information for the policymakers to develop the MRSS for better performance in the rubber sector of Sri Lanka.

METHODOLOGY

Eight rubber growing divisional secretariat divisions in Colombo were selected for the study. Medium Scale Rubber Holdings (MSRHs) were selected using the stratified random sampling technique based on the land extent of MSRHs in Colombo District. The total sample size was 127. Both primary and secondary data were collected for this study in 2019. The cross-sectional pre-tested questionnaire survey was carried out to gather the information from MSRHs based on the objective of the study. A structured direct interview schedule was used to gather data from owners and Latex Harvesters (LHs) of MSRHs. Descriptive analysis was used to generate a general picture of workforce availability in major practice of mature rubber holdings namely harvesting. An attitude scale namely; Scarce, Adequate and Plentiful was used in measuring the respondent's attitude towards workforce availability for harvesting according to their experience to manage the above-mentioned operations in mature rubber holdings. The perceived issues of LHs in MSRHs were listed out by discussing with them prior to the questionnaire survey and the list was then administrated for LHs. There were six issues listed in the questionnaire. Perceived issues of LHs were measured by the Henry Garrett Ranking Method.

RESULTS AND DISCUSSION

Labor availability with respect to the latex harvesting

Rubber is a plantation crop, of which its mature period is suitable for harvesting after reaching the harvestable girth and is preceded by an immature period. LHs are the people who extract (harvesting/tapping) latex from the rubber plant. Harvesting of rubber is a highly skilled task and the LHs have to be adequately trained to perform harvesting to get the best returns and also to protect the rubber tree to get an optimum economic result over the total lifespan of the tree. Latex harvesting can be considered as the backbone of the rubber industry as latex extraction is the initial step of the manufacturing cycle of rubber products (Gunarathne *et al*., 2019).

According to landowners' experience, the shortage of workforce of harvesting practice of rubber farming in different land categories is depicted in Figure 1. The lowest 'adequate' workforce for harvesting is found in 41-50 ac. land category, whereas the highest 'adequate' workforce for harvesting is found in 11-20 ac.

It indicates that with the increase of the land extent, the availability of workforce in harvesting becomes problematic. Because of that, the average rubber extent that is not-tapped was 43.5 ha/day in Colombo District. This abandonment of rubber holding is a serious issue among landowners who maintain MSRHs. On the other hand, it will affect the sustainability of rubber farming in MRSS in Colombo District. Finally, it will lead to a decline in national rubber production. The LHs under a 'plentiful level' shows below 5% in all types of land categories.

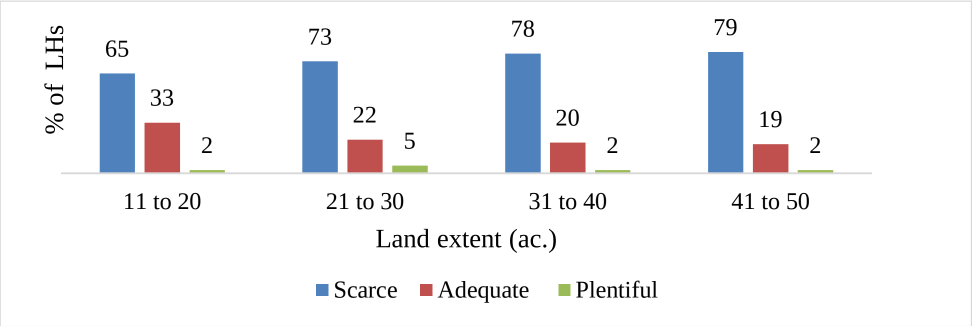

Fig. 1. Labor availability with respect to harvesting operation of rubber farming in different land categories in MRSS

Latex harvesting was exclusively female-dominated (70%) in all land categories (Fig. 2). There was no existence of gender inequity in terms of wage rates in latex harvesting in MSRHs. Therefore, most of the time male workforce did not engage in harvesting as they joined other jobs due to low wages. According to the respondents' view, prominent working places/sectors that male LHs moving were carpentry work, security services and restaurants/food cabins.

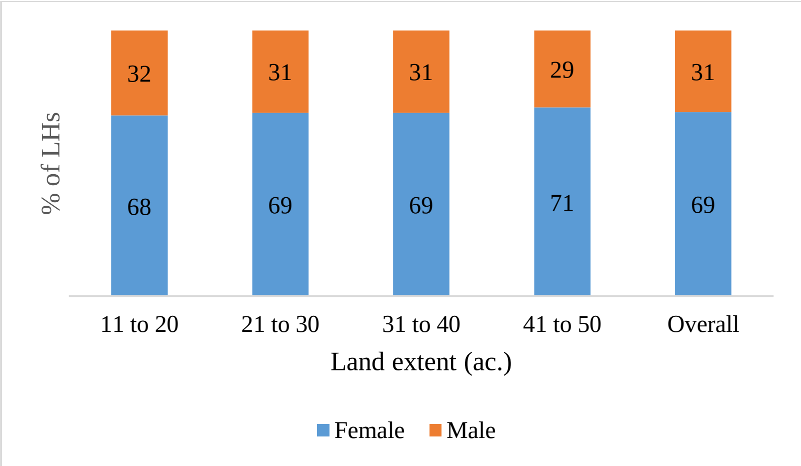

Fig. 2. Gender composition with respect to harvesting operation of rubber farming in different land categories in MSRHs

Constraints faced by latex harvesters

In Table 1, perceived issues faced by the LHs in MRSS in Colombo District were ranked according to the Henry Garrett Ranking Method.

The low wage rate was the major issue. LHs receive daily wages ranging from LKR 550-880. The mean value was LKR 660. Only 4% of LHs were entitled to the Employee Provident Fund. Low wage rate problems which exist were similar to the small-scale smallholders (<10 ac.) (Dissanayake *et al*., 2004). In general, skilled work was usually paid higher than unskilled work, but in rubber farming, there was no salary variation among the LHs' workforces based on a skilled level.

Low social prestige was the second issue. Since the establishment of rubber cultivation, Sri Lankan society considered that engaging as the workforce in the plantation sector is low prestige job. Particularly in Sri Lankan social context, latex harvesting has a lower level of social recognition compared to most other jobs for the same category of people (Rodrigo, 2007). Therefore, the policymakers should focus on changing the social norms, values and attitudes in the society regarding the low prestige jobs such as harvesting.

