ISSN 1391-0051

BULLETIN OF THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

Rubber Research Institute
of Sri Lanka

Vol. 58 2021

BULLETIN OF THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

Vol. 58	**2021**

Published in 2023

BULLETIN OF THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

Vol. 58 **2021**

CONTENTS

Underutilized clone RRIC 102 can be used to balance the clone composition of Sri Lanka
Priyani Seneviratne and R K Samarasekara 1

Rainfall forecasts for the benefit of rubber growers
Wasana Wijesuriya and Dilhan Rathnayake 9

A comprehensive overview of the clone RRIC 102
K K Lianage, T T Dahanayake and B W A N Baddewithana 16

Policy directions for improving the extension service in the smallholder rubber sector through overlooking the institutional and structural transformation in the history
P K K S Gunarathna 32

Level of adoption of recommended rubber harvesting practices by self-latex harvesters in Ratnapura district
P K K S Gunarathna 38

Low planting densities have many advantages in rubber plantations
P Seneviratne, P G N Ishani, M K P Perera, R Handapangoda and W K S W Watawala 45

Comparison of performance of two types of rubber planting materials: bare root budded stumps and young buddings
P Seneviratne, M K P Perera and R Handapangoda 56

The historical rubber-rice pact
Priyani Seneviratne 65

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 1-8

UNDERUTILIZED CLONE RRIC 102 CAN BE USED TO BALANCE THE CLONE COMPOSITION OF SRI LANKA

Priyani Seneviratne and R K Samarasekara

Development of clones for rubber

Since the introduction of the rubber tree (*Hevea brasiliensis* Muell.Arg) to Sri Lanka in 1876, rubber seeds were used as planting material for propagation during the first half of a century. The first rubber trees planted at Henerathgoda Botanical Gardens started to flower in 1883, after seven years, and since then the production of seeds had been on the increase. It appears that the expansion of rubber cultivation had been massive from 120 ha. in 1890, 16,000 ha. in 1910, and 190,000 ha. by 1920. Every seed that was produced had been planted, as per the legend. In 1917, the bud grafting technique was introduced to rubber, and it was a real breakthrough in the development of the rubber industry, especially in producing planting materials with predictable yields at planting (Seneviratne, 2021).

During the 1920s high yielding individuals had been identified from commercial seedling plantations and used as a source of bud wood to produce budded plants in planting programmes. A few such selections were Mil 3/2 (identified from Millakanda Estate), HC 28 (identified from Hilcroft Estate), and Waga 6278 (identified from Waga Estate). The yield potential of these clones had been in the range of 330-400 kg/ha/y. In 1938, a new series of clones were recommended; Nab 12, Nab 15, Nab 17, and Nab 20 (selected from Nebuntenna Estate).

Hand pollination or artificial breeding to produce clones had begun at Rubber Research Institute of Sri Lanka, then Ceylon, in 1932, and many clones had been produced under the tag RRIC, to denote the Rubber Research Institute of Ceylon, and after 1972 under RRISL. The productivity of these clones has been on a gradual increase up to about 3000 kg/ha/year, at present.

The Rubber Research Institute of Sri Lanka has recommended a list of clones under three different groups (Advisory Circular No.2013/01-Clone Recommendation). RRIC 102 has been recommended in Group I for many decades. As per the results of the clone composition surveys, conducted in 2009 and 2020, it was reviled that the usage of the clone RRIC 102 is negligible The objective of this article is to highlight the performance of this clone by comparing experimental data with a popular high yielding clone and presenting yields of commercial scale fields to build confidence among prospective rubber farmers.

RRIC 100 series clones

The most significant milestone in *Hevea* breeding in Sri Lanka which received huge recognition from all rubber growing countries was the release of RRIC 100 series clones, especially the clone RRIC 100 which exhibited resistance to many foliar diseases that prevailed at that time. An international trial that was jointly conducted in

Thailand, Malaysia, India, and the Cote d'Ivoire revealed that the clone RRIC 100 was the best among all the clones presented by all countries at that time, as far as the growth rate, vigor, resistance to diseases and yield were concerned. Due to superior performance and world recognition, the clone RRIC 100 was extensively used in Sri Lankan planting programmes until it was temporarily taken out from the list in 1998. But it was allowed for non-traditional rubber growing areas throughout.

Clone balance

A balanced clone composition is required for a country, especially to reduce the risk of the rubber industry being affected by sudden and devastating foliar diseases. Accordingly, the Rubber Research Institute of Sri Lanka is maintaining a list of clones recommended under three different groups, Group 1 clones being well studied and widely used for both Regional Plantation Companies and the Smallholder sector. Clones in Group 11 and Group 111 are recommended only for the estates under Regional Plantation Companies.

According to the statistics of the Agriculture and Environmental Statistic Division of the Department of Census and Statistics in 2002, the clone composition in Sri Lanka was dominated by the foreign clone PB 86 (43%) followed by RRIC 100 (24%) and RRIC 121 (6%) followed by other clones in small proportions. With the introduction of RRIC 100 series clones for cultivation in the country, especially the clone RRIC 100, the clone PB 86 was taken out from the list of the clone recommendation. The clone PB 86 is highly susceptible to *Phytophthora* leaf disease and bark rot and low yielding compared to RRIC 100 series clones.

The clone composition in rubber plantations was surveyed by RRISL in 2009 and the results revieled that the three clones, PB 86, (29%), RRIC 100 (33%) and RRIC 121 (33%) were present, in almost equal proportions RRIC 121 and PB 86). Each clone in the group I is generally recommended to be used only up to 10% of the total extent of the estates under RPCs. But for the smallholder sector, only a limited number of clones are recommended, and therefore, growing up to 20% is acceptable. The clone RRIC 100 was removed from the list in 1986 in order to control the clone balance but continued to recommend for non-traditional areas as it was the most promising clone at that time.

In the list of recommended clones under group 1, there were RRIC 102 and RRIC 103 along with RRIC 100. Unfortunately, in 1985 the clone RRIC 103 got succumbed to the leaf disease *Corynespora* and the clone RRIC 103 got wiped out. Parent clones of both RRIC 100 and RRIC 103 are the same and this demonstrates the variation among the clones for their genetic makeup. The clone RRIC 102 was a Group 1 clone right from the beginning and has RRIC 52 one of the parents of RRIC 100 and RRIC 103. The colour of the latex of this clone is not pure white as it is in PB 86. Also, the growth during the first two years or so is not as impressive as that of RRIC 100. It also demands a bit more Magnesium fertilizer and the RRI has recommended extra Mg for RRIC 102 (Advisory Circular No.2016/04-Fertilizer to rubber). Due to these reasons, both the smallholder farmers and planters were reluctant to plant this clone

RRIC 102. The author attempted to popularize the clone RRIC 102 in 1995 by distributing 1000 plants free for the establishment of budwood nurseries to those who already had private rubber nurseries. Funds for this exercise were issued by the management of RRISL from the project SRRP-phase II.

As the share of the clone, RRIC 121 was 33% (in the country) in 2009, its further spread was restricted to estates under RPCs from 2012. Further, when the data were analyzed for the RPCs, the share of clone RRIC 121 was 43% and it was over and above the recommended limits. Although, its usage could not be stopped or limited for the smallholder sector due to the limited number of clones recommended for them. However, a plan was suggested to the Rubber Development Department (RDD) to gradually reduce the usage of clone RRIC 121 starting from 2011. The proposal was to use only 60% in the year 2011 and then to reduce 10% every year to reach 0% by 2017. The balance was to be supplied with other clones. Also, the clones RRISL 203 and RRISL 2001 were recommended for smallholder farmers since 2007, but with restrictions. It was recommended to allow planting only 10% of the total land area with each of these clones, and also only for the farmers having more than 10 ha. Also, it was highly recommended to use the clone RRIC 102 as it was underutilized.

However, when the usage of the clones was surveyed in 2020, the result was alarming. The clone RRIC 102 covered only 2% while RRIC 121 covered about 73% area. This is very unhealthy a situation for a country and under no circumstances is this high percentage of a single clone. If a clone-specific disease attack occurs for the clone RRIC 121, as it happened to the clone RRIC 103 in 1985 and the clone RRIC 110 in 1995, the entire rubber industry will be wiped out. Figure 1 shows the clone composition in Sri Lanka in 2002, 2009, and 2020.

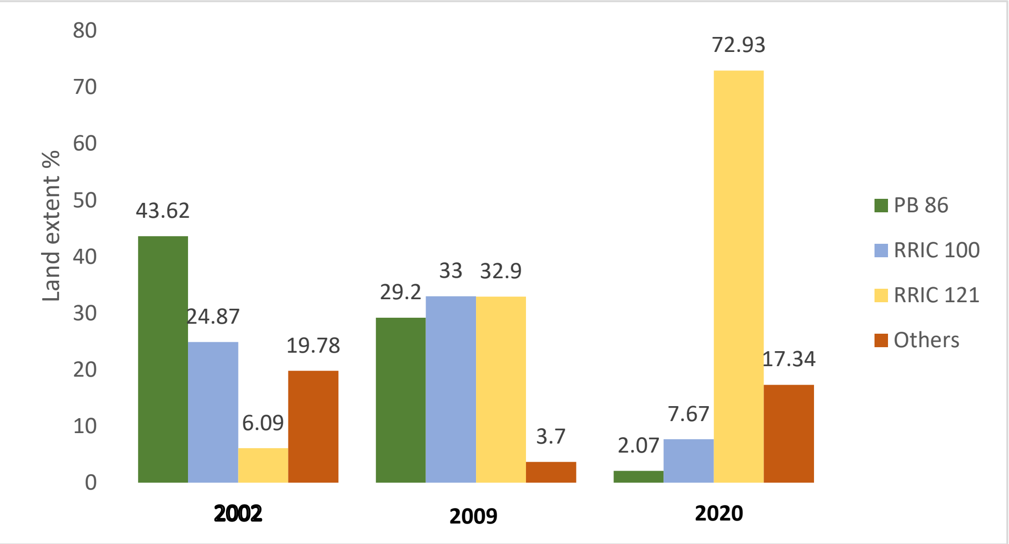

Fig. 1. The clone composition in Sri Lanka in 2002, 2009, and 2020.

Potential yield of the clone RRIC 102 under smallholder and estate management

The objective of this article is to discuss the true performance of clones that we are using at present. Though the breeders generally declare a potential yield or productivity for each clone along with the tapping system, a huge variation is observed from one clearing to the other of the same clone. The productivity of a clone is generally given as the yield in kg per hectare per year. Rubber clearings, irrespective of the clone show 3-4 times yield variation, mainly owing to the stand per hectare and the growth condition.

The average yield potential of the clones RRIC 100, RRIC 102, and RRIC 121 is about 2000 kg/ha/year. But, the potential yield of these clones is higher if cultivated properly as per the RRISL recommendations and harvested judiciously.

The actual yields obtained from one such field of clone RRIC 102 are discussed here to highlight the true performance of clones and the importance of adopting RRISL recommendations in cultivating rubber.

This observation was done in a block of clones RRIC 102, in the Kegalle district. Plants have been received from the government rubber nursery at Welikadamulla, Attanagalla. Planting had taken place in 2003 and tapping commenced in 2008, after 5 years.

When tapping practices were considered for up to five years of tapping, the panel position indicated that even the recommended d2 frequency has not been practiced but a lower frequency. Under S/2 d2 tapping system, about 160 tappings are allowed per year, but on average only 90 days had been tapped per year, as evident by the bark consumption (author's data).

As far as the growth of the trees is concerned, the average girth at the age of 10 years of planting was 72 cm measured at 120 cm height. Twenty percent of the trees show girth above 80 cm.

All RRISL recommendations have been fully adopted from planting up to date including the correct use of fertilizer application etc. The growth condition; the harvesting frequency and the quality of the tapping speak for the yield of this clearing which is above 3000 kg/ha/year and individual tree yield per tapping was above 80 grams per tree per tapping as per the data collected by the author from 2014. No extra effort had been taken to increase the number of tapping days through recovery tappings or the yield per tapping by applying any yield stimulant. Rainguards have not been used, perhaps due to a low number of rainy days in the area. The performance of this rubber field is a good insight and food for thought for the growers who are continuously complaining about the low prices of rubber, leaving behind all other important agro-management practices associated with rubber cultivation. There is no secret behind the attractive yield, but the growth condition of the trees.

The tapping system adopted is S/2 d2 but the actual number of tappings per year is similar to d3, without stimulation or rain-guard as mentioned earlier.

Performance of clone RRIC 102 under estate sector

A set of data collected from an RRIC 102 field at Galewatta of the Dartonfield Group is shown in Figure 2 as a correlation between girth and the mean yield of individual trees. Pearson correlation of Yield (ml) and Girth (cm) is 0.680 where P-Value is 0.000. Since P-value is <0.05 it can be concluded that there is a correlation between Yield and Girth at a 0.05 level of significance.

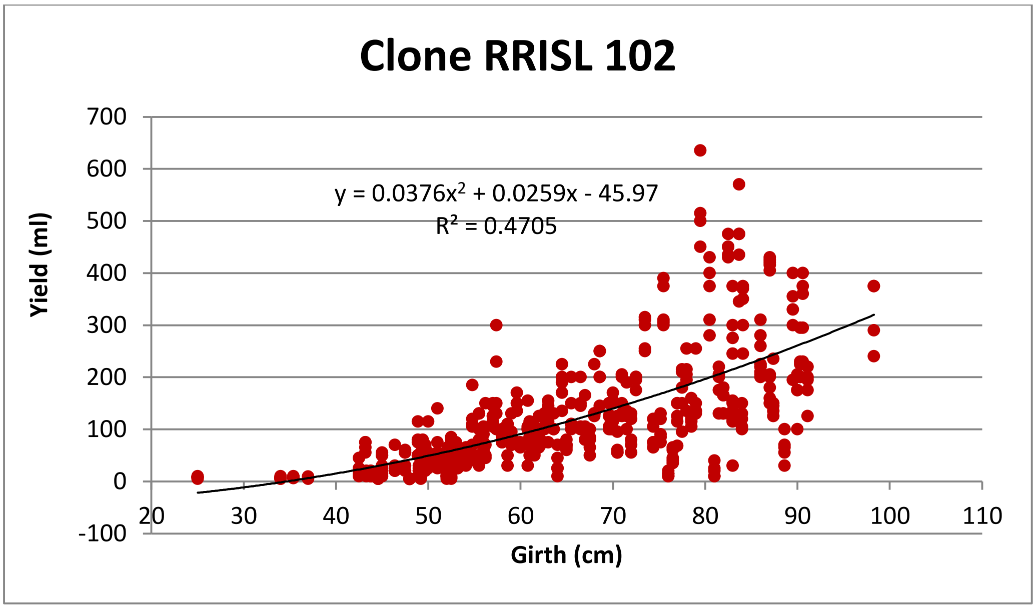

Fig. 2. Correlation of yield (ml) and girth (cm). for the clone RRIC 102

The same-aged field of RRIC 121 adjoining the 102 field was used as control, and the data is presented in Figure 3 as a correlation between girth (cm) and mean yield (ml) of individual trees. The Pearson correlation of Yield (ml)and Girth (cm)is 0.695 at a P-Value of 0.000. Since P-value is <0.05 it can be concluded that there is a correlation between Yield and Girth at a 0.05 level of significance.

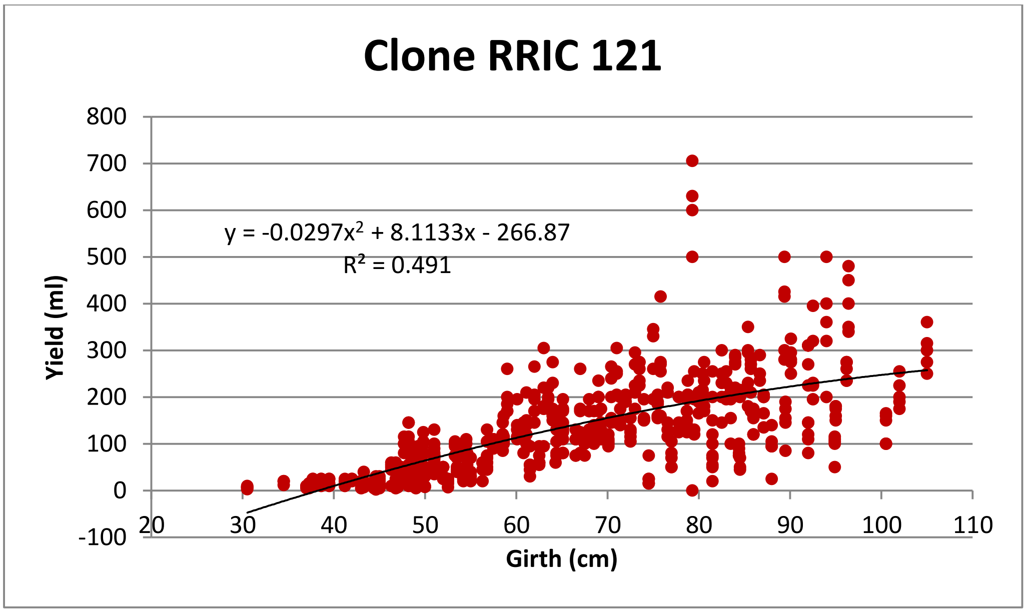

Fig. 3. Correlation of yield (ml) and girth (cm) for the clone RRIC 121

The message highlighted here is the importance of the growth of the tree than the clone for the yield and also the correlation between the girth of the tree and the yield. The reason to give the yields of individual trees without calculating the yield per hectare is to highlight the real cause for the low yields recorded in rubber fields in Sri Lanka.

Need for high-quality plants and adopting recommendations

A yield below 800 kg/ha/year is achieved in many rubber clearings belonging to the RRIC 100, RRIC 121, and the rest of the clones in the recommended clone list. For each of these clearings, the yield obtained can be well explained in the contest of the number of trees in the land area, growth condition, tapping frequency, tapping quality, number of TPD trees, and also the adoption of agro-management practices.

Figure 4 compares the yield of the two fields of RRIC 102 and RRIC 121 of the trees under different girth classes. This confirms that the growth of a tree influences more the crop than the clone it belongs to.

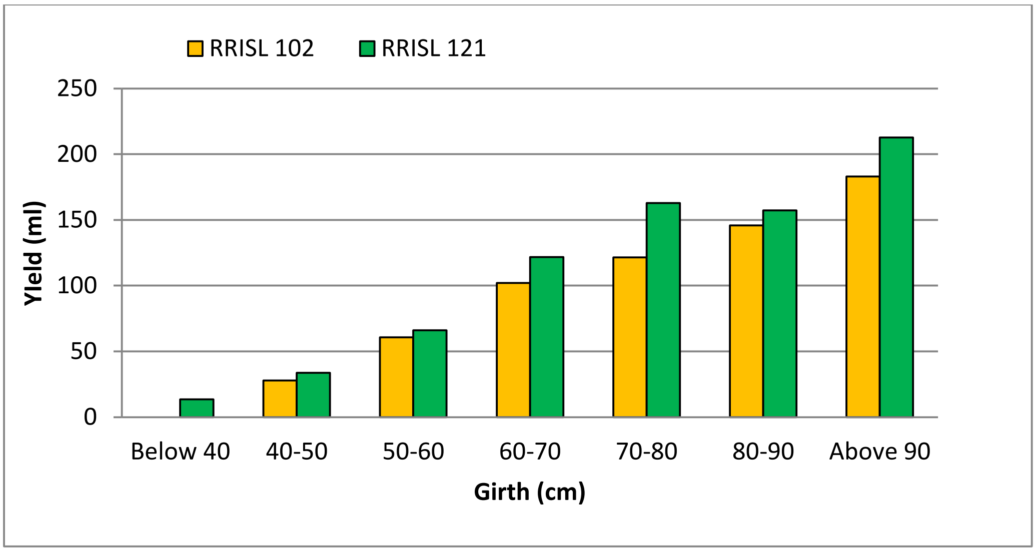

Fig. 4. The yield of RRIC 102 and RRIC 121 when the trees are grouped into girth classes.

