CONTENTS

BIOLoGY & CULTIVATION

Satellite-based remote sensing technique as a tool for real time monitoring of leaf retention in natural rubber plantations affected by abnormal leaf fall disease
B. Pradeep, Shanker Meti and James Jacob

Assessing agricultural drought in natural rubber plantations using MODIS Terra satellite data
S. M. Shebin, Shanker Meti, James Jacob, B. Pradeep and M. D. Jessy

Evaluation of growth and yield performance of wild Hevea germplasm in Tripura
Krishna Das, F. Deepthy Antony and S. K. Dey

Performance of certain exotic and indigenous clones of Hevea brasiliensis
V. C. Mercykutty, T. Meenakumari and Kavitha K. Mydin

Continued on back cover
CONTENTS

BIOLOGY & CULTIVATION

Satellite-based remote sensing technique as a tool for real time monitoring of leaf retention in natural rubber plantations affected by abnormal leaf fall disease
B. Pradeep, Shanker Meti and James Jacob 1

Assessing agricultural drought in natural rubber plantations using MODIS Terra satellite data
S. M. Shebin, Shanker Meti, James Jacob, B. Pradeep and M. D. Jessy 8

Evaluation of growth and yield performance of wild Hevea germplasm in Tripura
Krishna Das, P. Deepthy Antony and S. K. Dey 15

Performance of certain exotic and indigenous clones of Hevea brasiliensis
V. C. Mercykutty, T. Meenakumari and Kavitha K. Mydin 22

Twin rootstock plants of Hevea do not perform better than single root stock plants
Thomson Abraham, V. C. Mercykutty and Joseph G. Marattukalam 30

Long-term yield and growth performance of IRCA rubber clones in India
C. P. Reghu, G. P. Rao and Jayashree Madhavan 38

Plant regeneration via somatic embryogenesis from root explants in Hevea brasiliensis
S. Sushamakumari, K. Rekha, S. Sobha and U. K. Divya 45

Agromanagement techniques to mitigate drought in young rubber plantations
M. D. Jessy, P. Prasannakumari and James Jacob 54

Field evaluation of progenies of a canopy mutant of Hevea brasiliensis
T. Gireesh and Kavitha K. Mydin 61

Standardization of an alternative potting medium for raising Hevea plants in root trainers
T. A. Soman, Kavitha K. Mydin and M. D. Jessy 69

Inheritance of tapping panel dryness in a full-sib population of Hevea brasiliensis
Narayanan Chaendaekattu and Kavitha K. Mydin 78

EDITORIAL BOARD

Patron
Sheela Thomas IAS

Editor-in-Chief
Dr. James Jacob

Editors
Dr. R. Krishnakumar
Dr. Siby Varghese

Secretary
Dr. C. P. Reghu

Associate Editors
Dr. Kochuthresiamma Joseph
Dr. K. Karunaichamy
Dr. Joshua Abraham
Ms. K. Rekha
Mr. M. J. Reju
Ms. Phebe Joseph

Editorial Board Members
Dr. A. Thulaseedharan
Dr. Rosamma Alex
Dr. S. K. Dey

Treasurer
CA. Zachariah Kurian
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient and heavy metal status of soils under rubber-pineapple intercropping in comparison to rubber-cover crop system and natural forest</td>
<td>P. Prasannakumari, M. D. Jessy, P. A. Antony, Joseph Chacko and James Jacob</td>
<td>84</td>
</tr>
<tr>
<td>Pink disease of <em>Hevea brasiliensis</em> in northern West Bengal and North East India</td>
<td>G. C. Mondal, H. K. Deka, Shammi Raj and Sabu P. Idicula</td>
<td>91</td>
</tr>
<tr>
<td>CHEMISTRY &amp; TECHNOLOGY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peroxide vulcanization of polymers</td>
<td>Rejitha Rajan, Siby Varghese and K. E. George</td>
<td>98</td>
</tr>
<tr>
<td>Superior processing rubber from radiation cross-linked natural rubber latex</td>
<td>Joy Joseph, P. S. Sadeesh Babu, K. N. Madhusoodanan and Rosamma Alex</td>
<td>127</td>
</tr>
<tr>
<td>Stable free radical assisted scorch control in peroxide vulcanization of EPDM</td>
<td>Benny George and Rosamma Alex</td>
<td>135</td>
</tr>
<tr>
<td>Optimization of process parameters for stable ZnO dispersions</td>
<td>K. Anand, Siby Varghese, Shera Mathew and Thomas Kurian</td>
<td>146</td>
</tr>
</tbody>
</table>

Figure on cover
Embryyo induction
See Sushamakumari *et al.*, pages 45-53
SATELLITE-BASED REMOTE SENSING TECHNIQUE AS A TOOL FOR REAL TIME MONITORING OF LEAF RETENTION IN NATURAL RUBBER PLANTATIONS AFFECTED BY ABNORMAL LEAF FALL DISEASE

B. Pradeep, Shanker Meti and James Jacob
Rubber Research Institute of India, Kottayam – 686 009, Kerala, India

Received: 10 April 2014 Accepted: 20 May 2014

Most parts of the traditional natural rubber growing regions of India, extending from Kanyakumari district in the south to Kasaragod district in the north received excess and prolonged rains during 2013. This led to severe incidence of Abnormal Leaf Fall (ALF) disease caused by the fungus, Phytophthora sp. We demonstrate here for the first time the use of satellite-based remote sensing technique to monitor LAI in natural rubber holdings in real time. Leaf retention was monitored every month between April and December 2013 using real time satellite-based remote sensing measurements from rubber holdings spread across all districts in the traditional rubber growing region of the country that were earlier mapped using satellite imageries. Corresponding LAI data for 2012 was also similarly estimated from satellite data. It was found that as the monsoon advanced, LAI decreased substantially in both years, but the reduction was much more substantial and prolonged in many districts during 2013 than 2012, reflecting increased leaf fall due to ALF disease in 2013. The decline was more pronounced in central and northern Kerala than in the south. Kanyakumari district is generally known to be free from ALF disease, but there was considerable leaf loss due to ALF in June 2012 and June and July 2013 even as the monsoon was unusually severe in 2013. Weighted mean LAI for the entire period of April to December was estimated based on LAI and per cent of total area under rubber in each district for the two years. This was markedly less in 2013 than 2012. The implications of poor leaf retention for biomass production (net primary productivity), carbon sequestration and rubber yield are discussed.