The difficulty in harvesting due to the stature of the LHs was ranked as the third issue. Harvesting rubber trees on flat land is easier and faster than harvesting on the rubber trees of the terrain or uneven ground. It is easier and faster to harvest young trees with a smooth surface. The older trees with rough surfaces create difficulties in harvesting due to the harder surface. It is easier to harvest at the level of the waist of a person, than the levels above or below the waist, where extension of knife or use of a ladder is necessary to perform rubber harvesting. Therefore, the LHs are vulnerable to ergonomic hazards due to their overall job task (Yogaratnam *et al*., 2001).

Due to bad weather conditions in the early morning, most of LHs cannot go to the rubber field. It will affect their additional income as delaying harvest causes low rubber yield. The threat of bites by snakes/animals was another serious issue for the LHs; sometimes it will lead to the death of LHs. Not maintaining a regular weeding cycle was the highlighted reason for that issue. The least prioritized issue was the high rainfall on harvesting days. Only, 33% MSRHs adopted the rain guard technique. LHs from rain guarded holdings had shown more harvesting days (average 123 days/year) than others.

Table 1. *Perceived issues of latex harvesters*

Issues	**Garrett mean score**	**Rank**
Low wage rates	73.2	1
Low social prestige	72.2	2
Difficulty in harvesting due to the stature of the harvester	70.8	3
Bad weather conditions in the early morning	65.6	4
Threat of bites by snakes/animals	62.3	5
High rainfall on harvesting days	58.5	6

Age distribution in the work force of latex harvesting

The age distribution of the LHs in MSRHs is shown in Table 2. The 56 - 65 age category of the LHs was prominent in the study area. Although, there was a significant drawback in the young generation's contribution to the workforce of harvesting.

Table 2. *The age distribution of latex harvesters*

Age category (Years)	**%**
< 25	02
26-35	11
36-45	10
46-55	15
56-65	36
>66	26

The young generation's (age between 18 to 36 years) participation in the workforce crucially determines the labor productivity. According to this study, the contribution by the young generation to latex harvesting was lesser and it will create low labor productivity and increase the cost of production of rubber. The upper age limit of the LHs was unlimited. Sometimes it can go up to 81 years. Many export processing zones, supermarket channels and shopping complexes were located in the Colombo District. There are job opportunities in the above-mentioned organizations and also there is a greater demand for female workforce exerted by the garment factories. This may be the reason for the acute female workforce shortage observed in

MSRHs. Land owners and current workforces highlighted that attraction of the younger generation into the workforce of the MRSS should be enhanced by the mechanization of latex harvesting, enhancing social recognition and introducing insurance schemes and pension schemes for their job security. Therefore, policies should be implemented to attract a young workforce into the sector as well as prevent the turnover from MRSS.

CONCLUSION

An acute shortage of workforce necessary for latex harvesting was observed and the young generation's participation in was very poor. Hence, a deep attitudinal change is a requisite to attract the young generation to latex harvesting. The mechanization of latex harvesting should be implemented and it may be the motivational factor to attract younger generation into the MRSS. The ergonomic hazards should be a concerned theme among management research in the future. Rain-guard technology should be promoted among the MRSS in order to maintain the maximum harvesting days, through which LHs can optimize their income from the job.

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THE RUBBER RESEARCH INSTITUTE OF SRI LANKA REACHES A "GOLDEN MILESTONE" IN ITS PUBLICATIONS!

P Seneviratne, Chanika Wijesekara and Ramani Amaratunga

Fig. 1. The present appearance of the Rubber Research Institute of Sri Lanka which was built in 1961.

The Rubber Research Institute of Sri Lanka (RRISL) as shown in Figure 1, is the first in the world of its kind, and has been dedicated to research on rubber since 1909. The RRISL started from very humble beginnings with one scientist, and an analytical chemist, The Smallholding Advisory Department had also been formed in later years to provide advisory services, and to disseminate research findings had been disseminated through simple publications. The research work has undergone gradual and methodical expansion over the past 112 years since its inception and publications of the institute also records a long history.

Among the annual publications of the institute, Annual Review, Journal of RRISL, Bulletin and Rubber Puwath, are mainly to report the research findings. Handbooks and Advisory Circulars are published when the necessity arises and not annually. The Annual Report is compiled to report a summary of the performance of the institute to the Parliament (Fig. 2).

Our Publications

Fig. 2. Annual and other publications of the institute, Journal, Bulletin, Rubber Puwath, Annual Review, Rubber Hand Book.

"**The Journal of the Rubber Research Institute of Sri Lanka**" is a unique publication which provides a platform for the researchers to publish their findings and to share the knowledge with the rest of the world. This is exchanged with many national and international institutions on an exchange basis and its popularity is witnessed by the number of citations made by the researchers of the rubber growing world.

The Journal of the Rubber Research Institute of Sri Lanka" dates back to 1924 and has been published every year and the volume published in 2020 is the **memorial 100th Volume (Fig. 3)**. Due to multiple issues in some years the 100th volume is published within 96 years. The development of this publication over the years is a fascinating story. The first 16 Volumes, from 1924 until 1939, have been published as four quarterly issues under the title "***Rubber Research Scheme (Ceylon) Quarterly Circulars***". The next five volumes (from Volume 17 to 21), from 1940 to 1944 had been published as "***Rubber Quarterly Circulars***".

Then from 1945 to 1958 (Volumes 22-34) it carried the title "***Rubber Research Institute Quarterly Circulars***". The next 14 volumes from the year 1959 (Vol.35-49) have been published as" ***Rubber Research Institute of Ceylon Quarterly Journal***" until 1972. After Sri Lanka became a republic in 1972, Ceylon was changed to Sri Lanka and the title of the Journal too changed to "***Rubber Research Institute of Sri Lanka Quarterly Journal***" for the three volumes from 50 to 53. It has then been renamed *"**Journal of Rubber Research Institute of Sri Lanka**"* in 1977 with volume 54 and remains unchanged up to the volume 100, published in 2020.

Whilst appreciating all the contributors of articles from Volume 1 (Annex 1) up to 100 (Annex 2), those who were devoted to publishing ***Journal of Rubber Research Institute of Sri Lanka*** continuously, especially the Library staff and the management of the institute are acknowledged with heartfelt gratitude.