The crop of RRIC 121 is higher in the trees of all girth classes but, the variation among girth classes is higher within a clone.

All the prospective rubber farmers and planters need to adopt the recommendations given by RRISL (Rubber Research Institute of Sri Lanka) right from the beginning, *i.e.* from land preparation. If the old clearing has White Root Disease affected trees or a patch, all recommended steps should be followed to eradicate the deadly disease from the next replanting.

Soil conservation is as important as manuring the trees. Harvesting should not make any tree dry, as the closest possible reason for brown bast affected trees or dry trees in a clearing is over-exploitation. The trees give only what the tree can give.

The use of high-quality plants in replanting programmes is now guaranteed through issuing plants from government rubber nurseries which are monitored by the RRISL, as in the case of the RRIC 102 clearing reported here.

However, this under-utilized clone RRIC 102 should be planted up to about 20% and giving the priority to smallholder farmers who are short of clones.

REFERENCES

Advisory Circular No.2016/04. Fertilizer to rubber. Soils and Plant Nutrition Department, Rubber Research Institute of Sri Lanka.

Advisory Circular No.2013/01. Clone Recommendation, Genetics and Plant Breeding Department, Rubber Research Institute of Sri Lanka.

Seneviratne, P. and Zoysa, L. (2010). Usage of clones in Sri Lankan rubber plantations. *Journal of the National Institute of Plantation Management* **24**, 53-54.

Seneviratne, Priyani (2021). Establishing of Rubber Research Institute and a Century of Natural Rubber Research Activity in Sri Lanka. Pp.429-462. In: *Chemistry, Manufacture and Applications of Natural Rubber*. 2nd Edition (**Eds:** Shinzo Kohjiya, Yuko Ikeda, Shinzo Kohjiya and Yuko Ikeda), Elsevier Publication.

Seneviratne, P., Zoysa, L. and Wickramakumari, W.D.M. (2019). The change of clonal composition of rubber plantations in Sri Lanka: survey results. *Bulletin of the Rubber Research Institute of Sri Lanka* **56,** 22-28. (Published in 2022).

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 9-15

RAINFALL FORECASTS FOR THE BENEFIT OF RUBBER GROWERS

Wasana Wijesuriya and Dilhan Rathnayake

INTRODUCTION

Ancient people also used observations for predicting changes in the environment. Weather forecasting is still carried out basically in the same manner as it was done by the earliest humans, but the observations are done in a scientific manner. The early approaches require insights based on the accrued experience of the observer, while the modern techniques consist of solving equations or statistical models and also based on machine learning techniques. Moreover, with regard to rainfall forecasts, nowadays the reliability is assured by considering forecasts by different organizations into an ensemble forecast, which is finally delivered to the stakeholders.

Sri Lanka has a tropical climate. The sun shines more directly on the tropics than on higher latitudes, which makes the tropics warm (Stevens, 2011). Therefore, clouds and rain storms in the tropics can occur more spontaneously compared to those at higher latitudes, making it difficult to forecast the weather conditions, especially the rainfall. However, in the light of modern day forecasting, it makes the tasks easier by way of reliable forecasts. This article therefore focuses on raising awareness of rubber growers on forecast facilities by introducing them and encouraging them to use rainfall forecasts for their routine farming activities.

Why forecasts are important for rubber growers?

Rubber tree, which is perennial in nature has its all agronomic operations from land preparation for planting to felling of trees, are dependent on the rainfall and therefore, rainfall is considered the most important meteorological parameter in rubber planting (Wijesuriya and Rathnayake, 2021). More importantly, harvesting is affected by occurrence of rainfall and subsequently decides the profit margin of rubber farming. Disease incidences also is aggravated during rainy seasons and the grower has to take actions against them timely. Hence, early action is needed to control adverse impacts on growth and yield of rubber. Apart from these, land preparation, holing, filling and fertilizer application depend heavily on occurrence of rainfall. Therefore, forecasts of different lengths are required for the rubber grower. Daily and hourly forecasts are also needed for the rubber grower to make decisions, especially on harvesting of latex.

What types of forecasts are available for the rubber grower?

Seasonal forecasts - Seasonal forecasts are important for rubber growers to carry out activities related to land preparation, planting and management of the immature phase of planting when starting a new round of a crop cycle. A national activity, “The Monsoon Forum” is being carried out twice a year by the Department of Meteorology (DoM) before the commencement of the two monsoon periods to discuss the matters related to the seasonal forecasts for the coming season and also to discuss about the gaps in forecasting facilities. This forum gathers stakeholders from all over the country including local government authorities, Department of Agriculture, Irrigation Department, Ceylon Electricity Board and the Crop Research Institutions. The seasonal weather forecast for the coming season is disclosed at this forum by the DoM and the stakeholders are also given a chance to share the knowledge regarding the previous season's issues and success stories.

The seasonal outlook for June, July and August 2022 is based on the prevailing global climate conditions, forecasts from different climate models around the world and statistical down-scaling of General Circulation Model (GCM) outputs using the Climate Predictability Tool (CPT) (Mason and Tippett, 2017). In the past, seasonal forecasts were generated through consensus. The consensus approach, however, has several limitations. First, the forecasts are not available in digital/numerical form and thus cannot be objectively verified and assess their skill. Second, the forecasts cannot be used in application models. Third, the forecasts cannot be identically reproduced/replicated by a different forecast group due to the subjective nature of arriving at the final climate outlook. To address such deficiencies, the World Meteorological Organization (WMO) executive council at its 69th session in 2017 recommended that regional and national climate centres produce objective, traceable and reproducible seasonal forecasts.

The website of the Department of Meteorology (www.meteo.gov.lk) provides the following seasonal forecasts for the benefit of all in Sri Lanka in Sinhala, Tamil and English. As of today (15th June 2022), it provides details on current condition and forecasts of ENSO[1] and IOD[2] for JJA[3] 2022, Consensus Seasonal Weather Outlook for JJA for Seasonal Rainfall and Temperature, Seasonal, monthly and weekly Rainfall Forecasts for June-August 2022 and Temperature Forecasts for June-August 2022.

The probabilistic multi-model ensemble forecast published by WMO is depicted in Fig. 1. The colour shades over Sri Lanka are brownish in the Southern parts, indicating below-normal rainfall values. Above-normal rainfall values are expected in the Northern tip of the island but in the Eastern part, a near-normal condition will be observed.

[1] The El Niño-Southern Oscillation (ENSO) is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean

[2] The Indian Ocean Dipole (IOP), also known as the Indian Niño, is an irregular oscillation of sea surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean

[3] The period of June, July and August (JJA)

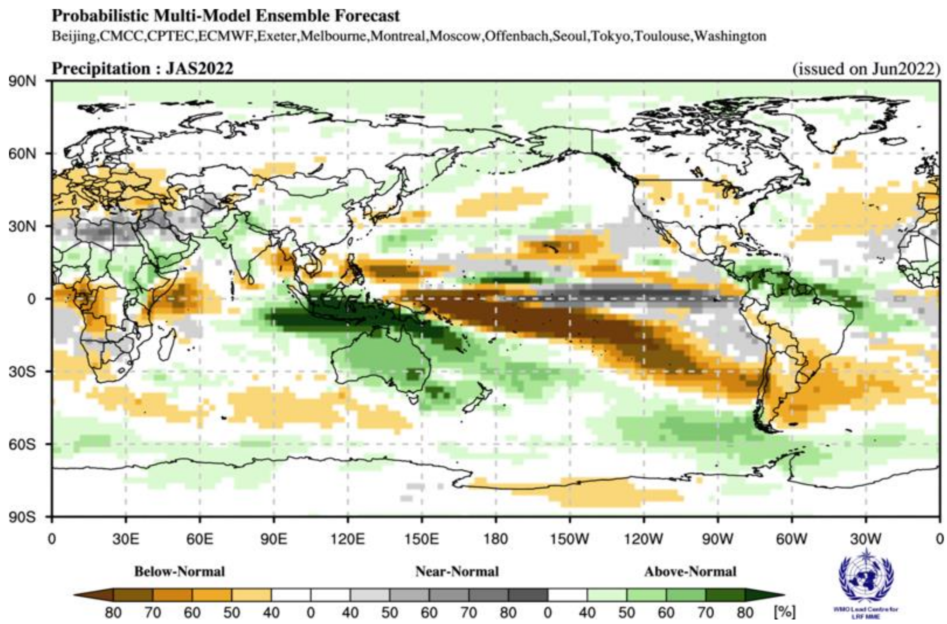

Fig. 1. The probabilistic multi-model ensemble forecast by WMO (Source: https://community.wmo.int/latest-global-seasonal-forecasts

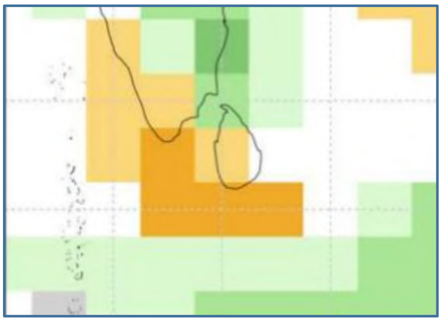

Fig. 2. The rainfall situation over Sri Lanka (The colour code of Fig. 1 also applies to this figure)

In addition to weather maps, DoM provides a probabilistic forecast for all the districts of Sri Lanka. The most recent probabilistic forecast is provided here for the benefit of readers (Table 1). An indication is given in that, there is a possibility to receive above average rainfall in some areas with a probability of 60% (Given in Table 1 in boldface letters). Other meteorological information is also available in DoM website, where the users can employ them in decision making together with the seasonal forecasts. For instance one such useful report is the "Monthly Drought Bulletin" published by the DoM. Meteorological drought is usually defined on the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. This Bulletin has been prepared employing the Standardized Precipitation Index (SPI) recommended by WMO. The high resolution maps given in this bulletin are derived from monthly rainfall data from more than 250 stations. Inferences such as whether, "Dryness becomes severe" or "Dryness continues for several months" can be made by employing the seasonal forecasts (Table 1) and the details provided in the monthly drought bulletin for different districts, which are immensely helpful for decision making in the agricultural sector. The weekly agro-meteorological bulletin is also available in the DoM website giving information for the standard week basis.

Weekly and sub-seasonal weather forecasts - These forecasts are available in the DoM website and can be used for short-term agricultural planning, especially the human resource planning in rubber plantations and to minimize the risk of losing production due to rain interference. DoM provides these forecasts and continuously update them based on numerical forecasting models employing the facilities available in the European Centre for Medium-Range Weather Forecasts (ECMWF) https://www.ecmwf.int/en/research/modelling-and-prediction. Readers can find 7-day (weekly) and 9-day forecasts in the DoM website for rainfall and temperature. An example for 9-day forecast for rainfall is provided below for the benefit of readers.

Table 1. *Probabilistic Rainfall Forecast for JJA season 2022 using CPT*

District	**Probability (%)**			
	Average rainfall In JJA (mm)	**Below**	**Normal**	**Above**
Colombo	590.1	45	30	25
Kalutara	861.5	50	30	20
Galle	771.0	45	30	25
Matara	604.3	20	20	60
Hambantota	146.9	20	20	60
Ampara	131.5	20	20	60
Batticaloa	141.2	20	20	60
Trincomalee	168.8	25	25	50
Mullaithivu	99.5	25	25	50
Jaffna	71.6	20	20	60
Killinochchi	57.1	20	20	60
Mannar	40.3	25	25	50
Puttalam	98.4	30	25	45
Gampaha	478.5	40	30	30
Kegalle	934.8	40	30	30
Ratnapura	675.1	20	20	60
Monaragala	125.9	20	20	60

District	**Probability (%)**			
	Average rainfall	**Below**	**Normal**	**Above**
Badulla	183.7	20	20	60
Pollonnaruwa	128.9	20	20	60
Vavuniya	109.8	30	30	40
Anuradapura	89.7	20	20	60
Kurunegala	212.4	20	20	60
Matale	163.5	20	20	60
Kandy	497.6	20	20	60
Nuwara-eliya	767.1	20	20	60

Source: Consensus Seasonal Weather Outlook June, July and August (JJA)

Seasonal Rainfall and Temperature for Sri Lanka, Department of Meteorology

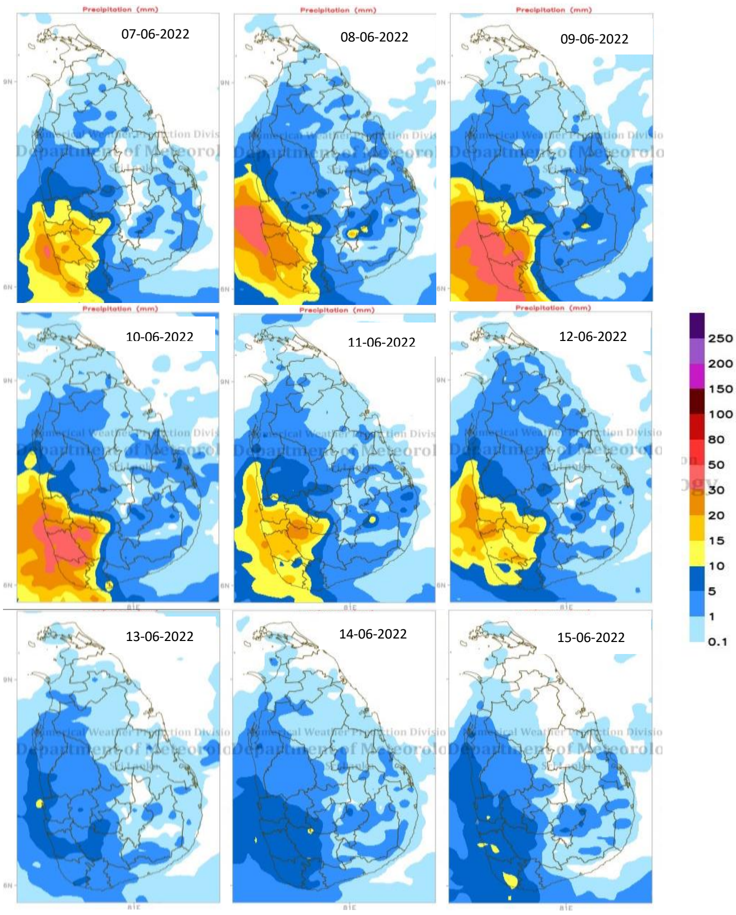

Fig. 3. ECMWF rainfall forecast (24 hr) valid for 07^{th} to 15^{th} June 2022

Integrated use of satellite data and conventional meteorological observations is found to be very useful for synoptic analysis and conventional forecast to extract information relevant for agriculture. Every satellite image tells us a story and satellite images are everywhere, on the Internet, the evening news, and even in some newspapers. The ability to interpret weather information from satellite images enables people to make informed decisions about planning their day. Satellite forecasting of weather is favored because of its global reporting, accuracy and high resolution. It also has the ability to predict the weather for quite a long period. In the future, farmers will rely on satellite forecasting more than usual because of its many advantages.

Daily and hourly weather forecasts - On an everyday basis, many use weather forecasts to plan a given day. Since outdoor activities are severely curtailed by heavy rain, forecasts can be used to plan activities around these events, and to plan ahead and survive them. In rubber cultivation, the farmers need to know whether they can fertilize their fields, spray chemicals for weeding and disease control and more importantly harvest their fields, to minimize the risk of losing resources and the latex collected in plantation. Moreover, in rubber plantations, when there is no possibility latex in the usual time, the growers need to know whether they could carry out harvesting late in the day. For such activities we need forecasts throughout the day and facilities are available through many service providers. Some of them are; WeatherBug (https://www.weatherbug.com/), Weather Underground (https://www.wunderground.com/), The Weather Channel (https://weather.com/), AccuWeather (https://www.accuweather.com/), Sat24 (https://en.sat24.com/en), Windy (https://www.windy.com/), Ventusky (https://www.windy.com/), World Weather Online (https://www.worldweatheronline.com/) and WeatherSpark (https://weatherspark.com/).

Farming provides us with life-sustaining food and rubber plantations provide us latex, the living bank for the rubber growers. Rubber is a critical raw material that the world's mobility relies on and the world comes to a halt without rubber. Therefore, rubber farming has to be more productive and sustainable than ever. Accurate weather forecasting and its use is essential in achieving a healthy crops along with increased productivity and profitability. Therefore, let us take wise decisions based on weather forecasts on our day-to-day activities in rubber farming.

Please send your email id to biometryrrisl@gmail.com to receive updates on weather forecasts.

REFERENCES

Mason S. J. and Tippet M. K. (2017). Climate Predictability Tool version 15.6.1. Columbia University Academic Commons. https://doi.org/10.7916/D8SF37S0.

Stevens, A. (2011). Introduction to the basic drivers of climate. *Nature Education Knowledge* **2**.

Wijesuriya, B.W. and Rathnayaka, A.M.R.S.D. (2021). Rainfall Pattern in rubber growing areas of Sri Lanka. *In: Handbook of Rubber Vol. 1: Agronomy*, pp. 44-53. (Eds. V.H.L. Rodrigo and P. Seneviratne), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, 12200, Sri Lanka.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 16-31

A COMPREHENSIVE OVERVIEW OF THE CLONE RRIC 102

K K Lianage, T T Dahanayake and B W A N Baddewithana

INTRODUCTION

The historic rubber breeding program of Sri Lanka initiated by the Geneticist Dr C.E. Ford from 1939 to 1945 utilized a wide range of clones from Indonesia, Malaysia, Sri Lanka, and Vietnam (Murray, 1940). The crosses made at these breeding programs provided the data for the better-combining ability of a number of clones such as Tjir1, Mil 3/2, Waga 6278, RRIC 7, RRIC 8, LCB 1320, PR 107, PB 86 and PB 5/139**.** The cross's outcome provides an appreciable number of progenitors, and RRIC 52 is one of the excellent clones resulted from those breeding programmes with a favourable growth and foliage. The preliminary studies on RRIC 52 showed that the vigour of this clone was highly transmissible, and therefore this clone was combined with the clones such as RRIC 7, PB 86, PB 5/139 and Ch 26 in order to produce a high yielding and more favourable secondary characters to the progenitors. The RRIC 102 is the outcome of the combination of RRIC 52 x RRIC 7 synthesized in 1957, and its original clone number was 1103 (Baptist, 1966; Fernando, 1971a; Fernando, 1971b).

Parentage and the characters of the parents

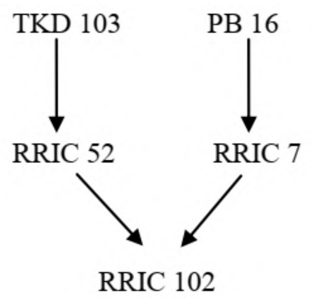

Fig. 1. Pedigree of the clone RRIC 102

The female and male parentage of clone RRIC 102 was RRIC 52 and RRIC 7, respectively. Parents possessed good latex properties at early selection stages as well as improved disease-resistant characteristics. The clone TKD 103 and PB 16 were the grand parentages, and they were also considered as promising clones in very early selection stages. Therefore, clone RRIC 102 possessed high yield, vigorous growth and some important disease-resistant features especially the rubber powdery mildew resistance, transmitted from both parentages and grand parentages (Liyanage, 2008).

Yield data of Small Scale Clone Trial (SSCT)

For the primary selections process, two ten-tree plots of Small Scale Clone Trials (SSCT) were established at the RRISL substation of Kuruwita and Nivitigalakele during the South-West monsoon season in 1962. The data were compared with promising clones such as PB86, RRIC 7, RRIC 52, PB 28/59, IAN 6754 and IAN 45-713, in the large scale clone trial established in the same season in the same sites. In both trials, tapping started from 1967 on S/2 d3, 67% intensity and from 1969 onward S/2 d2, 100% intensity. Another SSCT was established at Dartonfield group in 1965 and tapping commenced after 5 years in 1971. The test tapping was done twice a month, and dry weight was measured as dry rubber yield per tree per tapping (g/t/t) (Table 1 and Table 2) (Fernando, 1962; Wijewantha, 1964; Fernando, 1967; Fernando, 1969).

