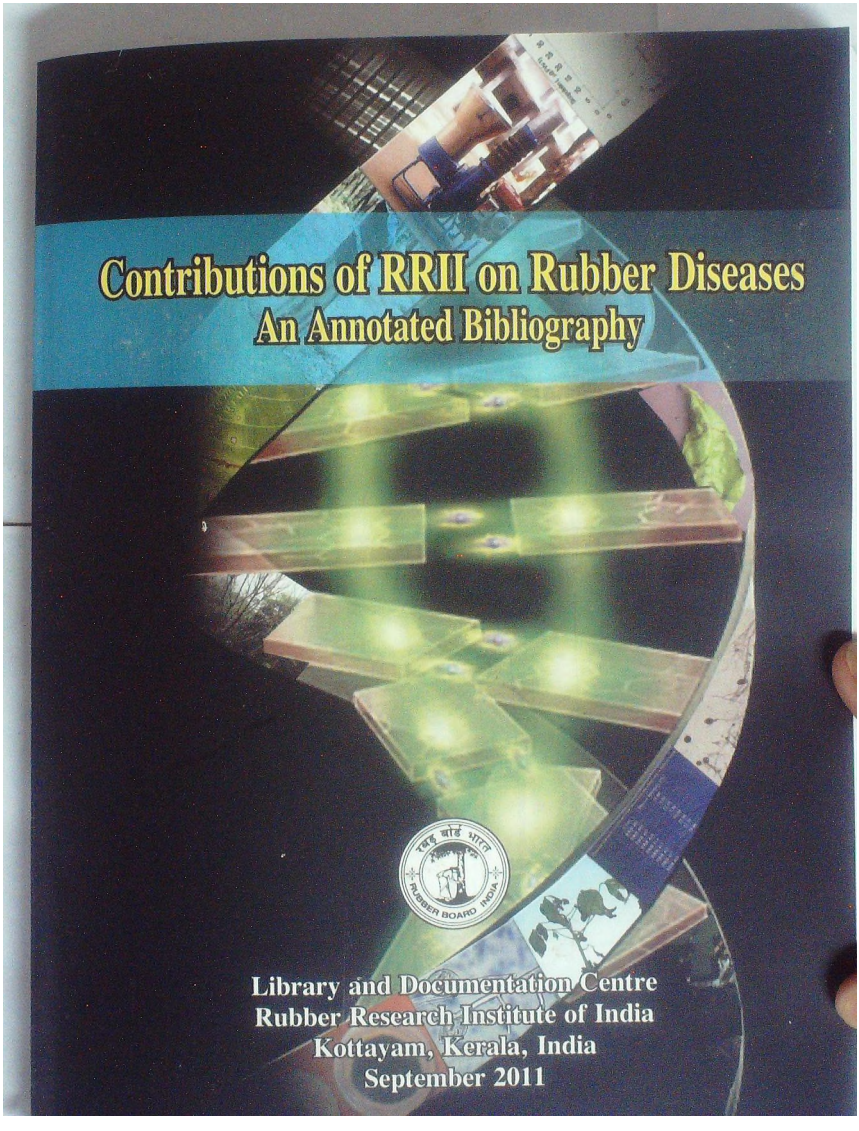

Contributions of RRII on Rubber Diseases
An Annotated Bibliography

Library and Documentation Centre
Rubber Research Institute of India
Kottayam, Kerala, India
September 2011

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Contributions of RRII on Rubber Diseases

An Annotated Bibliography

Editors
Accamma C. Korah
N. Latha

Library and Documentation Centre

FOREWORD

Phytophthora is one of the most destructive plant pathogens causing enormous economic loss in crops worldwide. Phytophthora diseases are common in plantation crops like rubber, cocoa, coconut and pepper and a lot of research has been done on *Phytophthora* by the Rubber Research Institute of India during the last more than five decades and the findings are scattered in different sources such as periodicals, monographs, conference proceedings, books, etc. The Library and Documentation Centre of RRII has made an attempt to bring together all scattered information and list them in a single publication in a systematic and user-friendly sequence with added facilities of key word, author and author-title indices.

This compilation entitled **Contributions of RRII on Rubber Diseases: An Annotated Bibliography,** being published when RRII is hosting an ***International Workshop on Disease Management in Rubber*** would definitely be a valuable reference material.

I express my appreciation to the authors for their immense efforts to bring out this very timely and extremely useful publication.

James Jacob
Director
Rubber Research Institute of India

Kottayam
2nd September 2011

ABOUT THE COMPILATION

This compilation, **Contributions of RRII on Rubber Diseases: An Annotated Bibliography,** is published in conjunction with the *International Workshop on Disease Management in Rubber,* 2011. It covers literature on diseases, their etiology, diversity and management, pests and their management, plant protection equipment, etc. The bibliography contains 336 records reported by scientists from RRII covering the period from 1956 to till date. The materials are collected from periodicals, monographs, conference proceedings, books, etc. The compilation endeavours to bring together all scattered information and to list them in a single publication in a systematic and user-friendly sequence with added facilities of key word, author and author- title indices.

This compilation consists of four major sections. Section I is the bibliography and it is divided as diseases/disease management, non-microbial maladies, pests/pest management, plant protection equipment and microbiology. In each division, the articles are arranged as per author's alphabet in a chronological manner. Section II, the key word index brings together all relevant key words from respective articles, Section III gives author index and Section IV is author-title index. The indices are suffixed with their respective entry numbers. Maximum effort has been contributed by authors to collect all relevant references available and any omission is unintentional.

The authors are extremely grateful to Dr. James Jacob, Director of Research, for granting permission to publish this bibliography. The help received from Dr. C. Bindu Roy, during the preparation of abstracts is duly acknowledged. We also record our thanks to Mrs. Mercy Jose, former Documentation Officer and the colleagues of RRII Library for their whole-hearted co-operation and support in bringing out this compilation.

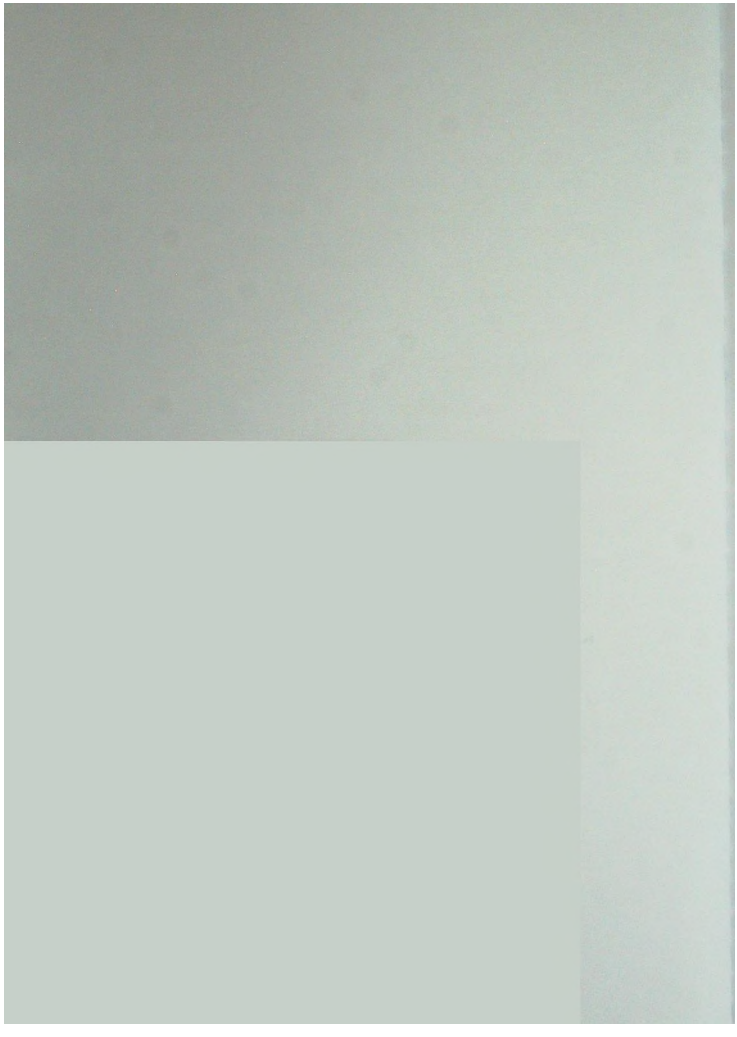
Kottayam
2nd September 2011

Accamma C. Korah
N. Latha

CONTENTS

SECTION I

BIBLIOGRAPHY



DISEASES/DISEASE MANAGEMENT

1. George, K.V. (1965-66). Development of plant protection in the rubber plantation industry in India. *Rubber Board Bulletin*, **8** (3): 152-157.

   This article deals mainly with the most destructive leaf disease of rubber in India, *viz.* Abnormal leaf fall caused by *Phytophthora palmivora*. High-volume bordeaux spraying is effective, but suited to smallholdings only. For medium-sized holdings spraying of oil based copper fungicides is economical, whilst for large stretches of rubber aerial application appears to be the best suited because of the quick coverage. Brief information is presented on powdery mildew caused by *Oidium heveae*, and on other diseases and pests.

   Key words: Crop protection; Rubber plantation industry

2. Idicula, S.P., Jacob, C.K. and Nair, R.B. (2005). Current status of disease management strategies in smallholdings in traditional rubber growing region of India. *Proceedings of the Ninth Seminar on the Progress and Development of Rubber Smallholders*, 9-11 November 2005, Cochin, India, pp. 140-148.

   The occurrence, economic importance and various practices employed for the management of rubber diseases of importance in smallholdings in traditional region, covering Kanyakumari District in Tamil Nadu, entire Kerala and Dakshin Kannada District in Karnataka have been discussed. Various impediments faced by small growers for undertaking high and low volume spraying against Abnormal leaf fall disease (ALFD) over the years and reasons for their shift in preference for these methods of spraying are also summarized. Surveys indicated drastic reduction in the extent of sprayed areas. The major reasons for this reduction are also included. Attempts made by RRII on reducing spraying cost yielded promising results. Survey conducted for three years on severity of ALFD in clone RRII 105 indicated that 62% area recorded <25% disease and the rest of the area had disease severity warranting control measures. Among the three zones, 95% area in south registered <25% disease, whereas 40 - 50% area in central and north zones need protection from ALFD. The other advantages of spraying in clone RRII 105 are also briefly mentioned. Other leaf diseases such as powdery mildew, *Colletotrichum* and Corynespora leaf diseases are also important in smallholdings.

Among the stem diseases, pink and bark rot diseases are of major concern. Pink disease incidence in different regions in traditional belt ranged from 3.47 to 13.21%, though individual cases up to 40% have been reported. Disease management strategies are important for reduction of immaturity period as well as for enhancement of productivity. Concrete recommendations for disease control have been evolved through five decades of research and these innovations are being transferred to growers through effective extension methods.

Key words: Abnormal leaf fall; Disease management; Extension method; Smallholdings; Traditional regions

3. Jacob, C.K. (1997). Diseases of potential threat to rubber in India. *Planters' Chronicle*, **92**(10): 451-461.

Two of the main diseases, Corynespora leaf disease and South American Leaf Blight, affecting rubber (*Hevea*) are described. Information is provided on (1) epidemics in various countries, reports of the disease in India, symptoms, mechanisms of infection and disease development, susceptibility of clones, host range and control measures for Corynespora leaf disease caused by *C. cassiicola*; and (2) symptoms, distribution, causal organism (*Microcyclus ulei*), host range, life cycle, physiological races, physiology of plant resistance, behaviour of *M. ulei* in Asia, management, crown budding, chemical control, prevention, quarantine agreements, phytosanitary arrangements in India and emergency eradication of South American Leaf Blight.

Key words: Disease control; Quarantine regulation; Rubber disease

4. Jacob, C.K. (2003). Disease control in rubber: Latest trends. *Planters' Chronicle*, **99**(11): 38-47.

Diseases are important constraints in realizing the potential productivity of our plantations. Although high yielding clones are widely cultivated, due to the occurrence of diseases the full potential productivity of our plantation is not achieved. This paper discusses on the different diseases of rubber, leaf, stem and root and the effective treatment procedure that can be adopted to present disease epidemic.

Key words: Disease control; Rubber disease

5. Jacob, C.K. (2003). Management of microorganisms and insects for cost reduction in rubber plantation. *In: Global Competitiveness of Indian Rubber Plantation Industry: Rubber Planters' Conference, India 2002.* (Ed. C.Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 283-297.

Careful management of microorganisms and insects can improve productivity and reduce cost of production from rubber plantations. Cost reduction, improvement in crop production and healthy farm environment were the goals in crop protection research. Control of fungal diseases of rubber with reduced inputs cost was attempted. As Abnormal leaf fall disease causes significant crop loss, its control can improve productivity even in clones like RRII 105. Reduction in spray volume, mechanization, partial replacement of $CuSO_4$ and use of additives like rubber seed oil to Bordeaux mixture resulted in reduction in cost of fungicide and labour without compromising on the disease control using high volume spraying. In micron spraying, reduction in weight of the sprayer, improvements in atomization of spray fluid, reduction in use of copper oxychloride and partial replacement of spray oil with rubber seed oil were effective in cost reduction. Crown budding and development of resistance clones have long-term benefit. Control of powdery mildew in disease-prone areas using integrated schedule of systemic and non-systemic fungicides resulted in considerable improvement in crop production. Strategies developed for control of Corynespora leaf disease could arrest the spread of disease beyond South Karnataka. Survey of clones have shown that RRII 105 is highly susceptible and GT 1 tolerant among clones cultivated in the disease affected area. The mechanism of tolerance in GT 1 appears to be due to triggering of PR proteins. Control of *Colletotrichum acutatum* in young plantations could be achieved by integrated use of systemic and non-systemic fungicides. Prophylactic protection either by painting or spraying on the disease-prone loci with copper fungicide reduced incidence of pink disease. Rain wash of Bordeaux paste could be reduced by using additives like rubber seed oil. Dry rot and patch canker diseases cause problems only in limited areas and could be controlled by fungicide painting on affected portion. Black stripe is a problem during rainy season which demands regular protection. Cheap alternatives for mercurial fungicides could be identified for its control. Root disease incidence is sporadic and its spread

can be controlled using systemic fungicides. Investigations on biotic etiology of TPD have indicated that involvement of phytoplasma, bacteria, fungi and protozoa can be ruled out. Association of low molecular weight RNA with TPD has been observed. Hence, a possible viroid etiology is suspected. Insect pests are confined to limited areas and hence their control strategy is targeted to such areas only. Termites cause problems in relatively dry areas like Orissa but can be controlled by repeated application of insecticide like synthetic pyrethroids. Borer beetles that penetrate dry bark of trees and make galleries into wood causing breakage of trees could be controlled to some extent by painting with insecticides. Bark feeding caterpillar, though could be controlled using insecticide dust and spray, their use may lead to pollution of environment. Hence biological alternatives are being sought. Crickets damaging rain guards could be avoided by painting repellant oils like cashew kernel oil. Root-knot nematode population in nurseries could be reduced by incorporating leaves of *Pongamia*, *Azadirachta* and *Mucuna* into the soil. Microorganisms which are beneficial in rubber cultivation include N-fixers, P-solubilizers and mycorrhizae. Isolates of *Bradyrhizobium* which promote growth and establishment of cover crops like *Mucuna* and *Pueraria* have been identified, multiplied and used. Among the free N-fixers *Azotobacter* and *Azospirillum* reduce the requirement of N fertilizers in nursery by 25 per cent. Use of phosphobacteria and mycorrhizae reduces the P requirement in nursery culture. Solid waste from rubber wood processing is found to be a very good substrate for mushroom cultivation. Effluent form sheet processing units is a good substrate for biogas generation. Biogas generation system was developed for households and group processing units. The biogas generated could replace the firewood requirement in smoke houses by about 40 per cent. Its use improved the quality of the sheets produced. The technology has been widely adopted. Honey bees are beneficial insects which give additional income to the rubber cultivators. The Indian honey bee, *Apis cerana indica*, has shown signs of revival after the Thai sac brood virus attack and the honey production has improved. Vermicomposting is another beneficial activity on rubber based farms. Rubber wood saw dust is a good substrate for vermicomposting. The vermicompost so developed is useful as organic manure for young rubber.

Key words: Disease control; Insect; Microorganism; Rubber plantation

6. Jacob, C.K. (2008). Potential use of endophytic microorganisms for tree disease management. *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production,* 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 62-63.

Management of diseases of trees poses several challenges. Development of sustainable plant protection techniques is the most desirable approach for tree disease management. As the endophytic microorganisms occur naturally within the plant system, they can be manipulated for sustainable protection of trees. Observation of endophytic bacteria on rubber trees revealed colonisation on different plant parts. Effective antagonistic endophytes when sprayed on susceptible immature and mature rubber trees grown in *C. cassiicola* disease endemic locations protected them from the disease. The trees sprayed with the endophytic bacteria showed faster sprouting and enhanced growth.

Key words: Disease management; Endophytic microorganisms

7. Jacob, C.K., Kothandaraman, R. and Idicula, S.P. (1996). Advances in the control of diseases of rubber in India. *National Symposium on Diseases of Plantation Crops and their Management,* 18-20 February 1996, Sreenikethan, India.

Key words: Abnormal leaf fall; Disease control; Minor disease; Pink disease; Powdery mildew

8. Joseph, K. and Jacob, C.K. (2009). Biological management of pathogens in plantation crops. *In: Role of Biocontrol Agents for Disease Management in Sustainable Agriculture.* (Eds. P. Ponmurugan and M.A. Deepa). Scitech Publishers (India) Pvt. Ltd., Chennai, India, pp. 89-106.

Plants harbour a heterogenous population of epiphytic and endophytic microorganisms. Colonisation of plant and its rhizosphere by disease suppressive microorganisms can prevent pathogens from establishing on plant. The chapter reviews microorganisms used for disease management of agricultural crops, different mechanisms of biocontrol and studies carried out in different plantation crops.

Key words: Biological control; Disease management; Plantation crops

9. Mathew, J., Roy, C.B., Raj, S., Abraham, T., Jose, V.T., Mondal, G.C. and Sailajadevi, T. (2010). Changing climate and changing patterns of occurrence of pests and diseases in natural rubber in India. *In*: *Climate Change, Low Carbon Economy and Sustainable Natural Rubber Industry: Preprints of Proceedings of IRRDB International Rubber Conference,* 18-19 October 2010, Hainan, China, pp. 193-196.

Weather parameters have an important role in triggering and spreading pests and diseases in natural rubber. Abnormal leaf fall disease caused by the fungus *Phytophthora* occurring during monsoon season is highly influenced by rainfall pattern. ALF has not been observed in rubber plantations of North East India, where a *Phytophthora* susceptible clone RRIM 600 is widely cultivated. Corynespora leaf fall disease caused by the fungus *Corynespora cassiicola* has been found in nursery plants in Central Kerala from 1958 onwards. Powdery mildew disease caused by *Oidium heveae* is the major leaf disease in the North Eastern states of India during the winter period from January to March. Though pest incidence in natural rubber is comparatively less, the same is also found to be on the rise because of warming temperature in recent years. In general, a change in the disease and pest incidence in natural rubber in India corresponding to the changes in climatic parameters could be observed. Therefore, in the current scenario of climate change, shift in the pattern of these pests/disease attacks in natural rubber should be anticipated and their evolution should be closely watched.

Key words: Climate change; *Corynespora cassiicola; Oidium heveae; Phytophthora*

10. Mathew, J., Abraham, T. and Biju, B. (2010). Rubber clinic: A distance diagnostic and information system for the rapid diagnosis and management of pests and diseases of natural rubber. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp.197.

A Distance Diagnostic and Identification System (DDIS) – 'Rubber Clinic' was designed and developed at RRII. The Clinic, which forms a part of the Rubber Board's website www.rubberboard.org.in is an interactive portal and is a rapid diagnosis and identification portal of pests and diseases of rubber. DDIS is a NET/MS SQL based three-tier application using objects database technologies which was launched in January 2010. Farmers can compare the images/

photographs of the disease symptoms along with the descriptions and remedial measures uploaded in the web pages, to diagnose the problems on their own and adopt the appropriate control strategies. If, in any case, the grower finds it difficult to diagnose the problem from the details already available on the clinic site, digital images of the problems in the field may be taken by him which is to be uploaded on the site along with a brief description of the symptoms and their history. Experts from the RRII will in turn identify the problem and appropriate recommendations will be given back to the grower within 24 hours. Each user can create a login user account through which he can communicate/interact with experts and receive the recommendations. In the Rubber Clinic, there is provision for online live chatting with scientists/experts from 2 to 3 pm(IST) on every working day. The user can also log on to the Clinic at any time of the day for diagnosis on his own or for fixing an appointment with the expert. Apart from disease and pest problems, users can also ask questions on any topic related to rubber cultivation/processing etc. which will be examined by experts in the respective fields and recommendations will be given through the Rubber Clinic.

Key words*:* Digital image library; Distance Diagnostic and Identification System (DDIS); Pests and diseases; Rubber clinic

11. Pillay, P.N.R. (1972). Diseases of rubber tree in India. *Planters Journal and Agriculture.*

Key words: Rubber disease

12. Pillay, P.N.R. (1972). Use of low USR value diluent mineral oil for rubber spraying. *Rubber Research Newsletter*, **1.**

Key words: Mineral oil; Spraying

13. Pillay, P.N.R. and George, M.K. (1973). Recent advances in plant protection of rubber in India. *Seminar on Rubber*, 1973, Palai, India.

Key words: Crop protection; Rubber disease

14. Pillay, P.N.R., George, M.K. and Thankamma, L. (1974). Effect of defoliation in the yield of *Hevea*. *IRRDB Scientific Symposium*, Part I, 26-28 September 1974, Cochin, India.

1956 planted G1. 1 plants were defoliated at 0, 25, 50, 75 and 100% levels by clipping off the leaves. Five trees were included in each treatment. Defoliation was uniformly carried out spread over the entire canopy. Yield data indicated that there was 0.37% increase in yield in the case of plants on which 25% defoliation was effected. Decrease in yield was 22.79, 30.60 and 24.14% in the case of plants defoliated at 50, 75 and 100% levels, respectively. The results indicated that in a clone like G1. 1 with a very sparse canopy there was no drop in yield when 25% defoliation was effected. All the plants included in the different treatments in this experiment wintered uniformly during the month of February indicating that the critical factor influencing wintering habit in *Hevea* is not the age of the leaves.

Key words: Defoliation; Yield

15. Pillay, P.N.R. and Edathil, T.T. (1979). Problems of plant protection in rubber smallholdings in India. *In: Progress and Development of Rubber Smallholders: Proceedings of the Third Seminar*, 24-30 November 1977, Cochin, India. (Eds. Sumardi Reksopoetranto and G.S. Tan). Association of Natural Rubber Producing Countries, Kuala Lumpur, Malaysia, pp. 187-190.

The paper points out that smallholdings in India face many plant protection problems. The various types of diseases affecting rubber trees are mentioned and measures adopted to eradicate them are discussed. Reasons are given for the non-adoption of adequate plant protection measures by smallholders and the various schemes drawn up to assist them are analysed.

Key words: Disease management; Plant protection; Smallholdings

16. Rajalakshmy, V.K. (2000). Use of wild germplasm in breeding for disease resistance. *Rubber Board Bulletin*, **27**(4): 21-24.

The cheapest and most effective method of combating diseases and pests is the use of resistant varieties. Provided that inherited resistance is not associated

with low yield and poor quality, it is as cheap for a farmer to grow a resistant variety as one which is susceptible. Wild germplasm has been widely used in breeding for disease resistance.

Key words: Disease resistance; Germplasm

LEAF DISEASES

17. Abraham, A., Philip, S., Joseph, K., Joseph, J., Pramod, S. and Jacob, C.K. (2008). Isolation and screening of Antagonistic bacterial endo-symbionts from rubber (*Hevea brasiliensis*) and their growth promoting activity. *IPS-MEZ Annual Meeting and National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production*, 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarkhand, Souvenir and Abstracts.

Hevea brasiliensis is the commonly cultivated commercial crop for the natural production of rubber. Population of endophytic bacteria colonizing aerial plant parts (stem and leaf) of *H. brasiliensis* was estimated from the newly developed RRII 400 series clones (RRII 414, RRII 417, RRII 422, RRII 429, RRII 430) and the popular clone RRII 105. Greater population of endophytic bacteria was recovered from stem than leaf tissues. Population densities in aerial parts ranged from 6.3x103 to 1.9x104 cfu/g stem and 1.4x103 to 1.3x104 cfu/g leaf on dry weight basis. Endophytic bacteria were localized in the intercellular spaces of plant tissue by 2,3,5-Triphenyl tetrazolium chloride staining. Antagonistic activity of endophytes against these fungal pathgens of *H. brasiliensis viz. Phytophthora meadii, Corynespora cassiicola* and *Corticium salmonicolor* was studied *in vitro*. Out of 127 isolates, 21 showed antagonism against *P. meadii*, 16 against *C. salmonicolor* and 14 against *C. cassiicola*. Three best antagonists from each group were selected and the production on antifungal compounds *viz.* non-volatile and volatile organic compounds, siderophores, HCN, salicylic acid and lytic chitinase were checked. A consortium of three efficient antagonists were prepared and their role in inducing Systemic resistance (ISR) of treated plants detected by the elevation of the PR proteins *viz.* chitinase and peroxidase. Bioassay using consortium of bacteria showed lower disease incidence on the clone RRII 105 and RRIM 600. The growth promoting activity of the consortium were checked by

measuring the photosynthetic rate and accumulation of starch granules in plant tissues. The consortium of bacteria when applied to seedling plants showed growth promotion. Isolates which showed promising results were identified as *Bacillus* sp. and *Pseudomonas* sp. by 16S rDNA sequencing. The results indicate that endophytic bacteria of *H. brasiliensis* offer potential as biocontrol agents and plant growth promoters.

Key words: Bacterial endosymbionts; *Corynespora cassiicola; Corticium salmonicolor; Phytophthora meadii*

18. Abraham, A., Philip. S. and Joseph, K. (2011). Antagonistic potential of bacterial endophytes isolated from *Hevea brasiliensis* against *Phytophthora meadii*. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Bacterial endophytes colonize the internal tissues of the plants and help the plants in many ways such as increased stress tolerance (abiotic and biotic), plant growth promotion etc. Population of endophytic bacteria in different tissues of *Hevea brasiliensis* was estimated and were found to be more in root than petioles and leaf. Out of 252 morphologically different endophytic bacterial isolates of *Hevea* from five different locations, 42 showed *in vitro* antagonisms against *Phytophthora meadii*, causing various diseases in rubber. Out of the six selected antagonists, five were identified as *Pseudomonas* sp. and one as *Alcaligenes* sp. by 16S rDNA sequencing. Bioassay of the antagonistic efficiency of *Alcaligenes* sp. against *P. meadii* was studied using polybag plants of *Hevea* clones RRII 105, tolerant to *P. meadii* and susceptible clone RRIM 600. *In vitro* assessment was carried out in plants inoculated with broth culture of bioagent by foliar spraying and soil application. Controls were maintained with cell free broth treated and untreated plants. Leaves were collected after 7days of inoculation under each treatment and inoculated with *P.meadii* spore suspension. Lesion size was recorded after 72 h of incubation. In RRII 105, bioagent treated plants showed less infection in leaf tissues (lesion size, 3.3 mm) compared to plants treated with cell free broth (lesion size, 5.8 mm) and untreated control (lesion size, 6.3 mm) plants. In RRIM 600 lesion, size was 4.3 mm in bioagent treated plants, 6.2 mm in cell free broth sprayed control plants and 6.5 mm in untreated control plants. For *in vivo* bioassay, plants were inoculated with spores of *P.meadii* after bioagent application and

recorded the disease intensity after 7 days of incubation. No significant difference was observed in the disease development between bioagent inoculated and control plants of the tolerant clone RRII 105 while in RRIM 600, the susceptible clone, bioagent treated plants showed less disease development compared to control plants. This study clearly indicates that endophytic bacteria of *H. brasiliensis* offer great potential as antagonistic agents against *P. meadii*.