Fig 3. The memorial 100th volume of the Journal of the Rubber Research Institute of Sri Lanka" published in 2020

It is the hope and the wish of all scientists at RRISL for the Journal of the Rubber Research Institute to prosper for another 100 years or more on the institute's path to a radiant future.

RRISL' s Journey

The leading role played by Sri Lanka, Ceylon then, in the long journey of the domestication of the rubber tree from its wild Amazonian ancestors in 1876 is still a fascinating story remembered by all rubber growing countries in South East Asia.

The events that took place in Sri Lanka, especially in research and development, are no less fascinating. The Rubber Research Institute of Sri Lanka, established in a remote rubber plantation namely Dartonfield, in the Kaluthara district, is thriving in its original location from 1909 to date (Fig 4).

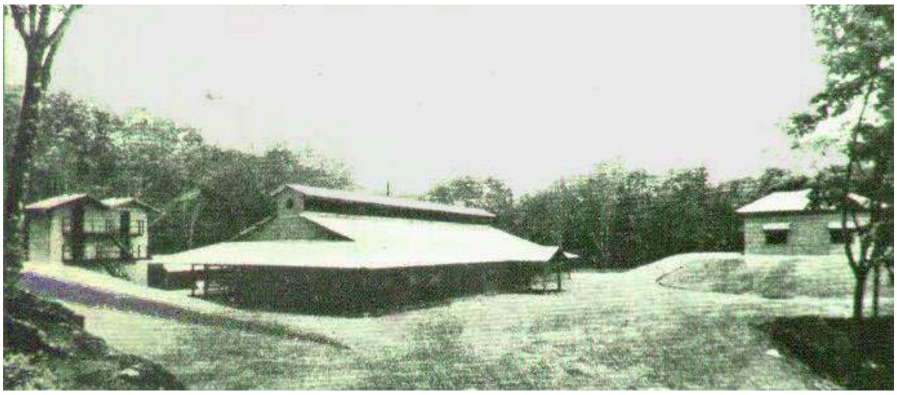


Fig. 4. The view of the Rubber Research Institute of Ceylon and the factory in 1935

The original scheme had been reorganized in 1913, when it was named ***Rubber Research Scheme*** and the Government agreed to provide 60% of the expenses and the balance was provided by the private subscribers. In 1914, the Rubber Growers' Association, based in London inaugurated the Rubber Growers' (Ceylon) Research fund to expand research activities. The Rubber Growers' (Ceylon) Research fund and Ceylon Rubber Research Scheme amalgamated the activities in 1920 with the continuation of 60% of the funds provided by the government. Planting and testing on new clones were initiated in a land of 65 acres at Nivithigalakale, in the Kaluthara district in 1926. The Smallholding Advisory Department was also formed in later years to provide advisory services and planting material for smallholder rubber growers at subsidized rates. This advisory unit was established in Colombo. ***The Rubber Research Ordinance of No.10 of 1930*** was incorporated with the Rubber Research Scheme to operate in 1930. This ordinance provided provisions to collect a cess of one-eighth cent per pound of rubber exported and to utilize the same for research on rubber under a Board of Management. The Research station comprising of laboratories, factory and the quarters had been formed in its present headquarters at Dartonfield estate in Agalawatta in 1934 in a land of 178 acres. The very first building of the Rubber Research Institute shown in Fig.4 holds a historical value as the starting point of a research institute dedicated for rubber in the entire world. The research laboratories were slowly expanded with time and a rubber processing factory was built to process the crop from the estate "Dartonfield Group" which is about 825 acres in extent and meant to conduct field trials on rubber agronomy.

In 1942, an additional 1000 acres were acquired from Hedigalla, close to Agalawatta, to expand research facilities for the growing demand and interest of the planters. Research findings were disseminated through publications, visits and meetings with interested parties of the District Planters' Associations formed by then. The Rubber Research Scheme was named the Rubber Research Institute in 1951 by the provision of Rubber Research (Amendment) Act No.30 of 1951.The activities of the institute was expanded greatly in 1953 with the introduction of the subsidized rubber replanting scheme. The original Act of Parliament was amended again by the Rubber Research (Amended) Act No.39 of 1987.

Since its establishment, the Rubber Research Institute has expanded according to the needs of the researchers and to fulfill the demands of the growers and the industry. “Nivithigalakele” was named the first substation which had already established for testing of clones. it is about 10 km away from the main station at Dartonfield and was one of the divisions of the Dartonfield group then. The second substation, named “Kuruwita” is 250 acres in extent and was opened in 1996 in the Ratnapura district about 125 km away from Dartonfield in the Wet Zone. In 2004, another substation was established in Polgahawela in the Intermediate Zone about 200 km away from Agalawatta and 100 acres in size. The most recently established substations in the Southern province of the country, in the Moneragala district belong to the Intermediate Zone with an area of 62 acres.

Contribution to the industry

In order to manage the available research staff and other physical resources effectively to cater to the needs of the rubber cultivation and product manufacturing industry, different research disciplines have been identified. At present, the research on agronomy is divided into Genetics & Plant Breeding, Plant Pathology & Microbiology, Plant Science, Soils & Plant Nutrition, and Biochemistry and Physiology. Some units have also been formed to support the research work of main departments, namely Biometry, Agricultural Economics and Adaptive Research. Research laboratories of the Rubber Chemistry Department were later moved to a building in the Colombo district to help the rubber manufacturing sector especially for trouble shooting, product development and for issuing of testing and analytical reports. The Rubber Chemistry Department was further divided into five departments in 1988 namely, Rubber Technology, Polymer Chemistry, Raw Rubber & Chemical Analysis, Raw Rubber Process Development & Chemical engineering to handle research and development more effectively.