Keywords: Abnormal leaf fall, Leaf area index, MODIS, Remote sensing

INTRODUCTION

Almost 90 per cent of India’s natural rubber is produced from the traditional rubber growing regions that stretch from Kanyakumari in the south to Kasaragodu in the north (IRSI, 2012). This part of the country has been witnessing marked rise in temperature in recent years and decades (Jacob and Satheesh, 2010; Raj et al., 2011; Satheesh, 2014). Earlier analyses have shown that for a unit concomitant rise in maximum
ASSESSING AGRICULTURAL DROUGHT IN NATURAL RUBBER PLANTATIONS USING MODIS TERRA SATELLITE DATA

S.M. Shebin, Shanker Meti, James Jacob, B. Pradeep and M.D. Jessy
Rubber Research Institute of India, Kottayam, Kerala, India- 686 009
*University of Horticultural Sciences, Bagalkot, Karnataka, India

Received: 12 January 2014 Accepted: 30 April 2014


Drought assessment and monitoring are important in the management of a crop particularly in the context of global warming and climate change. Rubber being a perennial crop goes through periods of moisture deficits during different phases of its growth. Real or near real time drought monitoring is required for adopting proper management strategies to mitigate the adverse effects of drought. Satellite-based remote sensing techniques are increasingly becoming handy in assessing and monitoring drought in many crops. Severe drought during the summer season results in appreciable reduction in growth and yield in natural rubber. In the present study, an attempt has been made to identify the spatial extent of agricultural drought stress in natural rubber plantations of Kerala and Kanyakumari district of Tamil Nadu using satellite based remote sensing data and GIS. By combining remotely sensed land surface reflectance and thermal properties from Terra MODIS, changes in land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) over a region is estimated. Vegetation Temperature Condition Index (VTCI), derived from the association between NDVI and LST gives an estimate of the temperature status of the vegetation for a given NDVI which is an indirect reflection of the soil moisture status. Our results indicate that VTCI is a powerful proxy estimate of the drought stress rubber plantations experience during peak summer season in Kerala and Kanyakumari district of Tamil Nadu.

Keywords: Land surface temperature, NDVI, Terra MODIS, VTCI.

INTRODUCTION

Assessing and monitoring drought in time and space is important in the agronomic management of any crop. Measurement of thermal radiation from the earth surface in the infrared wavelength of the electromagnetic spectrum yields useful information for monitoring drought (Wan et al., 2004; Parida, 2006; Mukund, 2008). Several studies have used different vegetation indices like NDVI which represent vegetation vigour as an indicator of soil water availability. NDVI is the most popularly used vegetation index, but this index is a rather conservative indicator of water stress as the vegetation remains green well after water deficit stress has set in (McVicar and Bierwirth, 2001) and this is particularly so in a perennial tree crops such as natural rubber.

Correspondence: S. M. Shebin. (Email: shebin.gis@gmail.com)
EVALUATION OF GROWTH AND YIELD PERFORMANCE OF WILD HEVEA GERMPLASM IN TRIPURA

Krishna Das,* P. Deepthy Antony and S.K. Dey

*12112, Prestige Shanthiniketan, Whitefield Main Road, Bangalore - 560 048
Regional Research Station, Rubber Research Institute of India, P.O. Kunjaban, Agartala - 799 006, Tripura

Received: 12 September 2013  Accepted: 24 January 2014


The presently cultivated clones of Hevea brasiliensis represent only a very small gene pool. Considering the urgent need for broadening the narrow genetic base of Hevea, the wild germplasm collected through the 1981 IRRDB expedition from the three states of Acre, Rondonia and Mato Grosso of Brazil needs to be utilized for further improvement of the crop.

Eighty seven accessions belonging to the 1981 IRRDB collections were evaluated in two trials in the experimental farm in Tripura, North East India. The present study revealed that certain accessions had superior growth character compared to the check clone, RRIM 600. Two accessions viz. MT 4713 (74.4 cm) and MT 4874 (72.7 cm) showed significantly higher girth than RRIM 600 (63.5 cm) in trial I. In trial II, the accessions RO 5449 (46.8 g t⁻¹t⁻¹) and MT 4788 (22 g t⁻¹t⁻¹) recorded high dry rubber yield and RRIM 600 yield 55.1 g t⁻¹t⁻¹. The accession MT 4713 also recorded the highest clear bole volume (0.11 m³) at the age of 13 years growth. Anatomical studies revealed that MT 4796 had the highest bark thickness (5.8 mm) and number of latex vessel rows (7.5) among the accessions evaluated. The accessions from Mato Grosso provenance revealed superiority for dry rubber yield in comparison with the accessions from Acre and Rondonia. The superior wild accessions identified for growth and yield in this study can be utilized as parents in future breeding programmes to enrich the available gene pool of Hevea.

Keywords: Gene pool, Growth and yield, Wild Hevea germplasm

Hevea brasiliensis (Willd. ex Adr de Juss.) Muell. Arg., a native of the Amazonian rain forest in Brazil, is the major source of natural rubber. Commercial rubber cultivation was the result of effective introduction of Wickham germplasm from the Amazonian rain forest of Brazil to the eastern hemisphere (Wycherley, 1968; Schultes, 1977) which consisted of a few surviving seeds collected by Sir Henry Wickham in 1876. Most of the clones under cultivation today are derived from the Wickham base and they represent a very small gene pool compared to the wide variability of the species in its natural habitat. This narrow genetic base has further narrowed down through directional selection for yield and wide spread adoption of clonal materials.
PERFORMANCE OF CERTAIN EXOTIC AND INDIGENOUS CLONES OF HEVEA BRASIILIENSIS

V.C. Mercykutty, T. Meenakumari and Kavitha K. Mydin
Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

Received: 19 April 2013 Accepted: 30 December 2013


A large scale trial, which is the second stage of clone evaluation in Hevea, was laid out at Central Experiment Station of Rubber Research Institute of India during 1994. Twelve clones consisting of three exotic hybrid clones introduced from Malaysia in 1993 and three indigenous hybrid clones and four ortets developed by RRII were evaluated along with RRII 105 and RRIM 600 as controls. Among the 12 clones, indigenous hybrid clone 86/44 recorded the highest yield of 67.17 g t⁻¹ t⁻¹ in the BO-1 panel over six years of tapping. The yield performance of introduced clone RRIM 712 (59.87 g t⁻¹ t⁻¹) and hybrid clone 86/120 (54.68 g t⁻¹ t⁻¹) were on par with that of RRII 105 (54.0 g t⁻¹ t⁻¹). The highest summer yield was recorded in 86/120 (38.31 g t⁻¹ t⁻¹) which was significantly superior to that of RRII 105 (29.64 g t⁻¹ t⁻¹).