Key words: Antagonism; Endophytic bacteria; *Phytophthora meadii*

19. Ananth, K.C. and Menon, K.N.G. (1965). Shade as a culture for the control of leaf-spot disease occurring in *Hevea* seedling nurseries. *Rubber Board Bulletin,* **8**(2): 78-89.

While the incidence of leaf-spot disease caused by *Helminthosporium heveae* in rubber nurseries of southern India is decreasing, that of a similar but more serious disease caused by *Corynespora cassiicola* is on the increase. A nursery trial showed that shading by palm fronds from the 2nd to the 6th month after planting reduced the severity of this disease and the proportion of casualties, and considerably increased the proportion of seedlings transplantable to the field after 10 months. The usual NPK fertilizer dressings had no or an adverse effect on the severity of leaf spot; they increased plant height and the proportion of casualties. Fertilizers in combination with shade enhanced the beneficial effects of shade. Four low-volume sprayings with Bordeaux mixture had a slight beneficial effect on the unshaded beds only.

Key words: *Corynespora cassiicola*; *Helminthosporium heveae;* Leaf spot

20. Chacko, N., Philip, S., Zachariah, C.A. and Jacob, C.K. (2005). Artificial induction of chitinase and phenylalanine ammonia lyase activity in *Hevea brasiliensis*. *In: Preprints of Papers. International Natural Rubber Conference, India 2005,* 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 523-526.

A comparative study of biochemical variation in expression of defense related enzymes in response to salicylic acid and pathogen inoculation was carried out in two *Hevea brasiliensis* clones showing varying degrees of tolerance to Corynespora leaf disease. Similar increasing trend was noticed in chitinase activity

in both salicylic acid and pathogen-inoculated plants. The activity was more prominent in the tolerant clone GT 1 compared to the susceptible one, RRII 105. Phenylalanine ammonia lyase activity showed an initial increase up to 96 h after treatment and thereafter it declined. The enzyme activity induced by the pathogen and salicylic acid were comparable.

Key words: *Corynespora cassiicola*; Isozyme

21. Deka, H.K., Thapliyal, A.P., Mondal, G.C., Sinha, R.R. and Sethuraj, M.R. (1996). Occurrence of *Gloeosporium alborubrum* on rubber in Meghalaya. *Indian Journal of Natural Rubber Research*, **9**(1): 55-57.

The incidence, seasonal occurrence and extent of damage caused by *G. alborubrum* (*Glomerella cingulata*) on rubber (*Hevea brasiliensis*) trees in Meghalaya, India, was studied. The fungus was abundant in the rainy seasons, but the % disease index diminished when temperature and RH were comparatively low. In the plants examined, the disease was so mild that defoliation and dieback of plants did not occur.

Key words: *Gloeosporium alborubrum*; Secondary leaf fall; Meghalaya

22. Edathil, T.T. (1987). South American leaf blight: A potential threat to the natural rubber industry in Asia and Africa. *Rubber Board Bulletin*, **22**(3): 5-13.

The blight, caused by *Microcyclus ulei*, is the main limiting factor to the development of natural rubber industry in South and Central America. Present knowledge of its distribution, epidemiology and spore viability, the risks of its entry into Asia and Africa and its possible behaviour in these countries are reviewed. In the control of this disease, application of defoliants and fungicides, breeding for leaf blight resistance and crown budding of high yielding susceptible panel clones with leaf blight-resistant crowns are measures currently being investigated. As the present quarantine regulations appear inadequate the need for more rigorous measures is emphasized.

Key words: South American Leaf Blight; Africa

23. Edathil, T.T. and George, M.K. (1976). *Phytophthora nicotianae* var parasitica (Dastur) Waterhouse on *Hevea brasiliensis* in South India. *Rubber Board Bulletin*, **13**(1&2): 3-4.

Phytophthora infected petioles and fruits of *Hevea brasiliensis* were collected from an isolated rubber estate during the *Phytophthora* disease season of July 1971. *P. nicotianae* var *parasitica* was isolated from the infected petioles and fruits of rubber. The isolate, when artificially inoculated on healthy twigs of the clone RRIM 701, produced typical symptoms of Abnormal leaf fall disease of rubber under controlled conditions in the laboratory. The pathogen was reisolated from artificially inoculated and infected plant parts.

Key words: Abnormal leaf fall; *Phytophthora nicotianae*

24. Edathil, T.T. and Pillay, P.N.R. (1976). Studies on the role of wind and insects in the dissemination of Abnormal leaf fall disease of rubber in South India. *Rubber Board Bulletin*, **13**(4):107-115.

On rainy days healthy and viable sporangia contained in small water particles blown by wind were caught on the slides exposed in spore traps which were placed 6-120 metres away from mature rubber area at different locations of the RRII Experiment station. Insects, which were observed to visit infected fruits, were found to carry large number of viable sporangia on their body parts. Such sporangia, contained in water particles blown by wind and carried by insects on their body parts, germinated readily and took infection on leaves and fruits of *Hevea* when artificial inoculation was carried out. Hence, dissemination of Abnormal leaf fall disease could be clearly possible with the help of these two agencies.

Key words: Abnormal leaf fall; Insect

25. Edathil, T.T. and George, M.K. (1980). *Phytophthora botryosa* Chee on *Hevea brasiliensis* in South Andaman Island. *International Rubber Conference*, 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

Incidence of Abnormal leaf fall disease for rubber plants in South Andamans was investigated during the year 1976. *Phytophthora* infected petioles and tender shoots were collected from there and the pathogen was isolated by tissue culturing the

infected materials on potato-dextrose agar medium. In the preliminary studies the isolate showed much variation to the other three known species of *Phytophthora* infecting rubber plants in the main land. The isolate was observed to produce sporangia, in large clumps, in oats agar medium. When artificial inoculation studies were conducted with this isolate, 100 per cent infection was obtained on cut twigs of rubber plants (RRIM 701). This isolate was identified as *Phytophthora botryosa* Chee by the Commonwealth Mycological Institute.

Key words: *Phytophthora botryosa*; Andamans

26. Edathil, T.T., George, M.K., Krishnankutty, V., Jacob, C.K. and Pillay, P.N.R. (1984). Fogging for controlling *Phytophthora* and *Oidium* leaf diseases of rubber in India. *Fourth National Seminar on Rubber*, June 1984, Salvador, Brazil, pp. 156.

The leaf falls caused by *Phytophthora* spp. and *Oidium heveae* are the most serious leaf diseases of *Hevea brasiliensis* in India. The former occurs during the southwest monsoon months of June, July and August and causes very severe defoliation and extensive die-back of tender twigs of the mature plantations. It also causes leaf fall and shoot rot in young plants. It is an annually recurring disease and warranting costly control operations with copper fungicides. Yield loss due to this disease is estimated to be about 30-50 per cent in susceptible clones. *Oidium* leaf fall is mainly confined to high elevation plantings and to Kanyakumari District at Tamil Nadu. This pathogen infects the tender leaves of rubber during the refoliation period of February-March and causes premature leaf fall and die-back. If left unprotected it can cause yield losses upto 30% in susceptible clones. Fogging trials conducted during 1982 season with "TIFA" Tiga fog generator using 5 kg of copper oxychloride powder 56% in 20 l of diluent spray oil per hectare gave better control of *Phytophthora* leaf fall than conventional aerial spraying of 8 kg of copper oxychloride powder 56% in 42 l of oil per hectare. This experiment was repeated during 1983 season with reduced dosage of copper i.e. 4 kg of COCl 56% in 16 l of diluent spray oil per hectare. The result was poor; although in one location fogging was better than aerial spraying, in three others it was marginally less effective. Calixin 80 EC (tridemorph) 3% in diluent spray oil fogged four times at the rate of 5 l/ha/round at an interval of 10-15 days gave

better control of powdery mildew disease than an equal round of sulphur dusting at 12 kg/ha/round.

Key words: Disease control; Fogging equipment; Leaf disease; *Oidium heveae*; *Phytophthora*

27. Edathil, T.T., Krishnankutty, V. and Jacob, C.K. (1984). Thermal fogging: A new method for controlling powdery mildew disease of rubber in India. *Pesticides*, **18**(5): 35-36.

A portable fog generator Pulsfog K3 was field tested for fogging tridemorph against powdery mildew disease of rubber. Further investigations on improving the feasibility of its use are suggested.

Key words: Disease control; Powdery mildew; Thermal fogging

28. Edathil, T.T., Jacob, C.K., Idicula, S.P. and Jayarathnam, K. (1984). Combating leaf fall. *Planters' Chronicle*, **79**(5&6): 199-200.

The need for prophylactic spraying against Abnormal leaf fall disease of *Hevea* caused by *Phytophthora* spp. in Kanyakumari district was investigated. Annual prophylactic spraying was found to be unnecessary.

Key words: Abnormal leaf fall; Kanyakumari

29. Edathil, T.T., Krishnankutty, V., Idicula, S.P. and Jayarathnam, K. (1988). Powdery mildew disease management in *Hevea brasiliensis* using non-sulphur fungicides. *Indian Journal of Natural Rubber Research*, **1**(2): 61-65.

Experiments were conducted to identify more efficient non-sulphur fungicides, in place of sulphur fungicides, for effective management of powdery mildew disease of mature as well as young *Hevea* rubber plants. In mature areas application of tridemorph 1.5 per cent dust was found superior to sulphur dust. Spray application of carbendazim 0.05 per cent was found to give better control than the conventional wettable sulphur. As repeated use of any systemic fungicide may lead to development of resistance to the fungicide by the pathogen, alternate use of systemic and non-systemic fungicides is suggested.

Key words: Dust fungicide; Powdery mildew

30. Edathil, T.T., Krishnankutty, V., Jacob, C.K. and Idicula, S.P. (1988). Protection of young rubber plants from powdery mildew disease with systemic fungicides. *Rubber Board Bulletin*, **24**(2): 22-23.

Applications of Bavistin [carbendazim] at 0.2% a.i. gave the best control of *Oidium heveae*, followed by Topsin [thiophanate]. The alternate use of carbendazim and wettable sulfur is suggested, to prevent the possible development of fungicide resistance in the pathogen.

Key words: Fungicide; Powdery mildew; Young rubber

31. Edathil, T.T., Idicula, S.P., Jacob, C.K., Krishnankutty, V. and Jayarathnam, K. (1992). Recent experiments on management of two *Phytophthora* diseases of *Hevea* rubber in India. *International Natural Rubber Conference*, 5-8 February 1992, Bangalore, India.

The varied performance of certain clones against Abnormal leaf fall disease of rubber caused by *Phytophthora* spp. in low and high rainfall areas and the escalation cost of copper fungicides spray oil and spraying operation necessitated the need for clone wise and region wise recommendations for rubber spraying. In order to achieve this objective, experiments were started in a low rainfall area at Punalur and high rainfall area at Palapilly on the clone RRII 105 during 1990 and this was extended to the susceptible clone RRIM 600 also during 1991 in the high rainfall area. In low rainfall area the lower and higher dosages tested were 2 kg and 8 kg copper oxychloride (COC) 56 per cent oil dispersible powder (ODP) in 30 litres of spray oil per hectare respectively. In high rainfall area the dosages were higher than that of the low rainfall area with 4 kg COC 56% ODP for the lower dose and 10 kg COC 56% ODP for the higher dose. However, the volume of the spray oil remained same for both locations. Spraying was carried out with micron sprayers in two disease seasons in 0.4 ha plot each with four replications. The results for the trials indicated that there was no difference in leaf fall among treatments in low rainfall area in 1990 and 1991 seasons. However, there was marked difference between treatments in high rainfall area with regard to clone RRII 105 in both the years. The unsprayed plots suffered heavy leaf fall of 81 and 91 per cent respectively in the first and second year. In RRIM 600, there was severe leaf fall although better leaf retention was noticed in plots applied with

higher dosages. The spray volume and dosage experiments in aerial sprayed plots indicated that a definite conclusion could not be drawn with the available data. High volume spraying experiments were conducted on the clone GT 1 with various dosages of 1 per cent Bordeaux mixture. The results indicated that a spray volume of 3000 l/ha has given satisfactory protection for that clone. The lower dosages 1000 and 2000 l/ha were quiet inadequate for giving satisfactory leaf retention. In order to find out the interval of the application of the most effective fungicide, mancozeb against bark rot disease control, experiments were conducted in 28 tapping blocks to accommodate seven treatments with four replications each for two disease seasons. It was observed that mancozeb at 0.75 per cent a.i. with weekly application was significantly superior to fortnightly application schedule.

Key words: Disease control; *Phytophthora*

32. Edathil, T.T., Krishnankutty, V., Idicula, S.P. and Jayarathnam, K. (1992). Economic and effective management of powdery mildew disease of *Hevea* rubber in South India. *Placrosym* IX, 1990, Bangalore, India. *Journal of Plantation Crops*, **20**(Supplement): 61-64.

Experiments were conducted to find out methods of economic and effective management of powdery mildew disease of mature as well as young *Hevea* rubber plants. In mature plantations it was found that 4 rounds of alternate application of sulphur dust (12 kg/ha/round) and tridemorph 1.5 per cent dust (10 kg/ha/round) gave better control of the disease than 4 rounds of sulphur dusting at 12 kg/ha/round. However, two rounds of tridemorph 1.5 per cent dust at 10 kg/ha/round with one round of sulphur dust at 12 kg/ha/round in between was the most effective. In an attempt to reduce the dosage, two rounds of tridemorph 1.5 per cent dust at 7 kg/ha/round with one round of sulphur dust (12 kg/ha/round) in the middle, was found to be equally effective. In young rubber plantations, 4 rounds of spray application of 0.025 per cent carbendazim in combination with 0.1 per cent wettable sulphur was equally effective with carbendazim in combination with 0.1 per cent wettable sulphur was equally effective with carbendazim, and triademoforn and gave more economic disease control.

Key words: Disease control; Powdery mildew

33. Edathil, T.T., Jacob, C.K. and Idicula, S.P. (1994). Evaluation of copper fungicide dosage requirements against Abnormal leaf fall disease of rubber for a high and low susceptibility clone in two agroclimatic regions. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 52-55.

Evaluation of copper fungicide dosage requirements against abnormal leaf fall disease for a high susceptibility clone (RRIM 600) and a low susceptibility clone (RRII 105) in two different agroclimatic conditions, *viz.* low and high rainfall areas, from 1990-1992 was carried out to assess the necessity for the evolution of clonal and regional recommendations for rubber spraying. A minimum dose of 2 kg/ha was sufficient to protect clone RRII 105 in a low rainfall area whilst 4 kg/ha was required for clone RRIM 600. A higher dose of 10 kg/ha was necessary to protect the low susceptibility clone in a high rainfall area whereas even this dose was not effective on the highly susceptible clone.

Key words: Abnormal leaf fall; Agroclimatology; Copper fungicide; *Phytophthora*

34. Edathil, T.T., Jacob, C.K., Idicula, S.P. and Joseph, M. (1998). Efficient management of powdery mildew disease of *Hevea* rubber plants with integrated use of systemic and non-systemic fungicides. *In: Developments in Plantation Crops Research: Placrosym* XII, 27-29 November 1996, Kottayam, India. (Eds. N.M. Mathew and C. Kuruvilla Jacob). Allied Publishers, New Delhi, pp. 287-291.

Experiments were conducted to evolve suitable techniques of fungicidal application for the integrated use of systemic and non-systemic fungicides and to identify effective non-systemic fungicides in the management of powdery mildew disease of rubber plants (*Hevea brasiliensis* Muell. Arg.). In the mature trees, it was found that two rounds of dusting of 1.5 per cent tridemorph dust with one round of dusting of 70 per cent sulphur dust in the middle proved to be the most effective and significantly superior to three rounds of either tridemorph or sulphur dusting. The mixed use of systemic and non-systemic fungicides (tridemorph + sulphur) was on par with this treatment. The cost of application of these two treatments was also comparable. In spraying experiments, mixed use of systemic and non-systemic fungicides (carbendazim +wettable sulphur) and microsul a new non-systemic fungicide was found to be much promising and economic.

Key words: Disease control; Fungicide; Powdery mildew

35. Edathil, T.T., Jacob, C.K. and Joseph, A. (2000). Leaf diseases. *In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 273-296.

This chapter deals with the leaf diseases of rubber. The chapter is divided into several chapters. A general introduction on the leaf diseases. This is followed by details regarding each disease. The diseases including abnormal leaf fall, shoot rot, powdery mildew, Corynespora leaf disease, *Gloeosporium* leaf disease, Bird's eye spot, Anthracnose, Thread blight and South American leaf blight are discussed. The disease development and symptoms, causal organism, economic importance, clonal susceptibility, and control measures are discussed in detail for each disease.

Key words: Abnormal leaf fall; Disease control; Leaf disease; Powdery mildew; South American Leaf Blight

36. Edathil, T.T., Lakshmanan, R. and Thomas, V. (2009). Screening of clones of rubber (*Hevea brasiliensis*) for growth and tolerance to powdery mildew disease at a high altitude station in Kerala, India. *Natural Rubber Research,* **22**(1&2): 151-155.

Ten ortet selections and five popular clones of *Hevea brasiliensis* were screened to ascertain powdery mildew disease tolerance in a high altitude station at Ambalavayal, Wayanad in Kerala. The experiment was conducted during the refoliation from January to April for a period of four years. The plants were protected with alternate application of systemic (carbendazim 0.05 per cent) and non-systemic (wettable sulphur 0.2 per cent) fungicides as per standard practice. Girth of the plants and powdery mildew disease assessments prior to and after treatments were recorded. The ortet selection Iritty 1 showed high degree of disease tolerance with better growth.

Key words: Disease screening; Fungicide; Ortets; Powdery mildew; Susceptibility; Tolerance

37. George, M.K. and Edathil, T.T. (1975). Over summering of *Phytophthora* causing Abnormal leaf fall disease of rubber. *Rubber Board Bulletin,* **12**(3): 112-114.

Studies on over summering of *Phytophthora* infecting rubber were carried out by collecting infected specimens and soil samples from different estates and isolating

the pathogen from such materials, during the off season. The fungus was isolated from oospores from infected dried up plant materials. Similarly the pathogen was isolated from soil samples using a selective medium and by baiting with healthy green fruits. The isolates obtained from soil and dried up plant parts were identified as *P. meadii*. The sources of inoculum for primary infection of Abnormal leaf fall disease on rubber were discussed.

Key words: Abnormal leaf fall; *Phytophthora meadii*

38. George, M.K. and Edathil, T.T. (1980). A report on Corynespora leaf spot disease on mature rubber. *International Rubber Conference,* 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

The mature rubber trees were found infected by *Corynespora cassiicola* (Berk & Curt). This was so far noticed only on rubber seedlings and immature rubber trees in India. But this fungus was found infecting mature rubber trees in India during February-March period causing leaf spot. If humid conditions prevail during this period, disease becomes severe and causes leaf fall in all the popular clones. Further spread of the disease is controlled by regular copper fungicide spraying carried out against Abnormal leaf fall disease, during April-May.

Key words: *Corynespora;* Disease management; Fungicide

39. Gogoi, N.K., Dey, S.K. and Idicula, S.P. (2011). Baiting of *Phytophthora* species from rubber (*Hevea brasiliensis*) soil of Tripura and testing cross infectivity of *Phytophthora* species of other crops in rubber. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Abnormal leaf fall (ALF) caused by *Phytophthora* spp. is the most destructive leaf disease of rubber in India. In traditional rubber growing regions of India, extensive defoliation due to ALF results in considerable crop loss ranging 7 to 32%. Fortunately ALF is not observed in rubber plantations of North East region, which is one of the non-traditional regions of India. In Tripura, popular and high yielding clone RRIM 600, a *Phytophthora* susceptible clone is widely cultivated and therefore a sudden outbreak of ALF may pose a serious threat to rubber plantations. In India, four species of *Phytophthora viz. P. palmivora* (Butler), *P. meadii* McRae.,

P. nicotianae var. *parasitica* (Dastur) Waterhouse and *P. botrosa* Chee were isolated from infected specimens of rubber. Though ALF is not observed in Tripura, incidence of other *Phytophthora* diseases like late blight of potato, blight of taro, leaf rot of betelvine, foot rot of black pepper, citrus gummosis, leaf spot of *Philodendron* etc. are observed in varying intensity. Among these, the inciting agent of leaf rot of betelvine, foot rot of black pepper and leaf spot of *Philodendron sp.* are reported to be *P. nicotianae* var. *parasitica* and *P. palmivora* (Holliday and Mowat, 1963, Ridings and Mcritchie, 1974, Tripathi *et al.*, 2003), which also infects rubber. Therefore, an attempt was made to examine the presence of *Phytophthora* spp. in rubber soil of Tripura by baiting technique, to test its pathogenicity on rubber leaf and to perform cross infectivity test of *Phytophthora sp.* isolated from betelvine, black pepper and *Philodendron sp.* on rubber leaves of RRIM 600 clone. Leaf baiting technique was used for fishing out the *Phytophthora* spp. from soil of RRIM 600 plantation, Research Farm of RRII, Taranagar. The baited leaves were placed in potato carrot agar (PCA) medium amended with antibiotics ampicillin and refampicin. The incubation temperature was adjusted at 22 ±1°C for all *in vitro* observations. From majority of the baited leaf bits, rapid growth of *Pythium* spp. was observed, while the growth of *Phytophthora* was little. The pathogenicity of the isolated soil *Phytophthora* spp. was tested in mature rubber leaves of RRIM 600 clone *in vitro* by detached leaf method. None of the isolates could produce characteristic black-brown lesions of *Phytophthora* on inoculated leaves. Incidence of *Phytophthora* leaf rot of betelvine (variety-Mithapatti) and foot rot of black pepper (variety-Panniur1) was observed at Horticulture Research Complex, Nagicherra, Tripura (West) during May-June, 2011. *Phytophthora* leaf spot was also observed in ornamental *Philodendron* plant at Rubber Board complex, Agartala. Diseased leaves, stems and rhizosphere soil samples were collected for isolation of the pathogen as well as baiting of *Phytophthora*. The pathogens were isolated in PCA medium and observed to be *Phytophthora* sp. under microscopic study. Isolated *Phytophthora* spp. was subjected to sporangia production using non-sterile soil extract. Profuse lemon shaped papillate sporangia and terminal as well as intercalary chlamydospores were observed under compound microscope. The mean linear growth of *Phytophthora* spp. of betelvine plant in PCA medium was observed fast recording 39.69 mm in 144 hours after incubation (HAI), while it was only 11.67 mm in potato dextrose agar medium. The culture developed

white colony with aerial habit in PCA medium. Cross infectivity of *Phytophthora* species isolated from betelvine, black pepper and *Philodendron* was done in mature leaves of RRIM 600 clone by slight modification of detached leaf method (Pongpisutta and Sangchote, 2004). The pathogen was simultaneously inoculated in healthy leaves of betelvine and *Philodendron* plant. In both the cases, leaves inoculated with PCA agar plugs devoid of *Phytophthora* spp. served as control. The mean diameter of lesions in betelvine leaf was 7.4 mm in 24 HAI, 12.8 mm in 48 HAI, 22.8 mm in 72 HAI, 30 mm in 96 HAI and 40 mm in 120 HAI. In rubber, lesion development started in 48 HAI and it enlarged slowly. The mean diameter of lesions in rubber leaf was 0 mm in 24 HAI, 9.8 mm in 48 HAI, 14.0 mm in 72 HAI, 18.4 mm in 96 HAI and 20.4 mm in 120 HAI. *Phytophthora* was reisolated from the artificially infected lesions and thus confirmed it pathogenicity on rubber leaves. Brown lesion development was also observed in rubber pod inoculated with the same *Phytophthora* spp. Leaves inoculated with PCA agar plugs devoid of *Phytophthora* spp. did not develop any brown or necrotic symptoms. In *Philodendron* leaves also, the lesion development was observed fast and the mean diameter of lesion recorded 31.3 mm in 120 HAI. Hence, the betelvine pathogen, *Phytophthora* spp. was observed to be moderately virulent to rubber leaves inflicting infection and developing lesions under laboratory condition. *Phytophthora* isolated from black pepper and philodendron plant also observed partially pathogenic to rubber. Baiting of *Phytophthora* was also done in soil samples collected from rhizophere region of betelvine, black pepper and philodendron plant and both rubber and host plants were observed equally efficient in fishing out *Phytophthora* from soil. ALF which occurs during south west monsoon season in traditional rubber growing regions is highly influenced by the rainfall pattern (Mathew *et al.*, 2010). A few weather parameters of Agartala were analyzed for the rainy period (May to August) of 2008-2010. The mean maximum and minimum temperature was observed to be 32.6 and 25°C respectively. The mean monthly rainy days was 18; however, the mean daily rainfall was recorded only 9.14 mm. Average rainfall duration was observed to be very short (1-2 days) and considerably less which is a main predisposing factor for ALF development. Hence, absence of virulent and *Hevea* specific *Phytophthora* strains and prevalence of warm weather coupled with short spell of rainfall may be some of the factors governing the absence of ALF in north east rubber plantations. However,

emergence of virulent *Phytophthora* strains from already existing strains of other crops in the changing climatic scenario and infecting rubber cannot be ruled out in future days.

Key words: *Phytophthora;* Soil; Tripura

40. Idicula, S.P. (2006). Corynespora leaf disease control through cultural practices. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 97-101.

Manipulation of crop management methods has been an age old practice with farmers for prevention of damage due to diseases. Though application of chemicals and evolving resistant planting materials yield better disease control, cultural methods of disease control is important against many diseases. This chapter discusses on adopting cultural practices such as base budding, crown budding and over budding for the management of Corynespora leaf disease in *Hevea*.

Key words: *Corynespora;* Cultural practices; Disease management

41. Idicula, S.P., Edathil, T.T. and Jacob, C.K. (1989). Spray fluid requirements in high volume spraying of rubber. *Placrosym* VII, 1986, Coonoor, India. *Journal of Plantation Crops*, **16**(Supplement): 273-275.

An experiment to determine the minimum spray volume required for adequate protection of mature rubber trees against Abnormal leaf fall by spraying one per cent Bordeaux mixture revealed that satisfactory leaf retention could be ensured by using 3000 litres per hectare. The reduction in spray volume to 3000 litres from the current recommendation of 5000 litres helped in a saving of Rs. 560.00 per hectare.

Key words: Abnormal leaf fall; High volume spraying

42. Idicula, S.P., Krishnankutty, V., Edathil, T.T. and Jacob, C.K. (1989). Comparative efficacy of different copper fungicide formulations and spraying methods in controlling Abnormal leaf fall disease of *Hevea brasiliensis*. *In: Recent Trends in Plant Disease Control.* (Eds. H.B. Singh, D.N. Upadhyay and L.R. Saha). Today and Tomorrow Publishers, New Delhi, India, pp.55-62.

Key words: Abnormal leaf fall; Copper fungicide; Disease control

43. Idicula, S.P., Edathil, T.T., Jayarathnam, K. and Jacob, C.K. (1990). Dry rot disease management in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research*, **3**(1): 35-39.

Three years trials on screening of different fungicides indicated that methoxyethyl mercury chloride, thiram, oxycarboxin, carbendazim, thiophanate methyl and propiconazole were effective in checking dry rot disease of rubber were superior to Bordeaux paste. Comparison of two carriers for fungicides *viz*. pidivyl compound and petroleum wound dressing compound indicated a significant superiority of the latter. The interaction between fungicide and carrier was also significant. Incorporating the fungicide in petroleum compound and applying to the affected area was as effective as applying fungicide solution followed by subsequent application of petroleum compound.

Key words: Disease control; Dry rot; Fungicide

44. Idicula, S.P., Edathil, T.T. and Krishnankutty, V. (1992). Evaluation of fungicides for the control of *Phytophthora* shoot rot of rubber. *Placrosym* IX, 1990, Bangalore, India. *Journal of Plantation Crops*, **20** (Supplement): 76-78.

Field experiments were carried out at two locations for three years using systemic and non-systemic fungicides against shoot rot disease caused by *Phytophthora* spp. on young rubber plants. Copper fungicides were superior to other non-systemic fungicides. The systemic fungicide, Fosetyl A1, was not consistent in its efficacy. Addition of Zinc sulphate to Bordeaux mixture yielded better control. Merits of spraying 0.5 per cent Bordeaux mixture with 0.5 per cent zinc sulphate are discussed. The girth increment of rubber in the experimental plots was not significant.