Table 1. *Average yield and the girth of the genotype 1103 (RRIC 102) at SSCT at Nivitigalakele and Kuruwita established in 1962*

	Nivitigalakele (RRIC 102)		**Kuruwita (RRIC 102)**		**Control RRIC 52 (Kuruwita)**
Year	**Girth (cm)**	**Yield (g/t/t)**	**Girth (cm)**	**Yield (g/t/t)**	**Yield (g/t/t)**
1967	48.5	40.1	47.6	40.7	20.7
1968	52.4	41.4	53.7	58.3	20.5
1969	54.6	42.2	57.6	48.5	24.1
1970	57.1	32.7	60.3	55.3	19.6
1971	58.5	49.2	62.2	57.2	28.1
1972	59.8	50.8	64.1	44.4	28.2
1973	60.8	44.6	66.4	50.7	31.1
Average		**43.0**		**50.8**	**24.6**

RRIC 102, both at Nivitigalakele and Kuruwita, yielded best in both SSCT (Table 1). As the large scale areas of this clone had been planted and came into tapping in 1973, these two experiments were windup (Fernando, 1973).

Table 02. *Average yield and the girth of the genotype 1103 (RRIC 102) at SSCT at Dartonfield established in 1965*

Year	**Girth (cm)**	**Yield (g/t/t)**
1966	08.2 (at 3ft)	
1967	14.6 „	
1968	23.6 „	
1969	37.8 „	
1970	46.9 „	
1971	53.5 „	32.4
1972	59.7 „	35.4
1973	62.6 „	57.2
1974	64.5	51.7
1975	63.6 (at 5ft)	50.4

1976	64.0	,,	51.5
1977	64.7	,,	21.7*
1978	65.6	,,	43.6
1979	67.6	,,	49.1
1980	68.5	,,	42.2
Average			**46.4**

(*In 1977, RRIC 102 was attacked by *Colletotricum*, and as a result, a yield drop was observed (Fernando, 1977)

Yield data of Estate – RRI Collaborative Clone Trials (ECT)

ECT trials were established at substation in Kuruwita (1964), Nivitigalakele (1967) and Geekiyanakanda Estate (1967) to evaluate the performance of the genotype 1103. Data had shown that genotype 1103 was a promising clone for large-scale testing, and therefore, it was registered as the clone RRIC 102 in 1970 (Wijewantha, 1964; Fernando, 1967; Fernando, 1970). The commercial yields obtained from ECT trials are given in Table 03.

Table 03. *Average girth and the commercial yield of the clone RRIC 102 in ECT's*

	Kuruwita (1964)		**Nivitigalakele (1967)**		**Geekiyanakanda Estate (1967)**	
Year of tapping	**Girth (cm)**	**Yield (g/t/t)**	**Girth (cm)**	**Yield (g/t/t)**	**Girth (cm)**	**Yield (g/t/t)**
1	55.8	26.8	53.6	33.2	49.6	27.2
2	58.5	44.3	55.5	55.9	56.3	33.9
3	59.4	46.8	57.5	54.6	61.8	41.6
4	60.8	49.8	59.3	37.4	64.1	40.6
5	66.3	63.8	61.9	28.4	66.1	49.0
6	-	62.3	63.5	42.6	68.5	43.2
7	69.2	59.9	65.4	43.1	71.4	27.3
8	70.0	46.5	67.5	43.5	-	*
9	70.7	58.5	70.2	43.6	-	-
10	-	-	72.7	30.8	-	-
Average		**51.0**		**41.3**		**37.5**
BB%		**9.7**		**6.0**		**13.6**

*****With improved rubber price in 1978, there was a greater amount of recovery tapping resulting in near 200% intensities, and under these conditions, clones showed a high amount of dry trees. Therefore, the clone trial at Geekiyanakanda was abandoned (Fernando, 1978).

Evaluation of clone RRIC 102 at high elevation

With the spread and the severity of powdery mildew disease in upland areas, nearly 10,000 acres of rubber plantations were abandoned or converted into tea lands. At the same time, the subsidy programs were also withdrawn for all rubber planting at an elevation above 1,000 ft. However, during the latter part of 1953, due to the stabilization of the rubber market, replanting of rubber at high elevation areas had been reconsidered. An effort was made in 1953 to introduce clones resistant to powdery mildew, and the clone LCB 870 was sorted out. Later, the vigorous and resistant clone RRIC 52 was also used in the replanting program. However, in both clones, the yield was not sufficiently high for large scale plantations, and therefore, crosses made out from RRIC 52 with high yielding clones were used for the purposes. In 1959 a very close planting of 268 hand-pollinated progenies, including original genotype number 1103 (RRIC 102), was established at Keppitigalla Group, Matale, at an elevation of 1,200 ft under a very suitable condition for the development of powdery mildew disease. In 1963, another trial was established at Clodagh Group, Matale, with a regular spacing among the plants. Assessments of powdery mildew resistance were made from time to time (Wijewantha, 1965, Fernando, 1969), and two genotypes 1103 (RRIC 102) and 1108 were immerged as tolerant to powdery mildew as there was no leaf fall immediately after re-foliation and no evidence of severely affected leaflets. However, the close spacing trial was discontinued due to the adverse effect of 3 ft spacing between trees in the sampling process. The average pre-tapping girth increment was around 6.5 cm/year, and it took seven years to reach the tappable stage, while control clone PB 86 took more than nine years. The average post-tapping girth increment was around 0.7 cm/year at Matale, located at 1,200ft above mean sea level. However, the yield, girth and foliage of RRIC 102 at Matale were satisfactory (Table 04), and the growth was superior to the control clone PB 86. Therefore, clone RRIC 102 was permitted in planting in higher elevations (Fernando, 1970; Fernando, 1976).

Table 4. *Girth and yield data of RRIC 102 and control clone PB 86 at Matale (1963)*

	RRIC 102			PB 86		
Year	**No. of trees tapped**	**Girth (cm)**	**Yield (g/t/t)**	**No. of trees tapped**	**Girth (cm)**	**Yield (g/t/t)**
1970	34	47.4	15.4	-		
1971	33	51.9	25.7	-		
1972	34	53.5	32.0	-		
1973	43	54.1	23.3	5	52.8	16.4
1974	45	54.7	43.8	5	55.1	36.1
1975	45	55.1	40.0	6	57.3	20.1
1976	45	55.6	29.0	8	58.2	19.6
Average			**30.0**			**23.5**

Evaluation of clone RRIC 102 at dry weather conditions

In order to evaluate the performance of the clone RRIC 102 at drier areas, a replicated SSCT was established at Kumarawatta Estate, Monaragala, during the North-East monsoon in 1965 (Fernando, 1965). The trees in this trial were opened for tapping at the seventh year of age, which is quite early for this district. RRIC 102 showed the possibility of obtaining first-year yields equivalent to the Wet Zone (Fernando, 1973). RRIC 102 showed a higher mean girth than the control clone (RRIC

45) throughout the evaluation period (Table 05). As girth is an important criterion for evaluating clones, especially in dry areas, RRIC 102 could be a suitable clone for dry areas. RRIC 102 showed a good yield compared to control clone RRIC 45, with some variation according to the locality. The resistance to powdery mildew leaf disease stabilizes the yield when considered as an average.

Table 5. *Girth and yield data of RRIC 102 and control clone RRIC 45 at Monaragala (1965)*

	RRIC 102		RRIC 45	
Year	**Girth (cm)**	**Yield (g/t/t)**	**Girth (cm)**	**Yield (g/t/t)**
1973	55.3	20.0	51.4	14.1
1974	56.0	20.0	53.5	16.5
1975	57.2	30.3	56.3	17.1
1976	58.5	26.1	57.9	23.1
1977	59.4	38.0	58.9	21.2
1978	-	-	-	-
1979	60.3	28.3	60.1	21.5
1980	61.6	22.2	61.9	11.3
1981	63.2	24.5	63.7	12.8
1982	64.6	23.1	65.5	15.1
1983	65.4	21.6	66.5	10.0
1984	66.6	31.2	67.5	19.3
Average		**26.0**		**16.5**

Girthing properties

In general, the early measurement of growth at traditional rubber growing areas revealed that RRIC 102 is a vigorous clone and achieves a girth increment of 9.2-9.6 cm per year, easily resulting early opening of trees for tapping. However, there was some variation in girthing according to the locality (Table 06).

Table 6. *Girth increment of RRIC 102 at different localities*

Locality	Pre-tapping girth increment (cm/year)	Post tapping girth increment (cm/year)
Traditional rubber growing areas	9.2-9.6	2.4-2.8
Higher elevation areas (Above 1,200ft)	6.3-6.7	0.6-0.9
Dry areas (Monaragala)	7.9-8.2	1.0-1.2

Use of RRIC 102 in clone recommendation

The clone RRIC 102 was first introduced into the advisory circular on clone recommendation in 1973 and was first recommended as a Group IV clone for small scale planting. Afterwards, the clone recommendation was revised several times, and clone RRIC 102 was upgraded to subsequent groups, accordingly (Table 7).

Table 07. *Recommendation of RRIC 102 clone*

Year of recommendation	Group included	Guide for recommendation
1973	Group IV	Small scale planting
1982	Group 1: -1b.	For areas having annual rainfall more than 3750 mm and elevation less than 300mm (Kegalle, Kandy and Matale)
	-1c.	For dry areas (Monaragala, Bibile and Koslanda)
1998	Group 1: -1a.	For areas having annual rainfall less than 3750 mm and elevation less than 300m.
	-1b.	For areas having annual rainfall more than 3750 mm and elevation less than 300 m
	-1c.	For elevation more than 300 m irrespective of the rainfall.
2000	Group 1: -1a.	For areas having annual rainfall less than 3750 mm, up to 10% of the total extent
	-1b.	For areas having an annual rainfall of more than 3750 mm, 10% of the total extent
2004	Group 1	Up to 10% of the total extent
	Smallholder sector	For all areas
2007	Group 1	Up to 10% of the total extent
	High elevations	Up to 300-900 m
	Smallholders	Both traditional and non-traditional areas
2013	Group 1	Bellow 300 m altitude and up to 10% of the total extent
	Smallholder sector - Group a.	For all areas
	High elevations - Group b	Above 300 m up to 900 m and not to exceed 5 ha of the plantation

Identification of clone

Proper identification of clone RRIC 102 is vital, and knowledge of relatively consistent characters of a clone is used to identify the clone (Liyanage *et al.*, 2013; Liyanage and Baddewithana, 2015; Anushka *et al.*, 2017). Characters of clone RRIC 102, which can be used for identification, are listed and illustrated in Table 08, Figures 2 and 3.

Table 08. *Morphological characters of the clone RRIC 102*

Descriptor	In clone RRIC 102
At immature stage (<2 years)	
1) Leaf (Middle leaflet)	
Shape	Obovate
Colour	Green (7.5 GY 4/6)
Lustre	Dull
Texture	Smooth
Leaflet thickness	Thin
Leaf base	Obtuse
Leaf Apex	Apiculate
Leaf area	150 – 220 cm^2
Leaf Margin	Smooth
Longitudinal Section	convex
Cross Section	flat
Degree of leaflet separation	Touching
Colour of veins	Light green
Nature of veins	Prominent
2) Petiolule	
Length	Short (0.5 – 1.0 cm)
Orientation	Down word
Angle between Petiolule	Wide (55 - 65^0)
3) Petiole	
Shape	Strait
Length	Medium (20 – 28 cm)
Orientation	Upward
Pulvinus	Swollen
Nectar Gland	Raised
4) Leaf Storey	
Shape	Conical
Separation	Well separated
Appearance	Dense or Closed canopy
5) Stem	
Appearance	Straight
Surface	Smooth
Leaf Scar Size	Small
Leaf Scar Shape	Heart shape
Auxillary bud appearance	More or less Protruded
Auxillary bud distance from petiole	Close
Latex Colour	Yellowish white
At mature stage (>5 years)	
1) Trunk	
Vigour	Good
Continuity	Persistent
Height	Tall
Shape	Round

Surface	Smooth
Colour	Light
Appearance	Straight
Virgin bark thickness	Average (8.5mm)
Bark hardness	Hard
Scar	Present
Bleeding	Present
2) Branching	
Position	Low (3 – 3.5m)
Habit	Clustered
Spreading	Close
Angle	Narrow
Continuity	Dissolve
Appearance	Straight
Surface	Smooth
Density	Average
3) Crown	
Shape	Oval
Size	Narrow
Density	Medium
Height	Moderate
Position	Balanced
Colour	Green
4) Seeds	
Size	Medium
Shape	Square cuboid
Length	Medium
Width	Medium
Thickness	Medium
Seed coat colour	Light brown
Seed coat luster	Dull
Seed coat variegation	Shaded
Seed coat variegation colour	Light brown
Dorsal prominent ridge	Present
Dorsal shape	Flat
Ventral groove	Slightly
Ventral lateral cheek	Normal
Ventral anterior	Flat
Ventral posterior	Normal
Weight	Medium
Microphyle	Normal

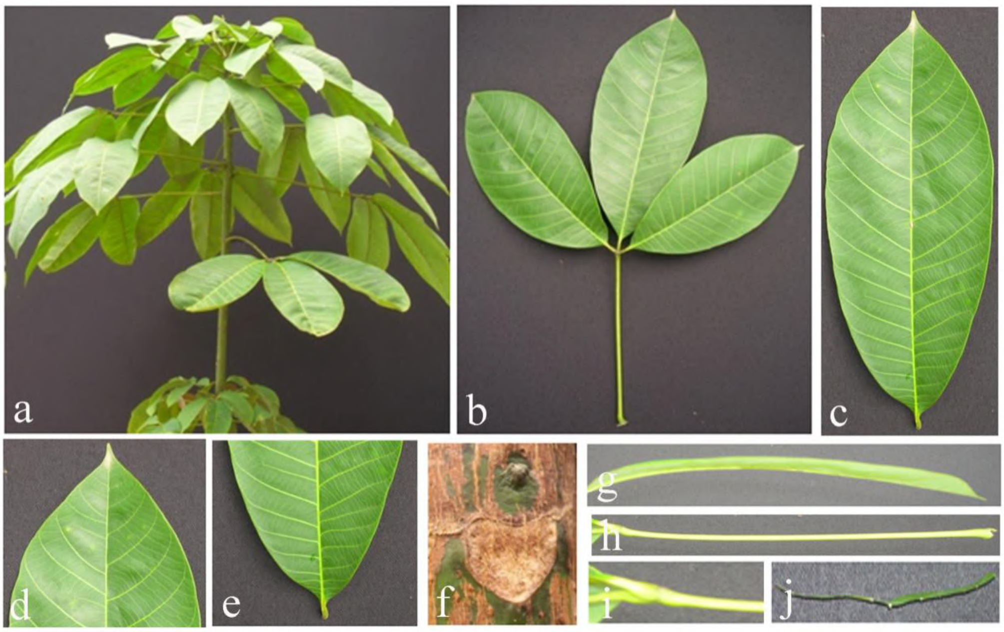

Fig. 2. Leaf and leaflet characters

a: Leaf Storey- It is the leaf-bearing part of the stem. It is hemispherical in shape (leaf stories look like half of the sphere), and the leaf story of a plant is well separated from each other by the bare stem. The density of leaves in the storey is high and indicates a close canopy.

b: Leaf - Leaf is palmately compound and consists of a pulvinus, leaf stalk (petiole), three leaflets which are attached by petiolule to the distal end of the petiole. At that point, extrafloral nectaries, the nectar secreting glands, are present.

c: Shape of leaf blade - Leaflets are elliptical to obovate in shape (leaf blade has its maximum width between the middle of the leaflet and apex). The leaf margin is smooth. Veins are prominent and light green in colour. The luster of the leaf is glossy and smooth in texture.

d & e: Leaf apex and leaf base - Usually, the mature middle leaflet is used to observe the character. Leaf apex is acuminate to apiculate, and leaf base is cuneate. Acuminate tip refers to an acute apex, sides of which are somewhat concave and tapers somewhat into an elongated tip. Cuneate leaf base appears triangular, with the narrow end at the point of attachment.

f: Leaf scar - The leaf scar is the mark that is left after the leaf shedding. In this clone, they normally heart shape to round with protruded margin, and the axillary bud (the bud found at the axil of leaves that branches and flowers arise from) are normal (not sunken or protruded) and visible.

g: The Longitudinal sectional appearance of a leaf - It is judged by viewing the leaflets from the side, and it is straight or flat

h: Petiole and orientation of petiole - To describe the petiole, its shape, length and orientation are considered. The lower leaves of the story are the best to observe the petiole characters. The orientation is horizontal to upward, and it describes the arrangement of petiole in relation to the stem. All the leaves of the storey may not show the same orientation, but the orientation exhibited by a majority of leaves is taken as the clonal character. The shape of the petiole is convex (there is no bending or curving of the petiole) straight.

i: Petiolule – It is the short stalk connecting the leaf lamina to the petiole. It also displays variability in size, orientation and inter petiolule angle. The orientation of petiolule is horizontal to downward with respect to the plane of the petiole and narrow with inter petiolule angle.

j: Cross-sectional appearance of a leaf - It is viewed by looking at the tip towards the direction of the base, and it is "V" shaped.

Fig. 3. Canopy, stem and branches at maturity

a: Mature plantation – The tree trunk is more or less rounded and no nodule appearance in the main trunk.

b and c: Branching habit of the tree at its tappable stage – Low branching with clustered habit. They are spreading closely with a narrow-angle to the main trunk-the strait in appearance and the dissolve in the continuity. The density of branching is average.

d: Canopy - Oval shape medium density canopy

e: Appearance of bark – Bark of the main trunk is smooth and light in colour

Assessment on disease resistance:

***a) Corynespora* leaf fall disease (CLFD)**

Based on the clonal screening techniques followed by the Plant Pathology and Microbiology Department of RRISL during the past 15 years, the average disease severity index is zero (0), and the clone RRIC 102 have been categorised as resistant to CLFD (Jayasinghe, 2004 -2009; Silva, 2010; Fernando, 2011 – 2018).

***b)* Phytophthora leaf disease**

The fruit set ability of this clone is relatively poor, and it indicates the reduced susceptibility to *Phytopthora* leaf-fall disease (Fernando, 1971b)

***c)* Powdery mildew disease**

Assessments of resistance to powdery mildew disease were made from time to time at Kappitigalla group at an elevation of 1,200 ft under conditions very suitable for the development of this disease in 1959 and 1960. RRIC 102 showed tolerance to powdery mildew disease, no leaf fall immediately after re-foliation, and no evidence of severely affected leaflets (Wijewantha, 1965; Fernando, 1969).

Latex and raw rubber properties

Table 9 shows some important raw rubber properties of unfractioned unbleached latex crepe samples generally used to assess the suitability and quality of raw material for rubber product industries. According to that, RRIC 102 shows more attractive latex and raw rubber properties compared with some other clones (Kudaligama et al. 2010).