Indigenous hybrid clone 86/120 showed significantly better girth over both the controls with a mean girth of 60.93 cm and maximum tappability of 88.63 per cent. 86/44 recorded 75 per cent tappability as against 70 per cent recorded for RRII 105. Incidence of wind damage and tapping panel dryness was comparatively low in the clone 86/44. 86/120 exhibited less incidence of pink disease. RRIM 712 was not affected by any forms of wind damage. The present investigation shows the superior performance of the hybrid clone 86/44.

Keywords: Clone evaluation, Growth and yield, Introduced clones, Large-scale trial

INTRODUCTION

Ortet selection and hybridization are the most important breeding methods adopted for crop improvement programme in Hevea which aims at improving latex yield and growth vigor. Ortet selection has resulted in the release of a number of primary clones from Malaysia, Indonesia, Sri Lanka and India. Such primary clones have helped to achieve significant improvement in yield in the early years of rubber cultivation in the South East Asian countries (Khoo et al., 1982). In hybridization, the heterogeneous seedling populations produced by hybridization programme are evaluated in the nursery, following which selected hybrids are cloned and evaluated in a phased manner in small scale trials, large scale trials and on-farm trials (Tan, 1987; Varghese and Mydin, 2000).

The Rubber Research Institute of India initiated conventional tree improvement programmes in 1954, for which the techniques adopted have been or the selection and hybridization (Nair and Panikkar, 1966; Nazeer et al., 1986; Saraswathyamma et al., 1992; Licy et al., 2003; Mydin and Mercykutty, 2007). Popular clones
TWIN ROOTSTOCK PLANTS OF HEVEA DO NOT PERFORM BETTER THAN SINGLE ROOTSTOCK PLANTS

Thomson Abraham, V.C. Mercykutty and Joseph G. Marattukalam
Rubber Research Institute of India, Rubber Board, Kottayam – 686 009, Kerala, India

Received: 09 September 2013 Accepted: 15 December 2013


A study was undertaken to compare the performance of plants having single rootstock (single root system) and twin rootstock (double root system) in terms of growth and yield in Hevea. Planting materials with single root system were produced as per the standard technique while plants with two root systems were produced by twin-grafting two stock plants at one whorl stage. Clone RRII 105 was used for the study. The plants were evaluated in the field. The design was RBD with three replications having a plot size of nine plants. Seven treatments were included; twin stocks and single stocks raised in polybags, twin stocks and single stocks raised directly in field by seed-at-stake planting, twin stocks and single stocks raised in seedling nursery and transplanted to the field as budded stumps and polybag plants as control. Annual girth was measured for 13 years and monthly dry rubber yield for four years.

The mean girth of plants having single rootstock and twin rootstock was found to be statistically comparable during immature phase as well as at the time of opening and after tapping for four years. The mean yield of plants having single rootstock and twin rootstock was also found to be comparable. On excavation after 17 years, only less than 27 per cent of the twin rootstock plants were found to have two separate fully developed root systems and in the other cases, either the two roots united or one root had become aborted. The present study showed that twin rootstock plants and single rootstock plants do not differ significantly in growth and yield indicating that twin grafting may not have an added advantage in Hevea.

Keywords: Growth and yield, Rootstock, Twin-grafting

INTRODUCTION

In agriculture, splice approach grafting to produce a tree with double root system is carried out in some fruit trees. The resultant tree has more than one root system and the trees are better able to obtain food and water, and can withstand stronger winds (Boonbongkarn, 1960). The twin grafting technique is also used to induce rapid flowering and fruiting (Aumeeruddy and Pinglo, 1988) and also to enhance faster growth and to produce a stronger root system. Some preliminary reports indicate that double and triple grafted material grew more vigorously and had higher fruit set than grafted plants with single rootstocks (Zabedah et al., 1992; Zabedah, 1993). In mango cultivation, grafting success in field
LONG-TERM YIELD AND GROWTH PERFORMANCE OF IRCA RUBBER CLONES IN INDIA

C.P. Reghu, G.P. Rao and Jayashree Madhavan
Rubber Research Institute of India, Kottayam – 686 009, Kerala, India.


India introduced five hybrid clones of Hevea brasiliensis in 1991 from the Institut de Recherches sur le Caoutchouc (IRCA), Cote d’Ivoire. A field evaluation trial comprising of these clones and a popular Indian clone, RRII 105 was laid out during 1992 in a randomized block design with five replications and a plot size of eight plants. The trial was opened for regular tapping at the age of nine years and the growth performance and monthly dry rubber yield trend were evaluated. Significant clonal differences were observed for all the characters studied. At the time of opening, IRCA 111 and IRCA 130 were superior to all other clones in terms of vigour, while RRII 105 had the least girth. The remaining three IRCA clones were on par with RRII 105. IRCA 111 and IRCA 130 maintained their superiority over the next 10 years of tapping too. In the 10th year of tapping, IRCA 111 and IRCA 130 continued to show the highest girth, followed by IRCA 18 and RRII 105.

Clonal differences for yield were highly significant every year. In the first year of tapping, IRCA 130 had the highest yield (52.0 g t⁻¹t⁻¹). IRCA 111 (47.2 g t⁻¹t⁻¹) was on par with it, followed by IRCA 18 (39.7 g t⁻¹t⁻¹), while the check clone RRII 105 recorded 36.2 g t⁻¹t⁻¹. Yield in the 10th year continued to be the highest in the clone IRCA 130 (93.0 g t⁻¹t⁻¹) followed by RRII 105 (72.1 g t⁻¹t⁻¹) and IRCA 111 (64.8 g t⁻¹t⁻¹). IRCA 130 had the highest mean yield over ten years of tapping (76.0 g t⁻¹t⁻¹), followed by RRII 105 (56.8 g t⁻¹t⁻¹) and IRCA 111 (55.9 g t⁻¹t⁻¹) which were on par.

Yield components such as plugging index (PI) and dry rubber content were recorded in the 19th year of growth. Lowest PI was recorded in the clones IRCA 130 and IRCA 111. The clone IRCA 109 had the highest dry rubber content, while RRII 105 and IRCA 230 were on par with IRCA 130. IRCA 111 had the lowest dry rubber content. IRCA 130 remained in the top for timber volume followed by IRCA 111, IRCA 109 and IRCA 18. These four clones had significantly higher bole volume than RRII 105. Two clones (IRCA 130 and IRCA 111) with good dry rubber yield and timber yield can be considered as potential latex-timber clones.