Key words: Fungicide; *Phytophthora*; Shoot rot

45. Idicula, S.P., Edathil, T.T., Jacob, C.K. and Jayarathnam, K. (1994). Improvement in the efficacy of bordeaux mixture for the control of Abnormal leaf fall disease of rubber by addition of zinc sulphate. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 56-58.

Field experiments were conducted to evaluate the efficacy of 0.5 Bordeaux mixture mixed with 0.5 zinc sulphate for the control of Abnormal leaf fall disease, caused by *Phytophthora* spp. compared to other conventional copper fungicides such as Bordeaux mixture and oil dispersible copper oxychloride. The experiments were conducted on clones RRIM 600 and RRII 105 in a high rainfall area. The results of the trial indicated that the addition of 0.5 zinc sulphate to 0.5 Bordeaux mixture could give adequate protection to the leaves in both clones against Abnormal leaf fall disease. The percentage leaf retention after the disease season was on a par or better than when the two other copper fungicides were employed. The reduction in the cost of chemicals for the spraying of 0.5 Bordeaux mixture with zinc sulphate compared to 1 Bordeaux mixture is discussed.

Key words: Abnormal leaf fall; Bordeaux mixture; Disease control

46. Idicula, S.P., Jacob, C.K. and Kothandaraman, R. (1998). Control of shoot rot disease in *Hevea*. *In: Developments in Plantation Crops Research*: *Placrosym* XII, 27-29 November 1996, Kottayam, India. (Eds. N.M. Mathew and C. Kuruvilla Jacob). Allied Publishers, New Delhi, India, pp. 251-254.

Field experiments were conducted during 1993-95 disease seasons at two high disease prone areas *viz.* Mundakayam and Palapilly, for the control of shoot rot disease caused by *Phytophthora* spp. in young rubber plants. Systemic fungicides such as metalaxyl MZ, fosetyl A1 and phosphorus acid were compared with Bordeaux mixture for their efficacy in checking the disease. Two herbal based fungicides *viz.* Kaarmar and Protect, were later included in the trial. The effect of phosphorus acid, which contained phosphorus, on plant growth was studied. The results indicated that phosphorus acid at 0.16 per cent and metalaxyl MZ at 0.20 per cent were the effective treatments. Spraying of phosphorus acid had significantly increased the girth of plants. Though the cost of spraying of phosphorus acid is high, it has some advantages over copper fungicides.

Key words: Bordeaux mixture; Shoot rot

47. Idicula, S.P., Jacob, C.K., Manju, M.J. and Kothandaraman, R. (2000). Corynespora leaf disease in India: A status report. *IRRDB Workshop on Corynespora Leaf Fall of Rubber*, 6-9 June 2000, Kuala Lumpur, Malaysia.

The Corynespora leaf disease caused by *Corynespora cassiicola* was first reported in 1958 from India. The disease was noticed more on nursery plants. The disease is more severe in mature plantations during the refoliation period after wintering. This paper discusses about symptoms, pre disposing factors, clonal susceptibility, pathogen, disease survey, awareness campaign, disease management, etc.

Key words: Corynespora leaf fall; Disease control

48. Idicula, S. P. and Joseph, A. (2011). Strategies of *Phytophthora* disease management in rubber. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management, 12*-17 September 2011, Kottayam, India.

Key words: Abnormal leaf fall; Bark rot; *Phytophthora*; Patch canker; Shoot rot

49. Jacob, C.K. (1996). *Phytophthora* diagnosis. *IRRDB Information Quarterly*, Part **4**: 14.

Standardization protocol for PCR reaction was optimized for rubber clones and it was found that 50 mg of template DNA, 5 picomoles of primer and 1 unit of Taq polymerase per 25 ml reaction mixture yielded the best amplification. An attempt was made to locate DNA markers linked to tolerance for *Phytophthora* in rubber, which will be of great use in rapid screening of rubber germplasm for incorporation in breeding programmes.

Key words: *Phytophthora* diagnosis

50. Jacob, C.K. (2006). *Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* Rubber Research Institute of India, Kottayam, India, 188 p.

This book is a compilation of reviews on the current status and projection of the possibilities for management of Corynespora leaf disease of *Hevea brasiliensis*, the rubber tree. The book contains detailed description of the impact, symptoms pathogen, environment, host defense, clonal resistance, toxins, control measures including cultural, genetic, biological and chemical methods and their integrated use. A detailed bibliography on the disease provided in this volume will facilitate further reference.

Key words: Corynespora leaf fall; Disease control

51. Jacob, C.K. (2006). Corynespora leaf disease of *Hevea brasiliensis*: A threat to natural rubber production. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 9-16.

This chapter deals with the history of Corynespora leaf disease, disease incidence as reported from Sri Lanka, Malaysia, Indonesia, Thailand, India, Vietnam, Africa, Cote d' Ivoire, Gabon and Cameroon as well as disease incidence in Nigeria. The impact of Corynespora leaf disease in different rubber growing regions in terms of crop loss due to the disease is also mentioned.

Key words: Corynespora leaf fall; Africa; India; Indonesia; Malaysia; Nigeria; Sri Lanka; Thailand; Vietnam

52. Jacob, C.K. (2006). Symptoms of Corynespora leaf disease on rubber (*Hevea brasiliensis). In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 17-25.

This chapter gives a description on the symptoms of Corynespora leaf disease on nursery plants and on mature trees along with colour photographs. Towards the end of the chapter a table clearly compares the symptoms of Corynespora leaf spot disease with the other leaf spot diseases namely powdery mildew disease, *Colletotrichum* leaf disease and Bird's eye spot disease.

Key words: Corynespora leaf fall; Disease symptoms

53. Jacob, C. K. (2008). *Phytophthora* diseases of rubber tree (*Hevea brasiliensis*). *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production,* 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 18-24.

This paper discusses about the Abnormal leaf fall disease of *Hevea brasiliensis*, the para rubber tree, crop loss due to the disease, causal agent, its biology and ecology, epidemiology, disease management, development of tolerant clone, chemical control etc. Other diseases caused by *Phytophthora* are also discussed.

Key words: Abnormal leaf fall; Disease management; *Phytophthora*

54. Jacob, C.K., Edathil, T.T., Idicula, S.P., Jayarathnam, K. and Sethuraj, M.R. (1989). Effect of Abnormal leaf fall disease caused by *Phytophthora* spp. on the yield of rubber tree. *Indian Journal of Natural Rubber Research*, **2**(2): 77-80.

Abnormal leaf fall disease was observed to cause 9 to 16 per cent yield loss in susceptible clones of *Hevea brasiliensis*, of 10 to 25 years age, when prophylactic spraying was skipped for one season. The disease adversely affected growth and bark renewal of the trees. The yield in the subsequent year was also affected adversely in unsprayed areas. The disease increased the plugging index and reduced the dry rubber content of the latex. Weed growth was more in the untreated plots.

Key words: Abnormal leaf fall; *Phytophthora*; Plugging index; Weed growth; Yield loss

55. Jacob, C.K., Edathil, T.T., Idicula, S.P. and Jayarathnam, K. (1992). Effect of powdery mildew disease on the yield of rubber trees in Kanyakumari district. *Indian Journal of Natural Rubber Research*, **5**(1&2): 245-247.

The impact of powdery mildew of *Hevea brasiliensis*, caused by *Oidium heveae*, was evaluated on 2 clones (RRIM 600 and PB 86) at separate locations in the Kanyakumari district, India. Clone RRIM 600 was evaluated during 1983-86 and PB 86 during 1984-87. Clones were either treated with sulfur dust (70%) or left untreated. Severe defoliation and reductions in tree growth were observed in untreated trees of both clones. Disease incidence was 8-12% higher in untreated PB 86, and 8-18% higher in untreated RRIM 600, than in sulfur treated trees of both clones. Crop losses were 20-32% higher in untreated PB 86, and 14-29% higher in untreated RRIM 600, respectively, than in their respective sulfur treated clones. Bark renewal was also higher in sulfur protected plants. It is suggested that the yield increases which would be achieved by using fungicides to control powdery mildew on *H. brasiliensis* in the Kanyakumari district would compensate for the cost of control measures.

Key words: Powdery mildew; Yield loss

56. Jacob, C.K., Jayarathnam, K. and Idicula, S.P. (1994). Use of oil dispersible mancozeb as an alternative fungicide for the control of Abnormal leaf fall disease of *Hevea*. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 39-42.

Oil dispersible mancozeb was tested in the field at different dosages over two seasons for the control of Abnormal leaf fall disease of rubber in clones RRIM 600 and PB 235. The new fungicide formulation gave comparable disease control to that of oil dispersible copper oxychloride at the same active ingredient levels when sprayed from the ground. In aerial spraying, mancozeb gave higher leaf retention compared to copper oxychloride at the same dosage of formulated product.

Key words: Abnormal leaf fall; Disease control; Fungicide; *Phytophthora;* Spraying

57. Jacob, C.K. and Rajalakshmy, V.K. (1994). *Phytophthora* diseases of rubber. *National Group Meeting on Phytophthora Diseases of Horticultural Crops*, 21-23 September 1994, Calicut, India.

Key words: Disease control; *Phytophthora*; Rubber disease

58. Jacob, C.K., Idicula, S.P., Edathil, T.T. and Jayarathnam, K. (1995). New strategies in the control of major leaf diseases of *Hevea*. *Global Conference on Advances in Research on Plant Diseases and their Management*, 12-17 February 1995, Udaipur, India.

Key words: Disease control; Dosage; Leaf disease; *Oidium heveae; Phytophthora*

59. Jacob, C.K., Idicula, S.P., Edathil, T.T. and Jayarathnam, K. (1996). Evaluation of dust formulations of two systemic fungicides for the control of powdery mildew disease of *Hevea brasiliensis*. *Placrosym* XI, 1994, Calicut, India. *Journal of Plantation Crops*, 24(Supplement) (Eds. K.V. Peter, Y.R. Sarma, V. Rajagopal, K.V. Ramana, S. Devasahayam and K.S. Krishnamurthy). Indian Society for Plantation Crops, Kasaragod, India, pp. 229-232.

The systemic dust formulations of the fungicides, tridemorph 1.5 % a.i. and carbendazim 1.5 % a.i. were evaluated for their effectiveness in controlling powdery

mildew disease of rubber in disease prone areas for two seasons. Both the formulations were more effective than sulphur dust. An integrated schedule involving both systemic and non systemic fungicides was as effective as the systemic fungicides, but was superior to non systemic fungicide when either was used alone. The advantages of the integrated approach are discussed.

Key words: Disease control; Fungicide; Powdery mildew; Rubber disease

60. Jacob, C.K., Manju, M.J., Idicula, S.P. and Kothandaraman, R. (2001). Evaluation of new oil-dispersible fungicide formulations for the control of Abnormal leaf fall of rubber (*Hevea brasiliensis*) caused by *Phytophthora* spp. *Indian Journal of Natural Rubber Research*, **14**(2): 112-115.

New oil-dispersible fungicide formulations, mancozeb and its combination with copper oxychloride (COC) and metalaxyl in combination with COC were field-tested in different locations for the control of Abnormal leaf fall disease of rubber (*Hevea brasiliensis*) caused by *Phytophthora* spp. by aerial and ground spraying. A powder formulation of mancozeb and a combination product of COC and metalaxyl (5 kg/ha) were found to be as effective as COC (8 kg/ha). The new fungicides are useful alternatives for COC, which has been continuously in use for about four decades.

Key words: Abnormal leaf fall; Disease control; *Phytophthora*; Spraying

61. Jacob, C.K. and Idicula, S.P. (2004). Developments in leaf disease epidemic management technology for rubber (*Hevea brasiliensis*) plantations in India. *International Workshop on South American Leaf Blight*, 4-6 May 2004, Salvador, Bahia, Brazil.

Strategies have been designed to combat the epidemic leaf diseases caused by *Phytophthora* spp., *Oidium heveae* and *Corynespora cassiicola* in India on the basis of the research over several years. The clones susceptible to *Phytophthora* disease have systematically been replaced with the disease tolerant clone RRII 105, evolved through hybridization. Environmental factors that trigger *Phytophthora* disease development have been identified. The species of *Phytophthora* widely prevalent in India has been identified as *P. meadii*. As clones resistant to *O. heveae* are not available, the disease control depends mainly on chemical

protection. The mechanism of tolerance of GT 1 to *Corynespora* leaf disease has been studied with a view to locate factors that could be transferred to susceptible high yielding clones. Among the *Corynespora* isolates, putative virulence-specific isolates could be identified. The virulence could be related to their efficacy of toxin production. For the control of *Phytophthora*, prophylactic high volume spraying of Bordeaux mixture 1% has been in recommendation from very early days. As this method was costly, efforts were made to reduce the requirement spray fluid and chemicals. Mechanization of high volume spraying was also attempted to reduce labour and to increase coverage. Ground spraying with copper oxychloride dispersed in spray oil using micro sprayers were introduced for prolonged protection and better coverage. Refinements were made to reduce the weight of the sprayers and improve the efficacy of fungicide discharge and light- weight low volume sprayers were developed. Alternative fungicides for copper were also located. Aerial application of copper fungicide was attempted and the method gained wide popularity among large estates. Impact of continuous use of copper fungicides to soil microflora and fauna was observed to be negligible. Powdery mildew disease has been controlled by prophylactic dusting of sulphur. Alternative systemic fungicides were tried for powdery mildew disease control and integrated dusting schedules evolved. Epidemics of Corynespora leaf disease occurred during 1996-98 for which control measures using high volume and low volume spraying as well as dusting of fungicides were evolved. Using these techniques, a campaign was launched for suppression of the pathogen during 1999. Subsequent surveys revealed considerable reduction in disease intensity and declined in spread of the disease. In order to prevent the entry of South American Leaf Blight into India, quarantine regulations have been stipulated. Under these rules, import of rubber plant materials from Tropical America is prevented. Import of rubber plants from any other country is permitted only through the Rubber Research Institute of India and strict post-entry quarantine is prescribed. Although techniques for sudden defoliation of rubber have been evolved, the choice is for chemical control as rubber is mainly grown in homestead gardens interspersed with many other crop plants in the smallholdings.

Key words: Disease control; Fungicide; Leaf disease; *Phytophthora*; Rubber plantation

62. Jacob, C.K., Srinivas, P., Prem, E.E., Manju, M.J., Mushrif, S.K. and Idicula, S.P. (2005). Potential use of rubber seed oil as carrier for copper fungicides in the management of Abnormal leaf fall disease of *Hevea brasiliensis*. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 456-462.

Rubber seed oil was evaluated for its potential use in oil based spray formulations against Abnormal leaf fall disease of *H. brasiliensis* leading to more economic disease management. Rubber seed oil (RSO) and mineral spray oil (SO) mixed in the proportion of 1:2 was assessed as carrier for the fungicide Copper oxychloride (COC), in comparison with mineral oil alone. The scope for reducing the dosage of COC, when RSO and SO were mixed (1:2 proportion) for spraying against Abnormal leaf fall disease, was also investigated in field trials in two endemic locations. Result indicated that the use of rubber seed oil for partial substitution of spray oil was promising and resulted in similar disease control as provided by the standard recommendation over six years of experimentation. Lower dose (6 kg/ha) of COC was found to be comparable to recommended dose of (8 kg/ha) when RSO+SO was used as carrier. RSO had no phytotoxic effect on the rubber leaves either alone or in different combination with spray oil. Reduction in the cost was evident by imposing of a combination of partial complementation with RSO and reduced dosage of COC.

Key words: Abnormal leaf fall; Copper fungicide; Disease control; Rubber seed oil; Spraying

63. Jacob, C. K., Prem, E. E., Manju, M.J., Idicula, S. P. and Edathil, T. (2006). Crop loss due to Abnormal leaf fall disease of rubber (*Hevea brasiliensis*) caused by *Phytophthora* spp. *Natural Rubber Research*, **19**(1 & 2): 1-8.

Evaluation of crop loss due to Abnormal leaf fall disease caused by *Phytophthora* spp. in rubber (*Hevea brasiliensis*) plantations of the clones RRIM 600, GT 1 and RRII 118 over 14 years revealed 31.66, 8.21 and 7.15 per cent loss respectively. No such loss was observed for the clone RRII 105 in the plantation in southwestern India. The mean leaf retention in clone RRIM 600 was only 14.32 per cent as against 54.82 in RRII 105. There was a significant and positive correlation between

crop loss in the clone RRIM 600 and the leaf fall in the preceding two years. For RRII 105, the depression in yield during the disease season was compensated by the post wintering resurgence in crop production. The weather conditions had more pronounced effect on crop production in this clone than the disease incidence. The adverse effect of disease on the affected clones resulted in poor girthing and lower wood volume at felling. An increase in crop by 2 to 3 per cent compensates for the cost of spraying. Location specific recommendations of clones for disease avoidance could be a useful strategy for higher crop production.

Key words: Abnormal leaf fall; Clone; Crop loss; Leaf disease; *Phytophthora*; Wood volume

64. Jacob, C.K., Srinivas, P. and Roy, C.B. (2006). *A Laboratory Manual for International Training on Strategies for Management of* Corynespora *Leaf Fall Disease of Hevea brasiliensis*. Rubber Research Institute of India, Kottayam, India, 58 p.

This manual is a guide to the various practical activities included in the training programme on "Strategies for management of Corynespora leaf fall disease of *Hevea brasiliensis*". This compilation covers techniques ranging from morphological identification to molecular plant pathology and disease management.

Key words: Corynespora leaf fall; Laboratory manual

65. Jacob, C. K., Srinivas, P., Prem, E. E., Manju, M.J., Mushrif, S. K. and Idicula, S. P. (2007). Rubber seed oil for partial substitution of mineral oil used as carrier for copper fungicide in the management of Abnormal leaf fall disease of rubber. *Journal of Rubber Research*, **10**(1): 54-61.

Rubber seed oil (RSO) was evaluated for its potential use in oil-based spray formulations against Abnormal leaf fall disease of rubber (*Hevea brasiliensis*) which could influence the economics of disease management. A mixture of RSO and mineral spray oil (SO) in a proportion of 1:2 was assessed as a carrier for the fungicide copper oxychloride (COC), in comparison with SO alone. The scope for reducing the dosage of COC, when RSO and SO were mixed (1:2 proportion) for spraying against Abnormal leaf fall disease, was investigated in field trials in two endemic locations over six years. Results indicated that the use of RSO for partial

substitution of SO was promising and resulted in similar disease control as provided by the use of SO. Lower dosage (6 kg/ha) of COC was found to be comparable to the recommended dosage of COC (8 kg/ha) when RSO + SO was used as carrier. RSO had no phytotoxic effect on the rubber leaves either alone or in combination with spray oil. Reduction in cost was evident when a combination of partial complementation with RSO and a reduced dosage of COC was applied

Key words: Abnormal leaf fall; Copper fungicide; Disease control; Rubber seed oil

66. Jayarathnam, K., Rao, P.S., Jacob, C.K. and Edathil, T.T. (1987). Prophylactic spraying against Abnormal leaf fall disease: Essential or not? *Rubber Board Bulletin*, **23**(2): 24-28.

This paper indicates that disease appear even in years when monsoon fall, but the intensity of the disease may not be severe. Considering the damage done to the bees such as leaf fall, die back of twigs and drying branches which result in the loss of vitality of the trees and also the crop loss, protecting the trees against the ravages of the disease is essential for a tree crop like rubber. Unprotected trees will be more prone to diseases. Moderately tolerant clones are likely to get protection with lower dosages and fungicide according to rainfall pattern of the region concerned.

Key words: Abnormal leaf fall; Crop loss; Prophylactic spraying

67. Jayarathnam, K., Rao, P.S. and Krishnankutty, V. (1987). A study on the weather associated with the Abnormal leaf fall disease of rubber (*Hevea brasiliensis*). *In: Agrometeorology of Plantation Crops.* (Eds. G.S.L.H.V. Prasada Rao and R.R. Nair). Kerala Agricultural University, Trichur, India, pp.93-97.

The meteorological factors associated with the triggering of the Abnormal leaf fall caused by *Phytophthora* spp. in rubber (*Hevea brasiliensis)* plantations are presented. An outbreak invariably follows a five-day rain spell with an overcast day. The epidemics can be expected within 9-15 days after the first overcast day, depending on the onset of South West monsoon.

Key words: Abnormal leaf fall; Agrometeorology

68. Jayarathnam, K., Jacob, C.K., Idicula, S.P. and Edathil, T.T. (1994). Incidence of Abnormal leaf fall disease in clone RRII 105 in traditional rubber growing areas. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 59-63.

The incidence of Abnormal leaf fall disease in the clone RRII 105 was studied over a two year period through a survey covering the traditional rubber growing tracts of India. The results indicated that this clone shows considerable tolerance to the disease. Disease incidence in the southern area, covering the Kanyakumari district and southern districts of Kerala, is very low and judicious omission of spraying is permissible. However, there were individual plantations, which showed a high disease incidence in most of the regions.

Key words: Abnormal leaf fall; RRII 105; *Phytophthora*

69. John, A., Joseph, A., Meenakumari, T., Saraswathyamma, C.K. and Varghese, Y.A. (2000). Clonal variation in the intensity of powdery mildew (*Oidium heveae* Stein.) disease of *Hevea*. *Indian Journal of Natural Rubber Research*, **13**(1-2): 64-68.

Twenty *Hevea* genotypes representing gene pools of diverse origin were screened in the nursery to identify sources of resistance against *Oidium heveae* causing powdery mildew incidence. An attempt was also made to understand the pattern of response of the genotypes in different years. Clonal variation for the intensity of powdery mildew was highly significant. Among the 20 genotypes studied, eight genotypes (RRIC 52, AC/S/12 42/186, PR 261, RO/CM/10 44/7, RRIM 703, AC/S/12 42/59, PB 86 and IAN 45-873) possessed high degrees of tolerance and stability in their response to disease intensity.

Key words: Clonal variation; Powdery mildew; *Oidium heveae*

70. Jose, M. and Latha, N. (2006). A bibliography on Corynespora leaf fall disease. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 174-188.

This chapter covers a list of publications on leaf diseases of rubber caused by *Corynespora cassiicola* published from 1917 to 2005. Articles are collected from

journals, proceedings of national and international conferences/workshop, monographs, books, theses, CD-ROM and Internet. The bibliography is arranged alphabetically and chronologically under author names.

Key words: Bibliography, *Corynespora cassiicola*, Leaf disease

71 Joseph, A. (1998). *Investigations on certain biochemical changes and phyllosphere microflora of Hevea brasiliensis as influenced by nitrogenous fertilizer application and Corynespora cassiicola inoculation*. Ph.D. Thesis, Mahatma Gandhi University, Kottayam, India. 188 p.

A pot culture study was carried out to find out the effect of graded levels of nitrogenous fertilizers on the incidence of *Corynespora* leaf spot disease in rubber seedlings. Seedlings were inoculated with the spore suspension of *Corynespora cassiicola* and leaf samples were collected at 0, 24, 48, 72, 96 and 168 h after inoculation. The leaf samples were quantitatively analysed for total phenols, phenols reducing and non reducing sugars, starch, amino acids, total nitrogen, ascorbic acid and for qualitative and quantitative determination of phenolic acids and amino acids. The activity of oxidative enzyme (PPO, PO and AAO) and lyase enzymes (PAL and TAL) was also estimated. The effect of nitrogen on the production of hydrolytic enzymes and toxin was studied. Further, the changes in leaf leachates and phyllosphere microbial population in rubber seedlings with different levels of nitrogen and the effect of phyllosphere microorganisms in the appressoria formation of *C. cassiicola* were also investigated. The results of the study clearly revealed that application of increased levels of nitrogen fertilizer to rubber seedlings creates a favourable condition for infection by *C. cassiicola* by augmenting sugars, amino nitrogen ascorbic acid, oxidative enzymes and phyllosphere microorganisms which induce appressoria formation in *C. cassiicola*. The post infectional changes in these constituents in plants applied with nitrogen were found to favour disease development. Nitrogen level in tissues of rubber plants also favoured toxin production by *C. cassiicola*. The reduced production of cell wall degrading enzymes cellulases, pectinases and protease of pathogen in plant receiving low nitrogen levels and the reverse in these activities at higher nitrogen level is attributed to the resistance/susceptibility of rubber seedlings to *C. cassiicola*.

Key words: *Corynespora cassiicola*; Biochemical change; Phyllosphere microflora

72. Joseph, A. (2006). Enzymes in host-pathogen interactions. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management*. (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 54-62.

Fungal pathogenesis commences when the spore contacts the host surface. This chapter deals with the enzymes involved in adhesion/disintegration of tissues and molecules favouring adhesion of spores. The different enzymes involved in disintegration of tissues such as pectic enzymes, hemicellulases, cellulolytic enzymes and proteolytic enzymes are discussed. A description on how pathogens adapt to nature of cell walls of host, how pathogens produce cell wall degrading enzymes in a sequence and on the hydrolytic enzyme production by *Corynespora* on *Hevea* are discussed. The enzymes involved in host defense such as the β-1, 3-glucanase and chitinase, oxidative enzymes peroxidase, polyphenol oxidase, ascorbic acid oxidase, catalase, phenylalanine ammonia lyase and tyrosine ammonia lyase is provided. The defense enzymes in *Hevea* are also indicated.

Key words: *Corynespora*; Enzymes; Host pathogen interaction

73. Joseph, A. (2006). Toxins in pathogenesis and toxin-based screening of *Hevea brasiliensis* clones against *Corynespora cassiicola*. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management*. (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 73-82.

This chapter deals with host specific toxins, host non-specific toxins, aggressiveness/virulence and toxins, toxins in cell membrane dysfunction and death and on toxins in suppression of host defense mechanism. The details on how pathogens induce membrane dysfunction only in susceptible hosts by detoxification of toxins and about toxin in *Corynespora cassiicola* is also provided. The specificity of *cassiicola*, role of *cassiicola* in pathogenesis, pathogenicity of different isolates of *C. cassiicola* in relation to toxin production and on screening of *Hevea* clones for *Corynespora cassiicola* resistance is provided in detail. A mention on the techniques of bioassay to determine toxin's ability to cause host cell damage by leaf-wilt bioassay and leaf puncture bioassay is also provided.

Key words: *Corynespora cassiicola*; Disease control; Leaf-wilt bioassay; Leaf puncture bioassay

74. Joseph, A., Idicula, S.P. and Rajalakshmy, V.K. (1994). Control of *Gloeosporium* leaf disease in young rubber plantations. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 82-84.

Gloeosporium leaf disease has become a serious problem on young rubber plants in certain parts of southern India. Trials were carried out in two consecutive years in a disease prone area on a susceptible clone RRII 105. These used different fungicides with the aim of selecting a suitable fungicide for control of *Gloeosporium* leaf disease. The results showed that mancozeb (0.2%) was the most effective and economic fungicide followed by carbendazim (0.05%) dithianon 2 (0.2%) bitertanol (0.25%) and Bordeaux mixture (1%).

Key words: *Colletotrichum gloeosporioides*; Disease control; Fungicide

75. Joseph, A. and Manju, M.J. (2002). Control of Corynespora leaf disease on young rubber plants in nurseries. *National Symposium on Crop Protection and WTO: An Indian Perspective*, 22-25 January 2002, Central Plantation Crops Research Institute, Kasaragod, India.

Corynespora leaf disease once considered, as a minor nursery disease is becoming a serious problem both in nurseries and in mature plantation of rubber. *In vitro* screening of fungicides with an aim to select suitable fungicides for controlling the disease showed carbendazim as the most effective. Complete inhibition of the growth of the pathogen and fungi toxicity at a concentration of 25 ppm was observed. Field trials were carried out three different disease seasons, one in a seedling nursery and two in polybag nurseries of clone RRII 105 the most susceptible clone. Nine fungicides were evaluated by spraying them at 8–10 day intervals. The results indicate that mancozeb (0.2%) carbendazim (0.05%) and metalaxyl + mancozeb (0.2%) were consistently effective in checking the disease in all the seasons tested. The cost analysis revealed mancozeb as the cheapest fungicide followed by carbendazim.