Table 09. *Raw Rubber properties of clone RRIC 102*

Raw rubber properties	Standard Values for crepe rubber	RRIC 102
Initial Wallace Plasticity of Rubber (P_0)	30 (min)	41
Plasticity Retention Index (PRI)	60 (min)	69
Mooney Viscosity (V_R)	75 -85	79
Ash Content % (w/w)	0.2 (max)	0.17
Lovibond Colour	1.5 units (max)	2.1
Nitrogen Content %	0.35 (max)	0.48

(Source: Kudaligama et al. 2010)

The P_0 test measures the original plasticity (before ageing). The clone RRIC102 has a P_0 value of 41, and it is in the range of moderate category and therefore does not influence the processability of rubber in the factory and is suitable for high-quality raw rubber production. Latex grades usually have PRI values above 60%, and PRI of RRIC

102 is 69 and grouped in the moderate category. Therefore, it provides quality latex for the raw rubber product industry. The Mooney Viscosity (V_R) is commonly used as the test to characterize and monitor the quality of rubber. The Mooney Viscosity value of clone RRIC 102 is 79 and was groped in moderate category and suitable for raw rubber production. The ash content % indicates the amount of inorganic chemical substances (metals) present in the rubber, and it should be below 0.2%. If the ash content of a rubber sample is high, it indicates higher deterioration of the manufactured product due to the oxidation of the metal contaminants. In clone RRIC 102, ash content is 0.17% and meets the specification required. The nitrogen content measures non-rubber components, usually the proteinaceous matter present in the rubber phase and the minor content of non-protein nitrogen-containing substances. It is an important determinant as higher nitrogen contents increase the storage hardening and reduce the dynamic and ageing properties. The nitrogen content of the clone RRIC102 is 0.48%, and therefore it is graded as high level showing difficulties in the production of high-quality standard crepe without fractionation. (Kudaligama *et al.* 2010, Baddewithana and Seneviratne 2016).

Other important characteristics

When RRIC 102 is in the tappable stage (*i.e.* in the 8th year of growth, average girth = 60.3 cm), they have a bark thickness of 6-8 mm ($\bar{x}$=7.6 mm, n=60) at 120 cm above from the ground. In the maturity stage (*i.e.* in the 15th year of growth, average girth = 72.6 cm), the virgin bark thickness was 9.5-13.5 mm ($\bar{x}$=12.5 mm, n=60), and the rejuanate bark thickness was 7-13 mm ($\bar{x}$=8.2 mm, n=30) at the same height. After this long term clonal evaluation process, the clone RRIC 102 is recommended as a d2 clone, and therefore it should be tapped on every other day.

RRIC 102 is a fertilizer sensitive clone, and especially it is very sensitive to magnesium (Mg) status in the soil. Once the Mg status is deficient in the soil, the plant showed deficiency symptoms like yellowing and buckling of leaves more or less similar to white root disease effected trees (Fig. 04). Therefore, Mg containing fertilizer should be applied 25% more than the normally recommended rates for field plants as an insurance dose (Advisory circular of RRISL - Fertilizer to Rubber, 2013).

Fig. 04. Mg deficiency symptoms of the clone RRIC 102

The measurable timber volume of the RRIC 102 is around 0.270 m^3/tree, and it is almost similar to RRIC 100 (*i.e.* 0.271 m^3/tree) and low compared to RRIC 121(*i.e.* 0.406 m^3/tree) (Advisory circular of RRISL-Yield profiles of outstanding clones, 2009). Therefore, RRIC 102 is considered as a good timber clone.

Based on all these factors, the clone RRIC 102 is considered as a promising clone with good raw rubber properties and a higher timber value for both estate and smallholder sectors. Therefore, clone RRIC 102 is recommended for planting to maintain the correct clone balance in the rubber plantations of Sri Lanka.

REFERENCES

Anushka, P.V.A., Liyanage, K.K., Withanage, S.P. and Baddewithana, B.W.A.N. (2017). Analysis of phenotypic diversity of selected hevea accessions from irrdb 1981 germplasm collection conserved in Sri Lanka, *International Proceedings of IRC* 2017, **1** (1), 203-212.

Baddewithana, B.W.A.N. and Seneviratne, P. (2016). Possible reasons for yield variation in RRIC 102 clearings of *Hevea brasiliensis* (Muell. Arg.*). International Journal of Recent Trends in Engineering & Research,* **02** (06), 116-130.

Baptist E.D.C. (1966). Breeding for high yields and disease resistance in *Hevea.* Proc. of the *Nat. Rubb. Conference*, Kuala Lumpur, pp. 430.

Fernando, D.M. (1962). Review of the Plant Breeding Section, Annual Review for 1962, Rubber Research Institute of Ceylon, pp. 42-56.

Fernando, D.M. (1965). Review of the Plant Breeding Section, Annual Review for 1965, Rubber Research Institute of Ceylon, pp. 33-43.

Fernando, D.M. (1967). Review of the Genetics and Plant Breeding Department, Annual Review for 1967, Rubber Research Institute of Ceylon, pp. 33-43.

Fernando, D.M. (1969). Review of the Genetics and Plant Breeding Department, Annual Review for 1969, Rubber Research Institute of Ceylon, pp. 37-52.

Fernando, D.M. (1970). Review of the Genetics and Plant Breeding Department, Annual Review for 1970, Rubber Research Institute of Ceylon, pp. 26-42.

Fernando, D.M. (1973). Review of the Genetics and Plant Breeding Department, Annual Review for 1973, Rubber Research Institute of Sri Lanka, pp. 25-42.

Fernando, D.M. (1976). Review of the Genetics and Plant Breeding Department, Annual Review for 1976, Rubber Research Institute of Sri Lanka, pp. 50-66.

Fernando, D.M. (1977). Review of the Genetics and Plant Breeding Department, Annual Review for 1977, Rubber Research Institute of Sri Lanka, pp. 50-65.

Fernando, D.M. (1978). Review of the Genetics and Plant Breeding Department, Annual Review for 1978, Rubber Research Institute of Sri Lanka, pp. 45-53.

Fernando, D.M. (1971a). Breeding for multiple characters of economic importance in Hevea, preliminary assessment of recent selections. *Journal of Rubber Research Institute of Malaya,* **21**, 27-37.

Fernando, D.M. (1971b). The yield and secondary characters of clone RRIC 102, *Quarterly Journal of Rubber Research Institute of Ceylon*, **48**, 56-65.

Fernando, D.M. and Samaranayake, P. (1967). The method for the rapid determination of rubber in *Hevea* spp. *Quarterly Journal of Rubber Research Institute of Ceylon*, **43**, 1-3.

Fernando, T.H.P.S. (2011). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2011 (Eds. W.M.G. Seneviratne and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 75-88.

Fernando, T.H.P.S. (2012). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2014 (Eds. W.M.G. Seneviratne and V.H.L. Rodrigo), Rubber Research Institute of Sri Lanka, pp. 83-94.

Fernando, T.H.P.S. (2013). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2013 (Eds. W.M.G. Seneviratne, V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardena), Rubber Research Institute of Sri Lanka, pp. 77-90.

Fernando, T.H.P.S. (2014). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2014 (Eds. W.M.G. Seneviratne, V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardena*)*, Rubber Research Institute of Sri Lanka, pp. 77-96.

Fernando, T.H.P.S. (2015). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2015 (Eds. W.M.G. Seneviratne, V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardene***)***, Rubber Research Institute of Sri Lanka, pp. 89-108.

Fernando, T.H.P.S. (2016). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2016 (Eds. W.M.G. Seneviratne, V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardena), Rubber Research Institute of Sri Lanka, pp. 83-102.

Fernando, T.H.P.S. (2017). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2017 (Eds. W.M.G. Seneviratne, V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardena), Rubber Research Institute of Sri Lanka, pp. 73-94.

Fernando, T.H.P.S. (2018). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2018 (Eds. V.H.L. Rodrigo, G.P.W.P.P. Seneviratne, and S. Siriwardena), Rubber Research Institute of Sri Lanka, pp. 65-82.

Jayasinghe, C.K. (2004). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2004 (Eds. L.M.K. Tillekaratne, W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 69-77.

Jayasinghe, C.K. (2005). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2005 (Eds. L.M.K. Tillekaratne, R.C.W.M.R.A. Nugawela, and W.M.G. Seneviratne), Rubber Research Institute of Sri Lanka, pp. 50-57.

Jayasinghe, C.K. (2006). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2006 (Eds. R.C.W.M.R.A. Nugawela, W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 47-53.

Jayasinghe, C.K. (2007). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2007 (Eds. R.C.W.M.R.A. Nugawela, W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 68-77.

Jayasinghe, C.K. (2008). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2008 (Eds. R.C.W.M.R.A. Nugawela, W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 66-73.

Jayasinghe, C.K. (2009). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2009 (Eds. R.C.W.M.R.A. Nugawela, W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 64-73.

Kudaligama, K.V.V.S., Rodrigo, V.H.L., Attanayaka, A.P., Rodrigo, P.D.J. and Randunu, R.P.S. (2010). Raw rubber properties of *Hevea*: Should it be a selection criterion in breeding and planting programmes?, In*: Proceeding of the third symposium of plantation crop research – Stakeholder empowerment through technological advances* (Eds. R.S. Dharmakeerthi and A.M.W.K. Senevirathna). Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka pp. 157-166.

Liyanage, K.K. (2008). Role of PB and Tijikado clones in rubber breeding in Sri Lanka - A analysis of the pedigree of Sri Lankan rubber clones, *Bulletin of the Rubber Research Institute of Sri Lanka*, **49**, 50-58.

Liyanage K.K., Sumanasinghe V.A., Attanayake, D.P.T.S.G. and Baddewithana, B.W.A.N. (2013). Phenotypic diversity of rubber clones grown in Sri Lanka at their immature stage based on the available morphological descriptors, *Tropical Agricultural Research*, **24** (2), 112 – 127.

Liyanage, K.K. and Baddewithana, B.W.A.N. (2015). Phenotypic diversity of Sri Lankan rubber clones at their immature stage. *Journal of the Rubber Research Institute of Sri Lanka* **95**, 14-23.

Murray, P.K.S. (1940). Report of the Botanist and Mycologist. Report of the Rubber

Research Board (Ceylon), 56-57.

Silva, W.P.K. (2010). Review of the Plant Pathology and Microbiology Department, Annual Reviews 2009 (Eds. W.M.G. Seneviratne, and C.K. Jayasinghe), Rubber Research Institute of Sri Lanka, pp. 69-76.

Wijewantha, R.T. (1964). Review of the Botany Division, Annual Review for 1962, Rubber Research Institute of Ceylon, pp. 16-47.

Wijewantha, R.T. (1965). Some breeding problems in Hevea brasiliensis, *Quarterly Journal of Rubber Research Institute of Ceylon*, **41**, 12-22.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 32-37

POLICY DIRECTIONS FOR IMPROVING THE EXTENSION SERVICE IN THE SMALLHOLDER RUBBER SECTOR THROUGH OVERLOOKING THE INSTITUTIONAL AND STRUCTURAL TRANSFORMATION IN THE HISTORY

P K K S Gunarathna

INTRODUCTION

Rubber (*Hevea brasiliensis*) is one of the major plantation crops in Sri Lanka in terms of export earnings and employment generation. It produces natural rubber. The rubber sector contributes 0.3 % of the Gross Domestic Production and it has earned one US$ billion by exporting raw rubber and finished products in 2021 (CBSL, 2021). In its early stages it was defined as an export crop, the exports have been gradually replaced by the rising domestic consumption. The local consumption has increased over the years and is expected to rise further in the coming years too. The total production was 129,200 MT in 2021 and contributed 62.8% to local consumption that year (CBSL, 2021). Further, the rubber industry provides employment to over 500,000 both directly and indirectly (MPI, 2019). In the global scenario, NR demand is expected to be high in the long run. Therefore, there is a greater future for rubber industry in the local as well as in the global cortex. At present, Sri Lanka is the 10th in the world in terms of production and 10th in the world in terms of exports and hence is a price taker in the world market (IRSG, 2019). Rubber extent occupies 132,799 ha in the country (MPI, 2019). It is mainly a smallholders' crop and smallholdings occupy nearly 57 % of the total extent and are distributed among nearly 150,000 smallholders scattered in 14 administrative districts in different agro-ecological regions (MPI, 2019). Though, Sri Lanka cultivated high yielding clones (>3000kg/ha/yr) national productivity is 14th position in global rubber productivity. The major contributory factor is the gradual breakdown of the rubber extension service. This paper focuses on the smallholder rubber sector because it is one of the vital subsectors of the rubber plantation in Sri Lanka. This paper presents historical background of institutional and structural transformation, in a view to making policy directions for improving the extension service in the smallholder rubber sector to overcome the current issues by using the secondary data and semi structures interviews with eight experts (two from each organization) from the rubber sector under different organizations; the RRISL, the RDD, *Thurusaviya* fund, private sector with different disciplines..

The history of rubber cultivation in Sri Lanka

The first recorded evidence of the existence of a rubber producing tree was when Christopher Columbus made his voyage to America in 1493-1496 and observed inhabitants of Haiti playing with balls of a *gum*-like substance. Rubber was introduced in 1876 by Sir *Henry Wickham* to Sri Lanka under the British emperor. Formal commercial cultivation started in the 1900s and in 1928, the total extent of rubber cultivation in Sri Lanka was 214,000 ha to cater to the demand of the European and American manufacturers where rubber was exported as raw material. Until 1926, rubber was cultivated and managed by the British people under the government. At 1926, the government took the decision to expand rubber cultivation among smallholders in Sri Lanka. According to the land reform laws in Sri Lanka, the lands below 20.2 ha in extent are classified as ‘private sector’, which is dominated by smallholdings. Sri Lankan rubber sector comprises smallholdings (<20.2 ha) and large estates (>20.2ha). Regional Plantation Companies (RPC) manage estates, and smallholders manage smallholdings.

Main milestone of extension network in the smallholder rubber sector Rubber Research Institute (RRI)

In order to develop the technology demanded by the growers, a committee consisting of members of British plantation interests in this country was formed in 1909 and this was the origin of research on rubber in Sri Lanka. The committee initially engaged a chemist to study the coagulation of rubber and this activity later expanded to form the Rubber Research Scheme (RRS) in 1913. In 1933, RRS was officially styled as Rubber Research Institute (RRI) in 1951 by the provisions of the Rubber Research Act. No of 1951 of which the main aim is to develop economically viable and environmentally sustainable innovations and to transfer developed technology through training and advisory services to the industry (RRISL, 2001).

Extension service for the rubber sector launched by the RRI was carried out as two units under extension services namely, Smallholdings Department (SHD) for smallholders in 1926 and Estate Advisory Department (EAD) for large estates in 1972. The Rubber Instructors (RI) were the field level extension officials of rubber growing districts and carried out extension services in all the rubber growing districts. The need for an advisory service to cater to the rubber smallholders was realized in late 1936 with only 2 RI and within 10 years another 8 RIs were appointed and by 1948, this number was further increased to 47. In 1948, the Advisory Services Department (ASD) was formed under the RRI to provide service to the smallholders while planters were provided with service by the RRI. Smallholder Rubber Rehabilitation Project 1 (SRRP 1) was initiated by the ASD and established in 1981 under the Ministry of Plantation Industries (MPI). Smallholder Rubber Policy and Planning Unit (RPPU) was established under the SRRP 1 to look into all aspects of smallholders’ rubber cultivation, production, and marketing. The Rubber Control Department (RCD) and the ASD were directly involved with the smallholders, respectively by running the Rubber Replanting Scheme (RRS) and by providing extension support. Under this project training center for the smallholders was established under the ASD in 1982 and rubber plants, fertilizers and extension and advisory services were supplemented by the ASD for the new and re-planters of smallholders. Since 1980, the RCD has been supplying these inputs only to rubber planters.

Rubber Control Department (RCD)

The RCD was established in 1934 under the MPI to enforce the legislative provisions of Rubber Control Ordinance No 63 of 1938, which was later repealed by the Rubber Control Act No 11 of 1956. The RCD is the principal rubber regulatory agency of the government and has been responsible for the control of the production and planting of rubber through the administration of the RSS constitutes in Sri Lanka. The RCD was headed by a rubber controller and its field operations were undertaken through five regional offices in traditional rubber growing districts. The RCD had a total staff of 576, including 75 RIs who were not responsible for extension duties but for legal activities. The RCD was completely financed from funds raised through the rubber replanting and rubber control cess. The main functions of the RCD were the registration of rubber holdings and producers, licensing of dealers, manufacturers and nurseries, issuing of export licenses for rubber seeds and plants and collection of all industry related statistics. The RCD invited replanting and new planting applications and issued permits for smallholders. The RCD was responsible for inspecting fieldwork (seven times over a period of six years), on the basis of which the release of the Rubber Replanting Fund (RRF) benefits were authorized to the smallholders. The RCD provided inputs (planting material and fertilizers) to all smallholders supported under the RRS. The RCD issued permit to relevant land owners for replanting work. Copies of the permits were referred to the SHD of the RRI for starting the advisory function. In 1956, under the rubber control act, the RCD involved to motivate smallholder farmers by releasing subsidies and it was headed by a rubber controller while it was supported by deputy and assistant controllers who were Sri Lanka Administrative Service (SLAS) officers and also with heavy clerical staff for legal activities. The RCD was upgraded to Rubber Development Department (RDD) as a result of an amalgamation of the RCD with the ASD of the RRISL in 1994 (Dissanayake, 2009).

Advisory Services Department

The Advisory Services Department (ASD), which was under the RRI until 1981, became a separate institution under the Rubber Research Board (RRB). Since being elevated to the de facto status of an independent department under SRRP 1, the ASD has been responsible for extension and related activities to improve the quantity and quality of rubber produced by smallholders. Field extension work on rubber cultivation is carried out under the development division, through 17 Divisional Rubber Extension Officers (DREO) and 108 Rubber Extension Officers (REO). The Processing Advisory Division (PAD) with 15 Processing Advisors (PA) is responsible for providing advice to private sheet processing units and for promoting and supervising Group Processing Centers (GPC). The field operations are managed by five regional offices (Colombo, Galle, Kalutara, Kegalle, and Ratnapura). The ASD was responsible for supplying planting material (budded stumps) and fertilizer to smallholders. At the request of the RCD, the REOs also make mandatory inspections required for the release of payments from the RRF. The Smallholder Rehabilitation

Project 2 (SRRP 2) was started in 1986 and all duties were conducted by the ASD. During the SRRP 2, the ASD was strengthened through increasing the field staff as extension officers, establishing a publicity unit, and improving the infrastructure facilities to field staff to provide a more comprehensive service to smallholders. After analyzing the situation that prevailed in the rubber smallholder sector a necessity was arisen to re-establish an extension wing under the supervision of RRI (Jayasena and Herath, 1986a). As a result, the ASD was reformed as a new department with 35 extension officers selected from the RDD to cater to the requirements of smallholder sector in all rubber growing areas except Moneragala. AR present, the ASD is responsible for the technology transfer both to the rubber smallholders and plantation sector to enhance productivity and profitability of the rubber sector.

Present extension system of the smallholder rubber sector

The main involvement of extension services in the rubber smallholder sector is from the government and lesser involvement is done by the private sector. The RRI, the RDD and *Thurusaviya* fund under the MPI are the government sector organizations at present. The *Thurusaviya* fund has been established under act no. 23 in 2000 with the aim of uplifting the living standards of rubber smallholders by facilitating the production and marketing of quality rubber sheets to ensure a fair price for their products via *Thurusaviya* societies (http://www.rubberdev.gov.lk).

Extension service related issues of the smallholder rubber sector in Sri Lanka

Smallholdings occupy nearly 67% of the total extent but they provide a share of about 42% to the national rubber production. The overall productivity of rubber in 2008 in Sri Lanka was 1350 kg/ha while that of the smallholder sector is around 950 kg/ha. This comparatively low yields in smallholdings are mainly due to poor adoption of recommended agronomic practices owing to unstable income levels coupled with the escalating cost of production. Unsatisfactory extension service rendered to smallholder farmers is also among the major factors, which affect the adoption of recommendations. The private extension channels which presently exist are basically market-oriented and operated through factories which buy latex, rubber sheet collecting centers and agro input agencies. These channels are limited to information delivery and have minimum involvement in aspects of problem solving of rubber cultivation and production. One of the major problems that exist in the present extension service rendered by the RDD is the lack of the sufficient number of extension workers to cater to the smallholders. An extension officer of the RDD has to provide his services to nearly 2000-3000 farmers, which is not a convenient exercise at all and hinders the effectiveness of the extension service. The smallholders are also provided with various inputs such as planting materials, fertilizers, advisory and extension services and financial transfers by different state agencies. In order to optimize the productivity at each stage and reduce losses, appropriate technology and know-how are essential. These are developed by the RRI, Universities and private organizations, but they are not in close consultation with extension and advisory services as well as end-users. The research products must be provided to the technology users through suitable extension and advisory services. The end products of rubber farming require a complex process from land preparation, cultivation, crop management, harvesting, processing and value addition processes as well as marketing. Most of the training programmes for farmers are conventional in nature. This resulted in poor attraction by farmers leading to wastage of resources. Most farmers participate in the same training programmes conducted by various state institutions on the same topic in different places. Because of that farmers are not interested in participating in those programmes.