Keywords: Dry rubber yield, Girth, Plugging index, Timber yield

INTRODUCTION

Five promising IRCA clones were introduced into India during 1991 from Cote d’Ivoire as part of the bilateral clone exchange programme between Institut de Recherches sur le Caoutchouc (IRCA) and Rubber Research Institute of India. These elite clones were selected in the home
PLANT REGENERATION VIA SOMATIC EMBRYOGENESIS FROM ROOT EXPLANTS IN HEVEA BRASILIENSIS

S. Sushamakumari, K. Rekha, S. Sobha and U.K. Divya
Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

An efficient plant regeneration pathway through somatic embryo induction has been established in Hevea brasiliensis using root explants. In this experiment, actively growing roots of germinating somatic embryos were used as the initial explants. Different basal media viz. modified MS, white's low salt base, N6 basal and woody plant medium fortified with growth regulators 2, 4-D, NAA, IBA and BA were tried at various stages of the pathway. Compact calli could be induced at a high frequency (80%) when root explants were cultured over modified MS containing 2.0 μM 2, 4-D and 1.0 μM Kinetin. Modified MS and WPM were found to be effective for induction of friable embryogenic calli. A combination of 4.35 μM GA3 and 8.8 μM BA was optimum for embryogenesis (50%). A plant regeneration frequency of 60 per cent could be achieved on modified WPM medium fortified with 2.9 μM GA3 and 8.8 μM BA. Regenerated plants were successfully hardened. This system is reproducible and efficient in terms of frequency of embryogenesis and plant development and can provide a constant supply of target tissues for genetic transformation, which now depend upon the seasonal availability of floral explants. Moreover, after appropriate modifications, this pathway can be utilized for propagation of elite root stocks identified for specific desirable characters.

Keywords: Based media, Growth regulators, Root explants, Somatic embryogenesis

INTRODUCTION

Hevea brasiliensis, the natural rubber producing tree, is a cross pollinated, highly heterozygous, perennial tree crop with a very long breeding cycle, thus rendering crop improvement through conventional techniques of breeding and selection much laborious and time consuming. Biotechnological approaches hold much relevance in bringing about crop improvement in Hevea. Availability of established cell and tissue culture techniques and efficient protocols for regeneration of whole plants from these cultures is an essential pre-requisite for the application of genetic transformation technologies for plant improvement. In Hevea, plant regeneration has been reported from different explants like integumental tissue (Asokan et al., 1992, a,b; Carron et al., 1995), anther (Wang et al., 1980; Chen, 1984; Jayasree et al., 1999) and pollen (Chen et al., 1979). Sushamakumari et al. (2000) reported an efficient and reproducible plant regeneration pathway through somatic embryogenesis using immature

Correspondence: Sushamakumari.S (Email: sushama@rubberboard.org.in)
AGROMANAGEMENT TECHNIQUES TO MITIGATE DROUGHT IN YOUNG RUBBER PLANTATIONS

M.D. Jessy, P. Prasannakumari and James Jacob
Rubber Research Institute of India, Kottayam – 686 009, Kerala, India

Received: 09 November 2013 Accepted: 20 January 2014

In India, attempts are being made to expand rubber cultivation to agro-climatically less favourable regions also, where drought is the major constraint. Climate uncertainty and increasing drought are adversely affecting the establishment and growth of plants even in traditional regions. Objective of the present study was to develop a viable technology for mitigating adverse effects of drought in young rubber plants in dry areas. The effectiveness of super absorbent polymer, tillage and potassium (K) supplement was tested in a field experiment conducted at Puthukkad Estate, Trichur, which is a drought prone area during 2010-12. Three types of planting materials viz. polybag plants raised from green budded stumps, polybag plants raised through direct seeding and root trainer plants were evaluated. Observations on chlorophyll content index (CCI), soil moisture and plant growth were recorded. Plants which received super absorbent polymer, tillage and K supplement retained significantly higher CCI compared to control during dry period in January. Soil moisture status during dry period in January was significantly higher in the treatments with super absorbent polymer and tillage. Tillage and super absorbent polymer improved growth of plants during 2012. Polybag plants raised through direct seeding were significantly superior to polybag plants raised from budded stumps with respect to CCI and growth during both years and were superior to root trainer plants after two years. The results showed that tillage and super absorbent polymer are effective in mitigating adverse effects of drought in young rubber plants and polybag plants raised through direct seeding have a better performance in dry areas compared to the other two planting materials.

Keywords: Drought, Planting material, Potassium, Super absorbent polymer, Tillage

INTRODUCTION

In India, scarcity of land for further expansion of rubber cultivation in traditional rubber growing regions coupled with the comparatively stable and attractive income from rubber plantations in recent years has lead to expansion of rubber cultivation in agro-climatically less favourable regions. Area under rubber is fast expanding in Karnataka and Goa region, and many farmers are venturing to rubber cultivation in Maharashtra and Orissa also. Prolonged dry season is the main climatic constraint in these regions and its impact will be more pronounced during establishment and early growth of plants. Appropriate farm technologies to mitigate
FIELD EVALUATION OF PROGENIES OF A CANOPY MUTANT OF *HEVEA BRASILIENSIS*

T. Gireesh and Kavitha K. Mydin

Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

Received: 18 June 2013 Accepted: 12 November 2013


Canopy and tree architecture are important features determining both the tree-level and stand-level productivity of rubber and susceptibility towards wind damage in plantations. However, genetic base of crown architecture is less studied and is rarely utilized in tree improvement programmes. A natural mutant of *Hevea brasiliensis* showing distinct morphological variation in the crown was reported earlier. In the present study, genetic improvement of the compact canopy morphotypes was attempted through half-sib approach and selected progenies were subjected to field evaluation adopting recommended spacing. Girth and yield of four morphotypes (Compact: 12 cm, 5.5 g t\(^{-1}\) t\(^{-1}\); intermediate: 81.0 cm, 28.3 g t\(^{-1}\) t\(^{-1}\); semi compact: 46 cm, 17.2 g t\(^{-1}\) t\(^{-1}\); normal: 76 cm, 25 g t\(^{-1}\) t\(^{-1}\) and RRII 105-control: 64.2 cm, 45 g t\(^{-1}\) t\(^{-1}\)) showed significant variability while original natural mutant (compact) showed stunted growth and less yield. The mean canopy spread/width in the 5\(^{th}\) year in RRII 105 and the normal type ranged from 4.6 to 5.5 m; whereas, the intermediate type had a canopy spread of 2.2 m only. The intermediate crown type can be considered more promising than the check clone in terms of extent of crown width though rubber yield (28 g t\(^{-1}\) t\(^{-1}\)) is less. Increase in plant density can compensate for lower yield and can also reduce the damage/tree loss in wind prone areas. This type could be subjected to further density cum clone evaluations to arrive at an optimum tree stand for profitable yield. Compact canopy genotypes not only avoid wind damage but also help the planters in getting enough room for optimal utilization of land.