Key words: *Corynespora cassiicola*; Disease control; Fungicide

76. Joseph, A., Manju, M.J., Kumar, K.A., Jacob, C.K. and Nair, R.B. (2004). Aggressiveness of *Corynespora cassiicola* isolates and reaction of some *Hevea brasiliensis* clones to their infection. *In: Emerging Trends in Mycology Plant Pathology*

and Microbial Biotechnology. (Eds. G. Bagyanarayana, B. Bhadraiah and I.K. Kunwar). BS Publications, Hyderabad, India, pp. 28-36.

Corynespora leaf disease caused by *Corynespora cassiicola* is one of the most important diseases of *Hevea brasiliensis*. An attempt was made to study the aggressiveness of sixteen isolates of *Corynespora* and their interactions with sixteen *Hevea* clones in the laboratory by detached leaf inoculation technique. Aggressiveness of the isolates was also studied by estimating their toxin production. The disease intensity in 13 clones planted at RRII, *Hevea* breeding sub station, Nettana, Karnataka was compared with their disease severity in the laboratory test. The disease severity measured by the lesion size produced by the isolates on different clones varied significantly. RRII 105 was the most susceptible and GT 1 the most tolerant clone. The disease intensity in different clones under field condition were comparable to their reaction observed in the laboratory. The degree of virulence of the isolates on rubber clones was also found to vary significantly. A positive correlation was observed between the pathogenicity and the quantity of toxin produced by each isolate.

Key words: *Corynespora cassiicola*; Pathogenicity; Toxin production

77. Joseph, A., Philip, S., George, J., Zachariah, C.A. and Jacob, C.K. (2004). Variability of *Corynespora cassiicola* in pathogenicity toxin production, response to fungicides and molecular aspects. *National Symposium on Crop Surveillance: Disease Forecasting and Management*, 19-21 February 2004, Division of Plant Pathology, New Delhi, India, pp.20.

An attempt was made to study variability among 16 isolates of *Corynespora cassiicola* affecting *Hevea brasiliensis* in relation to their pathogenicity, toxin production, response to fungicides and molecular aspects. Pathogenicity studies in two clones *viz*. RRII 105 (susceptible clone) and GT 1 (tolerant clone) revealed variations. Similar results were obtained for toxin production when estimated by leaf wilting bioassay using crude culture filtrate. Percentage of wilting of the leaves was high in culture filtrate from the more pathogenic isolates. The results revealed a positive correlation between pathogenicity and quantity of toxin produced by an isolate. All the isolates were highly sensitive to carbendazim even at the lowest concentration tested (5 ppm) except the isolate Nos. 2 and 15. The isolate 2

showed 88.8 and 94.4% inhibition and isolate 15 showed 83.3% and 93.3% inhibition at 15 and 5 ppm respectively. The response of isolates to mancozeb was highly variable. RAPD analysis of the isolates clearly indicated existence of 3 distinct genetic patterns of *C. cassiicola*. The isolates 2,3 and 17 showed different RAPD profiles from others in all the primers tested. However this difference in molecular characters could not be correlated to the variation in pathogenecity, toxin production and in response of the isolates to fungicides.

Key words: *Corynespora cassiicola*; Fungicide; Pathogenicity; Toxin roduction

78. Joseph, A., Manju, M.J., Prem, E.E., Kothandaraman, R. and Jacob, C.K. (2005). Management of *Colletotrichum* leaf disease in young rubber plantations. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 462-465.

Colletotrichum leaf disease is very common in nurseries and immature plantations throughout the rubber growing regions of India. The disease is gaining importance recently due to the damage caused in high yielding rubber clone RRII 105 cultivated extensively. With a view to find out effective disease management strategy field trials were carried out to evaluate the efficacy of fungicides and formulate an effective spraying schedule. The results revealed that the fungicides mancozeb and carbendazim either as combination or as alternate sprays are equally effective when applied weekly for reducing the disease intensity. The alternate application of carbendazim and mancozeb and use of their combination is desirable, considering the danger of resistance build up by the frequent use of systemic fungicides.

Key words: *Colletotrichum*; Disease control; Fungicide; Leaf disease; Rubber plantation

79. Joseph, A. and Mushrif, S.K. (2006). Isolation and purification of cassicolin and its use in screening of rubber clones. *In: A Laboratory Manual for International Training on Strategies for Management of* Corynespora *Leaf Fall Disease of Hevea brasiliensis*. (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 21-24.

In this chapter methods for isolation of toxin from culture filtrate, purification of toxin by various processes, toxin activity bioassay and screening methods of *Hevea* clones for level of a clonal resistance are described.

Key words: *Corynespora cassiicola*; Cassicolin; Rubber clones

80. Joseph, A. and Roy, C.B. (2006). Morphology and culture techniques. *In*: *A Laboratory Manual for International Training on Strategies for Management of Corynespora Leaf Fall Disease of Hevea brasiliensis*. (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 1-7.

To determine the causal relationship between a microorganism and a plant disease, experimental investigations are required. If a mixture of organisms is present, precautions need to be taken to separate them and to examine them one at a time. In this chapter process of collection of samples, identification of pathogens, purification of fungal cultures by different methods, various culture media for isolation and growth of *C. cassiicola*, maintenance of culture collection, morphological and cultural characters of the isolates, artificial inoculation methods etc. are explained.

Key words: Causal relationship; *Corynespora cassiicola*; Culture media

81. Joseph, A., Divakar, K., Philip, S. and Jacob, C.K. (2009). Inactivation of phytotoxin produced by *Corynespora cassiicola* causing Corynespora leaf fall disease of *Hevea brasiliensis*. *Indian Phytopathology,* **62**(3): MEZ.29, pp. 397.

An attempt was made to study the possible detoxification of phytotoxin produced by the fungus *Corynespora cassiicola* causing Corynespora leaf fall disease of rubber. Thirty isolates of endophytic bacteria from leaf, petiole and stem of GT 1, a clone tolerant to *Corynespora* were screened for their antagonistic activity against the fungus and detoxification effected on Corynespora toxin. Out of 30 endophytes screened, four isolates were found to be antagonistic to *C. cassiicola*, in dual culture technique. Besides, the mixed culture filtrate of these isolates and pathogen were tested for phytotoxic activity using symptom bioassay on rubber leaves by detached leaf technique. It was observed that metabolites of two endophytes E34 and E85 were effective in reducing disease symptom on leaves of rubber against phytotoxin at mixed inoculation ratio of 1:3 of toxin and endophytes respectively.

The isolate E34 showed antagonism to the fungus as well as detoxification of the toxin proving that it can be used as a very effective biocontrol agent. However E85 showed only detoxification effect. The five isolates showing antagonism or detoxification effect were identified as *Bacillus* spp. through 16S rDNA sequencing. Effective isolates were also screened against the fungicides commonly used in rubber plantation *viz.* mancozeb, carbendazim, a combination product of mancozeb and carbendazim, tridemorph, copper oxychloride, wettable sulphur, propiconazole and hexaconazole. All the five endophytes were found to be resistant to the recommended dose of carbendazim, copper oxychloride and wettable sulphur but sensitive to recommended dose of mancozeb and tridemorph. The isolates E34 was resistant to 50% of the recommended dose of mancozeb and tridemorph, whereas E85 was sensitive to 50 and 25% of the same. The results of the study confirm that all the isolates except E85 can be used in integrated disease management along with recommended or lower dose of all the fungicides which are currently recommended against Corynespora leaf fall disease.

Key words: *Corynespora cassiicola;* Phytotoxin

82. Joseph, A. and Jacob, C. K. (2010). Evaluation of *Hevea brasiliensis* clones against powdery mildew and Abnormal leaf fall diseases. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp. 188-189.

Abnormal leaf fall disease (ALF) caused by *Phytophthora* spp. and Powdery mildew disease caused by *Oidium heveae* are the most important diseases of rubber in India. Severe incidence of these diseases adversely affects the growth and yield of the plants. Since the incidence and intensity of the disease varies among clones, an attempt was made to evaluate certain *Hevea* clones against Abnormal leaf fall and powdery mildew diseases. Twenty clones including the newly recommended RRII 400 series *Hevea* clones were evaluated against Powdery mildew disease in comparison with RRII 105, the popular clone cultivated in India in two large scale trials (Trial 1 & II) at Central Experiment Station, Chethackal in central Kerala. Trial 1 included twelve clones and trial II ten clones replicated six and three times respectively with sixteen trees per plot. Observation on Powdery mildew disease was carried out for three consecutive years at the peak time of disease season. Disease assessment was carried out on a 0-5 scale according to the intensity of infection on the leaves and thus the mean intensity per plot was

calculated. Wintering pattern and leaf stage at the time of assessment for each clone was also carried out. Similarly five promising 400 series clones *viz.* RRII 414, RRII 430, RRII 417, RRII 422 and RRII 429 were evaluated for Abnormal leaf fall disease in comparison with RRII 105 (in the 1982 small scale trial at Rubber Research Institute of India) for three consecutive years. Five twigs per tree were tagged, initial and final leaf count after disease season were recorded and per cent leaf retention was calculated. Visual assessment on leaf retention was also done at the end of disease season for all the years. The results indicated that in general all the clones were susceptible to powdery mildew disease with more than 50% disease intensity. Significant variation in disease intensity was observed among clones and years. Mean disease intensity was found to be significantly low for the clones RRII 55 and RRII 422 though RRII 55 was on par with RRII 105 and RRII 407. Variations in disease intensity were correlated to variations in the time of wintering of clones and climatic conditions during different years. Evaluation of clones for ALF disease revealed no significant variation in leaf retention among the five clones and were on par with RRII 105, a clone relatively tolerant to ALF disease. RRII 422 recorded lowest leaf retention though statistically did not differ from other clones.

Key words: Abnormal leaf fall; Clone; Powdery mildew

83. Joseph, A., Sailajadevi, T. and Singh, M. (2011). Report on the occurrence of Phytophthora diseases in the rubber plantations of Konkan region of Maharashtra. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Abnormal leaf fall(ALF) and shoot rot caused by *Phytophthora* spp. are serious diseases of *Hevea brasiliensis* in the traditional rubber growing regions of South India. The disease occurs annually during south west monsoon months of June, July and August. In mature plantation the fungus infects pods, leaves and tender shoots causing heavy defoliation resulting in considerable loss of crop. In nurseries and on young rubber upto three years, leaf fall and shoot rot occur leading to extensive die-back. During 1988 and 1989 pod rot and ALF disease caused by *P.botryosa* was reported from three regions of Tripura in North East India. During 2010 the disease has been reported from Rambachodovaram at Andhra Pradesh. However, the disease has not been reported from the other non-traditional regions

until 2010. During the second week of July 2011, symptoms resembling the shoot rot disease i.e. brown lesions on tender shoots and leaves with leaf fall and shoot die-back was observed in polybag plants of the clone RRIM 600. The new sprouts developed were infected and 13% of the plants were lost due to the disease. Subsequently leaf fall was observed in the mature polyclone area and two year old wild *Hevea* germplasm accessions in the field. In the germplasm area, 50% of the plants were affected by shoot rot with severe die-back symptoms. In the mature plantation, 40-50% leaf fall was observed and the infected petiole showed the typical symptom of ALF with black lesion and drop of latex oozing from the centre. Brown lesions were observed in the lamina also. The fungus was isolated on PDA medium from the infected shoot, petiole and leaf lamina and identified as *Phytophthora* spp. by morphological characters. The sporangia were papillate and ovoid in shape.This is the first report on the incidence of shoot rot and Abnormal leaf fall diseases from Dapchari, Konkan region of Maharashtra. Weather plays an important role in the incidence and severity of the disease. A total rainfall of 112 mm or more with at least 1 mm per day for a period of 5 continous days and a minimum temperature of 22-23^{0}C and a maximum of 29-31°C with a mean R.H. of 80 per cent and a minimum of 0.1 hour sunshine per day during the south west monsoon period are reported to cause disease within in a period of 9-15 days. At Dapchari, similar environmental conditions were observed continuously for 7 days (7th to 13th) during July 2011. The critical period of seven fully overcast days with maximum temperature in the range of 26^{0}C – 30.5^{0}C, minimum temperature in the range of 22.8^{0}C– 23.5^{0}C and RH above 90% with varying rainfall amounts ranging from 13-143 mm might have favoured the disease incidence. Rainfall intensities recorded in this days were moderate (1 day), rather heavy (2days), heavy (3 days) and very heavy (1 day) as defined by India Meteorological Department. During July 2011, daily mean relative humidity remained above 90% continuously for 20 days from 7th onwards with all the meteorological conditions conducive for the prevalence of the disease.

Key words: Abnormal leaf fall; *Phytophthora;* Shoot rot; Weather parameters

84. Joseph, K. (2006). Use of biological control in tropical agrosystems and its scope for Corynespora disease management. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 109-121.

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This chapter deals with application of biocontrol agents for disease management, mechanisms of biocontrol, competition, antibiosis, plant growth promoting rhizobacteria (PGPR), role of lytic enzymes, role of lipopolysaccharides, role of salicylic acid, role of siderophores, role of volatile organic compounds (VOC), induced systemic resistance (ISR), mechanisms of ISR, bacterial endophytes as elicitors of induced systemic resistance (ISR), mixtures of microbial strains, inoculation methodology, biological control of pathogen of *H. brasiliensis*, scope for biocontrol of Corynespora leaf disease of rubber and on the major research priorities for effective disease management using biocontrol agents.

Key words: Biological control; *Corynespora;* Disease management; Induced systemic resistance; Plant growth promoting rhizobacteria; Volatile organic compounds

85. Joseph, K. and Deka, H.K. (2006). Biocontrol techniques. *In*: *A Laboratory Manual for International Training on Strategies for Management of* Corynespora *Leaf Fall Disease of Hevea brasiliensis.* (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 31-39.

The Corynespora leaf fall disease was earlier considered to be a minor leaf disease of rubber plants. Now it is considered to be a serious disease affecting rubber plants in almost all the rubber-growing countries. It attacks at all developmental stage of the rubber leaves causing repeated defoliation leading to die back. Hence chemical control is difficult and costly. Adoption of biological control measures for rubber diseases has recently attracted attention of the researchers and is being integrated effectively with other methods such as the use of fungicides. Biocontrol is considered as a safe method as it minimizes environmental pollution. The successes in biological control of plant pathogens have mainly been dependent upon resident antagonists managed/exploited by cultural practices.

Key words: Biological control; Corynespora leaf fall; Cultural practices

86. Joseph, K., Farha, A. K., Philip, S., Abraham, A. and Jacob, C. K. (2008). Non target effects of fungicides on antagonistic bacterial isolates from a rubber plantation. *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production,* 13-15 October 2008,

College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 174.

The population of bacteria in the rhizosphere and non rhizosphere soil and the bacterial root endophytes from two popular clones *viz.* RRII 105 and RRII 414 of natural rubber (*Hevea brasiliensis*) was estimated. Out of the 84 morphologically different isolates selected from different areas 30, were antagonistic to any of the four major pathogens of rubber, *viz. Phytophthora meadii*, *Corticium salmonicolor*, *Corynespora cassiicola* and *Phellinus noxius*. The compatibility of these antagonists with eight fungicides used in rubber plantations, *viz.* copper oxychloride, carbendazim, mancozeb, SAAF (mancozeb+carbendazim). Wettable sulphur, tridemorph, propiconazole and hexaconazole at recommended levels showed that wettable sulphur and carbendazim were more safe. They inhibited the growth of only 2 and 5 isolates, respectively. Among the fungicides, tridemorph and mancozeb which inhibited the growth of 13 and 11 isolates, respectively were more harmful. Among the antagonists, three isolates inhibited the growth of all four pathogens studied by dual culture method and were identified as *Burkholderia* (from non rhizosphere soil) and *Bacillus* (from rhizosphere soil and an endophyte) groups by 16S rDNA sequencing. The eight fungicides tested were found to reduce the growth of these three isolates at the recommended levels. Mancozeb and hexaconazole at recommended levels prevented their growth in *in vitro* study. Even at 25% of the recommended level hexaconazole was inhibitory to two *Bacillus* isolates. These antagonists were compatible with the fungicides copper oxychloride, carbendazim and sulphur at 50% recommended level, even at the recommended level the impact was found to be less. They produced antifungal volatile compounds and sidereophores and exhibited plant growth promoting activities like solubilisation of phosphate and fixation of nitrogen. They also produced indole acetic acid and ammonia in the growth media. These three antagonists may be ideal candidates for integrated disease management along with low levels of selected chemicals fungicides for the control of various diseases of *H. brasiliensis*.

Key words: Antagonism; Fungicide

87. Joseph, K., Bijitha, P. K. and Elias, R. S. (2011). Characterisation of bacterial antagonists of *Phytophthora* from rubber plantations and their compatibility with

commonly used fungicides. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management*, 12-17 September 2011, Kottayam, India.

Rubber plants (*Hevea brasiliensis*), at their immature and mature stages of growth, are infected by *Phytophthora* spp. causing various diseases like Abnormal leaf fall, shoot rot, patch canker, black stripe etc. affecting their growth and yield. Seventy seven bacterial isolates collected from rhizosphere and non rhizosphere soils and endophytes of rubber plants were studied for their antagonistic activity against *Phytophthora meadii* by dual inoculation in potato dextrose agar plates. Five isolates (RB66, RI 31, PP36a, L54 and A1) showing more zone of inhibition of *Phytophthora* were selected and biochemical characterization was studied. The isolates belonged to *Bacillus, Pseudomonas* and *Proteus* group. The selected isolates were tested for the production of antifungal metabolites and growth promoting activities. The production of siderophores by these isolates was medium to low. The volatile organic compounds by the isolates had no effect on the growth of *Phytophthora* sp. The isolates were efficient in solubilising phosphate, producing IAA, NH_3 polysaccharides etc. The compatibility of the antagonists with commonly used fungicides in rubber plantations *viz.* tridemorph(Calixin), hexaconazole (Contaf), propiconazole(Tilt), carbendazim(Bavistin), mancozeb(Indofil M-45), wettable sulphur(Sulfex) and copper oxychloride(Fytran) were studied by incorporating to the bacterial growth media at 25, 50,75,100 and 200% recommended level. Among the fungicides, mancozeb was harmful to the five isolates, while carbendazim and sulphur were safe at all concentrations studied. The isolates belonging to Bacillus group (PP36a, L54, A1) were sensitive to tridemorph, hexaconazole, propiconazole and copper oxychloride at all the concentrations studied. The isolates RB66 *(Pseudomonas* sp.) and RI 31(*Proteus* sp.) were tolerant to these fungicides at all concentrations except to fytran, where they were tolerant only upto 25% recommended level. Even though the antagonists of *Phytophthora* are present in rubber plantation the diseases occurs every year. The reason may be the low population of the antagonist or may not be active at the cultural conditions prevailing in rubber plantations. The various cultural operations including fungicide application for managing various diseases also may affect them.

Key words: Antagonism; Fungicide; *Phytophthora*

88. Kothandaraman, R., Jacob, C.K. and Narasimhan, K. (1998). Advances in fungicide use in rubber plantations. *National Symposium on Recent Developments in Plant Pathology*, 12-15 February 1998, Madras, India.

Key words: Fungicide; Rubber plantation

89. Krishnankutty, V. and Edathil, T.T. (1987). Evaluation of new loco-systemic fungicide - Bitertanol (Baycor KWG 0599) for controlling powdery mildew disease of rubber in India. *Pesticides*, **21**(3): 40-41.

Sulphur dusting is the conventional control measure against powdery mildew disease of rubber. High rainfall during the refoliating period prompted the use of systemic fungicides like bitertanol to control powdery mildew disease. As bitertanol is a locosystemic fungicide, it penetrates the cuticle and enters the tissue, which enabled the fungicide to remain undiluted giving maximum protection and curative properties against powdery mildew disease.

Key words: Disease control; Powdery mildew

90. Kumar, K.A., Jacob, C.K. and Joseph, A. (2002). Morphological and cultural characteristics of *Colletotrichum* isolates from *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research*, **15**(2): 150-157.

The morphology of conidia and growth rate of isolates of the fungus causing raised, anthracnose and papery lesions of *Colletotrichum* leaf disease on rubber were compared. The isolates produced morphologically uniform conidia on potato dextrose agar (PDA). Conidial shape was more useful than size in differentiation of isolates. Growth rate of the isolates from raised lesions was significantly lower than that from anthracnose and papery lesions. The latter two appeared to be similar. In general, the isolates from raised lesions produced pink pigmentation on PDA while those from anthracnose and papery lesions produced grey pigments. The isolates from raised lesions were of *Colletotrichum acutatum*, distinct from anthracnose and papery lesion isolates which were of *C. gloeosporioides*.

Key words: *Colletotrichum acutatum*; *Colletotrichum gloeosporioides*; *Glomerella cingulata*; *Gloeosporium alborubrum*; Taxonomy; Variability

91. Licy, J., Dickinson, M. J., Bligh, F.J., Power, J.B., Saraswathyamma, C.K. and Davey, M.R. (2000). An approach to identify disease resistance gene analogues in *Hevea*. *Indian Journal of Natural Rubber Research*, **13**(1-2): 79-85.

A preliminary attempt was made to identify possible disease resistance gene analogues in rubber. A procedure was developed for the extraction of high quality DNA from rubber leaves, which can be used for the polymerase chain reaction (PCR) amplification of DNA. Eighteen primers, designed based on homologies between known resistance genes, were used in various combinations to amplify sequences from rubber cultivar FX 516, which is resistant to *Phytophthora* leaf fall disease and cultivar RRII 105, which is tolerant. The PCR products were cloned into plasmid vectors and the cloned inserts were sequenced. Although none of the clones obtained had high homology to resistance gene sequences, the putative protein encoded by one sequence had some homology to hem N gene.

Key words: Cloning; Phytophthora leaf fall; Polymerase chain reaction; Gene resistance

92. Manju, M.J. (2006). Chemical control of Corynespora leaf fall disease. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 102-108.

Control of plant diseases using chemicals is the most effective short-term disease management strategy. This chapter deals with chemical control of Corynespora leaf disease in rubber nurseries and young plantations as well as on disease control by chemical means in mature rubber plantations.

Key words: *Corynespora;* Chemical control; Nursery; Young plantation

93. Manju, M.J., Idicula, S.P., Joseph, A., Joy, M. and Kothandaraman, R. (1999). Incidence and severity of *Gloeosporium* leaf disease of rubber in South India. *Indian Journal of Natural Rubber Research*, **12**(1&2): 34-38.

A survey on *Gloeosporium* leaf disease [*Glomerella cingulata*] of rubber was conducted in South India to monitor the distribution of the disease and its severity. Eight representative rubber growing regions were selected and 95 sites surveyed.

The results indicated that the disease incidence and severity of infection were moderate to very severe in all the regions, except in Kulasekharam where the disease was mild. The clones RRII 105, GT 1 and PR 225 were more susceptible compared to the other clones covered under the survey.

Key words: Disease survey; *Gloeosporium*; *Glomerella;* Leaf disease

94. Manju, M.J., Idicula, S.P., Jacob, C.K., Vinod, K.K., Prem, E.E., Suryakumar, M. and Kothandaraman, R. (2001). Incidence and severity of Corynespora leaf fall (CLF) disease of rubber in coastal Karnataka and north Malabar region of Kerala. *Indian Journal of Natural Rubber Research*, **14**(2): 137-141.

Widespread incidence of Corynespora leaf fall (CLF) disease in mature rubber plantations was reported in 1996 from Nettana in South Karnataka, India. Surveys carried out in coastal Karnataka and North Malabar region of Kerala during 1998-2000 disease seasons indicated that the disease incidence and severity of infection varied between light to severe in all the locations. The intensity of infection was found to increase gradually and the incidence to widen year after year. Subramanya region in Karnataka exhibited maximum intensity of the disease. Fresh incidence was noticed in Hosdurg and Nileshwar in Kerala during 2000. Variation in intensity of disease among different clones was observed with the clone RRII 105 showing high and RRIM 600 and GT 1 showing low infection in all the locations surveyed.

Key words: *Corynespora cassiicola*; Corynespora leaf fall; Karnataka

95. Manju, M.J., Idicula, S.P., Jacob, C.K., Vinod, K.K. and Prem, E.E. (2002). Management of Corynespora leaf fall (CLF) disease of rubber with water-based fungicide formulations. *In: Plantation Crops Research and Development in the New Millennium*: *Placrosym* XIV, 12-15 December 2000, Hyderabad, India. (Eds. P. Rethinam, H.H. Khan, V.M. Reddy, P.K. Mandal and K. Suresh). Coconut Development Board, Cochin, India, pp. 527-530.

Epidemics of Corynespora leaf fall (CLF) disease of *Hevea* rubber caused by *Corynespora cassiicola* (Perk Curt) Wei. was listed as fourth most serious disease of *Hevea* by IRRDB 1993/94 disease survey. As a management practice, an investigation was carried to evaluate the efficacy of a few water dispersible fungicides to form a part of the integrated management system for CLF disease.

The fungicides included were mancozeb 75 WP, Carbendazim 50 WP, copper oxychloride (COC) 50 WP, Bordeaux mixture (BM) 1. Along with the treated plots, an unsprayed controlled plot was also maintained. Treatments were imposed during refoliation period, on the appearance of disease symptoms. Among the fungicide formulations tried, mancozeb 75 WP was found to be superior to other formulations. Similar trend was observed in plots treated with carbendazim and COC 50 WP. However, with BM 1 disease infested was higher than mancozeb 75 WP and carbendazim recording 30.60, 32.70 and 28.00 respectively, for the disease seasons. The cost analysis revealed mancozeb to be the best fungicide, being both cheap and effective followed by carbendazim. In mature rubber plantations, spraying of systemic fungicides can be of more advantage than the contact fungicides. Carbendazim was found to be equally effective to mancozeb, it could be better option for mature plantations of susceptible clones, although spraying carbendazim involved slightly higher cost per round.

Key words Corynespora leaf fall; Disease control; Fungicide; Perk curt

96. Manju, M.J., Jacob, C.K., Idicula, S.P. and Vinod, K.K. (2002). Corynespora leaf fall disease management in *Hevea* using oil-dispersible and dust fungicide formulations. *Indian Journal of Natural Rubber Research*, **15**(1): 44-48.

Corynespora leaf fall (CLF) disease caused by *Corynespora cassiicola* (Berk & Curt) Wei. is currently considered as one of the major leaf diseases of *Hevea brasiliensis* in South and South East Asian countries. Chemical control of this disease by high volume spraying in mature plantations is expensive. Field experiments were conducted from 1988 to 2000 to assess the efficacy of oil-dispersible and dust fungicide formulations in controlling the disease. Four oil-dispersible fungicides *viz.* mancozeb 75% powder, mancozeb 50% liquid, copper oxychloride (COC) 56% powder and mancozeb 50% + COC 15% (mixed powder) and three dust fungicides *viz.* hexaconazole 2%, carbendazim 1.5% and tridemorph 1.5% were tested. Mancozeb 75% powder and mancozeb liquid formulations were found to be more effective treatments among the oil-dispersible fungicides. COC 56 ODP and mancozeb + COC mixed formulations also gave significant control of the disease. Hexaconazole 2% and carbendazim 1.5% were found to be superior among the dust formulations. Dusting during refoliation period is more

advantageous for controlling CLF disease as compared to spraying of oil-dispersible fungicides.

Key words: *Corynespora cassiicola*; Disease control; Fungicide

97. Manju, M.J., Vinod, K.K. and Idicula, S.P. (2002). Occurrence of major leaf diseases of *Hevea* in rubber growing regions of Karnataka. *National Symposium on Crop Protection and WTO: An Indian Perspective*, 22-25 January 2002, Central Plantation Crops Research Institute, Kasaragod, India.

Key words: Disease incidence; Leaf disease; Karnataka

98. Manju, M.J., Vinod, K.K., Idicula, S.P., Suryakumar, M. and Jacob, C.K. (2002). Study on the pattern of occurrence of *Corynespora cassiicola* leaf fall and *Colletotrichum* leaf spot disease of *Hevea* in rubber plantations of Coastal Karnataka. *Asian Congress of Mycology and Plant Pathology*, 1-4 October 2002, Indian Society of Mycology and Plant Pathology, University of Mysore, Mysore, India.