Strategies to overcome barriers of the extension service of smallholder rubber sector

The strategies need to be focused on the following; *viz.* a) development of appropriate technology, b) transfer of developed technologies together with the necessary knowledge, c) promotion of avenues for adoption and diffusion of transferred technologies, d) creation of a suitable environment for implementation and e) the revitalizing of government policies. The revitalizing of government policies and the creation of a suitable environment for implementation are important to minimize resource wastage at the state level as well as the farmer level. The education and training of extension workers are highly inadequate and need intensification. Also, they should have ample time to learn a technology before they can effectively teach others. Extension workers need more training than farmers to garner credibility. Therefore, properly planned human resource development programmes for extension officers after careful analysis of their present level of knowledge, skills and responsibilities is needed as an extension is the battlefront of technology transfer.

CONCLUSION

At present, basically, three types of field officers the REO, the RDO and *Thurusaviya* field officers are providing service to the same target group of rubber smallholders. Differential acceptance of these three groups by the smallholders as a result of poor coordination is an unfortunate situation. This leads to wastage of resources through duplication of some services. Sound discussions between institutions at the planning are highly important to overcome such conditions. Thus, according to the historical changes of the institutions can be concluded that there is no single organization that is responsible for the smallholder rubber sector until the present day. Therefore, rational policy imperative is essential to either make optimum the use of the link between the research, policymakers or regulators and technology users or to establish a single organization responsible from above to lessen resource wastage and improve the efficacy of the service while improving the satisfaction of the rubber smallholders.

REFERENCES

Central Bank of Sri Lanka. (2020). Central Bank Annual Report, Central Bank of Sri Lanka. Colombo, Sri Lanka.

Dissanayake, D.M.A.P. (2009). Strategies for efficient technology transfer in the smallholder sector, *Proceedings of the centennial rubber conference Sri Lanka*, Rubber Research Institute of Sri Lanka, Agalawatta, Sri Lanka, pp. 40-43.

Jayasena, W.G. and Herath, H.M.G. (1986). Smallholder Rubber Rehabilitation Project: innovation receptivity and adoption in rubber smallholdings of Sri Lanka (Research study no.71). Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo

Jayasena, W.G. and Herath, H.M.G. (1986). Smallholder Rubber Rehabilitation Project: Smallholder rubber replanting in Sri Lanka: trends, problems and factors influencing their decisions (Research study no.72). Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo.

Handbook of Rubber, Vol. 1, Agronomy. (2001). Rubber Research Institute of Sri Lanka, Agalawatta, Sri Lanka.

Sri Lanka - Second Smallholder Rubber Rehabilitation Project (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/949991468101346257/Sri-Lanka-Second-Smallholder-Rubber-Rehabilitation-Project

The Ministry of Plantation Industries. (2019). Plantation Sector Statistical Pocket Book, Sri Lanka. Ministry of Plantation Industries of Sri Lanka, Colombo 2, Sri Lanka, pp. 100-150.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 38-44

LEVEL OF ADOPTION OF RECOMMENDED RUBBER HARVESTING PRACTICES BY SELF-LATEX HARVESTERS IN RATNAPURA DISTRICT

P K K S Gunarathna

INTRODUCTION

In the Sri Lankan context, smallholder rubber sector is considered as the most dynamic segment with 68 % of the total rubber extent of Sri Lanka which contributes to 69% of the national rubber production, and is yet far behind the expected targets (MPI, 2020). The Rubber Research Institute of Sri Lanka (RRISL) has developed and recommended Harvesting Practices (HPs) which plays a key role in increasing the rubber productivity and economic lifespan of rubber smallholdings and is a vital investment to enhance the overall performance of the rubber industry in the country. There are many approaches for Transfer of Technology (TOT) that were launched by both public and private sectors to enhance the adoption level of recommended HPs. The level of adoption and reasons for non-adoption of recommended HPs are important to plan the TOT programmes. This study therefore, attempted to assess the level of adoption and find reasons for non-adoption of recommended HPs by rubber smallholders who harvest their own rubber holdings (self-latex harvesters) and also to suggest possible means of improving adoption of recommended HPs among them. As there were no planned studies undertaken so far, to assess the adoption level of recommended HPs of the smallholder rubber sector in Ratnapura District.

METHODOLOGY

Sampling procedure and data collection

The study was conducted in Ratnapura District (6.5741° N, 80.5438° E) in Sri Lanka during 2019. The questionnaire survey was conducted with 202 self-latex harvesters (SLHs) in 7 rubber Rubber Extension Officer (REO) ranges (Table 1). The stratified sampling technique was applied according to the distribution of rubber smallholders in each range. Pre-tested questionnaire and field observations were used to collect data from the respondents. The questionnaire consists of questions from three main domains and key general information of smallholdings, with reasons for less/non-adoption of nine selected recommended HPs (Table 3).

Table 1. *The Selected sample of self-latex harvesters from different REO ranges in Ratnapura District*

REO range	No. of self-latex harvesters
Kuruwita	35
Ratnapura	29
Ehaliyagoda	34
Nivitigala	32
Opanayaka	29
Karawita	18
Pelmadulla	25
Total	202

Testing for adoption and finding the reasons for non-adoption of harvesting practices

Rogers and Shoemaker (1971) defined adoption as a decision to make full use of a new idea as the best source of action available. Accordingly, adoption in this study refers to utilization and application of nine HPs recommended by the RRISL (RRISL, 2001). They were: 1. Harvesting system, 2. Panel marking, 3. Time of harvesting, 4. Girth at opening for harvesting, 5. Height of opening for harvesting, 6. Placement of spout, 7. Placement of cup, 8. Cleanliness of harvesting area and 9. Cleanliness of harvesting utensils. For the areas from five to nine, as mentioned above, ten rubber trees were randomly selected from each smallholding and assessed to determine the level of adoption. The level of adoption in each HPs was measured using an adoption scale which comprises three different levels of adoption as not-adopted (NA), partially-adopted (PA) and fully-adopted (FA) (Table 2). The reasons for non-adoption of each recommended HPs were listed out by discussing with SLHs prior to the survey and the list was then used to evaluate the response at the time of survey. Descriptive analyses were employed in data analysis.

Table 2. *The type of harvesting practices, scale and level of adoption*

Harvesting practices	Level of adoption	Scale of adoption*
Harvesting system	S/2 d2	FA
	Some days with S/2 d2	PA
	Daily harvesting	NA
Harvesting panel marking	Annually	FA
	At the commencement of harvesting	PA
	Not attended	NA
Time of harvesting	Early morning (5.00am-6.00am)	FA
	Morning (6.00am-7.00 am)	PA
	Late (after 7.00am)	NA
Girth at opening for harvesting	>20’’ or 20”	FA
	18”- 20”	PA
	<18”	NA

Harvesting practices	Level of adoption	Scale of adoption*
Height of opening for harvesting	> 4’or 4’	FA
	4’-3’	PA
	<3’	NA
Placement of spout	1”-2” away from latest line marked	FA
	3”-5” away from latest line marked	PA
	>5” away from latest line marked	NA
Placement of cup	2”-3” away from last marked line	FA
	3”-5” away from last marked line	PA
	>5” away from last marked line	NA
Cleanliness of harvesting area	Fully cleaned	FA
	Partially cleaned	PA
	Not cleaned	NA
Cleanliness of harvesting utensils	Fully cleaned	FA
	Partially cleaned	PA
	Not cleaned	NA

* FA – Fully adopted, PA – Partially adopted and NA – Not adopted

RESULTS AND DISCUSSION

Key information of smallholdings and self-latex harvesters

The summary of the characteristics of smallholdings is presented in Table 3. The majority of the smallholdings falls into the size of 1-1.5 acres (0.4 – 0.6 ha). The clone RRIC 121 occupies 82% of the smallholdings selected for the study. The prominent current harvesting panels were B0-1 and B0-2. The average harvesting stand was 170 trees/acre. The average number of harvesting days was reported as 104 per year and average yield was 990 kg/ha/year.

Table 3. *The summary of the characteristics of rubber smallholdings*

Characteristics of smallholdings	% (N=202)
Size of the holding (acres.)	
<1	9
1-1.5	87
1.5-2	4
Type of the clone	
RRIC 100	18
RRIC 121	82
Harvesting stand per ac. (no. of trees)	
Average	170
Range	(129-208)
Current harvesting panel	
B0-1	47
B0-2	41

B1-1	10
B1-2	2
Harvesting days/year	
Average	104
Range	(65-175)
Yield (dry basis) kg/ha/year	
Average	990
Range	(340-1100)

Female SLHs has dominated, with a female: male ratio of nearly 4:1. About 98% of SLHs were married. The age of SLHs varied from 20 to 79 years. The majority of SLHs belonged to the age category of 46-55 years. Nearly 8% of the respondents was above 65 years, while only 30% was found below 35 years. However, the young age (<35 years) category was not prominent in this study area, and it differs from a previous study carried out in Moneragala District. The most of younger generation (<35 years) in Moneragala was employed as SLHs due to a lack of job opportunities (Wijesuriya *et al*., 2008). The attraction of the younger generation must be directed to the smallholder rubber sector, mainly as SLHs, to ensure the sustainability of rubber farming. None of the SLHs has obtained higher education (diploma and degree level), and 1% of SLHs had not attended to a school. Further, only 3 % of SLHs had attended to tertiary education level (GCE A/L). The majority of SLHs (53%) have achieved more than ten years of work experience as a latex harvester with an average of 6.5 years. The average number of working days per week was four days.

Adoption of harvesting practices

The adoption levels of nine recommended HPs by SLHs are presented in Figure 1. The results showed a wide variation among HPs with respect to their adoption levels. While the highest adoption level (62%) was recorded for correct time of harvesting, the lowest (3%) was recorded for harvesting panel marking and placement of the cup. The adoption levels for the rest of the HPs; *viz.* harvesting system, girth at opening for harvesting, height at opening for harvesting, cleanliness of the harvesting area and utensils and placement of spout were recorded as 7%, 15%, 8%, 7%, 5% and 7%, respectively, indicating poor adoption levels of recommended HPs by SLHs.

Reasons for non/partial adoption of harvesting practices

An attempt was made to explore the reasons for non-adoption of recommended HPs from the perspective of SLHs. The lack of awareness (Fig. 2) was the main reason which was prominent in HPs except for correct time of harvesting. There were several reasons other than lack of -awareness leading to r non-adoption of HPs. Among other reasons, weather condition including high rainfall, not giving the due recognition for recommended HPs, non-availability of required utensils, threat of wild animal attacks, lack of capability to complete the harvesting task and height of the SLHs were the major reasons for non-adoption and partial-adoption of recommended HPs (Table 4).

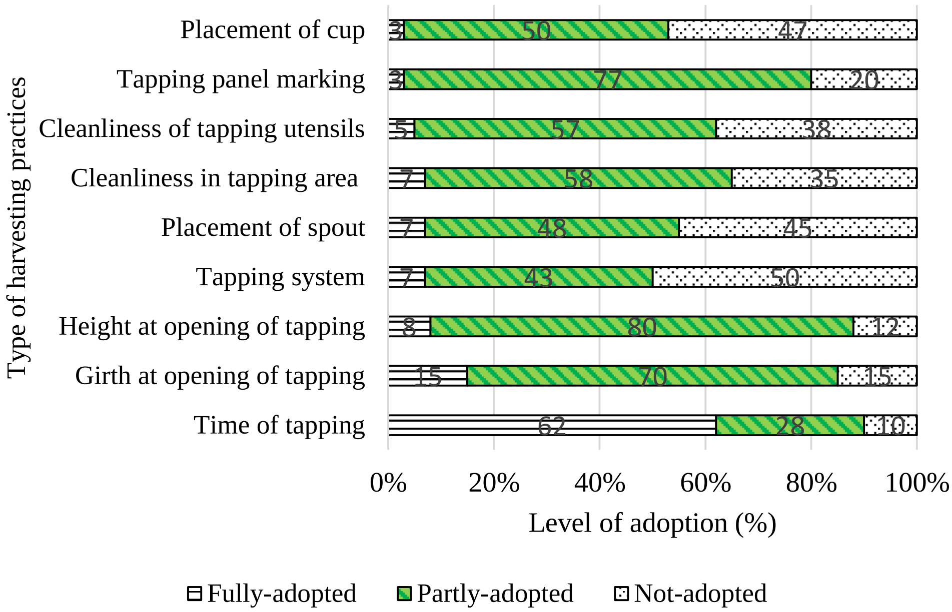

Fig. 1. Level of adoption of harvesting practices by self-latex harvesters.

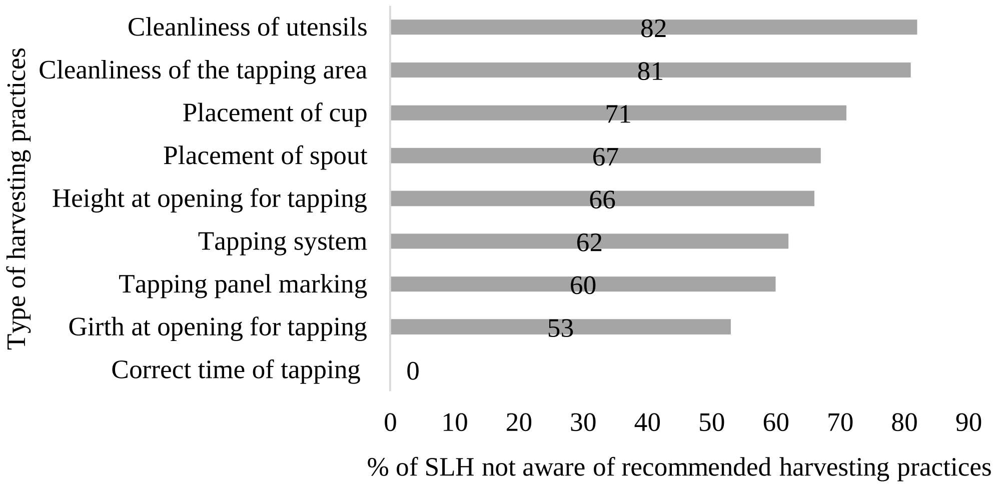

Fig. 2. The percentage of self-latex harvesters who reasoned out non-awareness as the reason for non-adoption of harvesting practices

Table 4. *Reasons for partial or non-adoption of harvesting practices by self-latex harvesters who are already aware of recommended harvesting practices*

Harvesting practices	% of SLHs	Reason/s for partial or non-adoption
Harvesting system	88	High rainfall on harvesting days
	12	Not given the due recognition
Harvesting panel marking	98	Non-availability of marking stencils
	02	Reluctance to allocate extra time for marking
Correct time of harvesting practice	53	Bad weather condition in early morning
	47	Threat of bites by snakes/animals
Girth at opening for harvesting	100	The criteria for commencement of harvesting (>50cm girth) was not practiced as their desire was to harvest the full harvesting task
Height of opening for harvesting	81	Difficulty in practicing due to the stature of the harvester
	19	Not given the due recognition
Cleanliness of the harvesting area	96	Reluctance to allocate extra time for cleaning the harvesting area
	04	Not given the due recognition
Cleanliness of the harvesting utensils	97	Reluctance to allocate extra time for cleaning the harvesting utensils
	03	Not given the due recognition
Placement of spout	93	Not given the due recognition
	07	Reluctance to allocate extra time to properly place the spout
Placement of collecting cup	84	Not given the due recognition
	16	Reluctance to allocate extra time to properly place the cup

The policy changes pertaining to material distribution (stencils) are required in order to improve level of adoption of recommended HPs. In addition, this study shows the important areas of TOT with a view to enhance the level of adoption of recommended HPs among SLHs. New TOT approaches could be formulated based on factual data and such models should be tried out in pilot scale initially. The multi-stakeholder collaborative TOT approaches (government, private and non-governmental organizations) could be suggested as a possible way out to address this issue.

CONCLUSION AND RECOMMENDATIONS

The findings of the study reveal that the level of adoption of recommended harvesting is not satisfactory in smallholder rubber sector in Ratnapura District. Reasons for non-adoption and partial-adoption suggest the necessity of improving the knowledge, attitude and awareness on HPs mainly harvesting system, harvesting panel marking, girth and height of opening for harvesting, placement of spout/cup and the cleanliness of harvesting area and harvesting utensils through present extension and advisory system. Findings of the study need to be focused on considering of necessary changes in TOT approaches presently available.

Acknowledgment

The authors are grateful to the Rubber Extension Officers of the Advisory Services Department of the Rubber Research Institute of Sri Lanka in Ratnapura District and the rubber smallholders in Ratnapura District for their valuable support.

REFERENCES

Gunarathne P.K.K.S., Jayasundara, K., Ratnayaka S., Dissanayake D.M.A.P. and Wijesuriya W. (2021). Socio-economic status of latex harvesters in the smallholder rubber (*Hevea brasiliensis*) sector: A case study in Kegalle District, Sri Lanka. In: *Proceedings of the Second Faculty Annual Research Session* (FARS) 2021, Faculty of Applied Science, Vavuniya Campus of the University of Jaffna, Sri Lanka, 23-26.

Handbook of Rubber, Vol. 1, Agronomy (2001). Exploitation for economic yields, Rubber Research Institute of Sri Lanka, Agalawatta, Sri Lanka, 176-197.

Rogers, E.M. and Shoemaker, F.F. (1971). Communication of innovation: A cross cultural approach. The Free Press: New York, 1971, 65-74.

The Ministry of Plantation Industries. (2020). Plantation Sector Statistical Pocket Book, Sri Lanka. Ministry of Plantation Industries of Sri Lanka, Colombo 2, Sri Lanka, 2015, 100-150.

Wijesuriya, W., Dissanayake, A., Samarappuli, L., Wijesratne, M., Abeywardene, V. and Gunaratne, P.K.K.S. (2008). Issues and Perspectives of Smallholder Rubber Farmers and Possible Solutions for Sustainable Rubber Farming in Non-traditional Rubber Growing Areas. *In Proceedings of the Second Symposium on Plantation Crop.* Coconut Research Institute of Sri Lanka, Lunuwila, Sri Lanka, 247-256.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 45-55

LOW PLANTING DENSITIES HAVE MANY ADVANTAGES IN RUBBER PLANTATIONS

P Seneviratne, P G N Ishani, M K P Perera, R Handapangoda and W K S W Watawala

INTRODUCTION

Rubber (*Hevea brasiliensis* Muell Arg.) is grown mainly for its latex. The vegetative growth or the size of the tree is more important to obtain the potential yield from a tree than the clone it belongs to. Rubber wood has a commercial value as timber, fuel wood and for other industries such as plywood, brush handles, *etc.* At present, there are about 40 rubber clones recommended to cultivate under three groups (Advisory Circular No.2013/01). The size of the tree is a clonal characteristic but the agro-management practices during the immature phase of the tree seems to determine whether the potential yield of the clone is obtainable when the trees are tapped (Jayasekara, *et al*, 1977). As a rule of thumb all trees are expected to grow to the size of 50 cm girth measured at 120 cm from the ground level. This growth condition is expected to be achieved in 5 years. When a field has more than 70% of such trees, then the field is eligible to open for tapping.

The effect of planting density on growth and the yield of rubber has been studied from the early days. The general observation has always been the increased girthing with decreasing density, after 3-4 years of age of the clearing when the canopies are closed. Studies carried out on the density of plants also revealed that at higher densities a high percentage of trees would never reach to tappable girth (Westgraph and Battery.1965). Further, at higher densities, the total yield is a little higher but the tree girth, number of tappable trees, bark thickness, etc. are low and the overall gain is therefore minimal (Annual Reviews of Plant Science dept, 2010-2014).