Genetics and Plant Breeding is one of the main disciplines identified from the inception of the institute The research department is situated in the Nivithigala Kale substation, close to the main station, and it is the site of origin of all the world recognized clones. The Rubber Research Institute has been the pioneer in *Hevea* breeding and a remarkable contribution was made to the industry by improving the genetic material of the plants, which enabled planters to harvest a yield that was more than ten times the crop obtained from the seedlings of Wickham’s collection. Disease resistant clones recommended through thorough screening methods have guaranteed plantations free from chemical spraying to control foliar diseases, thus paving the way to a safer environment while saving the cost incurred. During the olden days, the Rubber Research Institute had to persuade planters to use-sulphur dusting to protect the plantations from *Oidium* leaf disease on clones planted until 1950s. Having witnessed the disease resistance especially to *Oidium* in the fields planted with new clones, and disease incidences and severity not being severe enough to undertake foliar spraying, the Rubber Research Institute recommended to stop sulphur dusting in Sri Lanka. Apart from the world wide large scale adoption of RRIC clones, they are used by the rubber breeders across the world in their hand pollination programmes to develop clones with disease resistance.

Yet, the new leaf fall disease reported in Sri Lanka for the first time in 2019 is spreading in rubber plantations affecting all the clones planted today. Trials are being carried out in search of controlling measures and interim chemical recommendation has been issued to delimit further spread. Rainy and overcast weather prevailing from May onwards this year has favoured the pathogen to grow while affecting the chemical spraying programmes. The best disease resistant clone RRIC 100 is added back to the Group I of the list of recommended clones from this year and the clone RRIC 121 is withdrawn temporarily due to its over usage covering over 70% of the extent.

RRISL utilizes highly developed nursery techniques, and the nursery monitoring system developed and adopted by the RRISL to monitor the plant production process, guarantees high quality planting material for the farmers. Since the rubber plantations in Sri Lanka is expanded across several climatic zones in Sri Lanka, RRISL has paid special attention to provide irrigation systems that are specifically tailored to suit the requirements of the different zones. One such example is the sprinkler irrigation system which was developed for nurseries, especially in the Intermediate Zone of the country. Due to the high costs, drip irrigation systems are used only for the immature phase. Providing site specific fertilizer is another important agronomic practice of RRISL, and various methods which offer benefits have been introduced Slow release techniques such as fertilizer embedded coir bricks and porous tubes filled with fertilizer has increased the efficiency of fertilizer use, whereas Bio-film bio-fertilizers and biochar applications and the use of liquid herbal preparations as fertilizer are recommended for nurseries and immature plantations. Site-specificic fertilizer recommendations based on soil and foliar analysis guarantee zero waste, and as a result are highly economical. Among the cover crops for rubber lands *Mucuna bractiata* is shade tolerant and produces a thick layer of organic matter to support moisture retention, while adding organic matter to the soil. Integrated nutrient management, judicious harvesting methods, use of primers and botanicals for improved performance of the tree, from the seeds up to harvesting stage are among the latest findings to be implemented for productivity improvement in rubber cultivation.

With respect to latex processing, Sri Lanka produces the world's purest and highest quality crepe rubber, which are largely used for pharmaceutical products and toys. Value added novel sole crepe rubber material with greater hardness, improved abrasion resistance are used for special usages. Scientists have invented safer and more effective chemicals for the processing of various types and products of natural rubber, making the rubber products suitable even to contact with food. Sri Lanka is leading the glove production industry through manufacturing and introducing a variety of types from surgical gloves to industrial glove types including the invention of rubber based adhesive for the glove industry. Use of nano technology for the development of a reinforced nitrile rubber based adhesive to bond nylon fabric onto vulcanized rubber surface, production of natural rubber/styrene butadiene rubber/palmyra fiber composites suitable for tire treads, development of preservative system consisting of readily available non toxic low cost chemical, to produce low ammonia centrifuged latex with low Volatile Fatty Acids (VFA) and high Mechanical Stability Time (MST) values for latex based products, are significant contributions of the scientists of the Rubber Research Institute.

Temperature and impact resistant tire paint for inner heal compound in solid tires, abrasion resistant, crack resistant and wear resistant screen printing ink for natural rubber gloves and slippers have been developed for the manufacturers of rubber products. Natural rubber latex foam and cast films for Eastern "Ayurvedic medicine" applications were produced by adding *Aloe vera* to rubber in order to make the products acceptable. Rubber compound was developed for oil seals using nitrile latex compound waste. Hard abrasion resistant coating for textile rollers, moulds for producing different shapes for soap industry, composites for solid tire treads using coconut shell powder, ground tire and bitumen mixtures for paving materials are the most recent innovative developments of RRISL. Apart from this, natural rubber latex compounds have been introduced to produce robot arms. A novel high-performance, light weight prosthetic foot based on hybrid mono-material filled natural rubber compound was developed targeting the war heroes who are in need.

Effective knowledge dissemination for both the RPC managed estates and smallholder sector farmers through novel techniques such as Technology Transfer Centers and Social media applications are among the prospective interests of the Rubber Research Institute to increase the local rubber productivity through technology adoption.

Today rubber is a profitable agricultural commodity due to its extensive utilization in diverse domestic and global manufacturing projects. With a contribution of around 1% to the Gross Domestic Production in Sri Lanka, the interest of all stakeholders in the rubber industry has escalated. And with the RRISL spearheading this expansion, the rubber industry of Sri Lanka is on the path to a radiant future.

Rubber Research Scheme

(CEYLON).

First Quarterly Circular

FOR

1924

Peradeniya, May, 1924.

MILLER & CO., LTD. KANDY. 4360

GENTLEMEN,

At the Meeting of the Executive Committee of the Rubber Research Scheme held on January 8th, 1924, the question of publications was discussed and the following Minute placed on record :—

"In connection with the work of the Technical Officers it was decided that circulars dealing with the work of the Officers and with matters of interest to Subscribers be issued at quarterly intervals." The present Circular is the first of the series and deals with the following subjects :—

"Smoking Sheet Rubber."
"Glass Hydrometers for latex."
"Containers for preserved latex."

By T. E. H. O'Brien, Chemist.

"Brown Bast."
"Notes on Budding of Rubber from Observations in Java and Malaya."

By R. A. Taylor, Physiological Botanist.

"Notes on Budded Rubber."
"Notes on Packing of Rubber."

By J. Mitchell, Organising Secretary.

Bulletins and Reports received.

J. MITCHELL,
Organising Secretary.

May 3rd, 1924.

SMOKING SHEET RUBBER.