**Keywords:** Compact canopy, Crown variation, Half-sibs, Mutant

INTRODUCTION

Para rubber tree, *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg. is one among the rubber synthesizing species that produce commercially acceptable latex which is one of the important raw materials for thousands of products. Belonging to the family *Euphorbiaceae*, it is cultivated extensively in tropical areas of South East Asia. Trees are fast growing, reaching a height of up to 25 to 40 m, and replanted after tapping for 25-30 years. Breeding, selection and vegetative propagation of this species revolutionized global natural rubber output. Evolving new cultivars with high yield potential and other favorable quantitative traits through recombination breeding is a priority area (Licy et al., 2003; Priyadarshan and CleAment-Demange, 2004).

Due to its rare occurrence and complexity, introgression of traits like compact canopy needs several generations. Damage to plantations due to uprooting and
STANDARDIZATION OF AN ALTERNATIVE POTTING MEDIUM FOR RAISING HEVEA PLANTS IN ROOT TRAINERS

T.A. Soman, Kavitha K. Mydin* and M.D. Jessy*
Rubber Research Institute of India, Hevea Breeding Sub-station, Kanyakumari- 629 581, Tamil Nadu, India
*Rubber Research Institute of India, Kottayam- 686 009, Kerala, India

Received: 14 May 2013 Accepted: 10 April 2014


Conventionally, cured coir pith is used as the potting medium to raise advanced planting materials of rubber in root trainers. An alternative potting medium suitable to fill root trainers was needed in areas where coir pith is not available. Top soil, which is the commonly used potting medium, was found not suitable for root trainer planting technique. However, properties of top soil as a potting medium was considerably improved when mixed with powdered cow dung up to 25 per cent by volume of the potting mixture. It was also found that fertility of coir pith could be improved by adding powdered cow dung up to 25 per cent by volume of the potting mixture, without much adverse impact on the consistency and compactness of the soil core.

Keywords: Coir pith, Compost, Cow dung, Root trainer, Soil core, Top soil

INTRODUCTION

Polybag planting technique was introduced to natural rubber (Hevea brasiliensis) during 1980s and at present more than 90 per cent of the advanced planting materials in India are being raised in polybags. However, polybag plants were reported to have a number of disadvantages as explained in detail by Josiah and Jones (1992), Khedkar and Subramanian (1996) and several other eminent scientists working in various crop species world over. Coiling of tap root and spiraled growth of lateral roots are the most important drawbacks of polybag plants (Wilson, 1986; Subramanian and Jha 1995; Ginwal et al. 2001) and these coiled and spiraled growth of roots were reported to result in root strangling and distortion subsequently leading to slow growth, poor drought tolerance and lack of wind fastness (Wilson, 1986; Sharma, 1987; Josiah and Jones, 1992; Gera and Ginwal, 2002). Root trainer planting technique was standardized for rubber as an alternative to poly bag plants (Soman and Saraswathyamma 1999). In addition to improving the quality of planting materials, root trainer planting technique was found to be labour and environment friendly as well as cost effective. Hence, this planting technique is attaining wide popularity among the rubber planters in Kerala.

Correspondence: T.A. Soman (Email: soman@rubberboard.org.in)
INHERITANCE OF TAPPING PANEL DRYNESS IN FULL-SIB POPULATION OF HEVEA BRASILIENSIS

Narayanan Chaendaekattu and Kavitha K. Mydin
Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

Received: 27 August 2013  Accepted: 10 December 2013


Tapping panel dryness (TPD) is a serious problem of Para rubber tree (Hevea brasiliensis) causing significant losses in latex yield. The present study was conducted to assess heritability of TPD using a full-sib population planted in a small scale trial at Central Experimental Station, Chethackal (Pathanamthitta, Kerala). Symptom of TPD among the full-sibs was confirmed through tapping for two consecutive years. Narrow-sense heritability of TPD was estimated based on parent-offspring regression. There was considerable variation for TPD in the population. Incidence of TPD ranged from 3.6 per cent in clone PB 5/51 to 46.4 per cent in PB 235. Clone RRII 33 did not show any incidence of TPD. Progenies of PB 5/51 x RRII 208 showed minimum TPD incidence (3.6%) while those of RRIM 600 x PB 235 exhibited maximum incidence (29.6%). Progenies of RRIM 600 x RRII 33 did not exhibit TPD symptoms. The study showed high narrow-sense heritability ($h^2=0.50$) for TPD. Progenies from hybridization between clones with very low TPD incidences (e.g. RRII 33) exhibited very low TPD incidences. Similarly, progenies from hybridization between clones with very high TPD (e.g. PB 235) possessed more TPD incidences. Overall, the study indicated that TPD may be governed by heritable gene action, which may possibly imply scope for achieving appreciable genetic gain through breeding for TPD tolerance.

Keywords: Breeding, Full-sib, Narrow-sense heritability, Selection, Tapping panel dryness

INTRODUCTION

Hevea brasiliensis (Willd. ex A. Juss.) Müll. Arg. (family, Euphorbiaceae; diploid, $2n=36$), the Para rubber tree, is monoecious, entomophilic and predominantly out-crossing. Laticifer cells in the bark tissue of the tree yield significant amount of natural rubber latex in the entire plant kingdom. TPD is a symptom expressed by the tree when laticifer cells do not exude latex on tapping which ultimately causes significant loss in yield in almost every rubber plantation. The precise cause of TPD is yet to be recognized (Jacob and Krishnakumar, 2005). It is generally observed that trees which yield precocious amount of latex may ultimately show high incidence of TPD, and the symptom of TPD may be reversible or permanent. It has also been observed that a gap in tapping sometimes result in alleviation of TPD symptoms. Numerous studies have already been done on TPD, however, from breeding and yield-improvement point of view, we still need more information on TPD causing factors and ways to address this important problem affecting yield.