The recommendation on the number of plants per hectare changes with the new findings of research and at present, it is 516 trees per hectare and three different spacing systems are also recommended to be adopted mainly to suit different terrains (Advisory Circular 2019/07).

The objectives of the study had been to find out whether the lower densities will enhance both latex and timber yield of deferent clones.

MATERIALS AND METHODS

This trial had been initiated at the RRISL in 1996 to see the effect of lower densities with the control and one higher density, in two locations (Galewattta and Nivitigalakele divisions of the Dartonfield group) with four clones RRIC 100, RRIC 121, RRIC 133 and PB 260.

Four densities i.e. 350, 425, 500 and 575 trees per hectare have been tested. However, the vacancies filled to maintain the density had been done with RRIC 100 and therefore the clonal effect had to be taken from a very limited number of trees.

Annual girth measurements were taken and the girth was measured at 120 cm from the ground level. When the trees were opened for tapping the volume of latex from the effective trees were collected. The Metrolac reading was taken for the total volume of the clone to calculate the dry rubber content as grams per tree per tapping (g/t/t).

Financial analysis was conducted only for the RRIC 100 clone under the four planting densities. Tapping of rubber trees has been conducted for seven years after the establishment. Benefit-Cost Analysis (BCA) was used to compare the financial profitability of the four planting densities. Hence, two metrics namely, Benefit-Cost Ratio (BCR) and Net Present Value (NPV) which are incorporated in the BCA approach were used to evaluate the different planting densities. Due to the time value of money, future cost and benefit values were discounted to enable comparison with present values. This required discounting and compounding. The costs and benefits were discounted using the discount rate of 10%.

NPV means the difference between the discounted present values of future benefits and the discounted present values of future costs. If NPV is positive that means the project benefits are greater than its costs, and *vice versa*. Net Present Value was calculated using the following formula.

$$NPV = \sum \frac{B_t - C_t}{(1+r)^t}$$

where,

B_t = total value of benefits for a period of years, t
C_t = total value of costs for a period of years, t
r = discount rate

BCR of a project can be calculated by dividing the discounted present value of future benefits by the discounted present value of future costs. BC ratio is greater than one when the discounted benefits exceed the discounted costs. Investments with higher BC ratios are preferred over investments with lower BC ratios. The benefit-cost ratio (BCR) was calculated using the following formula:

$$B / CRatio = \frac{\sum \frac{B_t}{(1+r)^t}}{\sum \frac{C_t}{(1+r)^t}}$$

where B_t, C_t and r has the same meaning as above.

RESULTS

The girth measured after 2 years of planting at 120 cm from the ground is given in Table 1 (Annual Review, 1999).

Table 1. *The girth measured at 120 cm from the ground of four clones under four densities after two years of field establishment*

Planting Density (tree/Ha)	Mean Girth (cm)			
	RRIC 100	**RRIC 121**	**RRIC 133**	**PB 260**
350	10.5	12.6	10.9	11.2
425	12.1	12.8	11.6	12.5
500	10.9	11.4	10.6	9.0
575	11.97	11.9	10.7	10.2

As is expected no density effect is seen in the data, at this age, but the girth of clone RRIC 121 is slightly higher than the other three clones.

The average girth after five years of planting under four densities irrespective of the clones is shown in Figure 1.

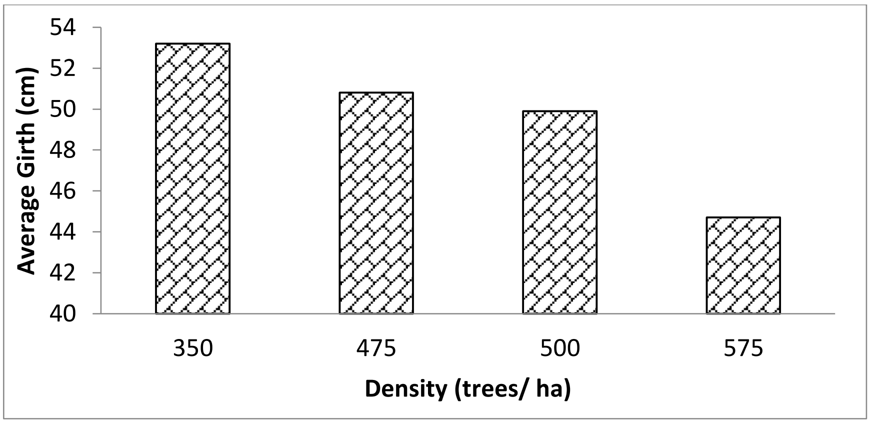

Fig 1. Average girth of trees under four planting densities after 5 years of planting

As this trial was affected due to the loss of some trees, at the age of 6 years, the effective trees were renumbered and the girth measurements were taken (Annual Review, 2002) and are shown in Figure 2.

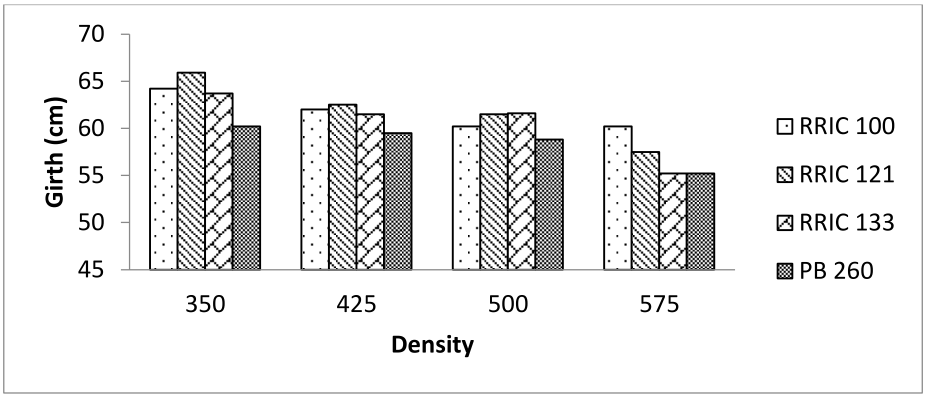

Fig. 2. Average girth of four clones under four densities after 6 years of planting

The trees of this trial were opened for tapping after seven years and the average girth at opening are shown in Table 02.

Table 2. *Average girth of trees of four clones at four densities measured after 7 years*

Density (Plants/ha)	RRIC 100	RRIC 121	RRIC 130	PB 260
350	66.56±2.13	69.08±1.45	69.41±2.70	63.36±0.97
425	65.46±2.34	66.73±1.23	68.24±1.49	64.78±1.14
500	61.93±1.41	63.37±1.59	61.51±3.22	57.08±1.30
575	58.71±1.18	60.99±1.20	55.64±4.08	58.79±1.84

In the 8th year of planting, only one block at Nivitigalakele was chosen and effective trees were renumbered. The girth measured at 120 cm is given in Table 03 (Annual Review 2004).

Table 3. *Average girth of the trees (cm) for four 4 clones under four densities after 8 years*

Density (Plants/ha)	RRIC 100	RRIC 121	RRIC 133	PB 260
350	72.29	73.46	75.12	67.65
425	70.28	72.06	72.55	67.36
500	63.97	67.12	67.65	61.31
575	61.72	65.36	58.04	60.51

Yield data (g/t//t) of the effective trees were recorded during the 9th year after planting of Nivitigalakele replicate and are given in Table 04.

Table 4. *Average g/t/t for four clones in 72 tapping's at the end of 2nd year under four planting densities and the calculated yield per hectare*

	RRIC 100			RRIC 121			RRIC 133			PB 260		
Density	**Girth**	**g/t/t**	**Yield kg/ha/yr**	**Girth**	**g/t/t**	**Yield kg/ha/yr**	**Girth**	**g/t/t**	**Yield kg/ha/yr**	**Girth**	**g/t/t**	**Yield kg/ha/yr**
50	7.1	2.12	09.42	8.9	5.54	95.61	9.4	3.67	48.48	4.1	8.22	6.14
25	5.1	1.90	76.14	5.9	4.32	045.25	5.9	2.59	97.25	2.2	5.44	084.46
00	6.4	1.64	139.04	8.9	3.91	220.76	0.5	1.84	146.24	3.2	5.16	260.00
75	4.6	7.91	155.47	6.5	0.18	246.45	2.2	0.08	245.31	4.5	2.23	334.32

As it is clear from Table 04, g/t/t decreases with the increase of density from 350 trees per hectare to 575 trees per hectare.

The number of tappings was 72 days for the year and accordingly yield per hectare was calculated as in Table 04. Although g/t/t shows a clear decrease with the increase of density in all four clones. The yield per hectare increases with the increase number of trees in higher densities.

Although a higher yield is obtained from higher densities, inputs, such as fertilizer are relatively higher and also a higher number of trees need to be tapped and the cost factor should be considered.

The girth data from the 9th to 13th year of the trees after planting (2nd to 6th year after tapping) of four clones under four densities are shown in Table 05.

Table 5. *Mean girth from the 2nd to 6th year after tapping of the trees of four clones under four densities with percentage values*

Clones	Density (Plants/ha)	Density %	Years after tapping				
			2	**3**	**4**	**5**	**6**
RRIC 100	350	70	77.10	81.80	82.50	89.80	91.80
	425	85	75.10	78.60	79.40	82.20	84.80
	500	100	66.40	70.25	76.57	78.90	80.90
	575	11 5	64.60	67.40	68.31	71.10	74.30
RRIC 121	350	70	8.90	1.60	2.92	87.30	90.10
	425	85	5.90	7.50	4.98	78.90	84.70
	500	100	8.90	2.60	4.75	76.50	80.40
	575	115	6.50	2.60	3.95	76.00	78.30
RRIC 133	350	70	9.40	3.80	4.92	91.30	94.00
	425	85	5.90	9.00	1.30	83.70	85.10
	500	100	0.50	5.40	6.21	77.80	83.70
	575	115	2.20	8.50	9.42	74.00	81.50
PB 260	350	70	4.10	7.30	9.21	82.90	85.70

	425	85	2.20	4.30	5.24	77.30	80.00
	500	100	3.20	7.20	8.60	69.40	73.30
	575	115	4.50	7.30	8.00	69.00	72.80

Table 6. *Mean girth deviation as a percentage from the value of 500 trees / Ha during 2nd and 6th year after tapping of four clones under four densities*

Clone	**Density (Plants/ha)**	**Density %**	**Years after tapping**				
			2	**3**	**4**	**5**	**6**
RRIC 100	350	70	116.1	116.4	107.7	113.8	113.5
	425	85	113.1	111.9	103.7	104.2	104.8
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	97.3	95.9	89.2	90.1	91.8
RRIC 121	350	70	114.5	112.4	110.9	114.1	112.1
	425	85	110.2	106.7	100.3	103.1	105.3
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	96.5	100.0	98.9	99.3	97.4
RRIC 133	350	70	112.6	111.1	111.4	117.4	112.3
	425	85	107.7	104.8	106.7	107.6	101.7
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	88.2	90.8	91.1	95.1	97.4
PB 260	350	70	117.2	115.0	115.5	119.5	116.9
	425	85	114.2	110.6	109.7	111.4	109.1
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	102.1	100.1	99.1	99.4	99.3

Table 7. *Mean g/t/t from the 2nd to 6th year after tapping of the trees of four clones under four densities with its percentage*

Clones	**Density (Plants/ha)**	**Density %**	**g/t/t (Years after tapping)**				
			2	**3**	**4**	**5**	**6**
RRIC 100	350	70	32.12	33.40	38.50	54.20	49.50
	425	85	31.90	33.10	38.09	45.16	47.70
	500	100	31.64	31.30	33.68	38.50	42.30
	575	115	7.91	9.20	0.75	1.30	7.20
RRIC 121	350	70	5.54	5.70	9.78	7.70	4.80
	425	85	4.32	4.80	9.77	9.00	8.90
	500	100	3.91	3.10	4.55	3.33	3.80
	575	115	0.18	0.60	3.66	7.18	8.90
RRIC 133	350	70	3.60	4.70	8.01	1.68	0.80

	425	85	2.59	2.80	3.36	6.03	7.60
	500	100	1.84	2.90	3.42	0.67	0.40
	575	115	0.80	0.00	1.13	4.33	5.90
PB 260	350	70	8.22	6.10	7.18	8.00	3.50
	425	85	5.44	4.30	6.56	3.60	0.70
	500	100	5.16	4.00	5.10	9.70	7.10
	575	115	2.23	0.70	2.31	4.80	3.20

Table 8. *Mean g/t/t deviation percentage from its values at 500 trees during the period of the 2nd to 6th year after tapping of the trees of four clones under four densities with its percentage*

Clone	Density (Plants/ha)	Density %	g/t/t (Years after tapping)				
			2	3	4	5	6
RRIC 100	350	70	101.5	106.7	114.3	140.8	117.0
	425	85	100.8	105.8	113.1	117.3	112.8
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	88.2	93.3	91.3	81.3	87.9
RRIC 121	350	70	104.8	107.9	115.1	133.2	125.1
	425	85	101.2	105.1	115.1	113.1	111.6
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	89.0	92.4	97.4	85.8	88.8
RRIC 133	350	70	105.7	105.5	113.7	127.1	125.7
	425	85	102.4	99.7	99.8	113.2	117.8
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	94.5	91.2	93.1	84.4	88.9
PB 260	350	70	108.7	106.2	105.9	120.9	117.3
	425	85	100.8	100.9	104.2	109.8	109.7
	500	100	100.0	100.0	100.0	100.0	100.0
	575	115	91.7	90.3	92.1	87.7	89.5

Table 9. *Mean YPH from the 2nd to 6th year after tapping of the trees of four clones under four densities with its percentage*

Clones	Density (Plants/ha)	Density %	Mean YPH (Years after tapping)				
			2	3	4	5	6
RRIC 100	350	70	809.42	818.30	1522.00	1965.00	2772.00
	425	85	976.14	984.70	1848.00	1996.00	3242.00
	500	100	1139.04	1095.50	1898.00	1871.00	3386.00
	575	115	1155.47	1175.30	1981.00	1871.00	3421.00
RRIC 121	350	70	895.61	918.70	1573.00	2100.00	3066.00
	425	85	1045.25	1035.30	1909.00	2166.00	3323.00

	500	100	1220.76	1158.50	1952.00	2253.00	3500.00
	575	115	1249.45	1231.60	2187.00	2235.00	3565.00
RRIC 133	350	70	848.48	850.10	1503.00	1881.00	2842.00
	425	85	997.25	975.80	1602.00	2034.00	3234.00
	500	100	1146.24	1151.50	1888.00	2123.00	3230.00
	575	115	1245.31	1207.50	2022.00	2053.00	3300.00
PB 260	350	70	963.14	1263.50	1470.00	1742.00	2436.00
	425	85	1084.46	1020.40	1755.00	1927.00	2766.00
	500	100	1260.00	1190.00	1983.00	2064.00	2970.00
	575	115	1334.32	1235.60	2099.00	2081.00	3053.00

Table 10. *Mean YPH percentage from the 2nd to 6th year after tapping of the trees of four clones under four densities with its percentage*

Clones	Density (plants/ha)	Density %	Mean YPH (Years after tapping)				
			2	3	4	5	6
RRIC 100	350	70	71.06	74.70	80.19	105.02	81.87
	425	85	85.70	89.89	97.37	106.68	95.75
	500	100	100.00	100.00	100.00	100.00	100.00
	575	115	101.44	107.28	104.37	100.00	101.03
RRIC 121	350	70	73.36	79.30	80.58	93.21	87.60
	425	85	85.62	89.37	97.80	96.14	94.94
	500	100	100.00	100.00	100.00	100.00	100.00
	575	115	102.35	106.31	112.04	99.20	101.86
RRIC 133	350	70	74.02	73.83	79.61	88.60	87.99
	425	85	87.00	84.74	84.85	95.81	100.12
	500	100	100.00	100.00	100.00	100.00	100.00
	575	115	108.64	104.86	107.10	96.70	102.17
PB 260	350	70	76.44	106.18	74.13	84.40	82.02
	425	85	86.07	85.75	88.50	93.36	93.13
	500	100	100.00	100.00	100.00	100.00	100.00
	575	115	105.90	103.83	105.85	100.82	102.79

The percentage values obtained only for the 6th year after tapping, shown in Tables 6,8 and 10, are presented in Figure 3. The important factor to highlight in Fig. 3 is the large variation among clones for the different densities and the values of girth, yield per tapping and the total calculated crop based on the g/t/t are not correlated as per the percentage change from one density to the other.

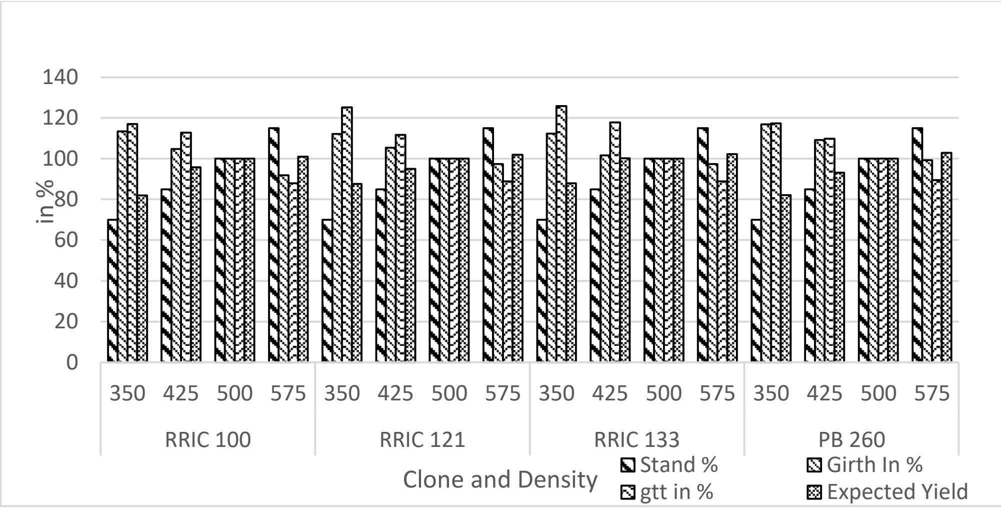

Fig. 3. The change of the percentage values for girth, yield per tapping and the calculated total crop based on the average g/t/t, with compared to 500 trees per hectare. The percentage values obtained only for the 6th year after tapping, shown in Tables 6,8 and 10, are presented here.

Net present values

Except for the treatment of 575 plant density, the rubber plantations show positive NPV values for the RRIC100 clone. Hence it is not economically worthwhile to establish cultivations under the plant density of 575. Here the discounted present values of costs are higher than the discounted present values of benefits (Table 11).

Table 11. *The NPV values of RRIC 100 clone at different plant densities*

	Planting Density (Plants/ha)			
	350	425	500	575
NPV value	126028	92890	60065	-180814

According to the results, it is economically worthwhile to establish rubber cultivations under the plant densities of 350, 475 and 500. However, the NPV values gradually increase when decreasing the plant densities from 500 to 350. Highest NPV is recorded with the planting density of 350. Therefore, it is obvious that the NPV values have a negative relationship with the plant densities.

Cost benefit ratios

Except for the treatment of 575 plant density the rubber plantations show more than one B/C ratio for the RRIC100 clone. Then it is not economically worthwhile to do cultivations under the plant density of 575. As the B/C ratio is higher than one it is economically profitable to do cultivations under the plant densities of 350, 425 and 500. The calculated B/C ratios gradually increase when the plant densities decrease from 500 to 350. The highest B/C ratio was recorded with the planting density of 350. Similar to the NPV values the B/C ratios also have a negative relationship with the plant densities (Table 12).