Key words: *Corynespora cassiicola*; *Colletotrichum*; Leaf fall; Leaf spot; Karnataka

99. Manju, M.J., Idicula, S.P. and Jacob, C.K. (2004). Corynespora leaf fall disease management in mature rubber plantations. *Symposium on Biology, Biotechnology, Epidemiology and Management of Plant Diseases*, 9-10 December 2004, Gulbarga, Karnataka, India.

Corynespora leaf fall disease is currently considered as one of the major leaf diseases of *Hevea brasiliensis* in South and South East Asian rubber growing countries. The recent outbreak of this disease in Karnataka and North Malabar region of Kerala poses threat for the rubber cultivation in this region. Use of recommended water-based or oil-based fungicides for Corynespora leaf fall disease management is expensive and more labour consuming. The dust fungicide formulations are preferred in mature plantations due to the ease in application and better disease control. Field experiments carried out to evaluate the efficacy of hexaconazole dust fungicide for Corynespora leaf fall disease management revealed that 2 per cent dust was superior. The advantages of the uses of systemic

dust fungicide formulations in mature rubber during the refoliation period are discussed.

Key words: *Corynespora cassiicola*; Dust; Fungicide; Hexaconazole; Leaf fall

100. Manju, M.J., Idicula, S.P., Suryakumar, M. and Murthy, P.V. (2004). Responses of some *Hevea brasiliensis* clones to major leaf and stem diseases in higher elevations of Karnataka region. *Placrosym* XVI, 2004, Kasaragod, India. *Journal of Plantation Crops*, **32**(Supplement): 388-390.

Cultivation of rubber (*Hevea brasiliensis*) in both plains as well as at higher elevations of Karnataka experiences outbreak of various diseases. Important among them are leaf diseases like Abnormal leaf fall, powdery mildew, *Colletotrichum* leaf spot and Corynespora leaf fall. Among the diseases, affecting the stem, pink and patch canker diseases cause serious damage during rainy season. A study, conducted at higher elevations in the Regional Research Station, University of Agricultural Sciences, Mudigere, Chikmangalore district, Karnataka, to assess the susceptibility of twelve *Hevea* clones for major leaf and stem diseases revealed that, powdery mildew is the major disease, and among clones assessed RRIM 501 and PB 235 recorded >80 per cent disease intensity and hence, are highly susceptible to powdery mildew. Mild to light (9-34%) intensity of Abnormal leaf fall disease was recorded. Occurrence of various stem diseases was very mild and disease was absent in some clones.

Key words: Clonal susceptibility; Higher elevation; Leaf disease; Stem disease; Karnataka

101. Manju, M.J., Idicula, S.P., Suryakumar, M. and Jacob, C.K. (2005). New generation water-based fungicides in Corynespora leaf fall disease management. *National Seminar on Emerging Trends in Plant Pathology and their Social Relevance*, 7-8 March 2005, Department of Plant Pathology, Annamalai University, Annamalainagar, pp. 87.

Corynespora leaf fall disease (CLF) incited by *Corynespora cassiicola* is one of the major leaf diseases of *Hevea brasiliensis* in major rubber producing countries in South and South East Asia. Incidence of CLF disease is confined only to dry months after the annual leaf fall and causes repeated leaf fall during the refoliation

period. Use of effective and economic fungicides is very important for efficient disease management in immature rubber plantations. Field trials were carried out to evaluate new-generation water-based fungicides in CLF disease management. SAAF, a combination fungicide containing mancozeb and carbendazim, @ 2 g/l was found to be more effective in CLF disease management in immature rubber as compared to the currently recommended fungicides like mancozeb and carbendazim. Being a fungicide having both contact and systemic action, SAAF provides protection from bud break to various stages of leaf development.

Key words: *Corynespora cassiicola*; Corynespora leaf fall; Fungicide

102. Manju, M. J., Jacob, C. K., Prem, E.E. and Mathew, J. (2010). Impact of herbicide and fungicide application in suppression of *Corynespora cassiicola* inoculum potential in rubber plantation. *In*: *Climate Change: Placrosym XIX,* 7-10 December 2010, Kottayam, India, Abstracts, pp. 190-191.

Corynespora leaf fall (CLF) disease incited by *Corynespora cassiicola* (Berk & Curt) is becoming one of the major production constraints to rubber cultivation in most of the rubber growing countries. Recent epidemic development of this disease in Asian rubber growing countries has created a new concern on the existence of rubber plantations in the world. As a result, special attention has been given to integrated disease management for booming the disease control. Hence, a study was undertaken to determine the impact of ground spraying of herbicides (Glyphosate) thrice in a year and fungicide (Mancozeb) at fortnightly interval during the disease season for reducing the inoculum load in rubber plantation. The results revealed that ground application of herbicide and fungicide are not effective in Corynespora leaf fall disease management or in the suppression of inoculum in the infected rubber plantation. No significant difference in disease intensity as well as in leaf fall was observed in all the three disease seasons. The disease intensity recorded in the different treatments ranged from 58.00 to 59.25 per cent, 55.00 to 59.00 and 60.50 to 61.25 per cent and the leaf fall ranged from 419 to 432, 416 to 423 and 444 to 467 numbers per M^3 during first, second and third disease season respectively. Number of fungal spore catched per cm^3 did not vary much. However the plots treated with weedicide along with fungicide recorded

less number of spores just above ground level (H-1), but it did not show any significant correlation on the disease development at canopy level.

Key words: *Corynespora cassiicola;* Corynespora leaf fall; Fungicide; Herbicide

103. Manju, M.J., Idicula, S.P. and Mathew, J. (2011). Propensity of *Hevea brasiliensis* clones and ortet selections to Abnormal leaf fall disease (ALF). *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Abnormal leaf fall disease (ALF) of rubber caused by *Phytophthora spp.* is the most disparaging leaf disease of para rubber in most of the traditional rubber growing regions in South India. The disease occurs regularly during southwest monsoon months of June to August and it cause heavy defoliation as well as diebacks leads to reduction in annual yield of 9 to 16 per cent. Commercially cultivated *hevea* clones and ortet selections were tested for ALF disease resistance under natural infection in the field. It was found that all most all the commercially cultivated clones are found to be susceptible to Abnormal leaf fall disease. Clones like RRIM 600, PB 311, PB 242, RRII 208, RRII 308 and RRII 5 recorded 70 to 92 per cent leaf fall, while popular clones RRII 105 and GT 1 recorded lesser leaf fall ranging from 40 to 45 per cent. Among the ortet selections tested showed differential reaction to Abnormal leaf fall disease susceptibility, leaf fall ranging from 8 to 96 per cent. The ortet selections O 47, O 15, O 53, O 30 & O 51 recorded less leaf fall ranging from 4 to12 per cent. The preliminary data and information generated on reactions of hevea clones and ortet selections to ALF disease is useful in successful disease resistance breeding programmes.

Key words: Abnormal leaf fall; Clone; Clonal resistance; Clonal susceptibility; Ortets

104. Mathew, J. (2006). Clonal resistance of *Hevea brasiliensis* to Corynespora leaf fall disease. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 83-96.

This chapter discusses on the clonal resistance to *H. brasiliensis*. The clones identified for resistance/ susceptibility in Sri Lanka, Malaysia, Indonesia, India,

Africa and Vietnam as well as a table on the resistance of recommended clones are provided. The performance of popular clones, estimation of management using resistant clones, responses of recommended rubber clones to *C. cassiicola* in Indonesia, screening *Corynespora* resistant clones in Thailand, screening of rubber clones for disease resistance in Malaysia, screening for Corynespora leaf disease tolerance in India and on development of resistant clones are discussed in detail.

Key words: Clonal resistance; Clonal susceptibility; *Corynespora*; Disease management; Africa; India; Indonesia; Malaysia; Sri Lanka; Vietnam

105. Mondal, G.C., Kothandaraman, R., Chaudhuri, D. and Varghese, Y.A. (1998). Occurrence of *Periconia* leaf blight disease on *Hevea brasiliensis* in North-East India. *Indian Journal of Natural Rubber Research*, **11**(1&2): 1-7.

The incidence and severity of leaf blight disease on *Hevea brasiliensis* Muell. Arg. caused by *Periconia heveae* were studied over 4 consecutive years from 1990 in 3 locations (2 in Assam and 1 in Meghalaya). High incidence and severity of the disease was noticed in January-February which decreased abruptly thereafter at all 3 locations. Temperature in the range 15-25°C, cool nights, dew and 90% RH favoured development of the disease. The optimum temperature for the growth of the fungal pathogen was 25°C and the pathogen exhibited very little growth at 10° and 30°C. *In vitro* studies revealed carbendazim (0.1% ai) to be superior to mancozeb (0.2% ai) in checking the growth of the pathogen. These fungicides proved to be effective under field conditions also.

Key words: Leaf blight; *Periconia heveae*; North East India

106. Mondal, G.C., Sethuraj, M.R., Potty, S.N. and Sinha, R.R. (1998). Influence of wintering pattern on the incidence of *Oidium* SLF disease in different clones of *Hevea* rubber in Assam. *Rubber Board Bulletin*, **27**(3): 18-24.

The extent of wintering increased gradually with ages of plantation and showed complete wintering in almost all clones in 7th year of plantation. High intensity of *Oidium* SLF was observed in PB 5/51 followed by RRII 105, PB 235, GI 1 and RRIM 605. The intensity of *Oidium* disease in PB 86 and GT 1 was comparatively less. Due to repeated massive premature defoliation caused by *Oidium* attack

from February to May in both 5th and 6th year of plantation, comparatively greater extent of die-back was noticed in PB 5/51 (70%) followed by RRII 105 (40%), PB 235 (30%), G1 1 (30%) and RRIM 605 (26.7%) in 6 year old trees. However, the clone PB 86 did not show any sign of die-back. Remarkable girth increment (above 10 mm) was not found in any of the experimental clones except PB 86 during June in both 5th and 6th year plantations as compared to 7th year plantation. This might be due to dusting of sulphur against the control of *Oidium* SLF disease in 7th year plantation where remarkable girth increment in the range of 11 to 29 mm in all the experimental clones was noted.

Key words: Clone; Disease control; *Oidium* disease; Wintering; Assam

107. Mondal, G.C. and Jacob, C.K. (2002). Effect of powdery mildew disease on yield of rubber in northern part of West Bengal. *Placrosym* XV, 2002, Mysore, India. (Eds. K.Sreedharan, P.K. Vinod Kumar, Jayarama and Basavaraja M. Chaluki). Central Coffee Research Institute, Karnataka, India, pp. 531-534.

A field trial was conducted during 1999 to 2001 at Regional Experiment Station, Nagarkata for evaluation of economic efficacy of sulphur dust against the powdery mildew disease in 10-year-old trees of *Hevea* clone RRII 105. The impact of this disease on growth and yield of RRII 105 was also reported. Severity of powdery mildew disease was very high in undusted block (3.0) as compared to the dusted block (1.3), which resulted an annual crop loss of 28.52 per cent. The disease also adversely affected the growth of trees which reflected on poor girth increment in undusted block as compared to the dusted plot. The economic significance of sulphur dusting as a control measure against powdery mildew disease was evident.

Key words: Crop loss; Powdery mildew; RRII 105; Sulphur dusting; West Bengal

108. Mondal, G.C., Kothandaraman, R. and Gupta, C. (2002). Effect of zinc on growth and incidence of powdery mildew disease of rubber seedlings in nursery. *Indian Journal of Natural Rubber Research*, **15**(2): 187-189.

Experiments were conducted during 1993/94, 1994/95 and 1995/96 at Kamrup, Assam, India to investigate the effect of Zn chelate on the growth of *H. brasiliensis* seedlings and the incidence of powdery mildew (*Oidium heveae*) in the nursery. The following treatments were used: untreated control (T1); 3 rounds of dusting

of sulfur (85%) at 21-day intervals from January-March (T2); 4 rounds of spraying of wettable sulfur (80 WP) at 2.4 g/litre alternated with carbendazim (50 WP) at 1 g/litre from February-March (T3); 3 rounds of spraying of Chelazin liquid (0.5, 2.5, 5.0 and 7.5 ml/litre) at 30-day intervals from October-December (T4-T7); and 3 rounds of spraying of Chelazin powder (0.1, 0.5, 1.0 and 1.5 g/litre) at 30-day intervals from October-December (T8-T11). Spraying was carried out using a hand compression sprayer and screens were used to prevent drift. The incidence of powdery mildew was assessed on 16 seedlings from the inner rows of each plot during March-April after the final round of all treatments. Incidence and severity of powdery mildew was maximum in T1, T8, T9 and T4. On the other hand, powdery mildew was completely controlled under T2. Disease incidence was comparatively low in T6, T7 and T3. Although incidence and severity were reduced in T10 and T11, neither was as effective as T2, T3, T6 and T7. Application of chelated Zn during October-November at 5 and 7.5 ml/litre of water in liquid form or 1.0 and 1.5 g/litre in powder form reduced the incidence of powdery mildew in the subsequent seasons. Maximum growth of rubber seedlings in terms of height (133.0 cm) and diameter (1.3 cm) was observed in T7. The growth of seedlings in other experimental plots, except T2 and T3, were adversely affected due to the high incidence and severity of powdery mildew. Significantly better growth was noticed in S-treated plots (T2) over the control as the incidence of powdery mildew was completely controlled. Application of chelated Zn, thus, appear to be a viable alternative for powdery mildew control and consequent healthy growth of rubber seedlings.

Key words: Disease control; *Oidium heveae*; Powdery mildew; Zinc chelate effect

109. Mondal, G.C., Deka, H.K. and Chaudhuri, D. (2005). Occurrence of powdery mildew disease of *Hevea* clones: A report from North East and northern part of West Bengal. *In: Preprints of Papers. International Natural Rubber Conference, India 2005,* 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 502-505.

The incidence and severity of powdery mildew disease caused by *Oidium heveae* were assessed in forty clones of *Hevea brasiliensis* in different experimental trials of Research Farm in Assam, Meghalaya, Tripura and northern part of West Bengal. At the mature stage of growth the severity of powdery mildew disease was

evaluated for the three consecutive years in different *Hevea* clones during peak time of the disease (i.e. March-April) after wintering. Out of forty clones the severity of powdery mildew disease was found in thirteen clones between the infection grade 1.5 to 2.5 in PB 86, RRIM 600, GT 1, PB 311, PB 310, SCATC 88/13, SCATC 93/114, Hiken 1, RRIM 703, RRII 429, RRII 417, RRIC 100 and RRII 176 indicating thereby that these clones are moderately tolerant to powdery mildew disease. Clones PB 235, PB 5/51, RRII 300, RRII 5, G1 1, RRII 105 and RRII 308 showed the severity of powdery mildew disease above the infection grade 3.5 which reflected that these clones are susceptible to this disease. Due to repeated massive premature defoliation caused by powdery mildew disease from March to May, comparatively greater extent of die-back damage was noticed in PB 5/51, PB 235, G1 1, RRII 300, RRII 51, RRII 105 and RRII 430 during July-August indicating thereby that these clones are highly susceptible to powdery mildew disease. The promising clones (*viz.* RRIM 600, PB 311, PB 235, PB 310, GT 1 and RRII 105) in terms of yield (g/t/t) potential reported from Assam showed to be moderately tolerant to powdery mildew disease and can be cultivated extensively in this zone except PB 235 and RRII 105.

Key words: *Oidium heveae*; Powdery mildew; West Bengal

110. Mondal, G. C., Deka, H. K, and Chaudhuri, D. (2007). Reaction of *Hevea brasiliensis* clones against powdery mildew disease in north eastern region of India. *Natural Rubber Research*, **20**(1-2): 90-93.

The incidence and severity of powdery mildew disease caused by *Oidium heveae* were assessed in forty clones of *Hevea brasiliensis* in different experiments in Assam, Meghalaya, Tripura and northern West Bengal. At the mature stage of growth, the severity of powdery mildew disease was evaluated for three consecutive years during the peak time of the disease (March-April) after wintering. Sixteen clones were found to be moderately tolerant with infection grades ranging from 1.5 to 2.5. Due to repeated massive premature defoliation caused by the disease during March to May, dieback was noticed subsequently in clones PB 5/51, PB 235, RRII 300, RRII 51, RRII 105, RRII 5, RRII 430 and RRIC 105. These clones are therefore rated as highly susceptible to powdery mildew disease.

Key words: Clone; *Oidium heveae;* Powdery mildew; North East India; West Bengal

111. Mondal, G. C., Meti, S., Sarma, A. C. and Nair, R. B. (2008). Response to zinc on growth and incidence of powdery mildew disease in RRIM 600 clone of *Hevea* in nursery. *Placrosym XVIII*, 10-13 December 2008, Puttur, Karnataka, India. *Journal of Plantation Crops*, **36**(3): 471-474.

Powdery mildew disease of rubber trees caused by *Oidium heveae* is known to be very severe at the time of refoliation after wintering in north east region and northern part of West Bengal. This investigation was undertaken to evaluate the effect of zinc on the growth and incidence of powdery mildew disease of RRIM 600 clone of *Hevea* in nursery. The experiment was conducted in nursery at Regional Experiment Station, Nagrakata under the agro-climatic conditions of northern part of West Bengal for two consecutive years. From the results of the present experiment, it may be concluded that the foliar application of chelated zinc has been found to be very effective and superior to zinc sulphate for increasing growth of RRIM 600 clone of *Hevea* and also for control of powdery mildew disease.

Key words: Powdery mildew; RRIM 600; Soil; Zinc chelate effect; Zinc sulphate

112. Mondal, G.C., Raj, S. and Mushrif, S.K. (2011). Comparison of weather favouring development of *Phytophthora* leaf fall in Kerala with that in northern part of West Bengal and North East India. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management*, 12-17 September 2011, Kottayam, India.

Abnormal leaf fall disease (ALF) caused by *Phytophthora spp.* is the most destructive disease of rubber in South India, where >90% defoliation is probable in absence of treatment, resulting in 30 to 50% reduction in yield. This disease was first noticed in 1910 at Palapilly area in Trichur district, Kerala in India. Pod rot and ALF disease of *Hevea* caused by *Phytophthora botryose* was first observed in 1988 at Pathalia and Paticheri rubber estate of the Tripura Forest Development and Plantation Corporation (TFPDC) in Northeast India. The main objective of this study attempts at finding out the favourable climatic conditions for the development of ALF in the non-traditional disease prone areas of northern part of West Bengal and Assam. These are then compared with that of the traditional rubber growing region of Kottayam. A survey on pod rot and ALF disease was

conducted in different locations of the Northeast India and northern West Bengal for isolation of *Phytophthora spp.* Bright green rubber leaf and healthy green mature rubber pods were used as baits to attract the swimming phase of *Phytophthora spp.* in water. Usually in this non-traditional rubber growing region, pod rot and ALF were seldom observed in subsequent years after a mild or moderate disease occurrence. This was also seen from the soil samples collected from Tripura where the inoculum density was seen to be very low. Weather plays an important role in determining the onset of Phytophthora leaf fall disease. It was observed that rainfall and temperature are the most important climatic factors governing the onset and severity of ALF disease in South India. Therefore, the important weather parameters like weekly (Standard Meteorological Weeks) rainfall, number of rainy days, temperature and relative humidity observed in Regional Experimental Station, Nagrakata in northern part of West Bengal and at Sarutarr Research Farm in Assam were examined during June-September, 1995 to 2005 and the findings were compared with the observations of the Research Institute of India, Kottayam, Kerala which is considered as the most susceptible pocket for the ALF disease. It was found that during the south-west monsoon rainy season, the mean maximum temperature at Nagrakata and Sarutari was in the range of 28 to 32.6°C and 30.5 to 34.4°C respectively, which was higher than that observed in Kottayam for the same period (23.7 to 27.7°C). During the period, though the relative humidity was found to be fluctuating on a higher range in Kottayam (93 to 97%) as compared to Nagrakata and Sarutary (both in the range of 85 to 96%), the congenial climatic threshold of 80% relative humidity favoured the disease occurrence in all three locations. Rainfall plays a very important role in prolonging the duration of surface moisture as well as the dispersal of sporangia, which ultimately leads to the onset of ALF disease, either in the month of June or July. This was clearly shown in the observations in Kottayam, where the high rainfall and number of rainy days during the June-July period for 1995-2001, caused severe disease incidences in the clones RRIM 600, RRIM 703, Hiaken1, PB 260 and PB 314. However, similar conditions in rainfall, number of rainy days and relative humidity was also experienced in Nagrakata and Sarutary, but the incidences were low most probably due to the variation of the temperature ranges between Nagrakata and Kottayam, which existed during the period of study. The higher temperature ranges in Nagrakata and Sarutary might have prevented the development of *Phytophthora* sporangia on green mature rubber pods. As reported for the traditional area, if a

continuous spell of rain of 350 mm or more persists for a period of 5 days with a temperature range of 24 to 28°C without sunny breaks between rainy days and a relative humidity of 80% during June-July, the onset of *Phytophthora* can be expected within 15 days in Nagrakata and Sarutary. Once the onset of the disease occurs in the June-July period, continuous rainy days of almost five days sustains the spread of infection. During the study period optimum conditions for disease occurrence, were never noted in the non-traditional areas of Nagrakata and Sarutary.

Key words: Abnormal leaf fall; Rainfall; Temperature; Weather; North East India

113. Mushrif, S.K. (2006). Morphology, physiology and survival of *Corynespora cassiicola* (Berk & Curt.) Wei. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 26-32.

This chapter describes in detail the morphology and physiology of *C. cassiicola*. A description on the survival of the fungus as soil-borne pathogens, seed-borne pathogens and on alternate host and off-season crops is also mentioned. A mention on the dispersal of *Corynespora cassiicola* is also made.

Key words: *Corynespora cassiicola*; Soil borne pathogen; Seed borne pathogen

114. Mushrif, S.K., Joseph, A., John, A. and Jacob, C.K. (2004). Evaluation of *Hevea brasiliensis* clones against Abnormal leaf fall disease caused by *Phytophthora* spp. *Natural Rubber Research*, **17**(1): 74-78.

Twenty-five modern clones of rubber (*Hevea brasiliensis*) were evaluated for tolerance to abnormal leaf fall disease caused by *Phytophthora* spp. consecutively for seven years under standard prophylactic spray. Two trials each consisting of 13 clones were included in the evaluation. High leaf retention was noticed in the clone RRII 105 closely followed by RRII 5 while it was poor in RRIM 703, RRIM 600, Haiken 1, PB 280, PB 260 and PB 314. Rainfall was found to be a major predisposing factor influencing the disease development.

Key words: Abnormal leaf fall; Clone evaluation; *Phytophthora*

115. Mushrif, S.K., Philip, S., Joseph, A., Prem, E.E. and Jacob, C.K. (2004). Factors affecting growth and sporulation of *Colletotrichum acutatum* and *C. gloeosporioides* and the changes in biochemical parameters in two *Hevea brasiliensis* clones due to their infection. *Symposium on Biology, Biotechnology, Epidemiology and Management of Plant Diseases*, 9-10 December 2004, Karnataka, India, pp.63.

Colletotrichum acutatum and *C. gloeosporioides* preferred fructose as carbon source for their growth. The two species did not differ significantly in their preference to various nitrogen sources with aspargine being the better source. Both the species responded similarly to different pH and temperature levels with pH levels of 6.0 to 7.5 and temperature of 25°C being optimum for growth and sporulation. The changes in the activity of peroxidase and phenylalanine ammonia lyase and total protein content were studied by inoculating the two species of *Colletotrichum* on the leaves of *Hevea brasiliensis* clones RRII 105 and RRIM 600. Significantly higher activity of peroxidase and phenylalanine ammonia lyase was noticed in the clone RRIM 600 inoculated with *C. acutatum* 48 and 24 hours after infection respectively. Increase in total protein content was also observed in this clone when inoculated with *C. acutatum* at 48 hours after infection. The tolerance in the clone RRIM 600 to *Colletotrichum* is attributed to higher enzyme activity.

Key words: Biochemical parameter; *Colletotrichum acutatum*

116. Mushrif, S.K., Philip, S., Joseph, A., Prem, E.E. and Jacob, C.K. (2009). Growth and sporulation of *Colletotrichum acutatum* and *C. gloeosporioides* and biochemical changes due to infection in *Hevea brasiliensis*. *Natural Rubber Research*, **22**(1 & 2): 72-80.

The *Colletotrichum* leaf disease caused by *Colletotrichum acutatum* and *C. gloeosporioides* is an important disease during the immature phase of rubber (*Hevea brasiliensis*). The aggressiveness of the pathogen varies between the species and therefore a study was undertaken to understand the physiological requirement of both the species and the biochemical changes consequent to infection. Both species preferred fructose as carbon source and spargine as nitrogen source. They also responded similarly to pH and temperature levels, with pH 6.0 to 7.5 and temperature 25°C being optimum for growth and sporulation.

The changes in the activity of peoxidase, phenylalanine ammonia lyase and total protein content were studied by inoculating the two species of *Colletotrichum* on the leaves of clones RRII 105 and RRIM 600. Significantly higher activities of peroxidase and phenylalanine ammonia lyase were noticed in the clone RRIM 600 inoculated with *C. acutatum* at 24 and 48 h after induction, respectively. Steady increase in total protein content was also observed up to 72 h in this clone when inoculated with *C. acutatum.* The tolerance in the clone RRIM 600 to *Colletotrichum* is attributed to this higher enzyme activity.

Key words: Carbon; *Colletotrichum acutatum*; *Colletotrichum gloeosporioides*; Nitrogen; Oxidative enzymes

117. Narasimhan, K., Thulaseedharan, A. and Kothandaraman, R. (2000). Detection of pathogenesis related proteins in *Hevea brasiliensis* infected by *Phytophthora meadii*. *Indian Journal of Natural Rubber Research*, **13**(1&2): 30-37.

A study was conducted to identify the pathogenesis-related proteins (PR-proteins) induced in rubber (*Hevea brasiliensis*) tree during *Phytophthora meadii* infection. Eleven PR-proteins were induced in the resistant clone during pathogen infection. In the susceptible clone, no new proteins were formed during 42 and 48 h after challenging with the pathogen. Two proteins with prominent bands and molecular weights 29 and 33kD were observed from tolerant plants 24 h after inoculation with the fungal pathogen. *In vacua* infiltration studies revealed the presence of similar proteins in the intercellular fluids. Isoelectric focusing studies on samples extracted from leaves of *H. brasiliensis* showed the appearance of several new anionic peroxidase bands in the resistant plants. Similar changes in the protein induction were observed on treatment with salicylic acid. Results show a systemic induction of a group of acidic proteins, along with anionic peroxidase and esterase in tolerant *H. brasiliensis* plants. The presence of acidic proteins in the intercellular fluids as well as induction of PR-proteins following salicylic acid treatment indicate the involvement of a possible systemic induced resistance mechanism in the resistant plants to ward off pathogens.

Key words: Anionic peroxidase; *Phytophthora meadii*; PR protein detection

118. Philip, S. (2006). Pathogenesis-related proteins, phytolexins their role in resistance of *Hevea brasiliensis* to leaf diseases. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 63-72.

This chapter discusses on pathogenesis-related proteins, the PR-2 proteins (β-1, 3-glucanases), PR-3 proteins, antifungal activity of chitinases, thaumatin – like protein (PR –5), PR-9 proteins, PR proteins from *Hevea*, b-1, 3-glucanases, chitinase and on phytoalexins in *H. brasiliensis*.