The effect of smoking on prevention of mould on sheet rubber is at present being investigated. Up to the present one series of experiments has been carried out. In these experiments rubber wood (dry) was used as fuel and the rate of combustion was regulated so that there was no flame, thus giving a smoke rich in phenolic and tarry substances. After smoking, in order to compare the liability of the sheets to become mouldy, portions of them were inoculated with mould and suspended in a vessel containing a small quantity of a 7% salt solution. This provides a moist atmosphere comparable to conditions on a wet day and favourable to development of mould. It was found that a sheet which was smoked to the colour of ordinary smoked sheet was much more readily attacked by mould than a sheet which was left in the smoke-house for a longer period, *i.e.*, until it was somewhat darker in colour than is usually considered acceptable for smoked sheet. Another sheet was washed in running water for two hours before being smoked for the usual length of time. This sheet showed signs of mould somewhat sooner than the "oversmoked" sheet, but the subsequent growth of mould was less rapid. Details of the experiment are as follows:—

Sheet No.		Time of smoking in days.	Weight of smoke absorbed.	Number of days before mould growth started.
1.	Unsmoked ...	—	—	3
10.	"Undersmoked" ...	8	—	6
2.	Average smoked ...	11	0.87 %	9
6.	"Oversmoked" ...	15	1.11 %	20
13.	Average smoked washed in running water for 2 hours ...	11	.90 %	12

This experiment indicates that washing, and the amount of smoke absorbed, are both factors which influence the liability of sheets to become mouldy, but many more experiments are required before any definite recommendations can be made.

GLASS HYDROMETERS FOR LATEX.

Mention is made in the Annual Report for 1923 (p. 12), of experiments on the use of glass hydrometers for latex. A number of experimental hydrometers have been constructed having approximately the same sensitivity as the brass metrolac. These were forwarded to estates for tests, but the general verdict was that it was difficult to obtain readings owing to latex adhering to the stem. This is an inherent disadvantage of glass hydrometers, it being found that latex adheres to glass more readily than to brass. If however the scale is etched in black on the outside of the stem (instead of having a paper scale inside the stem) it is found that there is no difficulty in obtaining readings. A hydrometer constructed on these lines has now been prepared for test.

CONTAINERS FOR PRESERVED LATEX.

As far as Ceylon is concerned exports of latex are at the present time negligible, but it seems likely that there will be a gradually developing demand for this product and the question of suitable containers for preserved latex is therefore of some interest. Kerosene tins are not satisfactory for various reasons, and apart from the use of tank steamers, steel barrels appear to be the most feasible. The disadvantages of the use of steel barrels are (1) the difficulty of cleaning; (2) the cost of return freight. A collapsible steel barrel, composed of two portions held together by a steel collar, was examined some months ago and was despatched to England filled with preserved latex. It was reported that the latex and barrel arrived in good condition. It is claimed by the makers that when empty, 17 barrels can be nested in the space occupied by three barrels and that the return freight would amount to about Rs. 3/- per barrel. It seems probable that the use of one of the various types of collapsible barrels on the market would be of advantage for the export of latex.

T. E. H. O'BRIEN,
Chemist,
Rubber Research Scheme.

RUBBER RESEARCH SCHEME LABORATORIES,
Culloden, Neboda,
3rd May, 1924.

BROWN BAST.

It is still not clear in what way the wounding of the bark in tapping brings about this disturbance. Many theories have been advanced as is well known and these need not be dealt with in detail.

Most observers now agree that the disease is not caused by any parasitic organism, but is an upsetting of the normal activities of the cortex. One station in the Dutch East Indies supports a Bacterium Theory and a method of treatment has been based on this. No causal organism has yet been demonstrated in Ceylon and the inoculation of healthy trees with sap expressed from diseased bark has not given rise to any appearance which could be called Brown Bast. Indeed another sample of this sap gave the same slight discolouration after thorough sterilisation by steaming. This seems to negative the theory that a bacterium is concerned, if it may be assumed that after the addition of one volume of distilled water and subsequent pressing, the liquid contained specimens of the bacteria present. The suggestion that one of the viruses or "filter-passers" is responsible is also disposed of.

At various times the disease has been credited to the action of an enzyme whose presence in excessive quantity is due to wounding. Support for this theory is given by Campbell in his Calcium estimations, but recently Belgrave in the F. M. S. Agricultural Journal advanced arguments against this. Belgrave has investigated the condition of the cell sap in diseased tissue from the point of view of hydrogen Ion concentration, but his work in this line was mainly concerned with latex and coagulation. None of the well known coagulating enzymes have yet been found in rubber.

Wounding of course affects different plants in different ways, but there seems no argument against using possible analogies to suggest new lines of investigation. When a potato tuber is pierced a considerable concentration of the glucoside Solanin has been found to accumulate round the wound. It may be possible that in the same way some organic base or other chemical compound is formed in Hevea. The substance formed need not be organic, but wounding may favour the accumulation or loss of particular inorganic substances in that region and these latter are often able to increase or decrease the action of enzymes by virtue of their power to alter the Hydrogen Ion concentration of a solution. In this way one sees a possibility of the disease being in a sense due to an enzyme which is however only present in normal quantities.

The fact that no starch is found in badly diseased bark may possibly be explained by the fact that large quantities of reserve material are needed for the meristematic activity which usually takes place to produce "burring." The amount of growth however in many cases does not correspond with loss in starch and to change starch to a mobile form, requires the services of an enzyme.

In considering the above hypothesis it would appear that the treatment of the disease by isolating the affected portion of bark by means of a channel cut out all round to the depth of the cambium, might be equally successful were the cause an enzyme, instead of a bacterium as stated by the theory on which this method is based. But why cannot a bacterium pass through the very delicate meristematic cells of the cambial region? There can be little difference for a time in the contents or cell sap concentration of cells split off practically simultaneously from either side of a common mother cell, at least not sufficient to prevent the spread of a colony of bacteria in search for new supplies. The organism believed to be present is of admittedly minute size and should it belong to the "filter passer" class it might be expected to diffuse through membranes almost as quickly as some of the organic soluble compounds. The success of such treatment need not necessarily support the Bacterial theory.

The work done in Ceylon last year on this disease was largely anatomical and confirmatory. Sections of bark in various stages of disease have been cut in different directions. Study of these has confirmed most of the points put forward by Sanderson and Sutcliffe in their book "Brown Bast."