Correspondence: C. Narayanan (Email: cnarayanan@rubberboard.org.in)
NUTRIENT AND HEAVY METAL STATUS OF SOILS UNDER RUBBER-PINEAPPLE INTERCROPPING IN COMPARISON TO RUBBER-COVER CROP SYSTEM AND NATURAL FOREST

P. Prasannakumari, M.D. Jessy, P.A. Antony, Joseph Chacko and James Jacob
Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

Received: 06 November 2013 Accepted: 10 January 2014

Soil pH, organic carbon, available nutrients and contents of heavy metals in soil in young rubber plantations under pineapple intercropping were compared with cover crop established plantations and natural forest. A total of 82 and 21 soil samples from rubber-pineapple intercropping system and rubber-cover crop system respectively were collected from surface layer (0-30 cm) of selected fields, including estates and small holdings in the central region of Kerala. Soil samples (15 nos.) were also collected from natural forest within the region of the study. Processed samples were analysed for pH, OC (%), available nutrients and phyto-available heavy metals such as Pb, Cd, Cr, Cu, Zn, Mn, and Fe. Compared to soil under rubber-cover crop system, significant decrease in soil pH, available calcium and magnesium, and significant increase in available P and K were observed in soil under rubber-pineapple intercropping system. Phyto-available heavy metal status of the soils showed significantly higher cadmium and iron contents, and significantly lower lead, chromium, copper and manganese contents in rubber-pineapple intercropping system, compared to rubber-cover crop system. Comparison with soil under natural forest showed significantly lower pH and available calcium and magnesium, significantly higher copper content, and a build up of available P in both the rubber based systems. Arsenic and mercury contents in soils of all the three systems were below detection limit.

Keywords: Cover crop, Heavy metals, Natural forest, Rubber-pineapple intercropping

Intercropping with pineapple is widely practiced in immature rubber plantations in the initial four years particularly in the central region of Kerala. This is a good source of income for farmers during the unproductive phase of rubber plantation. Experiments conducted in RRII indicated that scientific intercropping with pineapple improved growth of rubber and sustained soil properties (RRII, 2008).

Pineapple intercropping in young rubber is an intensively managed agricultural system involving high rate of addition of nutrients, manures, pesticides, herbicides and hormones. In a survey conducted in central Kerala, Jayasree et al. (2006) observed that the quantity of fertilizers applied to pineapple far exceeded the recommended doses.

Correspondence: P. Prasannakumari (Email: prasannakumari@rubberboard.org.in)
PINK DISEASE OF *HEVEA BRASILIENSIS* IN NORTHERN WEST BENGAL AND NORTH EAST INDIA

G.C. Mondal, H.K. Deka, Shammi Raj* and Sabu P. Idicula**

Rubber Research Institute of India, Regional Research Station, Housefed Complex, Dispur, Guwahati - 781006, Assam, India

*Regional Research Station, Rubber Research Institute of India, Agartala -799 006, Tripura, India

**Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

Received: 02 September 2013 Accepted: 10 February 2014


A survey was carried out in 180 locations covering in northern West Bengal and North East India, from August to November, during 1990-2011, on pink disease of rubber (*Hevea brasiliensis*) caused by *Corticium salmonicolor* (Berk. & Br.). The incidence of pink disease on rubber was higher in northern West Bengal than Meghalaya and Assam. Maximum incidence of pink disease was observed on four to six-year-old rubber plants at Rango (7.5%) followed by Jiti rubber estate (3.0%) in northern West Bengal. The disease was noticed on the main trunk of five-year-old rubber plants at Rango and Jiti rubber estates during September, 2001 for the first time in northern West Bengal and caused a total loss of the affected trees. Weather factors like monthly rainfall (mm), number of rainy days, maximum temperature (°C) and relative humidity (%) from July to September during 1996-2011 are also reported. The monthly rainfall above 500 mm and more than 17 continues rainy days were the major predisposing factors influencing the development of pink disease.

**Keywords**: Climatic factors, North West Bengal, North East India, Pink disease

Pink disease of rubber (*Hevea brasiliensis* Muell. Arg.) caused by *Corticium salmonicolor* (Berk. & Br.) is prevalent in South India during south west monsoon period. Though the incidence of pink disease is noticed on rubber plants of all age groups, the adverse effects due to infection were found to be more damaging for two to twelve-year-old plants (Ramakrishnan and Pillai, 1962). The pink disease occurs in almost all rubber growing locations in Kerala and causes considerable loss of canopy that ultimately retards the growth resulting in extension of immaturity period (Ramakrishnan and Pillai, 1962). The incidence of pink disease in north east region of India was first reported by Mondal *et al.* (1994) from Assam and Tripura and from Meghalaya by Deka *et al.* (1998). As the detailed scientific report on the occurrence of pink disease on different parts of rubber trees of various clones in northern West Bengal and North East India and its management is not available, this study was carried out in

Correspondence: G.C. Mondal (Email: gopalchandra@rubberboard.org.in)
PEROXIDE VULCANIZATION OF POLYMERS

Rejitha Rajan, Siby Varghese and K.E. George*
Rubber Research Institute of India, Kottayam-686 009, Kerala, India
*Cochin University of Science and Technology, Cochin - 682 022, Kerala, India

Received: 22 March 2014    Accepted: 05 May 2014


The present article reviews the use of different organic peroxides used for the crosslinking of various types of rubbers. The rubbers include both unsaturated and saturated elastomers as well as elastomer blends. The use of co-curing agents (coagents) to improve the vulcanizate properties is also discussed. Peroxide cure depends upon a number of factors like type and concentration of peroxides, type of elastomers, compounding ingredients like fillers, antioxidants, processing aids etc. However, by the proper selection of elastomers and coagents, peroxide cure systems can be effectively used as an alternative to sulphur cure system.

Keywords: Coagent, Natural rubber, Organic peroxide, Vulcanization

INTRODUCTION

When rubber is exposed to atmosphere, oxygen present in air easily oxidizes rubber and gradually transforms it into a solid substance at room temperature. This fact laid the foundation stone of rubber vulcanization by means of organic peroxides. In 1915, Ostromislensky (Ostromislensky, 1930) used benzoyl peroxide to vulcanize natural rubber. However, vulcanization of rubber with benzoyl peroxide never found wide applications because of the large proportion of benzoyl peroxide necessary for a good level of cure and blooming of the decomposition products, benzoic acid, on to the vulcanizate.

Although peroxides and sulphur can cure most types of rubbers, the chemistry behind peroxide crosslinking and the properties it provide, are much different. Due to these chemical differences, many additives that are essential in sulphur cured formulations might interfere with peroxide curing. There are many types of vulcanizing systems and hence deciding which system is ideal for a given application depends on the required curing conditions, the elastomer or elastomers blend employed and the desired physical properties of the vulcanizates. The process has acquired very little importance in unsaturated rubbers since the mechanical properties are inferior to those obtained with accelerated sulphur cure. However, peroxide vulcanization has got good ageing and low set properties.