Table 12. *The benefit cost ratios of the clone RRIC 100 at different plant densities*

	Planting density (Plants/ha)			
	350	425	500	575
Benefit to Cost Ratios	1.13	1.08	1.00	0.88

DISCUSSION

Improving the productivity and profitability of rubber cultivations is one of the major requirements of the rubber industry. The aim of this study had been to see the effect of different planting densities on the growth, yield, and financial profitability of rubber plantations. The financial analysis was possible only for the clone of RRIC100. It was conducted using Net Present Values (NPV) and Benefit to Cost ratios to find the most economically viable plant density under rubber plantations. According to the results, the highest mean yield was recorded with the lowest plant density of 350. The highest total rubber yield was recorded with the planting density of 575. According to both NPV values and B/C ratios, it is not economically worthwhile to cultivate rubber with the planting density of 575. And the planting density of 350 gave the highest NPV values and B/C ratios among the plant densities tested.

Among the other benefits of lower densities than the present 516 trees per hectare, (the closest in the study is 500 trees per hectare as the recommendation then was 500), less occurrence of leaf diseases could be considered. This has been observed in other trials on planting densities when sudden disease outbreaks took place in the past. Generally, the causative agents for many leaf diseases are fungi and their multiplication and spread are always supported under high humidity conditions in high planting densities. Especially lower densities could be an effective measure to combat the new leaf disease or circular leaf spot disease caused by combinations of *Colletotricum* and *Pestalotiopsis.*

Labour shortage, especially skilled tappers, can also be addressed by planting at lower densities. Environmentally, lower densities contribute more to protect the environment through lower demand for inputs per hectare, specially chemicals such as fertilizer, weedicides, etc. Soil disturbance in holing would be lower with the lower number of plants per hectare.

The main disadvantage with lower densities is that the total number of trees should be maintained throughout and also they all should contribute to the crop of the field. In other words, the contribution of one tree or the loss of one tree for BCR is higher in lower densities. N.B. The present analyzer were made on the assumption that planting density remain the same throughout. Accordingly, if all agro management practices and recommendations are adopted, especially those on quality of planting material and immature upkeep followed by harvesting, one could enjoy more benefits through planting at lower densities.

Acknowledgments

This trial was initiated by Dr. A. Nugawela in 1996 who was the Head of the Plant Science Department then. Mr. L.S. Kariyawasam and Mr. U.S.Weerakoon have assisted in maintaining the trial and taken up girth data. Mr. K.A.G.B. Amaratunga worked with the author from 2008 onwards to collect yield data from one replicate located in the Nivithigalakele substation. Their contribution is highly appreciated and recorded here with gratitude.

REFERENCES

Advisory Circular No.2013/01. Clone Recommendation, Genetics and Plant Breeding Department, Rubber Research Institute of Sri Lanka.

Advisory Circular No 2019/07. Field establishment and immature upkeep. Plant Science Department, Rubber Research Institute of Sri Lanka.

Annual Reviews of Plant Science department, (2010-2014). Rubber Research Institute of Sri Lanka.

Jayasekara, N.E.M., Samaranayake, P. and Karunasekara, K.B. (1977). Initial studies on the nature of Genotype-Environment interactions in some Hevea cultivars. *Journal of Rubber Research Institute of Sri Lanka*, **54**, 33-42.

Westgarth, D.R. and Buttery, B. R. (1965). The effect of density of planting on the growth, yield and economic exploitation of *Hevea brasiliensis* part I. The effect of growth and yield. *Journal of RRI of Malaya*, 1965, 62-73.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 56-64

COMPARISON OF PERFORMANCE OF TWO TYPES OF RUBBER PLANTING MATERIALS: BARE ROOT BUDDED STUMPS AND YOUNG BUDDINGS

P Seneviratne, M K P Perera and R Handapangoda

INTRODUCTION

During the period of domestication of rubber plants and cultivation in South East Asia, planting material used was unselected rubber seeds from seedling trees, originating from the Amazon river basin. This was soon replaced to a certain extent by selected rubber seeds collected from seed gardens specially maintained for the collection of seeds. This was possible in countries like Malaysia where the seed gardens could be established in faraway locations from rubber plantations to avoid traveling pollens getting cross-pollinated with flowers in seed gardens. However, monoclonal seeds are only superior to unselected seeds but with many drawbacks.

Since the introduction of bud grafting in 1917 by Van Helton, the desired planting material by the planters was bud grafted plants namely, bare root budded stumps that have no foliage but just the tap root and the grafted bud attached to it. Handling and transporting were all easy with bare root budded stumps. But, the main disadvantage of the bare root budded stumps was the quality of the plant, which is the most important as far as the productivity of the high-performing clones is concerned. When bare root budded stumps are used to establish fields, the clone can be identified when the grafted bud sprouts and grow into the stage of two leaf whorls. Also, the percentage of bare roots which do not sprout, due to mechanical damages or due to physiological problems in the bud and incompatibility, *etc* is considerable. Normally bare root budded stumps take about 3-4 months to obtain 2-3 leaf whorls after planting in the field, and even if the clones are mixed or if it is not the clone desired, the grower has no option. The other disadvantage is the age of the plant at field planting. Even to bud graft the plant in a ground nursery it takes a minimum of one & a half to two years. There were instances where the runts in the seedling nursery are grafted in the second or the third round after applying fertilizer, even after two years of age in the seedling nursery. In such instances, the quality of the plants was obviously inferior. Polybagged plants were the next option which is the bare root budded stump plants grown in poly bags and allowed to grow up to 2-3 leaf whorl stage or up to 5-6 leaf whorl stage in large size bags. Polybagged plants are costly due to the long nursery period and have advantages over the bare roots such as knowing the clone at planting, uniform growth, protection from rodents, etc. Anyhow, polybag plants are not recommended mainly due to their more than two years of age at field planting. When seedlings grown in poly bags are bud-grafted with green buds using green budding techniques the resulting plants are called young buddings (Ong, et al, 1989, Seneviratne, 1995, Seneviratne and Nugawela, 1996, Seneviratne, *et al,* 1996). Young buddings carry all the advantages of the polybagged plants and in addition, an original root system, less than one year planting age, lower in cost than even bare root budded stumps due to the shorter nursery period. More importantly, young budding plant production technique suits with the local climatic conditions well, *i.e.*, the main seed fall in Sri Lanka is in August and the main planting season is the South-West monsoon period in May-June. The young budding technique can produce a two-whorled plant within a 10-month period. Because of the smaller size, handling is easy and transporting cost is also low. Further, selecting good quality plants is possible only at the two-whorl stage and furthermore, the field performance too is superior with a high field establishment rate and uniform growth.

The primary objective of this study was to demonstrate the field performance of different planting materials while comparing the bare roots and young buddings at a commercial scale on field establishment, growth and yield.

MATERIALS AND METHODS

This trial was conducted at the Galewatta division of the Dartonfield group, the estate belongs to the RRISL which is located in the Kalutara District. The agro-climatic region is the low country wet zone (WL1) and is situated between 6° 32’ N and 80° 09’ E (Survey Department of Sri Lanka. The climate of this region is characterized by a mean monthly temperature of 22-31°C, ample rainfall around the year with no marked dry periods, high ambient humidity (88%), moderate wind, and bright sunshine. The soil type belongs to the Agalawatta series, which is silty clay loam in texture and strong brown to yellowish red (Red Yellow Podzolic).

Young budding plants of clones RRIC 121 and RRISL 201 and bare root budded stumps of clones RRIC 121 and PB 260 were used. The number of plants per each type and clone was 500 but only 185 young buddings of RRISL 201 were available for the trial. Field planting was done with the onset of the North East monsoon in the year 2007. Paddy straw application was done during the first five years and all other recommended agronomical practices were followed (Advisory circulars: 2016/04, 2016/07 and 2016/09).

Growth measurements of the trees were taken annually and the girth was measured at a height of 120 cm from the graft union. The thickness of bark in trees was measured at a height of 150 cm from the graft union in virgin bark, using a bark gauge. Tapping commenced in the year 2013 when six years were completed from planting. d3 tapping system was also tested with d2 clones to see the performances of the clones under d3 except for the clone PB 260 which is a d3 clone. The calculation of the yield per hectare was based on 450 trees and 160 and 107 number of tapping days for d2 and d3 tapping, respectively.

RESULTS

The main difference between the bare roots and the young buddings observed was the field establishment rate. Young buddings of both RRIC 121 and RRISL 201 resulted in 100% field establishment, partly due to planting them with the onset of the monsoon rains. Figure 1 shows a young budding plant of RRIC 121, three months after field planting. As it can be seen in Figure 1, two more leaf whorls have been grown. This was the case for the young buddings of RRISL 201 also.

Fig. 1. A young budding plant of RRIC 121 three months after the field planting showing two more leaf whorls grown

On the other hand bare root budded stumps showed a big variation in sprouting time. While some bare roots grew up to two leaf whorl stage some were only sprouting. About 10-15% of casualties and plants not sprouted were also replaced with new plants which increased the variation in growth among bare roots. Three bare roots of clone RRIC 121 are shown in Figure 2.

Fig. 2. The growth variation among bare root budded stumps of RRIC 121.

Figure 3 shows the bare root budded stumps of clone PB 260. Where one plant is grown up to two leaf whorl stage, the other plant has grown up to one leaf whorl with a very short intermodal length and only a few leaves attached to it.

Fig. 3. The growth variation of bare root budded stumps of PB 260.

Accordingly, field establishment can be maintained at a satisfactory level even with bare root budded stumps if the planting is completed with the onset of monsoon rains. But the variation among plants cannot be avoided as the sprouting time varies from one to another.

The average girth of the four different types of planting materials was measured at 120 cm from the graft union, on three occasions, *i.e.* 3 years after planting (in 2010), at the commencement of tapping (in 2013), and 3 years after the commencement of tapping (in 2016) are given in Table1.

Table 1. *Average girth at 120 cm from the graft union, 3 years after planting (in 2010) at the commencement of tapping (in 2013) and 3 years after the commencement of tapping (in 2016)*

Clone and the Type	**Average girth (cm)**		
	3 years after planting (2010)	**when tapping commenced (2013)**	**3 years after the commencement of tapping (2016)**
RRIC 121 Young budding	30.70±0.56	51.30±0.33	69.77±1.80
RRIC 121 Bare root	25.10±0.21	49.70±0.98	61.15±1.72
RRISL 201 Young budding	27.10±0.09	55.50±0.62	70.60±1.25
PB 260 Bare root	27.50±1.54	50.50±0.04	62.57±1.36

In order to compare the growth performance of the young buddings and bare root budded stumps, the average annual girth of the two types of planting materials from 2009 to 2014 is given in Figure 4.

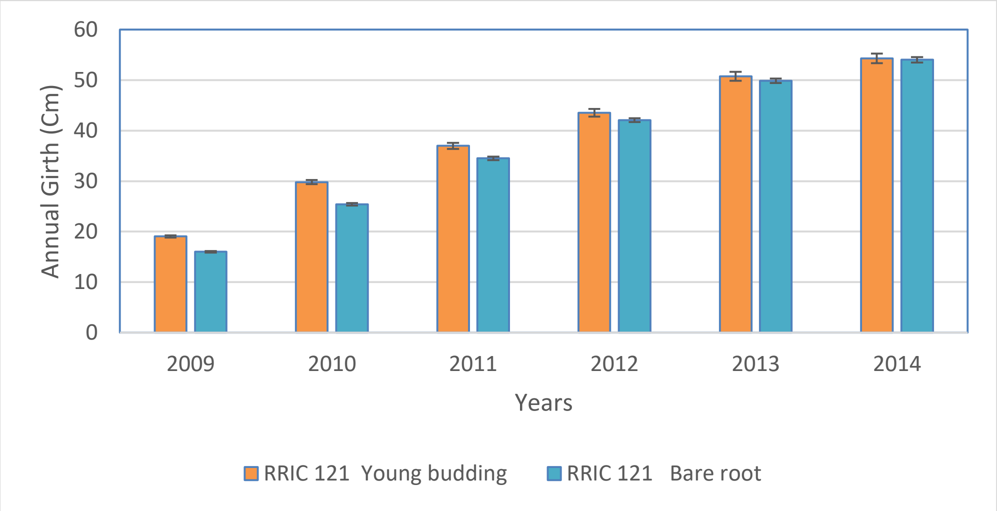

Fig. 4. The average annual girth of the young buddings and bare root budded stumps of clone RRIC 121 from 2009 to 2014. (The data presented of the graft are the means ±SEM of n = 500)

The percentage of plants in each of the girth classes the bare root budded stumps and the young buddings of clone RRIC 121, after 4 years of planting is shown in Figure 5.

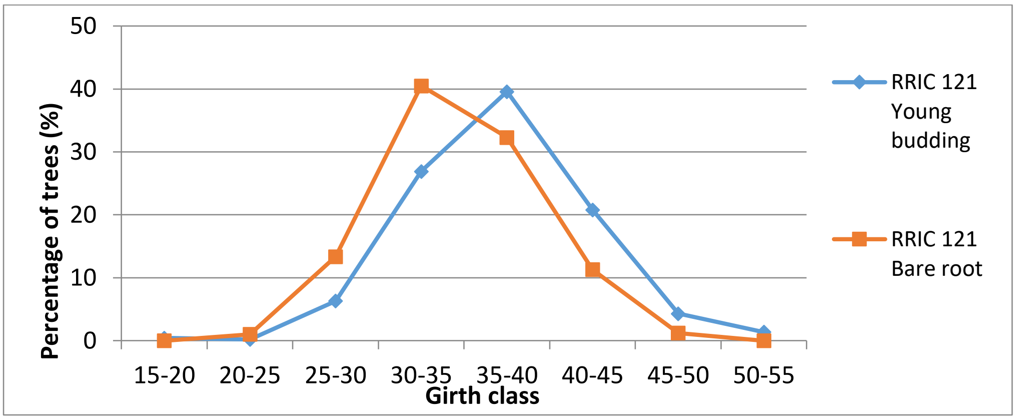

Fig. 5. The percentage of plants in each of the girth classes, the bare root budded stumps, and the young buddings of clone RRIC 121, after 4 years of planting

However, the clonal difference is also observed within each type of planting material as shown in Table 2 and Figure 6 for bare root budded stumps of clone RRIC 121 and PB 260.

Table 2. *The average annual girth of the bare root budded stumps of clone RRIC 121 and PB 260 from 2009 to 2014*

Year	**RRIC 121 Bare root (cm)**	**PB 260 Bare root (cm)**
2009	16.04	17.35
2010	25.42	27.42
2011	34.50	37.40
2012	42.05	44.06
2013	49.85	50.66
2014	54.00	55.06

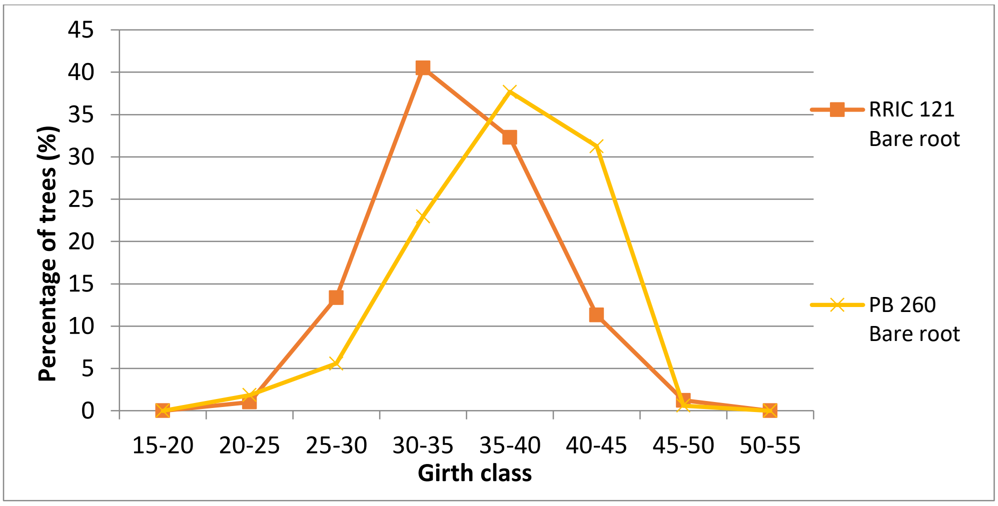

Fig. 6. The percentage of plants in each of the girth classes of bare roots of clone RRIC 121 and PB 260 after 4 years of planting

The bark thickness measured at the age of 5 years of field planting show differences among different types of planting materials as shown in Table 3.

Table 3. *Average girth (cm) and the average bark thickness (mm) of different planting materials at the age of 5 years of field planting*

Planting material	Average girth (cm) at 120 cm	Average Bark thickness mm) at 120 cm
RRIC 121 young budding plants	45.41	6.31
RRIC 121 bare root plants	43.20	3.75
RRISL 201 young budding plants	48.37	7.89
PB 260 bare root plants	47.56	5.09

The lower average bark thickness could be attributed to the high variation in the girth of bare root budded stumps and runts or very small trees having lower bark thicknesses.

The yield of the different types of planting materials as grams per tree per tapping and calculated yield per hectare at the second year of tapping are given in Table 4.

Table 4. *The average yield of the different types of planting materials as grams per tree per tapping and calculated yield per hectare at the second year of tapping*

Clearing	Tapping system	Yield (g/t/t)	Yield (kg/ha/year)
RRIC 121 Young budding	S/2d2	28.07	2105.19
RRIC 121 Bare root	S/2d2	26.72	2003.94
RRISL 201 Young budding	S/2d2	32.41	2430.56
PB 260 Bare root	S/2d3	22.32	1683.85

The lower g/t/t of bare root budded plants could be due to high variation in girth resulting in high variation in bark thickness. The tapping system was changed, in one-half of each field after 5 years of tapping, except for PB 260 from d2 frequency to d3 frequency. The tapping frequency of PB 260 was changed from d3 to d4 without stimulation and the results are given in Table 5 as grams per tree per tapping and calculated kg per hectare per year

Table 5. *The crop as grams per tree per tapping and calculated kg per hectare per year after changing the tapping frequency after 5 years of tapping*

Tapping block	Tapping system	Yield (g/t/t)	Yield (kg/ha/y)
RRIC 121 Young budding	$S/2d_2$	24.62	1858.46
RRIC 121 Young budding	$S/2d_3$	26.04	1953.00
RRIC 121 Bare root	$S/2d_2$	23.68	1730.77
RRIC 121 Bare root	$S/2d_3$	24.61	1846.00
RRISL 201 Young budding	$S/2d_2$	37.84	1967.68
RRISL 201 Young budding	$S/2d_3$	41.38	2151.50
PB 260 Bare root	$S/2d_3$	38.45	2114.75
PB 260 Bare root	$S/2d_4$	41.66	2291.67

As expected all types of planting material show higher g/t/t at lower frequency tapping.

The incidence of Tapping Panel Dryness (TPD) was taken 3 years after changing the tapping frequency in one half of each block *i.e.* 8 years after opening for tapping is given in Table 6.

Table 6. *The incidence of Tapping Panel Dryness (TPD) after 3 years of changing the tapping frequency in one-half of each block (8 years after opening for tapping)*

Clone and the type of planting material	Tapping system introduced after 5 years of tapping at d2 frequency	% of trees with Tapping Panel Dryness (TPD)
RRIC 121 Young budding	$S/2d_2$	8.85
RRIC 121 Young budding	$S/2d_3$	8.33
RRIC 121 Bare root	$S/2d_2$	10.20
RRIC 121 Bare root	$S/2d_3$	6.00
RRISL 201 Young budding	$S/2d_2$	10.00
RRISL 201 Young budding	$S/2d_3$	5.88
PB 260 Bare root	$S/2d_3$	18.46
PB 260 Bare root	$S/2d_4$	14.16

The incidence of TPD has decreased with a reduced frequency of tapping of all four types of planting materials. RRISL 201 being a higher yielding clone shows a higher reduction in the incidence of TPD than the other clones.

DISCUSSION

The quality of planting material is one of the key factors which determines rubber production and the productivity. The comparison in the present study is to see the performance of bare root budded stumps and young budding plants of the same clone on a commercial scale. As the planting was done with the onset of the monsoon rains and following all Rubber Research Institute recommendations, the casualty rate is minimum in the trial even with bare root budded stumps. If the vacancies created due to the death of a plant are not filled with a suitable plant, the stand of the clearing at tapping would be lower than the recommended 516 trees per hectare which in turn affects productivity.