3000 trees in three separate lots and in different habitats have been minutely examined for Brown Bast and the percentage of affected trees in each calculated. Trees showing any peculiarity of yield, latex, etc., are under observation. Some healthy trees were found in which the scrap rapidly darkened in colour. These are examined at intervals to see whether this has any connection with susceptibility. The darkening is caused by an enzyme in the latex, or which exudes from the bark with the latex, and varies in amount in different trees. An extreme case of darkening is seen in the case of latex from unripe pods.

A preliminary analysis of normal and diseased bark is in progress to determine whether there is any great difference in quality in the acetone, alcohol, and other extracts. An attempt is being made to collect sufficient of the oils, fats, glucosides, etc., from the barks to make an analysis possible should such be thought advisable.

With regard to the susceptibility of other laticiferous trees to the disease, I was told by Mr. Belgrave in Kuala-Lumpur, that he once tapped a Funtumia and it had developed unmistakable symptoms similar to Brown Bast. In Ceylon a jak tree was tapped three times a day for a period and this showed much discolouration even at a distance below the cut, and a great change in the inner cortex. The latex is present only in small quantities, but this dried up within a week. It was concluded that the tree had developed a similar disease.

For treatment no method seems to have been universally adopted. Stripping and scraping have their supporters and antagonists, the application of hot tar after light scraping is advocated in one part of Java, but another Experiment Station condemns it. The method of isolation seems to have been adopted extensively in Sumatra and is I am told very satisfactory. One argument in favour of this is that no rest is required—tap as usual. I have no personal experience of this method.

At first sight stripping, *i.e.*, actually getting rid of the diseased part, seems the most reasonable, but I am told by some that the disease may recur soon after a tapping cut is opened on the renewed bark.

If the disease is caused by an organism or is due to enzymes or a production of substances as suggested above, the isolation method would appear to be sufficient, *i.e.*, provided it is accepted that none of these can pass the meristematic region of the cambium.

R. A. TAYLOR,
Physiological Botanist.

RUBBER RESEARCH SCHEME LABORATORIES,
Culloden, Neboda,
24—4—24.

NOTES ON BUDDING OF RUBBER FROM OBSERVATIONS MADE IN JAVA AND MALAYA.

Where new areas are being planted up with rubber the advice given by the Java proef stations is "Plant a mixture of budded plants and selected seed and plant a sufficient number to the acre to allow of copious thinning out."

This gives a good indication of the current opinion on the subject, and shows the uncertainty of those writers as to whether budding will eventually prove the better method of propagation. Technical difficulties have been surmounted, but the recent results of tapping experiments carried out on budded areas emphasise the difficulty of choosing mother trees and show clearly that only on the strength of yield figures from budded progeny can a mother tree be classified as good.

Much can be done of course by way of choosing a mother tree for buds before any actual budding is done. It would be foolish when growing trees for high yield to choose any but the best yielders available, but there are other things to be attended to, *e.g.*, number and continuity of latex rings in a transverse section of the bark, number of available buds per unit length of branch, and ease with which the "bark" can be removed for budding purposes.

Another point of importance is the choice of stocks. This would appear to have been practically, and in some cases totally, neglected, any seeds to hand being considered good enough to produce that important organ of the plant—the root. Seeds for this purpose should be taken only from trees which show good growth. As little is known about the much discussed question of the effect of stock on scion, it is also advisable to take seed only from good yielding trees and I can see no objections whatever to using seeds from those trees chosen as mother trees for buds.

Some such procedure as the following is suggested for those contemplating an experiment on budding:—

(1) Find out from K. Ps., etc., the 100 reputed best yielding trees on the estate. Have these numbered or marked clearly.

(2) Choose from these, taking into consideration their growth, sufficient to provide seed to supply with stocks the area available. This should be done just before the seeds are ripe.

(3) Keep a record of the individual yield per tapping of each of these 100 trees and continue this for a year. (Much useful and interesting information is obtained by this operation, which is not so expensive as it seems.) Some trees show one, some two, seasons of maximum yield during the year and it is instructive to compare these times with times of wintering and rainfall.

(4) After about six months some evidence will be available of which trees are going to prove most suitable and if it is thought necessary these could then be pruned to encourage growth of "budwood."

(5) After the twelve or more months necessary for the stocks to grow to the proper size, possibly 20 of these 100 trees will show a higher average yield than the others and attention should now be concentrated on these.

(6) A bark examination will now enable a further choice to be made and the number retained depends on the number of buds available and number required. Possibly five trees will be sufficient. One can reckon on taking about 300 buds from a well grown tree without doing much damage. It is not wise to concentrate at this stage on one particular tree for the following reasons arrived at by tapping experiments in Java :—A tree may be an exceptionally good tree, but may not transmit its yielding capacity to its progeny. Also the buds may not easily unite with the stocks. These are physiological phenomena not yet understood, and part of this may yet be shown to be due to the stocks.

Budding is best carried out in a nursery where the plants are always under supervision and care should be taken to see that where a bud does not "take" no adventitious or dormant bud from the stock is allowed to shoot. Such a shoot emerging from ground level is in appearance very like the shoot from a transferred bud, and a regular systematic examination should be made and all undesirables removed.

At the Kultur Tuin at Buitenzorg in Java the importance of the proper stocks is fully realised and Dr. Cramer is experimenting with various species of Hevea as stocks and is also trying to bud on to the roots of old trees of known yielding capacity.

Yield figures of budded trees published by the various Dutch Stations show encouraging results. Yield of these has been correlated with girth, and although there still appear some trees of higher yielding capacity among seed plots, there are also many lower and the average of budded plots is higher. On the average in budded plots the best yielders are found to be twice as good as the poorest, whereas in seed plots they are eight times as good.

A slight digression from the subject may help to emphasise the value of having uniform trees in a field. The figures and graphs published in a recent paper from A. V. R. O. S. Experiment Station in Sumatra show one tree in a small budded plot which has yielded much less than the average and is the only example lying outside the area of correlation between yield and girth. On examination it was found to be suffering from "Pink Disease." While in an ordinary mixed plot the disease would no doubt have been noticed, the effect on yield would have almost certainly passed unobserved. This instance makes clear that such diseases have an effect on the yield of a tree and although this might be expected no figures are at present available to show the extent.