Interest in the industrial use of peroxides as curing agents increased with the introduction of a number of fully saturated elastomers (Hofman, 1999) for which the usual accelerated sulphur systems are unsuitable and also with the commercial introduction of dicumyl peroxide (DCP) in...
SUPERIOR PROCESSING RUBBER FROM RADIATION CROSS-LINKED NATURAL RUBBER LATEX

Joy Joseph*, P.S. Sadeesh Babu, K.N. Madhusoodanan and Rosamma Alex  
Rubber Research Institute of India, Rubber Board, Kottayam-9  
Received: 31 March 2014 Accepted: 09 May 2014


Superior processing (SP) natural rubber was prepared by blending different proportions of fresh and radiation vulcanised natural rubber latex, followed by coagulation and drying. The Mooney viscosity of SP rubber increased as the proportion of cross-linked rubber increased. Cross-linked and uncross-linked rubber blended in 20/80 proportion (P20) recorded very good mechanical and processing characteristics compared to pure NR. The better processing characteristics were attributed to the higher viscous nature of the modified rubber in gum and carbon black filled mixes. It was observed that the P20 rubber had a higher level of vulcanisation than the pure NR. The improved processability and vulcanisation characteristics were ensured from the analysis of viscoelasticity cure characteristics, physical property evaluation and filler dispersion characteristics. Blending of fresh natural rubber latex and radiation vulcanised latex in suitable proportions offer a very simple method to produce SP rubber with enhanced processing characteristics and mechanical properties.

Keywords: Radiation vulcanisation, Natural rubber latex, Processing rubber, Viscoelasticity.

INTRODUCTION

The latex which is called prevulcanised latex became indispensable for the manufacture of latex products like toy balloons, Rubber band, gloves, latex foam etc. Later an application of this cross-linked latex as a process aid (called superior processing rubber) in the form of dried rubber after coagulating the latex blend of uncrosslinked and cross linked latex was explored. (Karunaratne and Fernando, 1985). The Superior Processing (SP) rubber consists of well mixed vulcanised and unvulcanised rubber. They can be compounded in the manner similar to ordinary grades of natural rubber, with better processing properties. (George et al., 2000). Generally there is little loss of physical properties of the final vulcanisate but they show improved processing characteristics and ability to retain dimensional stability. The SP rubber is prepared using latex cross-linked by sulphur and accelerators in the latex stage. Field latex suitably compounded with the various compounding ingredients is steam heated using a water bath to the desired level of crosslinking, cooled and then intimately mixed with the required quantity of fresh field latex. The blended latex is coagulated with acid.

NR latex can be cross-linked by exposure to gamma radiation in presence of suitable sensitizers. The latex is called
STABLE FREE RADICAL ASSISTED SCORCH CONTROL IN PEROXIDE VULCANIZATION OF EPDM

Benny George and Rosamma Alex
Rubber Research Institute of India, Rubber Board, Kottayam, Kerala-686 009, India.

Received: 07 March 2014 Accepted: 20 May 2014


This study demonstrates the capability of a nitroxide stable free radical, 2, 2, 6, 6-tetramethylpiperidine 1-oxyl (TEMPO), to induce sulphur/accelerator like scorch control in peroxide vulcanisation of EPDM. Two commercially used peroxides; butyl 4,4-di(tert-butylperoxy) valerate (BPV) and Di(tert-butyl peroxisyopropyl) benzene (BBPIB) with cure temperatures of 160 °C and 175 °C respectively were used for vulcanisation. TEMPO induced scorch in both systems and the cure curves resembling typical sulphur/accelerator cure curves were obtained. The reduction in cross-link density with the addition of TEMPO was significantly less in BBPIB system. Addition of 4phr of trimethylolpropane trimethacrylate (TMPTM) could regain the loss of cross-links due to the scavenging action of TEMPO. The vulcanisate properties of the EPDM/BBPIB/TEMPO/TMPTM system were determined and compared with a control EPDM compound. The mechanism of scorch control by the stable free radical is also discussed.

Keywords: Peroxide vulcanization, Scorch control, Stable free radicals

INTRODUCTION

Peroxide vulcanisation of rubbers offers various advantages over sulphur vulcanisation like rapid vulcanisation without reversion at higher temperatures, good compression set, excellent heat ageing properties, possibility to co-vulcanise saturated and unsaturated rubber blends etc. These are attributed to the C-C cross-links formed during peroxide vulcanisation, which have the same bond strength as the C-C bonds in the polymer main chain. Due to the enhanced performance at high temperature, peroxide vulcanisation covers about 15per cent of the commercial ethylene-propylene-diene rubber (EPDM) applications (Orza et al., 2009).

As per the generally accepted mechanism, peroxide vulcanisation is initiated by the thermal decomposition of organic peroxides to highly reactive free radicals, which then predominantly abstract allyl hydrogen atoms in elastomers with internal double bonds [(R)HC = CH(R')] and pursue addition reaction with elastomers having vinyl pendant groups [ >C = CH2], either way yielding rubber macro-radicals. These macro-radicals combine to form the cross-links (Dluzneski, 2001). Recent 13C NMR studies on peroxide vulcanisation of EPDM rubber with 2-ethylene-5-norbornene (ENB) as the termonmer showed that hydrogen abstraction takes place both at the CH2 and CH units in the EPM main chain.
OPTIMIZATION OF PROCESS PARAMETERS FOR STABLE ZnO DISPERSIONS

Anand K, Siby Varghese, Shera Mathew, Thomas Kurian*
Rubber Research Institute of India, Rubber Board, Kottayam - 686 009, India
*Cochin University of Science and Technology, Kochi 682 022, India

Received: 27 September 2013 Accepted: 04 December 2013


As most of the nanomaterials are very expensive, the concept of stable ultrafine dispersions with uniform size distribution is gaining commercial importance. For optical applications including transparency and also for reducing the additive concentration, ultrafine particles should be uniformly dispersed in the polymer matrix. Dispersion of ZnO has been a consistent issue because of its strong tendency to form aggregates. Present research work focuses on combining ball milling and ultrasonication to produce stable aqueous dispersions of ZnO with consistent size distribution. Milling time and concentration of surface active agent (SA) were followed through, dynamic light scattering (DLS) and Zeta potential measurements. It was observed that 12h milling with 2-3 wt per cent SA was found to be the optimum conditions for the preparation of ZnO dispersion. Effect of ultrasonication on ball milled samples resulted in dispersions with reasonable stability.