The main difference between the bare root budded stumps and young buddings is the quality of the plants. As young buddings have two leaf whorls at the time of planting, the quality can be certified with external characteristics such as the angle of the shoot to the vertical, intermodal length, the diameter of the main stem, *etc.* The ability to identify the clone using leaves, shape of the top whorl of leaves, and stem characters is an added advantage of young buddings. Age of the plant at planting is the most important factor which directly affects the growth rate and also the length of the immature phase. There is no guarantee or a method to calculate the age of bare root budded stumps. Sometimes, weak seedlings grow up to buddable size in ground nurseries after three years or so. Such plants can be grafted and sold but the fast growth rate and immature phase will last only for another 3-4 years. As the tree enters the mature phase not only does the growth rate retards but also the tree will start flowering and wintering. Such trees will never reach a tappable girth of 50 cm measured at 120 cm from the ground level or the graft union even after about 10 years. Further, the variation among the trees of a clearing established with bare root budded stumps is so high and affects productivity. In the present study, the difference between the average girth of the two types is minimum and decreases with the age of the trees.

Differences between the clones are observed in young buddings as well as bare root budded stumps. The young buddings of clone RRISL 201 show a higher average girth of the trees than the same of RRIC 121. Also, PB 260 bare root budded stumps perform better than bare root budded stumps of RRIC 121.

As far as yield is concerned, the g/t/t values are always higher at a lower frequency and thereby the calculated crop is higher, though the number of tappings is lower with low frequency harvesting. The higher TPD percentage is observed with bare root budded stumps which could be partly due to runts getting tapped in fields established with bare root budded stumps. However, TPD incidences have a closer relationship with the tapping frequency, which is evident in the results of the present trial as well. Generally, high-yielding clones are more sensitive to the frequency of tapping and show a high percentage of TPD.

REFERENCES

Advisory circular No. 2016/04. (2016). Fertilizer to Rubber. Soils and Plant Nutrition Department. Rubber Research Institute of Sri Lanka, Agalawatta.

Advisory circular No. 2016/07. (2016). Field Establishment & Immature Upkeep. Plant Science Department. Rubber Research Institute of Sri Lanka, Agalawatta.

Advisory circular No. 2016/09. (2016). Production of Budded Plants. Plant Science Department. Rubber Research Institute of Sri Lanka, Agalawatta.

Ong, T S, Heh, W.Y and Wong, C.P. (1989). Young Budding – Commercial experience in a large plantation group. *Proceedings of the Rubber Growers Conference***,** 110-124.

Seneviratne, P**.** and Nugawela, A. (1996)**.** Use of young buddings as planting material in Sri Lanka. *Proceedings of IRRDB meeting*, Beruwala, Sri Lanka, 1-7.

Seneviratne, P. (1995). Young budding - A better planting material. *Bulletin of the Rubber Research Institute of Sri Lanka*, **32**(1), 35-38.

Seneviratne, P., Nugawela, A., Amaratunge, K.A.G.B. and Samarakoon, S.M.A. (1996). Uniform and early sprouting of young buddings and budded stumps of rubber. *Bulletin of the Rubber Research Institute of Sri Lanka*, **34**, 1-8.

Bulletin of the Rubber Research Institute of Sri Lanka, (2021) **58**, 65-77

THE HISTORICAL RUBBER – RICE PACT

Priyani Seneviratne

Rubber – Rice Pact is also called "Ceylon-China Trade Agreement in 1952", which was made exactly 70 years ago. This is known to be the most successful and durable agreement the pact was in operation for 30 years, benefitting Sri Lanka immensely. Mr R G Senanayake, then Minister of Commerce is honored to have brought this about.

Late R G Senanayake, Hon. Minister of Commerce in 1952

The government formed by Hon. Dudley Senanayake, in 1951 after the death of Premier D S Senanayake, faced a crisis of shortage of rice and a severe economic crisis which was aggravated by the world economic collapse.

Yet, the government was committed to provide every adult with two measures of rice per week at a subsidized price. However, rice was not available from regular suppliers such as Burma, Thailand and Indo-China and the world market for rice had risen by 38% from 1951 to 1952. Therefore, Sri Lanka had bought 60,000 tons and 10,000 tons of rice from USA and Equador respectively at a high price but discontinued it mainly due to rejection by the people for its taste and quality. Limited availability of foreign exchange had equally contributed to discontinue this importation. It is believed that the collapse of the export prices of the commodities by 23% from 1951 to 1952 was the key reason for foreign exchange crises. In particular, the price of natural rubber had declined by 36%, tea by 10% and coconut by 40%.

This situation has turned the trade surplus of Rs.345 million in 1951 into a trade deficit of Rs.200 million in 1952. Also, USA had not been supportive for any of the requests from the Sri Lankan government to supply rice at a lower price or to buy rubber at a reasonable price.

In the meantime, The Minister of Commerce Mr R G Senanayake has been successful in getting the advantage of the UN resolution imposed against China which prevented China to buy rubber from Malaya. As Sri Lanka was desperate to import rice, the negotiation with China on exchanging rice and rubber between the two countries was a smart: option.

Facing the opposition within the parliament had been the most difficult obstacle in going ahead with the Trade-agreement. China’s communism had been the main concern of the opposition. Due to this agreement Sri Lanka had with China, USA had not only stopped giving aid to Sri Lanka but also had stopped selling sulphur needed by Sri Lanka’s rubber plantations. The rubber trees were treated with sulphur dust to alleviate leaf diseases at the time. However, the Prime Minister Hon. Dudley Senanayake had realized that the benefits to Sri Lanka from this agreement far outweighed the losses due to cutting off of American aid and sulphur. Signing the trade agreement was a courageous step with a country having 500 million people and it has come a long way and influences the world market of commodities at present.

Essence of the Agreement.

This remarkable and historical agreement signed on 18.12.1952 was for a five year duration and renewable annually with negotiations based on quantities of rubber and rice needed by the two countries.

This solved the problems of lack of foreign currency required to purchase rice, as only the balance money after deducting the cost of rubber supplied to China was to be settled in foreign exchange if occurs. Whenever there was a balance to be settled by Sri Lanka to China, it had been further alleviated by the agreement as it allowed for carrying forward any outstanding balance to the following year without a settlement in foreign exchange. The arrangements on settling money and how the operations should take place are interesting and the copy of the agreement attached to this has all the details. The quantities that have been in the agreement for the year 1953 were to exchange 270,000 tons of rice from China and 50,000 tons of rubber on the basis of world market prices.

In addition, China had agreed to pay a premium price for rubber above the world market prices, (Singapore price), and handling charges for rubber exports in Colombo. Accordingly in 1953, China had paid Rs.1.74 per lb for Sri Lanka rubber whereas the average world market price was Rs.1.05 per lb. This premium price had changed with renewal of the agreement every five years along with fixed handling charge which was five cents per lb. Further, China had supplied rice to Sri Lanka below the world market price, Rs.720 per ton in 1953. Interestingly, this trade agreement had been renewed every 5 years by the successors to R G Senanayake’s ministerial post in

1958, 1962, 1967,1972 and in 1977 and wound up in 1982 due to lack of mutual interest in exchanging rubber and rice by both countries.

How the Minister R G Senanayake paid his tribute to China after negotiating with them is proved by what he had written in the Cabinet Paper asking for the approval for the Trade Agreement.

"We noted on the Chinese side the absence of the spirit of bargaining and haggling on comparatively small points. On the other hand, they gave us the impression of being large-minded and forthright in their dealings".

As per the records available, the premium received over the world market price during 1953 along had been 68-195 million Rupees, which was 56% higher than the world market.

The net benefit gained through rice imported from China through this agreement in 1953 was reported as Rs.92 million. It is noteworthy to mention that when China did not have exportable surplus rice, using a triangular trade agreement the quantity agreed had been supplied from Burman to Sri Lanka without charging anything extra.

More importantly, as a result of the agreement, to get rubber from Sri Lanka, a grant of Rs.125 million was received from China, to meet part of the costs of rubber replanting in Sri Lanka during the ten year period from 1958 to 1968. Thousands of acres of uneconomic rubber lands had been replanted revitalizing the rubber industry using this money. Even after the agreement in 1982, China had paid a premium price for rubber bought from Sri Lanka similarly supplying rice had also been continued.

Further, diplomatic relationships between the two countries had been strengthened by the late Mr S W R D Bandaranayke followed by the late Mrs Sirima R D Bandaranayake as the Prime Minister which is symbolized by the Bandaranayake Memorial International Conference Hall (BMICH) which is a kind of monument to the country. Further, a superior courts complex, Gin ganga scheme and assistance given to restore Abayagiri stupa etc., were followed. The strengthened friendship between Sri Lanka and China is maintained to date, as believed to have started with the Rubber-Rice pact signed in 1952.

It is with great pleasure that I report here, by 1982, Sri Lanka had been almost self-sufficient in rice and only a small quantity had been imported from other countries. China too had been able to purchase rubber from several other rubber growing countries and mostly without paying a premium.

A copy of the agreement was collected from the Sri Lanka Archives Department and is attached as an annex hoping that the details are interesting to read [Annexure 01].

FIVE-YEAR TRADE AGREEMENT RELATING TO RUBBER AND RICE BETWEEN THE GOVERNMENT OF CEYLON AND THE CENTRAL PEOPLE'S GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA

For the purpose of strengthening the friendship between the Governments and the peoples of Ceylon and China and of promoting long-term collaboration in trade between the two countries, the Government of Ceylon and the Central People's Government of the People's Republic of China (hereinafter referred to as the Government of China) have, on a basis of equality and mutual benefits, reached agreement as follows:-

ARTICLE I.

(1) The Government of Ceylon agrees to sell and the Government of China agrees to purchase sheet rubber in Ceylon for exportation to China during the period of five years commencing on the date of ratification of this Agreement by both Governments at the rate of 50,000 (Fifty Thousand) metric tons each year.

(2) The Government of China agrees to sell and the Government of Ceylon agrees to purchase rice in China for exportation to Ceylon during the period of five years commencing on the date of ratification of this Agreement by both Governments at the rate of 270,000 (Two Hundred Seventy Thousand) metric tons each year.

ARTICLE II.

(1)

(a) The price per pound for all purchases

of ....

of sheet rubber of Grades 1, 2 & 3 and the price per pound for all purchases of sheet rubber of Grades 4 & 5 made by the Government of China in terms of this Agreement, shall be fixed respectively by mutual agreement between the Government of Ceylon and the Government of China, having regard to paragraph (2) of this Article, and shall be applicable to all purchases of sheet rubber made during the period of one year commencing on a date to be determined at the time of fixation.

(b) The price per metric ton for all purchases of rice made by the Government of Ceylon in terms of this Agreement shall be fixed by mutual agreement between the Government of Ceylon and the Government of China at the same time that the aforementioned prices of sheet rubber are fixed and shall be applicable for the same period of one year.

(c) The prices for sheet rubber and rice shall be fixed, in accordance with sub-paragraphs (a) and (b) of this paragraph, once each year for a period of one year during the validity of this Agreement, and shall be fixed at least one month before the end of the preceding period of one year referred to in sub-paragraphs (a) and (b) of this paragraph.

(2) The Government of China agrees to pay for Grades 1, 2 & 3 and for Grades 4 & 5 of sheet rubber, purchased in Ceylon in terms of this Agreement, a price in excess of the average Singapore F.O.B. market price for Grades 1, 2 & 3 and for Grades 4 & 5 of sheet rubber respectively.

(3) ....

2

(3) The average Singapore F.O.B. market price for Grades 1, 2 & 3 sheet rubber referred to throughout this Article shall be the weighted average over one calendar month, using as weights the percentages of Grades 1, 2 & 3 sheet rubber to be supplied under the rubber contract which is signed under Article V and which is in force at the time. The average Singapore F.O.B. market price for Grades 4 & 5 sheet rubber shall be calculated in the same way.

(4)

(a) Whenever the average Singapore F.O.B. market price for sheet rubber of Grades 1, 2 & 3 over any one calendar month in the period of one year for which the price has been fixed under sub-paragraphs (a) and (c) of paragraph (1) of this Article, exceeds the current price for sheet rubber of Grades 1, 2 & 3 fixed under the provisions of this Article, the Government of China agrees that new prices for Grades 1, 2 & 3 sheet rubber and Grades 4 & 5 sheet rubber shall be negotiated, having regard to paragraph (2) of this Article, if a request for the revision of prices is made by the Government of Ceylon in the month following the calendar month in which the average Singapore F.O.B. market price for sheet rubber of Grades 1, 2 & 3 exceeds the current price for sheet rubber of Grades 1, 2 & 3 fixed under the provisions of this Article.

(b) If the Government of Ceylon makes a request as provided for in sub-paragraph (a) of

this ....

M

this paragraph for revision of the prices fixed for sheet rubber, the Government of China is entitled at the same time to make a request for the revision of the price of rice, whereupon the Government of Ceylon agrees that new prices for rice shall be negotiated simultaneously.

(c) Any new prices fixed under sub-paragraphs (a) and (b) of this paragraph shall be applicable to all purchases of sheet rubber and rice made in terms of this Agreement during the period commencing from a date to be determined at the time of fixation of the new prices to the end of the period of one year for which the prices were originally fixed under paragraph (1) of this Article. Any such new prices may also be revised under the preceding provisions of this paragraph. Any prices for sheet rubber and rice fixed under paragraph (1) of this Article, or any revised prices for sheet rubber and rice fixed under paragraph (4) of this Article, shall remain in force at least for a period of three months. Within such period of three months, both Governments shall have the right under paragraph (4) of this Article to seek negotiations for the revision of prices, but any new prices resulting from such negotiations will not be effective until the expiry of the period of three months from the date on which the prices last fixed became effective.

(d) Until any new price that might be fixed under the preceding provisions of this paragraph becomes

effective, ...

effective, purchase and sale of sheet rubber and rice under this Agreement shall be carried out by the two Governments in compliance with all provisions of the contracts signed under Article V which are in force at the time.

(5)

(a) In terms of paragraph (1) of this Article and having regard to paragraph (2) of this Article, the Government of Ceylon and the Government of China agree, subject to paragraph (4) of this Article, that the price per pound for all sheet rubber of Grades 1, 2 & 3 purchased under this Agreement shall be 32d (Thirty-two pence) F.O.B. Colombo and the price per pound for all sheet rubber of Grades 4 & 5 shall be 29d (Twenty-nine pence) F.O.B. Colombo during the first one year period commencing from the date of ratification of this Agreement.

(b) In terms of paragraph (1) of this Article, the Government of Ceylon and the Government of China agree, subject to paragraph (4) of this Article, that the price fixed for all rice purchased under this Agreement shall be £54 (Pounds Sterling Fifty-four) per metric ton F.O.B. China ports, during the same period of one year referred to in sub-paragraph (a) of this paragraph.

<u>ARTICLE III.</u>

(1) The sale of sheet rubber under this Agreement by the Government of Ceylon shall be made on a F.O.B. basis, and the

Government ....

Government of China shall be responsible for making all arrangements with respect to ocean freight for the exportation of all sheet rubber purchased in terms of this Agreement.

(2). The sale of rice under this Agreement by the Government of China shall be made on a F.O.B. basis, and the Government of Ceylon shall be responsible for making all arrangements with respect to ocean freight for the exportation of all rice purchased in terms of this Agreement.

ARTICLE IV.

(1) The Government of Ceylon will open an account in the Bank of China, Peking, and the Government of China will open an account in the Bank of Ceylon, Colombo, both accounts to be used solely for the purposes of financing the trade in sheet rubber and rice provided for in this Agreement.

(2) Notwithstanding that the price for sheet rubber is fixed under this Agreement in terms of Sterling, the full value of every shipment of sheet rubber exported from Ceylon to China in pursuance of this Agreement shall, upon presentation of the shipping and other necessary documents, be paid by the Government of China into the account of the Government of Ceylon, in the Bank of China, Peking, in Ceylon Rupees at the exchange rate current for the time being. The Bank of Ceylon, Colombo, will thereupon debit the account of the Government of China, in the Bank of Ceylon, Colombo, by the same amount.

(3) Notwithstanding that the price for rice is fixed under this Agreement in terms of Sterling, the full value of every shipment of rice exported from China to Ceylon in pursuance of this Agreement shall, upon presentation of the shipping and other necessary documents, be paid by the Government of Ceylon into the

account ....

account of the Government of China, in the Bank of Ceylon, Colombo, in Ceylon Rupees at the exchange rate current for the time being. The Bank of China, Peking, will thereupon debit the account of the Government of Ceylon in the Bank of China, Peking, by the same amount.

(4) The exchange rate referred to in paragraphs (2) and (3) of this Article shall be the average of the official buying and selling rates of exchange of the Ceylon Rupee as against the Pound Sterling at the time of presentation of shipping and other necessary documents referred to in paragraphs (2) and (3).

(5) The accounts established respectively by the Government of Ceylon and the Government of China under paragraph (1) of this Article, shall be settled once every three months by the Bank of China, Peking, and the Bank of Ceylon, Colombo, who shall also arrange between themselves all procedural matters arising therefrom. Any credit balance then outstanding may be carried forward or settled by payment in Sterling, or in any other manner as may be mutually agreed upon between the two Governments.

ARTICLE V.

(1) For the implementation of the trade in sheet rubber and rice in terms of this Agreement, contracts for sheet rubber and rice each covering a period of one year and including such items as specifications, unit prices, shipping, time of delivery, ports of delivery, arbitration, method of payment, quality and weight inspection, shipping documents, and any other necessary terms and conditions, shall be signed by the two Governments each year.

(2) In order to assure the implementation of this

Agreement, ...

Agreement, the annual contracts for sheet rubber and rice shall be negotiated and signed simultaneously. During the period of validity of the contracts, if one of the two Governments should fail to carry out its obligations under either contract, the other Government shall be automatically released from all its obligations under the other contract.

ARTICLE VI.

The contracts for the first year for sheet rubber and rice signed between the Government of Ceylon and the Government of China under Article V of this Agreement shall be regarded as the execution of a part of the General Trade Agreement signed between the Government of Ceylon and the Government of China in Peking, on the 4th October, 1952.

ARTICLE VII.

During the period of validity of this Agreement, any revision, if proposed by either of the two Governments, shall be made only upon agreement by the other Government.

ARTICLE VIII.

This Agreement may be extended through further negotiations, if a suggestion to that effect is made at least two months prior to the date of its expiry by either Government and is agreed to by the other Government.

ARTICLE IX.

This Agreement shall become effective for a period

of ....

of five years upon ratification by both Governments.

Signed in Peking on December 18th, 1952, in two copies, each copy written in the English and Chinese languages, both texts being equally valid.

REPRESENTATIVE FOR THE GOVERNMENT OF CEYLON

Susantha de Fonseka

REPRESENTATIVE FOR THE CENTRAL PEOPLE'S GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA

高存信

2022

03 16

20 22 මාර්තු මස 16 වෙනි දින
අංක 07, පිලිප් ගුණවර්ධන මාවතේ
ජාතික ලේඛනාරක්ෂක දෙපාර්තමේන්තුවේ දීය.

ජා.ලේ/8/3/ 1 / 10 / 179 / 2022

මෙම දෙපාර්තමේන්තුවේ තැන්පත් ලේඛනයක
සත්‍ය ඡායා පිටපත් බව සහතික කරමි.

....
ජාතික ලේඛනාගාර අධ්‍යක්ෂ ජනරාල් වෙනුවට

එම්.ඒ. මහින්ද ධර්මසිරි
ජ්‍යෙෂ්ඨ ලේඛනාරක්ෂක (රා.ආ.)
ජාතික ලේඛනාරක්ෂක දෙපාර්තමේන්තුව
නො.07, පිලිප් ගුණවර්ධන මාවත,
කොළඹ 07.