The difficulties and uncertainties have been brought out in these notes, but there is still no reason to take other than an optimistic view of vegetative propagation of rubber. The fact that there are still better trees in seed plots emphasises the point that the proper mother trees or rather the proper combinations of stock and scion have not yet been discovered An analogy may, I think, be fairly drawn between this and the grape culture in France. There, I am told, all grapes produced for any particular purpose are grown on vines which are the budded progeny of one found to produce fruit most suitable for that purpose. The stocks, however, are varied according to the nature of the soil, soils being classified on their chalk content.

The discovery of such suitable combinations of stock and scion in Hevea can only be made by a study of production and behaviour of budded plants, the origins of whose component parts are both known.

As the Rubber Research Scheme does not hold land in the different rubber growing districts in Ceylon, an appeal is made to those interested and having a few acres of land available to see that the Island is not left behind if it should happen (and the chances are not remote) that budding produced trees of double or more the present average yield. Any help in the choice of trees, and the actual budding work will be supervised by the Scheme at least for one plot in each of the different districts.

It has been suggested that a field of rubber, all progeny of the same mother tree, might be wiped out by any new disease to which that tree was particularly susceptible. There is, of course, this possibility, but it is not difficult to raise such objections. As far as my knowledge goes, no single rubber tree has been found immune to any of the present diseases, and should such a new disease appear it would almost certainly wipe out whatever rubber was being grown.

R. A. TAYLOR,
Physiological Botanist.

RUBBER RESEARCH SCHEME LABORATORIES,
Culloden Estate,
Neboda,
23—4—24.

NOTES ON BUDDED RUBBER.

In view of the importance of raising high yielding rubber trees on estates the comprehensive account on Bud-Grafting which appeared in the January issue of the Rubber Growers' Association Bulletin is worthy of close study. In this account Mr. H. C. Pinching, Senior Scientific Officer of the Rubber Growers' Association in Malaya, discusses the present position of "Bud-Grafting" in Java, Sumatra and Malaya. All Members of the Rubber Research Scheme are advised to carefully peruse Mr. Pinching's report from which the following summary has been extracted for general information :—

(1) No evidence could be found existing in the Dutch East Indies proving the unqualified success of Bud-Grafting as a certain means of raising high-yielding trees.

(2) Bud-Grafting as a means of producing new plants is well within the realms of practical planting politics.

(3) Judging by the present existing Bud-Grafted trees, these trees have generally a similar rate of growth to seed-produced trees.

(4) Bud-Grafted trees belonging to one clone* have marked similarities.

(5) A marked similarity in yield (as compared with seed-produced trees) of trees of one clone* is indicated by the results of tapping Bud-Grafted trees. Further, some high-yielding mother trees appear to always give high or above average yielding vegetative offspring. At the present time there appears to be no correlation, however, between the yields of mother trees and their vegetative offspring.

(6) It would appear that the success of Bud-Grafting as a means of raising high-yielding planting material depends upon the selection of those high-yielding trees which are constitutionally high yielders and whose vegetative off-spring are also high yielders.

(7) It is possible that planting a large number of seed-selected plants per acre and the removal of low yielders may result in as high a yielding area as that given by planting up with Bud-Grafted material. Unfortunately the supply of selected seeds is not sufficient at the present time.

(8) At the present time it would seem most advisable for practical purposes to plant mixed Bud-Grafted and seed-selected plants at about 200 per acre, and then to remove the low yielders.

J. MITCHELL,
Organising Secretary.

* Clone or cloon is a Dutch expression meaning group.

NOTES ON "PACKING OF RUBBER."

On numerous occasions during the past two years complaints have been made by rubber manufacturers that rubber from the plantations reached the factories contaminated with dirt, grit, and wood splinters. A considerable correspondence on the subject has passed between the Rubber Growers' Association, London, and the various interests concerned and efforts have been made to devise remedies for the condition complained of. In the Report of the Delegates from the Rubber Growers' Association, London, to the Rubber Association of America, New York, a special section (Appendix C) was devoted to this subject and certain suggestions for improvements made.

It is recognised that, on the whole, rubber leaves the estates in a clean and satisfactory condition and that contamination can, and does, take place during transit, at the wharves, in the warehouses while opening the cases for weighing and sampling, and during re-coopering of the cases. That is, the producer is, in many cases blameless in the matter and the responsibility rests on other shoulders.

Nevertheless, there is reason to believe that some of the responsibility rests with the producer owing to the packing being done in cases which were too fragile to stand the hard usage to which they are subjected, and to the insides of the cases being rough and splintery and unclean. It has been observed that inferior wood which easily splintered has been used, the cases have been badly put together leaving openings between the planks which admitted dirt, dust, etc., and lack of care in nailing down the cases has also been noted.

The number of hands through which the rubber passes from the estate to the manufacturer makes it difficult to ensure its reaching its destination in a satisfactory condition, and it is essential that each should observe such precautions as are possible. Concerning the producer the following suggestions have been made:—

1. That the fine rubber contents of each case be enclosed in a wrapper of plain rubber sheets similar to smoked sheet but of such a size as to afford complete protection to the rubber inside. Strips of ordinary sheet or crepe do not give complete protection being too narrow and leaving edges and corners open. Crepe is not a suitable wrapping material under any conditions as dust and dirt can easily penetrate. For the above purpose it is suggested that sheets be made of the requisite size in specially large coagulating pans or

by attaching several strips of plain rolled sheet together by means of benzine or rubber solution. The wrapper should be easily removable and consequently should be dusted with French Chalk before being wrapped round the rubber to be enclosed (the use of bromine is not advised).

2. The rubber should not be packed in a haphazard fashion as difficulties have been experienced owing to some sheets being packed running across or at right angles to the others, to tying several sheets into bundles, to rolling and folding sheets and pressing them into the corners of the cases. All sheets should run in one direction in the case and be wrapped in the way referred to above. To be fully effective the wrapper sheets should cover the corners as well as the sides and ends.

3. At a recent meeting of Rubber Planters in East Java, Mr. J. B. Harmsen of the Malang Experimental Station delivered a lecture on the subject of rubber packing and advocated a system of baling instead of casing. Unfortunately, the method as described is not clear and steps are being taken to obtain full information on the matter.