**Keywords:** Ball milling, Dispersion, Ultrafine ZnO, Ultrasonication, Zeta potential

INTRODUCTION

Zinc oxide is an important raw material for a broad range of products. The tyre industry remains the largest single market for ZnO, consuming more than half of the total worldwide demand of 1,200,000 metric tons (Walter, 2009). Many industries such as paints, dyes, cosmetics, pharmaceuticals, ceramics, micro-electronics, etc. employ colloidal dispersions of ZnO in the fabrication of products. The demand of such industries for stable colloidal dispersions is huge as use of fine particles will improve the homogeneity, solubility, strength, reactivity etc. (Inam et al. 2011.)

Grinding using ball milling technique is of great interest mainly because of specifications imposed on size and size distributions of grounded materials (Murthy et al., 1995; Fadhel et al., 1999; Suryanarayana et al., 2001; Gupta et al., 2001). Grinding using ball mills is a process applied to reduce the size of the particles which may have different nature and a wide diversity of physical, mechanical and chemical characteristics. Besides particle size reduction, mixing, blending and material dispersion can be achieved by ball milling (Monov et al., 2012). Advantage of using dispersions with fine particle size is that sedimentation during storage can be minimized with good processing easiness.
RESEARCH PAPERS
The manuscripts of research papers (about 8000 words) shall be divided into different sections.

1. Title page shall contain
   - The full title, brief but appropriate and informative,
   - a short running title, not more than six words,
   - name(s) of author(s) with surnames in bold
   - affiliation and address(es) of the author(s)
   - the name and email address of the principal author or the author to whom correspondence shall be made

2. Abstract shall include a brief statement of the work and major findings and not to exceed 200 words.

3. Keywords shall not exceed eight words.

4. Introduction shall include a clear statement of the scope indicating the essential background.

5. Materials and methods/Experimental shall contain sufficient details of the materials used and techniques followed.

6. Results and discussion shall include all the results, highlighting the significance of each. Theoretical explanations for the major observations may also be provided. The last paragraph shall contain major conclusions and recommendations, if any.

7. Acknowledgement shall be brief.

8. References shall be arranged in alphabetical order of the author’s surnames and typed on a separate page. This list shall include the name(s) of author(s), year of publication, title of the paper, name of the journal in full, volume, number and pages.

Examples:


References in the text shall be indicated by the surname(s) of author(s) and year of publication. For reference with more than two authors, the surname of the first author followed by et al. and the year of publication shall be used. References to the same author or group of authors in the same year shall be distinguished with small letters (Stanford, 1984a, b).

Tables, drawings and photographs
Each table shall be typed on separate page, consecutively numbered with arabic numerals and shall have an appropriate title. Data illustrated in figures shall not be repeated in tables.

Line drawings shall be printed bold in black ink. Each figure shall be drawn on a separate sheet and consecutively numbered in arabic numerals. Inscriptions and legends shall be relevant and legible.
Structures and schematic representations may be printed in black on separate page.

Photographs shall be glossy colour or black and white prints of high contrast. Photographs will be included only if essential. Magnifications must be clearly indicated in the case of photo-micrographs. Each photograph shall be consecutively numbered in arabic numerals. Colour photographs related to articles are welcome for printing on the cover page window.

Captions to figures and photographs shall be typed on a separate page. Explanatory material shall be placed in the caption and not in the figure.

Scientific names

The full scientific name (genus, species, authority and cultivar, if appropriate) shall be used for every organism when first mentioned. Subsequently, the genetic name may be abbreviated except where intervening references to other genera would cause confusion. Common names, if used, must be accompanied by the correct scientific names on first mention. Latin names shall be printed in italics. Chemical names shall conform to the IUPAC system.

Units

International system of units shall be used for exact measures of physical quantities. Standard abbreviations are preferred.

Abbreviations, formulae and schemes

Widely accepted abbreviations may be used, but the expansion shall be given on first mention.

Mathematical formulae must be carefully printed with symbols properly aligned and correctly spaced. When a manuscript contains several mathematical equations, each major equation shall be identified by a number in parenthesis.

Schemes shall be prepared on separate sheets, camera ready for direct reproduction. Captions and explanations shall be typed on a separate page and not in the scheme.

SHORT COMMUNICATIONS AND REVIEWS

The manuscript of short scientific communications (up to 2000 words) shall also follow the style of research papers. However, subheadings shall not be given.

Review articles shall be comprehensive and shall cover all relevant literature.

PROOFS

Proofs will be sent to the corresponding author by email unless otherwise specified. The corrected proof shall be returned to the Editor-in-Chief within one week of receipt.

CORRESPONDENCE

The Editor-in-Chief
Rubber Science
Rubber Research Institute of India
Kottayam – 686 009, Kerala, India
Phone + 91 481 2353311-20
+ 91 481 2352770-71
+ 91 481 2352773-79 (20 lines)
Fax + 91 481 2353327
Website : www.rubberboard.org.in
Email : rubberscience@rubberboard.org.in
CONTENTS

BIOLOGY & CULTIVATION
Continued from front cover

Twin root stock plants of Hevea do not perform better than single root stock plants
Thomson Abraham, V. C. Mercykutty and Joseph G. Marattukalam

Long-term yield and growth performance of IRCA rubber clones in India
C. P. Reghu, G. P. Raso and Jayashree Madhavan

Plant regeneration via somatic embryogenesis from root explants in Hevea brasiliensis
S. Sushanakumari, K. Rekha, S. Sobha and U. K. Divya

Agromanagement techniques to mitigate drought in young rubber plantations
M. D. Jessy, P. Prasannakumari and James Jacob

Field evaluation of progenies of a canopy mutant of Hevea brasiliensis
T. Gireesh and Kavitha K. Mydin

Standardization of an alternative potting medium for raising Hevea plants in root trainers
T. A. Soman, Kavitha K. Mydin and M. D. Jessy

Inheritance of tapping panel dryness in a full-sib population of Hevea brasiliensis
Narayanan Chaendaekantu and Kavitha K. Mydin

Nutrient and heavy metal status of soils under rubber-pineapple intercropping in comparison to rubber-cover crop system and natural forest
P. Prasannakumari, M. D. Jessy, P. A. Antony, Joseph Chacko and James Jacob

Pink disease of Hevea brasiliensis in northern West Bengal and North East India
G. C. Mondal, H. K. Deka, Shammi Raj and Sabu P. Idicula

Printed and published by Dr. James Jacob, Director, on and on behalf of the Rubber Research Institute of India, Rubber Board, Kottayam-686 001, Kerala, India, and printed at Abo Graphica, Kottayam, Kerala, India. Editor-in-Chief: Dr. James Jacob.