Key words: Chitinase; Molecular plant pathology; Phytolexins; Pathogenesis

119. Philip, S. (2011). The host factors in *Phytophthora – Hevea* interaction. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

In nature different host-pathogen interactions exist depending upon the susceptibility /resistance of plants to pathogens. In many plant species, response to infection by different pathogenic microorganisms such as bacteria, fungi and viruses is accompanied by the synthesis of a variety of host proteins which are termed PR proteins (Vanloon,1985).The expression of PR proteins resulted in the development of hypersensitive area around the infection site. Hypersensitive response is associated with a coordinated and integrated set of metabolic alterations that are essential for delaying further spread of pathogen as well as for enhancing the capacity of host to limit subsequent infection (Vidhyasekharan, 1993). Abnormal leaf fall caused by *Phytophthora* sp. is the most destructive disease of rubber (*Hevea brasiliensis*) in the traditional rubber growing areas. Many of the high yielding clones of rubber are highly susceptible to this disease. Expression of pathogenesis related proteins are reported in *Hevea* during pathogen infection (Philip *et al.*, 2001, 2010; Thansem *et al.*, 2004; Chacko *et al.*, 2005). Major PR proteins like β-1,3 glucanase, peroxidises and PR1 gene expression were observed in tolerant clone RRII 105 subsequent to challenge inoculation with *Phytophthora*. Anionic peroxidase(PR9) proteins were detected in tolerant clone RRII 105 during *Phytophthora* infection. Two anionic peroxidase proteins corresponding to molecular weights 29kD and 33 kD were prominent in the extracts

from challenged clone RRII 105. Vacuum filtration studies revealed the presence of similar protein in the intercellular fluids obtained from the leaves of RRII 105 (Narasimhan *et al.*, 2000). Thanseem *et al.* (2004) reported the role of β-1,3 glucanase gene in *Phytophthora* infection in rubber. β-1,3 glucanase gene expression was analyzed upon artificial inoculation of *Phytphthora* in susceptible clone, RRIM 600 and tolerant clone RRII 105 by northern blot analysis and higher level of expression was observed in RRII 105. Full length β-1,3 glucanase cDNA was amplified from the clone RRII 105 and expressed in an expression vector. Recombinant β-1,3 glucanase protein was purified and tested *in vitro* antifungal property and it inhibited the growth of *Phytophthora*. Supriya *et al.* (2006) reported the isoforms of β-1,3 glucanase gene in six *Hevea* clones. Major sequence variation was found with in the intronic sequences "CT" repeats within the intronic sequences show deletion /insertions among the clones studied. Only a minor variation in nucleotide was observed in the exons. The exact role of intron in a particular gene is not completely known it is reported that though alternative splicing and non-sense mediated mRNA decay; the introns play an important role in the expression of a particular gene. The PR1 gene expression was studied in *Phytophthora* inoculated clones such as RRIM 600 and RRII 105. RNA was isolated from the hypersensitive areas of the tolerant clone, cDNA prepared and the gene amplified with PR1 primers and sequence showed homology with other reported PR1 genes. Increasing amount of data enlarged the knowledge on the relevance of PRs to important plant performances such as, disease resistance and general adaptation to stressful environment. This research encouraged the application of PRs genes in screening for disease resistance and gene-engineering technologies for crop improvement.

Key words: β-1,3 glucanase; Pathogenesis related protein; *Phytophthora*

120. Philip, S., Joseph, A. and Jacob, C.K. (2001). Involvement of esterase isozyme in the surface attachment of conidia of *Corynespora cassiicola* on rubber (*Hevea brasiliensis*) leaves. *South Zone Meeting, Indian Phytopathological Society*, 10-12 December 2001, Calicut, India.

Corynespora leaf disease of rubber caused by *C. cassiicola* is spread through conidia of the fungus. The germination of spores of *C. cassiicola* was studied under the scanning electron microscope on rubber leaves and inert surfaces

(parafilm). The study indicated that the conidia germinate on the surface of rubber leaves and produce appressoria and infection peg prior to penetration. On labeling the conidia with a lectin Con A (1mg/ml), the germ tube failed to attach to the surface. Isozyme analyses showed two prominent esterase bands on 1 native PAGE gels. This is the first report on the role of esterase enzyme in the conidial attachment of *C. cassiicola* to rubber leaves.

Key words: *Corynespora cassiicola*; Isozyme

121. Philip, S., Joseph, A., Kumar, K.A., Jacob, C.K. and Kothandaraman, R. (2001). Detection of β-1, 3-glucanase isoforms against Corynespora leaf disease of rubber (*Hevea brasiliensis*). *Indian Journal of Natural Rubber Research*, **14**(1): 1-6.

Corynespora cassiicola causing leaf disease of *Hevea* is considered as a serious problem in most of the rubber growing countries. Production of a pathogenesis related [PR] protein β -1,3-glucanase upon infection was tested in four clones of *Hevea*. Considerable variability in the β-1,3-glucanase activity of enzyme was observed among different clones during pathogenesis. Increased enzyme activity was found in the tolerant clone (GT 1), while a decrease was observed in the susceptible (RRII 105). Three prominent β-1,3-glucanase isozyme bands were detected by 17.5 per cent PAGE in the tolerant clone.

Key words: *Corynespora cassiicola*; β-1, 3-glucanase

122. Philip, S., Joseph, A., Abraham, T., Zachariah, C.A., George, J., Manju, M.J. and Jacob, C.K. (2004). ERIC PCR based genomic fingerprinting of *Corynespora cassiicola* isolates infecting rubber (*Hevea brasiliensis*) plantations. *Placrosym* XVI, 2004, Kasaragod, India. *Journal of Plantation Crops*, **32**(Supplement): 301-305.

Corynespora cassiicola causing leaf disease of *Hevea* is considered to be a serious problem in most of the rubber growing countries. Attempts were made to study the presence of ERIC-like sequence in *C. cassiicola* and to determine the genetic diversity among the isolates. One hundred isolates collected from different rubber growing regions were subjected to molecular characterization to detect variation if any. Genomic DNA was amplified with ERIC 1 and ERIC 2 primers. ERIC profiles regenerated for one hundred isolates, on cluster analysis grouped

into four clusters. This is the first document of the use of ERIC PCR in genetic variability studies of *C. cassiicola*.

Key words: *Corynespora cassiicola*; DNA fingerprinting

123. Philip, S., Joseph, A., Zachariah, C.A., George, J., Prem, E.E. and Jacob, C.K. (2004). Molecular characterization of *Phytophthora* isolates infecting rubber (*Hevea brasiliensis*) using rDNA RFLP. *National Symposium on Crop Survirulence: Disease Forecasting and Management*, 19-21 February 2004, Indian Agricultural Research Institute, New Delhi, India.

Abnormal leaf fall caused by *Phytophthora* spp. is a serious disease of rubber (*Hevea brasiliensis*) in traditional rubber growing regions in India. Twenty five isolates from different rubber growing regions were subjected to molecular characterization to observe variation if any. Internal transcribed spacers (ITS) of ribosomal DNA of the isolates were amplified with ITS 4 and ITS 6 primers. Restriction analysis of amplified rDNA (900 bp) with different restriction enzymes gave uniform RFLP pattern for all isolates from *H. brasiliensis* and belonged to *P. meadii*. The RFLP patterns of amplified rDNA of isolates from *H. brasiliensis* were compared with other *Phytophthora* species *viz. P. capsici* and *P. palmivora* from pepper and coconut.

Key words: *Phytophthora*; rDNA-RFLP

124. Philip, S., Joseph, K., Priya, P., Riya, K.S., Zachariah, C.A., Chacko, N. and Jacob, C.K. (2005). Mechanisms involved in the antagonism of endophytic bacteria isolated from rubber (*Hevea brasiliensis*) against Corynespora leaf disease and their genetic variability. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 484-489.

Endophytic bacteria were isolated from different parts of *Hevea brasiliensis* and tested against a virulent strain of *C. cassiicola* causing leaf disease of rubber. Production of antibiotics and volatile compounds by the endophytes were tested *in vitro*. ERIC-PCR amplification of isolated DNA from endophytes showed variation. 2.4-DAPG gene amplified from antagonistic endophytes. Leaves of rubber treated with endophytes showed systemic tolerance to *C. cassiicola*. This

is the first report from the use of endophytic bacteria against *C. cassiicola* infecting *Hevea brasiliensis*.

Key words: *Corynespora cassiicola*; Antagonism; Endophytic bacteria

125. Philip, S. and Roy, C.B. (2006). Molecular characterization of *Corynespora cassiicola*. *In*: *A Laboratory Manual for International Training on Strategies for Management of* Corynespora *Leaf Fall Disease of Hevea brasiliensis*. (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 8-16.

Classical strategies of evaluation of genetic variation have been increasingly complimented by molecular techniques. This chapter discusses on the different molecular aspects involved in the characterisation of *Corynespora* beginning with the isolation of DNA, estimation of DNA concentration, setting up a polymerase chain reaction assay, RAPD assay, visualisation of DNA fragments by agarose gel electrophoresis, gel documentation, scoring and data analysis, amplification of ribosomal DNA, ribosomal DNA Restriction Fragment Length Polymorphism, cloning and sequencing.

Key words: *Corynespora cassiicola*; PCR; RAPD; rDNA-RFLP

126. Philip, S., Joseph, K., Abdul Kareem, V.K., Sneha, P., Abraham, A., Elias, R.S., Joseph, A. and Jacob, C. K. (2007). Antifungal activity of endophytic bacteria against major leaf pathogens of *Hevea brasiliensis*. *Microbes: Biofactories of the future, 48th Annual Conference of the Association of Microbiologists of India,* 18-21 December, Chennai, India, Abstracts, pp. 153.

Hevea brasiliensis is an important industrial crop cultivated in the southern states and north eastern regions of India. It is the major source of natural rubber. *Phytophthora meadii* and *Corynespora cassiicola* cause severe leaf infection leading to leaf fall in *Hevea brasiliensis*. To control these fungi presently, growers resort to prophylactic spraying of fungicides. Biocontrol measures are not practiced at present for the management of these diseases in rubber plantations. In the present study, an attempt was made for the isolation and selection of endophytic bacteria that exhibited significant antifungal activity against above two fungi. A total of 36 bacterial isolates collected from leaf, petiole and stem of three *H. brasiliensis* clones, RRII 105, GT 1 and RRIM 600, were screened for

antagonistic activity *in vitro* against the virulent strains of these pathogens. The isolates showing maximum antagonism were selected. Antagonistic isolates were identified as *Bacillus spp.* by 16S rDNA sequencing. *In vitro* testing of rubber leaves treated with a consortium of the selected endophytic bacteria showed systemic tolerance to *P. meadii* and *C. cassiicola*. Chitinase, Peroxidase and PAL activity increased in the treated seedlings up to 45 days.

Key words: Antifungal activity; *Corynespora cassiicola;* Endophytic bacteria; *Phytophthora meadii*

127. Philip, S., Joseph, K., Joseph, A., Abraham, A., Elias, R. S., Abraham, T., Thomas, V., Pramod, S. and Jacob, C. K. (2008). Influence of bacterial endosymbionts on Corynespora leaf fall disease of rubber (*Hevea brasiliensis*). *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production,* 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 180-181.

Hevea brasiliensis is an important commercial crop cultivated in the Southern states and North eastern regions of India. *Corynespora cassiicola* causes severe leaf infection leading to leaf fall and die back in *H. brasiliensis.* At present growers report two prophylactic spraying of fungicides. An attempt was made for the isolation and selection of endophytic bacteria that exhibited significant antifungal activity against *C. cassiicola.* Field evaluation showed that the spraying of bacterial endophytes on leaves at refoliation period after annual wintering reduced the disease incidence which was on par with fungicide treated control plants.

Key words: Bacterial endosymbionts; Corynespora leaf fall

128. Philip, S., Joseph, K., Abraham, A., Elias, R.S., Joseph, A. and Jacob, C. K. (2009). Antagonistic activity of endophytic bacteria against major leaf pathogens of *Hevea brasiliensis. First Asian PGPR Congress for Sustainable Agriculture*, 21-24 June 2009, India and Auburn University, USA, pp. 90.

A total of 154 bacterial isolates collected from leaf, petiole, stem and root of three clones of *H. brasiliensis viz.* RRII 105, GT 1 and RRIM 600, were screened for antagonistic activity *in vitro* against the leaf pathogens *Phytophthora meadii* and *Corynespora casiicola.* Six efficient antagonists were selected. These isolates produced antipathogenic volatile compounds, siderophores and salicylic acid.

Isolates were identified as *Bacillus* spp. by 16S rDNA sequencing. Colonization of bacterial endophytes in rubber seedlings were confirmed by ERIC-PCR. Rubber seedlings inoculated with a consortium of the selected endophytic bacteria showed induced systemic resistance (ISR) to *P. meadii* and *C. cassiicola*. Chitinase, Peroxidase and PAL activity increased in the treated plants up to 45 days.

Key words: Antagonism; *Corynespora cassiicola;* Endophytic bacteria; *Phytophthora meadii*

129. Philip, S., Joseph, K., Joseph, A., Abraham, A., Elias, R. S., Abraham, T., Thomas, V., Pramod, S. and Jacob, C.K. (2009). Influence of bacterial endosymbionts on Corynespora leaf fall disease of rubber (*Hevea brasiliensis*). *Indian Phytopathology,* **62**(3):MEZ.25, pp. 396.

Hevea brasiliensis is an important commercial crop cultivated in the Southern states and North eastern regions of India. It is the major source of natural rubber. *Corynespora cassiicola* causes severe leaf infection leading to leaf fall and die back in *H. brasiliensis.* At present growers report two prophylactic spraying of fungicides. Biocontrol measures are not yet practiced for the management of any disease in rubber plantations. An attempt was made for the isolation and selection of endophytic bacteria that exhibited significant antifungal activity against *C. cassiicola*. Fifty-four endosymbiont isolates collected from leaf, petiole and stem of *H. brasiliensis* clone GT 1 were screened *in vitro* for antagonistic activity against *C. cassiicola*. Three efficient antagonists were selected which produced antipathogenic volatile compounds, siderophores and salicylic acid. These bacteria were localized in the intercellular spaces of tissues by 2,3,5-tri phenyl tetrazolium chloride staining. Antagonistic isolates were identified as *Bacillus* spp. by 16S rDNA sequencing. *In vitro* testing of rubber leaves treated with a consortium of the selected endophytic bacteria showed induced systemic resistance (ISR) to *C. cassiicola*. Enhanced ISR activity was observed in endosymbiont treated seedlings up to 45 days. Field evaluation showed that the spraying of bacterial endophytes on leaves at refoliation period after annual wintering reduced the disease incidence, which was on par with fungicide treated control plants.

Key words: *Corynespora cassiicola;* Corynespora leaf fall; Disease management; Fungicide; Induced systemic resistance

130. Philip, S., Abraham, A. and Joseph, A. (2010). *Corynespora cassiicola* induced chitinase activity and cloning of chitinase cDNA from rubber (*Hevea brasiliensis*). *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp. 81-82.

The Corynespora leaf disease, caused by *Corynespora cassiicola* in rubber (*Hevea brasiliensis*) is now considered to be a serious threat in South Karnataka and adjoining regions of Kerala. Chemical control has been adopted to control the disease in the field. The repeated fungicide spray or dusting may lead to environmental pollution. Most of the high yielding clones are susceptible to *C. cassiicola*. Disease resistance in plants is brought about by constitutive and induced mechanisms. In incompatible host-pathogen interaction, various noval proteins are induced called pathogenesis related proteins (PR), which play a major role in plant defense mechanism. The defense genes remain quiescent in healthy plants. Infection of pathogen on host surface elicits defense mechanisms in plants which provide resistance to further attack of the pathogenic fungi. The chitinase (PR-3) is the most widely studied group of PR protein. Chitinase gene codes for antifungal chitinase, which catalyze the hydrolysis of 1,4 linkages of N-acetyl –D-glucosamine polymer (chitin) found in the cell wall of higher fungi. The objective of the present study was to investigate the influence of pathogen induced chitinase activity related to tolerance in *Hevea brasiliensis* clones / germplasm accessions during *C. cassiicola* induction and to amplify full length chitinase cDNA from the tolerant clone for the development of recombinant chitinase protein. The widely cultivated and susceptible clone of *H. brasiliensis* namely, RRII 105, the tolerant clone GT 1 and germplasm accessions (RO 3413, MT 1598, RO 3172, AC 2717, AC 4338) were selected for the study. Budded stumps of these clones/ germplasm accessions were raised in polybag in glasshouse to prevent infection by other fungal pathogens. Artificial inoculation was done by spraying the conidial suspension of *C. cassiicola* ($7x10^4$ spores/ml) on the leaves at the light green stage. Control plants were sprayed with double distilled sterile water and maintained under similar conditions. Induced leaves were collected at 24, 48, 72, 96, 120, 144, 168 and 196 hours. Spectrophotometric estimation of chitinase enzyme was carried out using colloidal chitin as substrate. Total RNA was isolated from the induced leaves of the clone GT 1 at 96 hours by lithium chloride precipitation. First strand cDNA was synthesized using ImProm II reverse

transcriptase kit (Promega, USA) and full length chitinase gene was amplified with chitinase specific primers. The PCR product was purified, cloned in T/A cloning vector, sequenced and analyzed. Chitinase activity increased from 72 to 96 hours and remained constant up to 144 hours in tolerant clone GT I and tolerant germplasm accessions. There was no increase in enzyme activity in the clone RRII 105. In GT 1 and tolerant germplasm accessions the difference in the enzyme activity between the treated and control plants was phenomenal, while in RRII 105 there was no remarkable difference in the activity. Chitinase full length cDNA (978 bp) from GT 1 showed similarity with other known chitinase genes. The present observation leads to further studies on the probable role of chitinase in the resistance against *C. cassiicola* in *Hevea brasiliensis*.

Key words: *Corynespora cassiicola*; Chitinase

131. Pillay, P.N.R. (1974). South American leaf blight disease of rubber. *Souvenir, Rubber Planters' Conference India*, 1974, Kottayam, India, pp. 62-65.

South America is the native home of rubber from where the para rubber tree was introduced to South East Asia. In the history of natural rubber as a plantation crop, reports are not available about attempts made for the large scale cultivation of *Hevea* in South America, in the beginning. But attempts to cultivate rubber on an extensive scale in South America were unsuccessful and those ambitious programmes were almost abandoned after some years, because of the incidence of the devastating disease of rubber, namely the South American Leaf Blight, caused by the fungus *Microcyclus ulei* (p.Henn) V.Arx(*Dothidella ulei*). In this paper the climate and disease incidence, disease symptoms, causative pathogen, dispersal of the pathogen, disease control, clones resistant to SALB, disease eradication and the precaution to prevent the entry of this disease into South East Asia etc. are discussed.

Key words: South American Leaf Blight

132. Pillay, P.N.R. (1977). Aerial spraying against Abnormal leaf fall disease of rubber in India. *Planters' Bulletin*, **148**: 10-14.

Key words: Aerial spraying; Abnormal Leaf Fall

133. Pillay, P.N.R. (1982). Abnormal leaf fall disease of rubber caused by *Phytophthora* spp. *Proceedings of the Workshop on Phytophthora Disease of Tropical Cultivated Plants*, 1980, Central Plantation Crops Research Institute, Kasaragod, India, pp. 17-23.

Key words: Abnormal leaf fall; *Phytophthora*

134. Pillay, P.N.R. and Chee, K.H. (1968). Susceptibility of *Hevea* rubber clones of leaf disease caused by two species of *Phytophthora*. *FAO Plant Protection Bulletin*, **16**: 49-51.

The degree of susceptibility of ten *Hevea* clones to *Phytophthora* leaf fall and the pathogenicity of five distinct strains isolated from diseased leaves were assessed in the laboratory by a technique described above. No significant differences in pathogenicity between the five isolates was revealed, nor was there any significant interaction between clones and isolates. Differences in clonal susceptibility were found to be highly significant. Among the ten clones studied, RRIM 701 was the most susceptible and GT 1 the least. Field observations on susceptibility of certain known clones (Tjir 1, PB 86 and PR 107) are in agreement with their reaction to the disease under the described method of artificial inoculation.

Key words: Clonal susceptibility; Leaf disease; *Phytophthora*

135. Pillay, P.N.R. and George, M.K. (1973). Recent experiments on the control of Abnormal leaf fall disease of rubber in India. *Quarterly Journal of the Rubber Research Institute of Sri Lanka*, **50**: 223-227.

Abnormal leaf fall disease is annually recurring disease of rubber in India. Prophylactic spraying of copper fungicides before the onset of the South-West monsoon had become a routine cultural operation among estates and smallholdings. Pre-monsoon protective spraying was carried out with rocker sprayers using Bordeaux mixture or low volume application from the ground, with micron sprayers and aerial application from helicopters. The cost of spraying was steadily increasing, field experiments carried out, with new copper fungicide formulations and low UR value diluent mineral oils have established that

satisfactory disease control could be obtained with these new formulations. By use of these materials, which are now recommended for large scale use in rubber plantations, considerable saving in spraying cost could be achieved.

Key words: Abnormal leaf fall; Disease control

136. Pillay, P.N.R., George, M.K., Rajalakshmy, V.K. and Krishnankutty, V. (1980). Crown budding: A method to avoid Abnormal leaf fall disease of rubber. *International Rubber Conference*, 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

One of the most important diseases of rubber in South India is the Abnormal leaf fall disease, caused by *Phytophthora* spp. Though this disease can be controlled by prophylactic spraying of fungicides, the operation is costly and has to be repeated every year. There is a possibility of avoiding this disease by crown budding the high yielding clones with clones resistant/ tolerant to *Phytophthora*. The characters of disease resistance was assessed from selections from old seedling population and imported clones. A selection from seedling population of two showed tolerance to Abnormal leaf fall disease. These clones were selected and were crown budded on GT 1, RRIM 628 and RRIM 600 in three locations. A block of 250 plants in one location was crown budded with each of the three selections during 1970 and 1971. The crown budded plants were left unsprayed from the beginning. The data indicated that the disease was almost absent in the case of crown budded plants compared to control. The initial yield data indicated that in two locations, the yield of RRIM 628 and RRIM 600, crown budded with the above resistance clones, as higher than that of control, except in RRIM 600 plot, crown budded with FX 516. In the other location, however, the yield of GT 1, crown budded with all the three selections, was found to be lower. Though crown budding appears to be a promising method in the avoidance of Abnormal leaf fall disease, further experimental data are necessary for making general recommendation in this regard.

Key words: Abnormal leaf fall; Crown budding

137. Pillay, P.N.R., George, M.K. and Rajalakshmy, V.K. (1980). Leaf and shoot diseases. *In: Handbook of Natural Rubber Production in India.* (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 249-278.

This chapter deals with all the leaf and shoot diseases of rubber. The details concerning Abnormal leaf fall disease are about its history and occurrence, the factors influencing the disease, the initial infection on pods, spread to leaves and twigs, causative organism, alternative hosts, spread and over-summering, clonal susceptibility, effect on growth and yield and its control measures. Regarding Powdery mildew, the factors influencing disease, clonal susceptibility, infection on mature rubber, infection on nursery and immature plants, causative organism, effect on growth and yield and the control measures are elaborated. For Corynespora leaf spot, Bird's eye spot, Secondary leaf fall, Anthracnose, Shoot rot and Thread blight disease, the symptoms, causative organism and control measures are discussed. For South American leaf blight, the influence of weather, symptoms, causative organism and control measures are mentioned. A brief note on the origin, history and preparation of Bordeaux mixture and its use in rubber is also included.

Key words: Abnormal leaf fall; Disease control; Leaf disease; Shoot disease

138. Pillay, P.N.R., Krishnankutty, V. and Edathil, T.T. (1989). Crown budding: A method to reduce cost of production of natural rubber in India. *Placrosym* VII, 1986, Coonoor, India. *Journal of Plantation Crops*, **16**(Supplement): 277-279.

Since the Abnormal leaf fall disease of rubber caused by *Phytophthora* spp. is very severe and debilitating, crown budding of high yielding susceptible clones, *viz.* GT 1, RRIM 600 and RRIM 628 with disease resistant/tolerant clones *viz.* F 4542, FX.516 and RRII 33 was tried to combat the disease. Leaf retention against Abnormal leaf fall disease of unsprayed crown budded plants was very good when compared to sprayed control plants. The yield of RRIM 600 and RRIM 628 crown budded plants was higher than control plants whereas yield of GT 1 crown budded plants was found to be lower in the cases of all the three crown clones. Though, the crown budding appears to be a promising method in the control of Abnormal leaf fall disease, further experimental data for all available high yielding clones are necessary for making general recommendation of this technique.

Key words: Abnormal leaf fall; Crown budding

139. Prem, E.E. (2006). Prospects of integrated disease management of Corynespora leaf fall disease. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 142-157.

This chapter deals with diagnosis of disease, monitoring pathogen, predicting critical level for disease control, prevention and management methods, site selection, host resistance, irrigation management, soil and nutrition management, cultural practices, budding, sanitation, weed control, biological control, chemical control and IDM strategy for Corynespora leaf disease in rubber.

Key words: Corynespora leaf fall; Disease control

140. Prem, E. E., Manju, M. J., Mushrif, S. K., Idicula, S. P. and Jacob, C.K. (2002). Evaluation of dust formulation of hexaconazole for the control of powdery mildew disease of *Hevea brasiliensis*. *Placrosym XV, 2002.* (Eds. K. Sreedharan, P.K. Vinod Kumar, Jayarama and Basavaraj M. Chaluki). Central Coffee Research Institute, Karnataka, India, pp. 572-575.

Field experiments were conducted to evaluate a triazole fungicide, hexaconazole, for the management of powdery mildew disease of rubber (*Hevea brasiliensis*) caused by *Oidium heveae* Steinm. The experiment was conducted on a susceptible clone PB 5/51 in Cheruvally estate, Kottayam, Kerala and also in a disease-prone area on clone RRIM 600 in Vaikundam estate, Kanyakumari district, Tamil Nadu for seasons (1999 to 2002). Hexaconazole (2) dust was evaluated as such and in alternate schedule with sulphur and in combination with recommended sulphur fungicide and at three concentrations. Results indicated that application of hexaconazole (2) as such and in alternate schedule with sulphur was found to give better control. Combination of hexaconazole (2) and sulphur and hexaconazole (1) as such were observed to reduce powdery mildew disease. Alternate use of hexaconazole with sulphur is suggested to avoid the development of resistant strains.

Key words: Disease control; Dust formulation; Hexaconazole; Powdery mildew

141. Prem, E.E. and Jacob, C.K. (2006). Disease intensity assessment of Corynespora leaf fall disease. *In: A Laboratory Manual for International Training on Strategies for Management of* Corynespora *Leaf Fall Disease of Hevea brasiliensis*. (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 25-30.

Key words: Corynespora leaf fall; Disease intensity assessment

142. Prem, E.E., Mushrif, S.K. and Jacob, C.K. (2006). Effect of certain fungicides on the incidence and severity of *Colletotrichum* leaf disease of immature rubber. *Placrosym* XVII, 2006, Kochi, India. *Journal of Plantation Crops*, **34** (3): 467-471.

Colletotrichum leaf disease (CLD) of rubber caused by *Colletotrichum acutatum* and *C. gloeosporioides* affect the young foliage of nursery and immature rubber plants (*Hevea brasiliensis*). Field studies were undertaken to assess the distribution of the two *Colletotrichum* species in the immature rubber plants. Propiconazole and SAAF (a combination product of mancozeb and carbendazim), which were selected based on the *in vitro* screening, were evaluated in the field during 2001, 2002, and 2003 seasons. On immature plants of the clone RRII 105, the incidence of *C. acutatum* and *C. gloeosporioides* was uniformly distributed. Propiconazole and SAAF completely inhibited the mycelial growth at 100 ppm and spore germination at 250 ppm. No variations in the sensitivity of fungicides were observed between the two *Colletotrichum spp.* Field studies showed that the fungicides SAAF (0.075%) and propiconazole (0.012%) were equally effective in checking the incidence and severity of CLD and was comparable to hexaconazole (0.02%), mancozeb (0.2%) and carbendazim (0.05%). The cost comparison studies clearly indicated that the fungicides SAAF (0.075%) and propiconazole (0.012%) are economic and can be used for the management of CLD in immature rubber.

Key words: *Colletotrichum;* Leaf disease control; Propiconazole; SAAF

143. Prem, E.E., Mushrif, S.K., Srinivas, P. and Jacob, C.K. (2006). Effect of systemic acquired resistance inducing compound benzothidiazole(Bion) on powdery mildew and *Colletotrichum* leaf diseases of rubber. *National Seminar on Recent Trends in Crop Science Research*, 21-22 January 2006, Calicut University, Calicut, India.