During the War some rubber was packed in jute hessian, but buyers complained that pressure during transit caused the bales to become almost solid which made sampling difficult and generally unsatisfactory. In addition, the jute hessian did not prevent dirt and dust from entering the rubber. The method advocated by Mr. Harmsen appears to prevent blocking of the rubber and would, therefore, remove one of the causes of dissatisfaction.

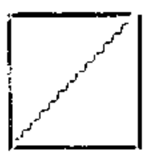
From a general consideration of the subject it would appear that baling of rubber would best meet the case and it appears desirable that experiments should be made to develop a suitable method of baling rubber in which adequate protection of the contents was secured without undue compression. In the meantime, it is certain that packing in wooden cases must continue and suggestions Nos. 1 and 2 should be carefully considered and put into practice so far as possible.

In this connection what appears to be a useful pamphlet has been issued by the proprietors of Bull Wharf Ltd., London, under the heading "Notes on Packing Plantation Rubber." The notes are the result of careful examination, extending over a considerable number of years, of all classes of packing, and it is contended that considerable expense can be saved by the use of suitable cases, by correctly assembling them and by carefully packing the contents. The pamphlet deals with packing in ordinary wooden cases and in 3 ply cases and special drawings are given showing the correct way of fastening lids on 3 ply cases.

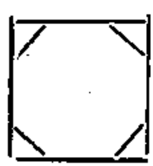
As the greater part of the rubber shipped from Ceylon is packed in ordinary wooden cases the points noted in the pamphlet in connection with such cases are given herewith.

Taking the outside measurement as 24″ × 19″ × 19″ the best method of packing crepe rubber is to have the hanks just under 9″ in width and either 23″ in length or a multiple thereof so that they will fold evenly into 23″. The hanks should be placed side by side, lengthwise in the package, so that no space is lost and crumpling of the rubbber is avoided. In packing sheet rubber the width should be 9″ or 18″ and the length 23″ or a multiple thereof.

Where corner battens are used care should be taken to see that the batten goes right down to the bottom of the case, otherwise rubber will get between the end of the batten and the bottom of the case and there is trouble in removing the rubber. Wooden battens made of 1¼″ to 1½″ quartering cut diagonally, thus:—

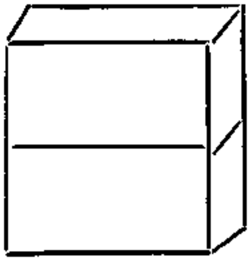


and fixed in each corner of the case, thus:—

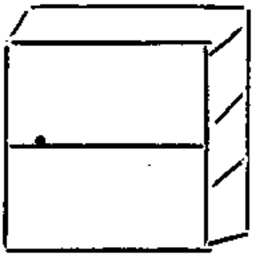


very much strengthen the package and are strongly recommended. Where these battens are used and the cases made properly iron bands are not necessary.

Cases with slotted or machine "dovetailed" sides when battens are used are unnecessary and considerably weaken the cases. In assembling cases care should be taken that sides and ends do not correspond or meet, thus:—



as the packages are then liable to split in half. They should be put together, thus:—



The wood should be perfectly sound. Many cases arrive with worn eaten wood and as a result the whole contents of a case are impregnated with saw dust. No soft or brittle wood should be used and the insides of the cases should be planed smooth or splinters will work into the rubber.

Cases should not be overpacked as this tends to burst the cases and after the rubber has been turned out for examination it is almost impossible to replace it in the cases. If the rubber is too tightly packed it tends to adhere and is difficult to sample. If underpacked the movement of the rubber inside tends to break the cases and wrappers get impregnated with splinters. For ordinary sized cases the nett weight should not exceed 200 lbs. for sheet rubber and 160 lbs. for crepe rubber.

It is probable that the majority of estates already take all the precautions outlined above, but it is also probable that some of the precautions are taken but others are neglected, and it is to these that attention is drawn.

While it is generally admitted that much of the trouble connected with packing of rubber arises after the rubber leaves the estates it will not be possible to remove all blame from the producer unless all possible precautions have been taken. Reference to the subject is made in the following Rubber Growers' Association Bulletins and the attention of Members of the Rubber Research Scheme is drawn to these references for further information:—

June,	1922, p. 268	March,	1923, p. 167
November,	1922, p. 581	September,	1923, p. 493
January,	1923, p. 9	October,	1923, p. 556
February,	1923, p. 80	January,	1924, p. 49

J. MITCHELL,

Organising Secretary.

Since going to press extracts from a paper read at the International Rubber Congress in Brussels have been published in the "Times of Ceylon" (May 5th), and the points noted will be given in the next Quarterly Circular.

J. M.

BULLETINS AND REPORTS RECEIVED.

Bulletins.

Bulletin No. 32, "Preservation of Latex" by Mr. T. E. H. O'Brien has been received from the Printers and copies have been circulated.

Bulletin No. 33, "Vulcanisation Tests" (New Series) being tests carried out at the Imperial Institute, London, on ubber prepared under the supervision of the Technical Officers in Ceylon has been received from the Printers and copies have been circulated.

Bulletin No. 34, "Vulcanisation Tests" (New Series) being tests carried out at the Imperial Institute, London, on rubber prepared under the supervision of the Technical Officers in Ceylon has been received from the Printers and copies have been circulated.

Reports from London.

(*a*) Report No. 3 on "Vulcanisation Tests" (New Series) is in the hands of the Printers for publication as Bulletin No. 35.

(*b*) Report on "Samples of Latex for paper making" by Mr. F. Kaye. The contents of this report, together with full details of other experiments, are given in the Rubber Growers' Association Bulletin for February, 1924, page 126, under the title "The use of Rubber Latex in the manufacture of boards, leather and linoleum substitutes, and as to the vulcanisation of these products." In this account acknowledgment is made by Mr. Kaye of samples of latex received from the Ceylon Rubber Research Scheme.

(*c*) Report on "Hopkinson Sprayed Latex Rubber." This report is printed in full in the Rubber Growers' Association Bulletin for February, 1924, page 93.

(*d*) Report on "Nature of Deposit" from latex preserved with Ammonia.

(*e*) Report on rubber prepared with Sodium Silicofluoride as coagulant.

(*f*) Report on rubber prepared with Sodium Sulphite.

Reports (*d*) to (*f*) were considered at the Meeting of the Technical Committee of the Rubber Research Scheme held on April 15th, 1924, and it was decided that these reports be included in the next Quarterly Circular.