Key words: *Colletotrichum;* Powdery mildew

144. Raj, S. (2011). An overview of weather and its influence on *Phytophthora* leaf fall in rubber. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Key words: *Phytophthora*; Weather

145. Raj, S. and Joseph, A. (2010). Critical climatic factors influencing the incidence and severity of Corynespora leaf disease in rubber (*Hevea brasiliensis*). *International Workshop on Climate Change and Rubber Cultivation: R & D Priorities*, 28-30 July 2010, Rubber Research Institute of India, Kottayam, India, pp. 96-98.

Key words: Climate change; Corynespora leaf fall

146. Rajalakshmy, V.K. (1976). Leaf spot disease of rubber caused by *Curvularia pallescens* Boedijin. *Current Science*, **45**: 530

Curvularia pallescens was reported to be infecting *Hevea* in budwood nursery in the months of June – July producing minute brownish red spots with yellow halo on leaves. The fungus was cultured and artificial inoculation on rubber seedlings produced high percentage of infection. *Curvularia pallescens* was reisolated from lesions produced by artificial inoculation.

Key words: *Curvularia*; Budwood nursery; Leaf disease

147. Rajalakshmy, V.K. (1986). Occurrence of basidial stage of *Corticium salmonicolor* in *Hevea brasiliensis*. *Indian Phytopathology*, **39**(2): 276-278.

Key words: *Corticium salmonicolor*

148. Rajalakshmy, V.K. and Pillay, P.N.R. (1975). Nectar stage of *Corticium salmonicolor* (*Pellicularia salmonicolor*) in culture. *Indian Phytopathology*, **28**: 112-113.

Key words: *Corticium salmonicolor;* Nectar stage

149. Rajalakshmy, V.K., Potty, S.N., Kothandaraman, R. and Karthikakuttyamma, M. (1979). Influence of nutrition on disease incidence: Glasshouse experiment to study the effect of N, P and K on leaf spot disease of rubber caused by *Corynespora cassiicola* (Berk & Curt) Wei. *In: Entomology, Microbiology, Nematology, Plant*

Pathology and Rodentology of Plantation Crops: Placrosym II, 1979, Ootacamund, India. (Ed. C.S.Venkata Ram). Indian Society for Plantation Crops, Kasaragod, India, pp. 118-125.

A pot culture experiment was conducted during 1977-78 season in the glasshouse to study the effect of N, P, and K on leaf spot disease incidence caused by *Corynespora cassiicola* (Berk and Curt) Wei. under controlled conditions. Two levels of nitrogen, phosphorous and potassium were tried in a completely randomized design with 5 replications. Germinated seeds were sown in earthenware pots filled with top soil passing through 2 mm. sieve. Six weeks after sowing, seedlings were thinned out retaining only one seedling per pot. The first manuring with half of the dose of nitrogen and the entire dose of phosphorus and potassium was given. The remaining quantity of nitrogen was given 12 weeks after sowing. Height and girth of plants were recorded after 4 months. Artificial inoculation of the seedlings was carried out with a spore suspension of *Corynespora* during the month March. Disease intensity was assessed 7 days after inoculation by leaf scoring method with regard to the number of spots. Leaf samples were analysed for nitrogen, phosphorus, potassium, calcium and magnesium. The study points out that high disease incidence was noticed in the presence of nitrogen and low incidence in its absence. It is indicated that application of phosphorus partly reduces the adverse effects of nitrogen. On the other hand rate of disease incidence is increased by potassium when applied along with nitrogen. The results indicate the need for balanced nutrition for ensuring proper growth so that the loss due to the diseased becomes less significant.

Key words: *Corynespora cassiicola;* Leaf spot

150. Rajalakshmy, V.K., Nair, V.R.A. and Jayadevi, M. (1980). Bavistin for control of leaf spot disease of rubber. *International Rubber Conference*, 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

Different fungicides *viz.* Calixin, Bavistin, Thiophenate methyl, RH. 124, RH. 893, Plondrel, Aureofungin sol, Daconil, Kitazin, MBC 50 per cent, Duter, Vitavax, Dexon, Bambro, Emisan and Karathane were screened against the leaf spot pathogen *Corynespora cassiicola*, in the laboratory by poisoned food technique

as well as by modified paper disc method. Plain potato dextrose agar plates and sterile water served as controls. Colony measurements of the test fungus in the treated and control were taken and percentage of inhibition with respect to control was calculated. Cent per cent inhibition was noticed in the case of Bavistin, Thiophenate methyl, RH. 893, Vitavax, Emisan and MBC 50 per cent at 250 ppm level and Dexon at 500 ppm level. Calixin, RH. 124, Duter and Aureofungin sol showed cent per cent inhibition at higher concentrations. Of the fungicides tested *viz.* Plondrel, Kitazin, Karathane, Bambro and Daconil were not very effective in checking the growth of the pathogen. Out of the effective fungicides, Bavistin, which was commercially available, was used for field trials. Using Knap-sack sprayer 0.2 per cent Bavistin was used for bulk spraying in the nursery at fortnightly intervals. Unsprayed seedlings in the adjacent area served as control. Disease assessment was made at the peak period of infection in March, April and May, by collecting 100 representative leaf samples from the treated and control plots by visual grading of the same. The results showed that four rounds of spraying of Bavistin (0.2 per cent) at fortnightly intervals effectively controlled the leaf spot disease incidence.

Key words: Disease control; Leaf spot

151. Rajalakshmy, V.K., Joseph, A. and Arthassery, S. (1985). Occurrence of two mating groups in *Phytophthora meadii* causing Abnormal leaf fall disease of rubber in South India. *Transactions of the British Mycological Society*, **85**(4): 723-725.

Heterothallism has been demonstrated in Indian isolates of *Phytophthora meadii* from rubber. Thirty two isolates were mating type A1, twenty four were A2, two were homothallic and four sterile.

Key words: Abnormal leaf fall; *Phytophthora meadii*

152. Rajalakshmy, V.K. and Joseph, A. (1986). Production of sporangia by *Phytophthora meadii*. *Indian Phytopathology*, **39**: 470-471.

High sporulation is essential for taxonomic or morphological studies of a fungus. In case of *Phytophthora*, a sporangial suspension is used as inoculum for artificial inoculation purposes. This paper provides the protocol for producing sporangia

abundantly in a short period by *Phytophthora meadii* in pure culture. It was found that profuse sporangial production was induced on culture media under continuous light intensity in a short period of 16 hours and also under low nutritional conditions.

Key words: *Phytophthora meadii*

153. Rajalakshmy, V.K. and Joseph, A. (1988). Occurrence of *Colletotrichum* leaf spot disease of rubber in India. *Indian Journal of Natural Rubber Research*, **1**(1): 50-52.

This paper reports on a leaf spot disease caused by *Colletotrichum* on rubber in India. This disease was earlier reported in Ceylon, Malaysia and Andamans. Severe disease incidence was noticed on six-year-old trees of RRII 105 and RRIM 701 in Manimala, Kerala. Subsequently it was found in many other estates, affecting both mature trees and budwood plants. Isolation of the pathogen from different types of symptoms *viz.* dark spots with yellow halo, dark black lesions and old spots with shot hole appearance yielded the same pathogen, which was identified by Commonwealth Mycological Institute, England.

Key words: *Colletotrichum*; Leaf spot

154. Rajalakshmy, V.K. and Kothandaraman, R. (1996). Current status of Corynespora leaf fall in India. *Proceedings of the Workshop on* Corynespora *Leaf Fall Disease of Hevea Rubber,* 16-17 December 1996, Indonesian Rubber Research Institute, Medan, pp. 37-43.

Corynespora leaf disease on rubber caused by *Corynespora cassiicola* (Berk & Curt) Wei. was first reported in India at the Experiment Station of Rubber Research Institute of India, Kottayam, Kerala, in the months of November – December 1958 (Ramakrishnan and Pillai, 1961). Since then, the disease has been observed in Mundakayam, Kanjirappally, Kalaketty, Thodupuzha, Chalakudy, Trichur and Vithura in Kerala State and Kaliyil and Nagercoil in Tamil Nadu. At present Corynespora disease is found to be prevalent in all the rubber growing regions in India. In South India, it is a warm weather disease and is common from November to May. The disease appears on a mild scale generally confined to nursery seedlings and budwood plants. In certain localities, the disease incidence is more widespread. Later on the disease was reported on mature trees (1) and in 1996, *Corynespora* infection has been found much damaging on young mature trees of

8-9 years old at *Hevea* breeding substation, Nettana, Karnataka, where many clones including RRII 105, the most popular high yielding clone, were seriously affected by the disease. Young leaves developed after wintering were attacked causing defoliation. Repeated defoliation resulted in the die-back of twigs and drying up of plants.

Key words: *Corynespora cassiicola*; Clonal susceptibility; Leaf fall

155. Rajalakshmy, V.K., Joseph, A., Varghese, Y.A. and Kothandaraman, R. (1997). Evaluation of *Hevea* clones against powdery mildew caused by *Oidium heveae* steinm. *Indian Journal of Natural Rubber Research*, **10**(1&2): 110-112.

In each of two trials conducted in 1992-95, 13 *Hevea brasiliensis* clones were evaluated for resistance to *Oidium heveae*. Disease intensity is tabulated for each clone in each year. There were significant differences between years and clones.

Key words: Clone; *Oidium heveae*; Powdery mildew

156. Ramakrishnan, T.S. (1956-57). Powdery mildew of rubber caused by *Oidium heveae* Steinmaan and its occurrence in South India. *Rubber Board Bulletin*, **4**(2&3): 3-6.

Powdery mildew controlled with sulphur dusts or wettable suphur sprays.

Key words: Powdery mildew; *Oidium heveae*

157. Ramakrishnan, T.S. (1956-57). Shoot rot of young rubber caused by *Phytophthora palmivora* Butl. *Rubber Board Bulletin*, **4**(2&3): 76-79.

Cuprosana dust effectively controlled a nursery outbreak.

Key words: *Phytophthora palmivora;* Shoot rot

158. Ramakrishnan, T.S. (1956-57). Thread blight and target spot of rubber caused by *Pellicularia filamentosa* (Pat) Rogers. *Rubber Board Bulletin*, **4**(2&3): 73-75.

A new disease of rubber was found to be prevalent in some of the estates in Kerala. The disease was caused by *Pellicularia filamentosa* and damaged tender

leaves. Details of the symptoms, pathogen, pathogenicity, record of the disease from other countries and the control measures adapted for the disease are discussed.

Key words: Thread blight; *Pellicularia filamentosa*

159. Ramakrishnan, T.S. (1961). Experiments on the control of Abnormal leaf fall of *Hevea* caused by *Phytophthora palmivora* in South India. *Proceedings of Natural Rubber Research Conference*, 1960, Kuala Lumpur, pp. 454-466.

Although a single pre-monsoon spray of 1% Bordeaux has proved consistently effective, the method is difficult to apply under S. Indian conditions. Preliminary work has shown low-volume, oil-based copper sprays to be promising.

Key words: Abnormal leaf fall; *Phytophthora palmivora*

160. Ramakrishnan, T.S. and Pillay, P.N.R. (1961). Abnormal leaf fall of rubber (*Hevea brasiliensis*) caused by *Phytophthora palmivora* Butl. in South India. 1. *Rubber Board Bulletin*, **5**(1): 11-20.

The earliest record of Abnormal leaf fall caused by *Phytophthora palmivora* in India was in 1910 from some estates in Pudukkad. This paper describes about the disease spread to different parts of the country. The detection of disease from other rubber growing countries is also recorded. The paper describes about the pathogen, pathogenicity test factors affecting the disease, survival of the fungus from year to year and the loss caused by the disease.

Key words: Abnormal leaf fall; *Phytophthora palmivora*

161. Ramakrishnan, T.S. and Pillay, P.N.R. (1961). Abnormal leaf fall of rubber (*Hevea brasiliensis*) caused by *Phytophthora palmivora* Butl. in South India. 2. *Rubber Board Bulletin*, **5**(2): 76-84.

This paper deals with the different experiments undertaken from early years for the control of Abnormal leaf fall of rubber. Bordeaux mixture proved to be the best for controlling the disease. Disease resistance was observed in certain clones.

Key words: Abnormal leaf fall; *Phytophthora palmivora*

162. Ramakrishnan, T.S. and Pillay, P.N.R. (1961). Leaf spot of rubber caused by *Corynespora cassiicola* (Berk & Court) Wei. *Rubber Board Bulletin*, **5**(1): 32-35.

Description of a disease of rubber seedlings on nurseries in India resembling the disease caused by *Helminthosporium heveae*. Damage may be severe so that protection by spraying Bordeaux mixture or dithane Z-78 is necessary. Susceptibility to this leaf spot disease varies with clone, RRIM 610 and 622 being the most susceptible according to these preliminary observation. Sometimes Tjir 1 clonal seedlings are also affected.

Key words: *Corynespora cassiicola;* Leaf spot

163. Ramakrishnan, T.S. and Pillay, P.N.R. (1961-62). Powdery mildew of rubber caused by *Oidium heveae* Stein. *Rubber Board Bulletin*, **5**(1): 187-201.

Powdery mildew of rubber has now reached the Western Hemisphere also, though it was considered to be confined to the East. In India it has spread through all rubber growing areas. The greatest damage is caused soon after refoliation of mature trees subsequent to wintering. Rubber trees of all ages are susceptible. There is positive correlation between the date of commencement, rate and uniformity of wintering and mildew infection. This is further influenced by the climatic conditions prevalent at the time. Cool nights, heavy dew and light showers occurring during the refoliation period favor the disease. All the commercially important clones are susceptible. The Indonesian clone LCB 870 is resistant but it is low yielder. Sulphur dusting is the most reliable method of control. Spraying against this disease is possible only in nurseries and trees below 15 feet in height and impracticable in mature plantations.

Key words: Powdery mildew; *Oidium heveae*

164. Ramakrishnan, T.S. and Pillay, P.N.R. (1961-62). Secondary leaf spot (Anthracnose of *Hevea brasiliensis)* caused by *Glomerella cingulata* (Stonem) S & VS. *Rubber Board Bulletin*, **5**(2): 85-87.

Anthracnose or secondary leaf spot caused by *Glomerella cingulata* has been reported from most rubber growing countries. This paper discusses on the symptoms of the disease, the details to the pathogen and preventive measures.

Key words: Secondary leaf spot; *Glomerella cingulata*

165. Ramakrishnan, T.S. and Pillay, P.N.R. (1962). Secondary leaf fall caused by *Glomerella cingulata* (Stonem) S & VS (*Gloeosporium alborubrum* petoh). *Rubber Board Bulletin*, **6**(2): 72-78.

A review of the occurrence, symptoms, pathogen and control of secondary leaf fall in rubber. In South India, the disease is of little importance probably owing to the common practice of spraying with Bordeaux mixture against Abnormal leaf fall caused by *Phytophthora palmivora*. The fungus responsible for secondary leaf fall is *Glomerella cingulata* (*Gloeosporium alborubrum*).

Key words: *Glomerella cingulata; Gloeosporium alborubrum; Phytophthora palmivora*; Secondary leaf fall

166. Ramakrishnan, T.S. and Pillay, P.N.R. (1963). Zinc deficiency. *Rubber Board Bulletin*, **6**(3&4): 134.

Foliar application of the mixture of Zinc sulphate and lime solution is effective for the control of zinc deficiency in young rubber plants. The infestation of slugs and snails in rubber plants can be prevented by painting eight inches of stem above the soil with Dieldrex 18 E.C. (1 in 400) or by dusting 10% gammexane in young shoots.

Key words: Slug; Snail; Zinc deficiency

167. Ramakrishnan, T.S. and Pillay, P.N.R. (1963). *Jatropha curcas* L.: A collateral host for *Oidium heveae* Stein. *Current Science*, **32**: 428.

Infection transferred from affected *J. curcas* plants to *Hevea* and shows that *J. curcas* is a collateral host for *O. heveae*. This is the first record of this host for this pathogen.

Key words: *Jatropha curcas* L.; *Oidium heveae*

168. Roy, C.B. (2006). Variability of *Corynespora cassiicola* as revealed through molecular analysis. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management*. (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 33-43.

This chapter describes in detail the variability of *C. cassiicola* as revealed through molecular analysis. A brief mention on the morphological variation among the isolates of *C. cassiicola* is provided in the beginning of the chapter. This is followed by providing details on what is molecular variation, different DNA fingerprinting methods and on how to measure genetic variability. A detailed description on genetic variability in fungal pathogens of rubber as well as among the isolates of *C. cassiicola* infecting *Hevea* is also provided.

Key words: *Corynespora cassiicola*; DNA fingerprinting; Genetic variability; Molecular variation

169. Roy, C.B. (2011). Tracking *Phytophthora* diversity in rubber. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

Key words: *Phytophthora*

170. Roy, C.B., Zachariah, C.A., Philip, S., Idicula, S.P., Jacob, C.K. and Saha, T. (2005). Molecular characterization of *Phytophthora* infecting rubber plantations in South Western India. *In: Preprints of Papers. International Natural Rubber Conference, India 2005,* 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 489-498.

The plant pathogenic fungus *Phytophthora* causes severe diseases in a number of important crops including *Hevea brasiliensis*. Genetic variability in 26 isolates of *Phytophthora* collected from diverse hosts and locations in Kerala and Kanyakumari during 2004 was assessed using random amplified polymorphic DNA (RAPD) analysis and restriction fragment length polymorphism (RFLP) analysis of the internal transcribed spacer (ITS) region of ribosomal DNA. RAPD profiles generated with 20 oligonucleotide decamer primers revealed significant polymorphism between the isolates. Genetic relationships among the isolates were determined by cluster analysis of the RAPD data and eight different clusters were identified. However, amplified ITS region along with the 5.8S rDNA from the 26 isolates exhibited an identical size, and restriction analysis with seven different restriction endonucleases revealed identity in all of the detected DNA fragments. Genetic relatedness was checked by the cloning and DNA sequencing of the

ITS1-5.8S rDNA-ITS2 region from one isolate each of Kerala and Kanyakumari from two different *Hevea* clones, RRII 105 and RRIM 600 respectively. The sequence data from both the clones revealed unique ITS sequence, which showed maximum homology with the sequence of *Phytophthora citrophthora*, which has not been reported in India till date. Further studies to confirm the existence of *P. citrophthora* in India are in progress.

Key words: Molecular marker; *Phytophthora*; Rubber plantation

171. Roy, C.B., Ravindran, R., Jacob, C.K., Nazeer, M.A. and Saha, T. (2006). Phylogenetic relationships of *Colletotrichum* species infecting rubber (*Hevea brasiliensis*) based on nuclear ribosomal DNA spacer sequences. *In: Emerging Trends in Mycology Plant Pathology and Microbial Biotechnology*. (Eds. G. Bagyanarayana, B. Bhadraiah and I.K. Kunwar). BS Publications, Hyderabad, India, pp. 284-298.

Colletotrichum leaf fall disease in rubber caused by the *Colletotrichum* spp. produces three different disease symptoms, namely, raised spots, anthracnose and circular papery lesions. Involvement of two different species of the pathogen namely *C. gloeosporioides* and *C. acutatum* could be established through rDNA-ITS-RFLP analysis of the fungal isolates from rubber. Ribosomal DNA spacer sequences from both the *Colletotrichum* species infecting rubber were compared to get an idea about the nucleotide divergence existing among them in the spacer regions including 5.8 S gene. Aligned sequence data of the spacer regions revealed the existence of more nucleotide divergence including base substitutions and indels in the ITS 1 compared to the ITS 2 region. Phylogeny of the rubber pathogen with the closely related fungal isolates from different hosts, based on the rDNA spacer sequences, clearly revealed their uniqueness. The bootstrapped consensus tree derived through neighbour-joining method comprised of two major branches having the fungal isolates belonging to two different species indicating clear species delineation of *Colletotrichum*. The fungal isolates belonging to *C. gloesporioides* and *C. acutatum* infecting *Hevea* appeared to be closely related to the pathogens infecting fragaria and cyclamen respectively.

Key words: *Colletotrichum gloeosporioides; Colletotrichum acutatum*; ITS-RFLP; rDNA spacers; Phylogenetic relationship

172. Roy, C.B., Zachariah, C.A., Jacob, C.K. and Saha, T. (2006). First report of leaf blight caused by *Alternaria alternata* on *Hevea brasiliensis* in India. *Placrosym* XVII, 2006, Kochi, India. *Journal of Plantation Crops*, **34** (3): 449-454.

Alternaria leaf blight caused by *Alternaria alternata* was observed on rubber (*Hevea brasiliensis*) tree, the source of natural rubber latex of commercial value. Initial symptoms appeared on young leaves as minute spots, which enlarged with the growth of the leaves. A characteristic browning and blackening of veins forming a 'fishbone' or 'railway track' symptoms was noticed at later stage of the disease. This disease symptom appeared similar to that of the devastating Corynespora leaf disease, caused by *Corynespora cassiicola* on *Hevea brasiliensis*. Twenty-six isolates from two states of India, Kerala and Karnataka, were characterized using random amplified polymorphic DNA (RAPD) analysis and two major profiles were detected. Cluster analysis resolved the isolates into two major groups. Restriction analysis of the PCR amplified ribosomal DNA including the flanking internal transcribed spacers of representative isolates from both the groups also revealed two distinct RFLP patterns reflecting the same grouping as detected through RAPDs. The amplified rDNA from representative isolates of both the groups was cloned and sequenced. Sequence analysis revealed significant homology of one group of isolates with *A. alternata* and the other with *C. cassiicola*. This is the first report of this disease from India.

Key words: *Alternaria alternata*; *Corynespora*; RAPD; RFLP

173. Roy, C. B. and Jacob, C. K. (2008). Differential gene expression during disease development in rubber (*Hevea brasiliensis*) by fungal pathogen *Corynespora cassiicola*. *IRRDB Natural Rubber Conference* 2008, 13-15 October 2008, Kuala Lumpur, Malaysia: Abstract of papers.

Corynespora leaf disease of rubber caused by *Corynespora cassiicola* is a major threat to natural rubber production in Asia. The present study was to identify and isolate genes that are differentially expressed in RRII 105, the popular clone in India, during disease development. Gene expression profiles of *Corynespora* challenged leaf samples along with the uninfected leaves of RRII 105 as control were studied using DD-PCR technique. Initially 60 differentially expressed (only up-regulated) major bands were cloned and sequenced to determine the identity

ITS1-5.8S rDNA-ITS2 region from one isolate each of Kerala and Kanyakumari from two different *Hevea* clones, RRII 105 and RRIM 600 respectively. The sequence data from both the clones revealed unique ITS sequence, which showed maximum homology with the sequence of *Phytophthora citrophthora*, which has not been reported in India till date. Further studies to confirm the existence of *P. citrophthora* in India are in progress.

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173. Roy, C. B. and Jacob, C. K. (2008). Differential gene expression during disease development in rubber (*Hevea brasiliensis*) by fungal pathogen *Corynespora cassiicola*. *IRRDB Natural Rubber Conference* 2008, 13-15 October 2008, Kuala Lumpur, Malaysia: Abstract of papers.

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of the candidate cDNA. Sequence analysis of the resulting clones revealed that most of the clones bear no significant similarity to those in nucleotide and protein databases and thus appeared to be unique transcripts. Stress responsive genes were also identified among the transcripts. However, two clones DDCT7 and DDCTl2 showed significant homology with Anthocyanidin 3-0--glucosyltransferase (E value: 4e-48) and GRAS transcription factor (E value: 1e-15) respectively. Anthocyanidin 3-0-glucosyltransferase is involved in the biosynthesis of a flavonoid compound. Beside their function as pigments in flowers and fruits, flavonoids are involved in UV -scavenging, fertility and disease resistance in plants. It is well known that transcriptional regulators of the GRAS family play essential roles in a variety of growth and developmental processes that are unique to plants. A novel defense function for the multifaceted GRAS family of transcriptional regulators has also been established in many plant species. Efforts are in progress to clone both these genes to understand their specific role in disease tolerance in rubber.

Key words: Corynespora leaf fall; Disease development; Gene expression

174. Roy, C. B., Jacob, C. K. and Saha,T. (2008). SCAR marker for the identification of *Alternaria alternata* causing leaf spot disease in rubber (*Hevea brasiliensis*). *Placrosym XVIII,* 10-13 December 2008, Puttur, Karnataka. *Journal of Plantation Crops*, **36**(3): 414-417.

The objective of the present work was to develop reliable sequence characterised amplified region (SCAR) marker to identify *Alternaria* causing leaf spot disease in rubber. The pathogens *Alternaria* and *Corynespora* cause similar disease symptom on rubber and was found to occur during the same season of the year. Two pairs of SCAR primers, derived from unique RAPDs, were successfully used in diagnostic PCR to identify *Alternaria*. This technique could detect the pathogen when the fungal DNA concentration was as low as 1 ng in standard PCR reaction volume of 25 µl. DNA samples from diseased lesions (0.2 to 0.5 cm diameter) were successfully used in identification of the pathogen using SCAR markers. This molecular tool appears to be very useful for epidemiological studies on *Alternaria* leaf blight in rubber

Key words: *Alternaria alternata; Corynespora;* Leaf spot; SCAR markers

175. Roy, C. B., Douhan, G., Coffey, M. D., Jacob, C. K. and Saha, T. (2008). Existence of two mating types causing extensive genetic diversity in the population of *Phytophthora* spp. associated with Abnormal leaf fall disease of rubber (*Hevea brasiliensis*). *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production*, 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 105.

Abnormal leaf fall disease caused by *Phytophthora* spp. is an annually recurring destructive disease of rubber in India causing significant loss to rubber production. During 2001 to 2007, eighty two isolates of *Phytophthora* spp. were collected from eight disease outbreak sites across South India. These isolates were characterized by mating type and genetic variation was assessed by amplified fragment length polymorphism fingerprinting technique. It was observed that both mating types co-existed in the plantations and one-third of them were of the A1 type. Considerable molecular diversity was observed with all the isolates having unique AFLP patterns. The presence of mixed mating type in the populations and the extent of AFLP diversity with no clonal genotypes indicate that *Phytophthora* spp. affecting rubber in India undergo sexual reproduction during its life cycle, and therefore their population is changing dynamically with the occurrence of new genotypes. This conclusion was also supported by population differentiation analyses, which indicate that gene flow occurs among populations and most tests of multi-locus disequilibrium analysis were consistent with random mating. When the *Phytophthora* population is highly diverse, as in rubber, selection forces can rapidly give rise to changes in the population structure rendering control strategies less durable.

Key words: Abnormal leaf fall; *Phytophthora*

176. Roy, C. B., Jacob, C.K. and Saha, T. (2009). Towards identification of genes involved in host tolerance to *Corynespora* leaf disease in rubber (*Hevea brasiliensis*). *5th International Conference on Plant Pathology in the Globalized Era*, 10-13 November 2009, New Delhi, India, pp.150.

Corynespora leaf disease of rubber caused by *Corynespora cassiicola* is a major threat to natural rubber production in South East Asian countries including India.

The present study was to identify and isolate genes that are differentially expressed during disease development caused by *Corynespora*. Gene expression profiles of *Corynespora* challenged leaf samples along with the uninfected leaves of RRII 105 as control were studied using DD-RT-PCR technique. Differentially expressed (only up-regulated) major bands were cloned and sequenced. Reverse Northern analysis was performed to screen for cDNA clones that truly represent differentially expressed genes in *Corynespora* challenge inoculated and control leaf samples of rubber clones RRII 105, GT 1 and RRIM 600. Majority of the cDNA clones showed consistent over-expression in all the treated samples when compared with the control. Among the positive clones, two of them showed significant homology with anthocyanidin 3-0-glucosyltransferase and GRAS transcription factor. Recently, the importance of these two genes in plant disease resistance has been established in other plant species. Northern analysis also confirmed over expression of the above two genes in *Corynespora*-challenged samples. Efforts are in progress to clone the stress responsive genes to understand their specific role in disease tolerance in rubber.

Key words: Corynespora leaf disease

177. Roy, C.B., Premraj, P., Coffey, M.D., Prem, E.E. and Jacob, C.K. (2010). *In vitro* screening of systemic fungicides against *Phytophthora* causing Abnormal leaf fall disease of rubber (*Hevea brasiliensis*). *Fifth International Union of Forest Research Organization (IUFRO) meeting on Phytophthora Diseases in Forests and Natural Ecosystems*, Rotorua, New Zealand.

Key words: Abnormal leaf fall; Fungicide; *Phytophthora*

178. Roy, C.B., Sailajadevi, T., Raj, S., Gogoi, N. and Mathew, J. (2010). Fishing for *phytophthora* from rubber plantations in Tripura (North East India) - Is climate inimical to the development of *Phytophthora* in NE India. *International Workshop on Climate Change and Rubber Cultivation: R & D Priorities*, 28-30 July 2010, Rubber Research Institute of India, Kottayam, India, pp. 93-96.

Key words: Climate change; *Phytophthora;* Tripura

179. Roy, C.B. and Coffey, M.D. (2010). DNA barcoding for species delineation of *Phytophthora* affecting rubber trees in India. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp. 71.

DNA barcoding is a diagnostic technique for species identification using a short, standardized DNA. This study aimed at presenting a genus-wide phylogeny for four *Phytophthora* species namely *P. meadii*, *P. botryosa*, *P. colocassiae* and *P. citrophthora* reported to be affecting rubber trees in India. Two nuclear DNA regions (Internal Transcribed Spacer region of the nuclear ribosomal DNA and the microtubule constituent protein b-tubulin) and one mitochondrial gene (cytochrome C oxidase subunit II) were used in the study to get a more resolved phylogeny of the four *Phytophthora* species affecting rubber, allowing better interpretation of the overall evolutionary history of the genus. Sequence information suggested that *P. meadii* had a hybrid origin with *P. colocassiae* as one of the parents and possibly *P. citrophthora* was an asexual derivative of *P. colocassiae*. Results of the analysis indicated a robust phylogenetic framework for interpreting the evolutionary history of these four species.

Key words: DNA barcoding; Molecular phylogeny; *Phytophthora*; Species identification

180. Roy, C. B., Srinivas, P. and Jacob,C. K. (2010). Effect of different long term storage methods on survival, growth and virulence of *Corynespora cassiicola* and *Phytophthora* spp. pathogenic on rubber (*Hevea brasiliensis)* trees. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts. pp. 166.

Two phytopathogenic fungi *Corynespora cassiicola* and *Phytophthora meadii* were preserved with 5 different storage methods *viz*. continuous growth method, immersion in sterile distilled water, desiccation (storage of fungi in sterile filter paper discs and storage of fungal spores in sterile soil), cryopreservation (colonized agar plugs placed in glycerol solution at -80^{0}C) and lyophilization. Survival of fungus was evaluated at 1, 3, 6, 9, 12, 18, 24 and 36 months after date of storage. Continuous growth method and immersion in sterile distilled water were found to be the best methods for both the test fungi with a revival rate of 71% and 62% for *C. cassiicola* and *P. meadii*, respectively. *P. meadii* could not survive well in any other method; however, *C. cassiicola* survived well in cryopreservation and

desiccation treatments also. It was significant to note that in contrast to continuous culturing, the virulence of the pathogen *C. cassiicola* could be maintained in all other preservation methods, which is of high value for tissue based germplasm screening against dreaded *Corynespora* leaf fall disease. However, 'immersion in sterile distilled water' was the only method which could preserve the virulence of Abnormal leaf fall pathogen *P. meadii*. This method was also the most cost effective being devoid of any specialized equipment or skills.

Key words: Culture maintenance; Viability; Virulence

181. Saha, T., Kumar, A., Sreena, A.S., Joseph, A., Jacob, C. K., Kothandaraman, R. and Nazeer, M.A. (2000). Genetic variability of *Corynespora cassiicola* infecting *Hevea brasiliensis* isolated from the traditional rubber growing areas in *India*. *Indian Journal of Natural Rubber Research*, **13**(1/2): 1-10.

Molecular characteristics of 20 isolates of *Corynespora cassiicola* from 16 different locations of two rubber growing states of southern India *viz*. Kerala and Karnataka, were investigated using random amplified polymorphic DNA (RAPD) markers. RAPD analysis clearly indicated the existence of at least seven different genotypes of *C. cassiicola*. Considerable genetic variations were detected among the Kerala isolates and three of them, KL01/97, KL04/98 and KL06/97 showed completely different RAPD profiles from others with each of the primers tested. Putative virulence specific RAPD profile of *Corynespora* was identified among the isolates where the disease became epidemic in Karnataka. Genetic relationships were established among the *Corynespora* isolates.

Key words: *Corynespora cassiicola*; Genetic diversity; Leaf disease; RAPD

182. Saha, T., Kumar, A., Roy, C.B., Ravindran, M., Joseph, A., Jacob, C. K. and Nazeer, M. A. (2002). Molecular characterization of fungal pathogens causing leaf diseases in rubber (*Hevea brasiliensis*). *Placrosym* XV, 10-13 December 2002, (Eds. K. Sreedharan, P.K. Vnod Kumar, Jayarama and Basavaraj M. Chaluki). Central Coffee Research Institute, Karnataka, India, pp. 195-203.

Identification of fungal races/pathotypes by using morphological criteria alone is difficult. Hence, molecular markers were used in the present study to characterize the pathogen causing leaf diseases of rubber. Molecular characterization of the

Colletotrichum isolates showed two major RAPD profiles suggesting the possibility of involvement of two different fungi inciting different disease symptoms, raised spots, Anthracnose and circular papery lesions of *Hevea*. RFLP analysis of ribosomal DNA spacers (ITS 4/5) including 5.8S ribosomal DNA also reflected two groupings of the *Colletotrichum* isolates confirming the existence of two different *Colletotrichum* species infecting *Hevea*. Nucleotide sequence analysis of the rDNAs revealed that the two groups of pathogens belong to two different species of *Colletotrichum*, namely, *C. acutatum* and *C. gloeosporioides*. Genetic structuring of the *Corynespora* populations, another fungal pathogen of rubber, was carried out through RAPDs. Ten different genotypes/races of *Corynespora cassiicola* were identified from different rubber plantations in Kerala and Karnataka states. Wide genetic variability was noticed among the *Corynespora* isolates from Kerala. Knowledge about the existence of different *Corynespora* races would be very useful to trace the development of new virulent races among the populations for avoiding out breaks of the disease.

Key words: Fungal pathogens; Leaf disease; Molecular characterization

183. Saha, T., Kumar, A., Ravindran, M., Jacob, C.K., Roy, C. B. and Nazeer, M.A. (2002). Identification of *Colletotrichum acutatum* from rubber using random amplified polymorphic DNAs and ribosomal DNA polymorphisms. *Mycological Research*, **106**(2): 215-221.

The fungal pathogen responsible for *Colletotrichum* leaf disease of *Hevea*, develops three different disease symptoms: raised spots, anthracnose and papery lesions. These diseases have been attributed to *Colletotrichum gloeosporioides* (teleomorph *Glomerella cingulata*) and the fungi involved are morphologically indistinguishable. Twenty-five *Colletotrichum* isolates, which originated from three different disease symptoms, were characterized initially using RAPD markers. Two major RAPD profiles were detected which were related to the type of disease symptom developed. *Colletotrichum* isolates causing raised spot symptom were easily distinguished from isolates originating from either anthracnose or papery lesions. Restriction analysis of the PCR amplified 5.8S ribosomal DNA (rDNA), including both the flanking internal transcribed spacers (ITS) of representative isolates from the three different disease symptoms, also revealed two distinct

RFLP patterns reflecting the same groupings as detected through RAPDs. Both molecular approaches suggested that there were two species of *Colletotrichum* associated with *Hevea* inciting the development of three different symptoms: *Colletotrichum acutatum* causing raised spot symptom, and *C. gloeosporioides* causing both anthracnose and papery lesions. This is the first record of *Colletotrichum acutatum* on *Hevea* in India.

Key words: *Colletotrichum; Glomerella;* Symptoms

184. Sailajadevi, T. (2006). Disease-weather relationship. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 44-53.

This chapter describes in detail the relationship between Corynespora leaf disease and weather. The chapter deals with weather-based forecast of disease outbreak, the need for surveillance, alternate host, carriers, host resistance, weather and systemic setbacks. The various approaches to anticipate pest and disease outbreaks such as geographic method, phenological technique, biological indicators and bioclimatic analysis are discussed. The different methods used in meteorological forecasting of diseases are also provided such as the physiological (laboratory) approach, empirical approach and weather warnings against diseases. The meteorological assistance for control operations such as chemical control and biocontrol is also provided. A relationship between disease and weather for Corynespora leaf disease of *H. brasiliensis* is also indicated. Epidemic of *C. cassiicola* and its geographical distribution as well as the environmental factors influencing Corynespora leaf disease are also mentioned. Epidemiology of *C. cassiicola* as well as prevention of epidemic occurrence is also provided in detail.

Key words: Corynespora leaf fall; Weather

185. Sailajadevi, T., Manju, M.J., Nair, R.B. and Jacob, C.K. (2005). Influence of weather on the incidence of Corynespora leaf fall disease of *Hevea* in Nettana. *In: Preprints of Papers. International Natural Rubber Conference, India 2005,* 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 505-509.

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An attempt has been made at *Hevea* Breeding Substation, Karnataka to understand the influence of local weather on the triggering and subsequent development of the Corynespora leaf fall (CLF) disease. Disease intensity was observed in an unsprayed field planted with the clone RRII 105 for a period of three years from 1999. Temporal and inter annual variation in the disease severity was analyzed in relation to the local weather to derive a set of environmental conditions congenial for disease initiation and progress. It could be inferred from the study that for this location a maximum temperature of 34 to 36 degree C, and a minimum of 17 to 20 degree C, a morning humidity of more than 85 per cent, an afternoon humidity of less than 40 per cent with a mean minimum sunshine duration of 8 hrs/day is an essential pre-requisite for the triggering and development of CLF disease. The study gives in indication that second fortnight of February may be the appropriate time for control measures that aim at minimizing the initial infection rate and preventing the build up of inoculum.

Key words: Corynespora leaf fall; Meteorological parameter; Karnataka

186. Sathik, M.B.M., Philip, S., Musthapha, M.P., Jose, R.M., Joseph, K., Jacob, C.K. and Jacob, J. (2008). Transient expression of chitinase gene in *Bacillus subtilis:* An endophyte of *Hevea brasiliensis*. *Journal of Plantation Crops*, **36**(3): 239-242.

Corynespora leaf disease in *Hevea* is a serious problem caused by *Corynespora cassiicola*. Over-expression of chitinase gene is known to control the spread of *Corynespora* leaf disease in *Hevea brasiliensis* (natural rubber trees). Engineering natural rubber trees to over-express chitinase is a cumbersome and time consuming process. As an alternative novel approach, an attempt has been made here to transform endophytic bacteria (*Bacillus subtilis*) which are known to be endosymbionts of *Hevea*, with the chitinase gene isolated from leaves of *Hevea* (clone GT1). An expression vector for *Bacillus subtilis* was engineered to express the chitinase gene and was introduced into *Bacillus subtilis*. Presence of the extra chromosomal chitinase gene in *Bacillus subtilis* and its over-expression was confirmed by estimation of chitinase activity in the transformed cells. Chitinase activity in the transformed cells was several times higher than the untransformed endosymbionts. This system of inducing expression of chitinase using endosymbionts in *Hevea* is faster and easier than developing a transgenic tree.

The experiment conducted to assess the colonizing ability of the transformed endosymbionts in *Hevea* leaves, yielded quite a good number of colony forming units indicating the colonizing ability of the transformed *Bacillus subtilis* in the intercellular regions of *Hevea* leaves. The over-expressing transformed endosymbionts when applied to *Hevea* prior to infection of *Corynespora* may prevent the spread of the disease.

Key words: *Bacillus subtilis; Corynespora cassiicola*; *Corynespora* leaf fall; Endophytic bacteria; Transient gene

187. Sethuraj, M.R. and George, M.J. (1973). Physiological studies on the abscission of leaves of rubber *(Hevea brasiliensis*) caused by *Phytophthora palmivora* and its inhibition by synthetic growth regulators. *Journal of Plantations Crops*, **1**(1 & 2): 32-36.

Physiological aspects of the abscission of rubber leaves caused by infection of *Phytophthora palmi*vora were studied. No enhancement of IAA-oxidase activity in the infected petioles was detected. Bioassay for emanation of ethylene by the infected twigs gave positive tests implicating ethylene in the abscission caused by *Phytophthora.* 2, 4-D spray at 100 and 200 ppm could counteract this process of abscission and prevent leaf drop in laboratory experiments. B-995 and IAA were ineffective in this respect.

Key words: Abscission; *Phytophthora;* Synthetic growth regulators

188. Singh, R. P., Baruah, N.J., Deka, H. K., Mondal, G.C. and Kothandaraman, R. (1998). Secondary leaf fall disease of *Hevea:* A report from Mizoram. *Rubber Board Bulletin*, **27**(3): 16-17.

A survey of rubber diseases in Mizoram during June to September 1994 revealed for the first time the occurrence of secondary leaf fall (SLF) disease caused by *Colletotrichum gloeosporioides* on budwood and seedling nurseries. The disease with moderate to severe spotting on immature leaves led to defoliation. Spraying of Carbendazim (Bavistin 0.05%) effectively controlled the SLF disease.

Key words: *Colletotrichum gloeosporioides;* Nursery; Secondary leaf fall

189. Srinivas, P. (2006). Possibilities of genetic control as sustainable management strategy against *Corynespora* leaf fall disease. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 122-141.

Plant genetic control is generally the most effective means of control when available, though, it must be continually monitored, as pathogens tend to develop virulence to tolerant material in course of time. This chapter concentrates on genetic control, genetic improvement of *Hevea*, breeding objectives in *Hevea*, breeding for disease resistance, factors in breeding for disease resistance, nature of pathogen, nature of host, screening methodology and selection environment, breeding methods, introduction of clones, ortet selection, hybridization and clonal selection, molecular genetics, molecular markers, molecular and biochemical markers in *Hevea*, molecular linkage maps in *Hevea*, marker assisted selection (MAS), biotechnological application in *Hevea* improvement, micropropagation, protoplast culture, somatic embryogenesis, *in vitro* conservation, genetic engineering, genetic transformation, candidate genes for genetic engineering of *Hevea brasiliensis* and on the few methodologies for resistance breeding.

Key words: Disease management; Genetic control

190. Srinivas, P., Seena, W., Krishnakumar, R. and Jacob, C.K. (2005). Induction of systemic acquired resistance in *Hevea brasiliensis* against *Colletotrichum acutatum* by chemical inducers. *Second Global Conference, Plant Health – Global Wealth,* 25-29 November 2005, Udaipur, India.

Key words: *Colletotrichum acutatum*; Induced systemic resistance

191. Srinivas, P. and Idicula, S.P. (2006). Fungicides in corynespora leaf fall disease management. *In*: *A Laboratory Manual for International Training on Strategies for Management of Corynespora Leaf Fall Disease of Hevea brasiliensis.* (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 40-50.

Key words: Corynespora leaf fall; Disease management; Fungicide

192. Supriya, R., Suni, A.M., Vineetha, M. and Thulaseedharan, A. (2011). Isolation and Molecular Characterization of a novel form of β-1, 3- glucanase gene from *Hevea brasiliensis*. *International Workshop Seminar and Exhibition on Phytophthora Diseases of Plantation Crops and their Management,* 12-17 September 2011, Kottayam, India.

β-1, 3-Glucanases, coming under the PR-2 family of pathogenesis related (PR) proteins, play a pivotal role in the plant response to microbial pathogens. It is a multi faceted enzyme exhibiting a plethora of activities in the diverse physiological and developmental processes in plants. In *Hevea*, β-1,3-glucanases play a major role in combating the Abnormal leaf fall disease caused by *Phytophthora* spp. Studies in different crops indicated that there are numerous genomic forms of ß-1,3-glucanases in a single host plant which vary in their expression patterns in different tissues. In the present study a novel form of β-1, 3-glucanase gene from the genomic DNA of the *Hevea* clone RRII 105 has been PCR amplified, cloned and characterized. Forward primer based on a ß-1,3-glucanase isoform specific promoter sequence characterized earlier and reverse primer based on the 3' untranslated region of a ß-1,3-glucanase cDNA reported earlier (NCBI accession no : U22147) were designed. The nucleotide sequence obtained was analyzed using bio-informatic tools like SignalP, Plant-mPLoc and NetN glycosylation prediction servers. The full length (from the translation initiation codon to stop codon) genomic sequence of this novel form is single intronic with 1233 nucleotides. This form codes for a class II acidic glucanase with 373 amino acids and designated as glucanase 4 (Gln 4) which varies with the other reported forms of *Hevea* in having a different promoter and posess a different stop codon, 'ochre' in comparison to the 'opal' codon in the other forms of ß-1, 3-glucanase. It is also showing a deletion of a single aminoacid in the 21st position (methionine). This form is also showing significant aminoacid variation compared with the other reported forms showing a phylogenetic distance of 0.10634. Signal P prediction showed signal peptidase I cleavage site probability of 0.99 between the positions 35th (alanine) and 36th (glutamine) amino acids. The Plant-mPLoc prediction showed that the protein is localized in the vacuole. The NetN glycosylation prediction showed the presence of two potential glycosylation sites which confirms to be a glycosylated protein. To understand the expression pattern of the gene in different tissues, RNA has been isolated from *Hevea* leaf, latex and callus. cDNA was

potential glycosylation s

synthesized and RT- PCR has been performed. A high level gene expression was observed in the latex and low level expression in the leaf. No expression was observed in the callus. The results indicate that this isoform is an acidic glucanase which localized in the vacuole is constitutively expressing in the latex and in the leaf. The gene expression with response to different biotic and abiotic stresses is yet to be studied.

Key words: cDNA; β-1,3-Glucanase; *Phytophthora;* RT- PCR

193. Sureshkumar, K.K. and Jacob, C.K. (2005). Role of physiological factors and pathogenesis related enzymes on the growth and pathogenesis of *Corynespora cassiicola* causing leaf disease in rubber (*Hevea brasiliensis*). *In: Preprints of Papers. International Natural Rubber Conference, India 2005,* 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 513-522.

A comparative study of six isolates of *Corynespora cassiicola* (Berk & Curt) Wei. on utilization of different amino acids, macronutrients, micronutrients and behavior of two defense related enzymes *viz.* catalase and lipase in susceptible (RRII 105 and PB 260) and resistant (RRIM 600 and GT 1) clones of *Hevea brasiliensis* were carried out. Proline supported excellent growth and sporulation of all the *C. cassiicola* isolates except one (Cc 03), which did not sporulate in the presence of any of the amino acids tested. All isolates except Cc 08 exhibited retarded growth in medium devoid of magnesium. Zinc and copper supported the growth and sporulation of all the isolates. A positive correlation was noticed with sporulation of isolates and colour of the culture filtrate and the intensity of the colour increased with the increase in sporulation. Biowilt assay proved the toxic nature of the culture filtrate with different trace elements and the wilting was more in copper and zinc-amended medium. Autoclaved culture filtrate also produced wilting in *Hevea* clones indicating thermostable nature of the toxin. Catalase and lipase showed significantly higher activity in infected samples than the uninfected controls. A steady increase in catalase activity was noticed in resistant clones from 24 to 96 hours after infection, but the activity declined after an initial increase in susceptible clones. Lipase activity was higher in susceptible clones than in resistant clones during the primary stages of infection.

Key words: *Corynespora cassiicola*; Leaf disease; Lipase activity

194. Sureshkumar, K.K. and Jacob, C.K. (2006). Post-infectional changes of enzymes and proteins in *Hevea brasiliensis* and their role in resistance to *Corynespora cassiicola*. *In: Preprints of Papers*: *International Natural Rubber Conference*, 13-14 November 2006, Ho Chi Minh City, Vietnam. (*Comps.* Mai Van son, Nguyen Ngoc Bich and Tong Viet Thinh). Rubber Research Institute of Vietnam, Vietnam, pp. 440-449.

The involvement of defense related enzymes and secondary metabolites in resistance of *Hevea brasiliensis* clones against the leaf disease pathogen *Corynespora cassiicola* was studied. Changes in PAL, TAL,CAD, total protein and total free amino acid were evaluated after *C. cassiicola* infection on the *H. brasiliensis* clones RRII 105, PB 260, RRIM 600 and GT 1. The former two clones show susceptible and the later two resistant reaction against the isolate of *C. cassiicola* used. The time course accumulation of defense enzymes triggered by pathogen inoculation showed greater activity in clones RRIM 600 and GT 1. A steep rise in activity of PAL was noticed in GT 1 at the initial stages of disease development and it continued even at the later stages of infection. A significant increase in activity of TAL was also noticed in both RRIM 600 and GT 1. The CAD activity was accelerated upto 72 h after infection in all these clones but a reduction was observed in RRII 105 and PB 260 at 96 h. While protein accumulation was noticed up to 96 h of infection in RRII 105 and PB 260, it declined after 72 h in GT 1 and RRIM 600. The total free amino acid content was greater in uninoculated plants of RRII 105 and PB 260. It reduced on infection with *C. cassiicola* in all the clones.

Key words: Amino acids; *Corynespora cassiicola*; Cinnamyl alcohol dehydrogenase; Host defense; Phenylalanine ammonia lyase; Proteins; Tyrosine ammonia lyase

195. Thankamma, L. (1968-69). *Bixa orellana*: An alternative host of *Oidium heveae* stein. *Rubber Board Bulletin*, **10**(1): 38-39.

This paper reports *Bixa orellana* as an alternative host for *Oidium heveae*. The cross-pathogenic nature of *Oidium heveae* was confirmed by inoculating the conidia of *Oidium* from *Hevea* on seedlings of *Bixa*. Mildew spots were observed

when spores from the inoculated leaves, which took up the infection, were transferred to healthy leaves of *Hevea* confirming that *Bixa orellana* is an alternative host of *Oidium heveae.*

Key words: *Bixa orellana; Oidium heveae*

196. Thankamma, L. (1969). Germination of oospores by *Phytophthora palmivora* (Butl.) and *P. meadii* McRae causing Abnormal leaf fall disease of rubber in India. *Rubber Board Bulletin,* **10**(3&4): 197-199.

Very young 2-4 days old oospores of *Phytophthora* formed by pairing of *P. palmivora* and *P. meadii* both isolated from rubber, were observed to germinate after 16 hours in PDA when incubated at 22°C and after 24 hours in distilled sterile water under room temperature. The germinating oospores produced germ tubes from the sides of the antheridium, oogonial stalk or oospore wall. Germ sporangia were also produced at the tips of germ tubes. The cultures developed from single germinated oospores were found to be pathogenic to rubber.

Key words: Abnormal leaf fall; *Phytophthora meadii; Phytophthora palmivora*

197. Thankamma, L. (1974). *Phytophthora nicotianae* var nicotianae on *Anacardium occidentale* in South India. *Plant Disease Reporter,* **58**(8): 767-768.

Shoot rot and leaf fall symptoms were observed on *Anacardium occidentale* L. in India during the south west monsoon months of June, July and August. *P. nicotianae* var *nicotianae* was isolated for the first time from infected leaves and shoot portions of Cashew tree. The isolate when artificially inoculated on healthy twigs of cashew tree produced typical symptoms under controlled conditions. The pathogen was reisolated from artificially inoculated and infected plant parts. The *Phytophthora* isolated from *Anacardium occidentale* has been identified as *P. nicotianae* var *nicotianae* at the Common Wealth Mycological Institute.

Key words: *Anacardium occidentale; Phytophthora nicotianae*

198. Thankamma, L. (1975). *In vivo* production of oospores by *Phytophthora palmivora* and *P. meadii. Rubber Board Bulletin,* **12**(1): 7-10.

Host tissues when dual inoculated with *P. palmivora* and *P. meadii* and incubated at low temperature produced oospores in abundance. Oospores were formed inside the cortical region, phloem, cambium, xylem and also the pith. The shape of oogonia and oospores varied slightly depending on the size and shape of the bost cell. Comparatively young oospores germinated *in situ* by the production of germ tubes passing through the oogonial stalk, antheridium or the oogonial wall. Potted plants when dual inoculated also produced oospores.

Key words: Oospore germination; *Phytophthora palmivora*

199. Thankamma, L., George, M.K. and George, K.V. (1968). Occurrence of two spp. of *Phytophthora* on *Hevea brasiliensis* in India. *Rubber Board Bulletin,* **10**(1): 43.

Key words: *Phytophthora*

200. Thankamma, L. and Pillay, P.N.R. (1970-71). Sexual compatibility of *Phytophthora* isolates causing diseases of *Hevea* in India. *Rubber Board Bulletin*, **11**(1): 9-13.

A comparison was made of 89 isolates from rubber by pairing for oospore formation on agar media and by other characteristics. Of these 33 were *P. meadii* and 56 *P. palmivora.* Oospores were also formed when compatible isolates of each sp. were inoculated into petioles of plotted rubber plants at 22°C. The natural occurrence of oospores was observed and it is therefore suggested that variation under natural conditions may be sexually induced.

Key words: *Phytophthora*; Rubber disease

201. Thankamma, L. and Kothandaraman, R. (1975). Effect of streptomycin on *Phytophthora* causing abnormal leaf fall disease of rubber. *Rubber Board Bulletin*, **12**(3): 115-117.

In laboratory studies streptomycin controlled *Phytophthora meadii* infection of cut rubber twigs when they were held in streptomycin solution, injected with streptomycin, or wounded and treated with the antibiotic on the wound site. The disease was not controlled by foliar sprays or soil drenches of streptomycin solution.

Key words: Abnormal leaf fall; Streptomycin

202. Thankamma, L., Rajalakshmy, V.K. and Pillay, P.N.R. (1976). Mode of entry of *Phytophthora* in *Hevea brasiliensis*. *Proceedings of the International Rubber Conference*, 1975, Kuala Lumpur, Malaysia, V 3, pp. 213-216.

Species of *Phytophthora* are causal agents of a number of diseases of rubber in India. This paper discusses the mode of entry of the pathogen into the host. Zoospores exhibited an attraction towards stomatal openings and the germ tubes were found to enter them. Infection of the leaf was therefore effected only through the lower surface, through the stomata.

Key words: *Phytophthora;* Zoospore germination

203. Thankamma, L. and Jayadevi, M. (1994). Ecofriendly heartwood extracts from different trees species as a safe natural fungicide against *Phytophthora*. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 70-73.

Attempts were made to evolve natural fungicides for the control of diseases of rubber by using water extracts of the heartwood of five tree species which are reported to contain phenolic compounds. The extracts were screened in the laboratory for inhibition of *Phytophthora* spp. which causes a variety of diseases in rubber. Heartwood extracts of Enterolobium saman showed the highest antifungal activity. Rosewood extract caused fungicidal activity against the sporangia. Anjily wood extracts showed antifungal activity against airborne fungi. The importance of using ecofriendly fungicides is discussed.

Key words: Antifungal activity; Heartwood extract; Fungicide; *Phytophthora*

204. Thankamony, S. and Philip, S. (2006). Enzymes and PR proteins. *In*: *A Laboratory Manual for International Training on Strategies for Management of Corynespora Leaf Fall Disease of Hevea brasiliensis*. (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp.17-20.

Key words: *Corynespora cassiicola*; Enzymes; PR proteins

205. Thanseem, I., Joseph, A. and Thulaseedharan, A. (2005). Induction and differential expression of beta-1, 3-glucanase mRNAs in tolerant and susceptible *Hevea* clones

in response to infection by *Phytophthora meadii*. *Tree Physiology*, **25**(11): 1361-1368.

Most cultivated rubber tree (*Hevea brasiliensis* Willd. ex A. Juss.) clones in India are susceptible to Abnormal leaf fall disease (ALF), which is caused by various *Phytophthora* species and results in yield losses of up to 40%. Because the conventional breeding programs for this perennial tree crop are complex and time consuming, we attempted to find a molecular solution to increase the tolerance of rubber trees to ALF. The expression patterns of the gene coding for the pathogenesis-related beta -1,3-glucanase (beta -glu) enzyme in a tolerant (RRII 105) and a highly susceptible (RRIM 600) clone of rubber tree were examined, following infection with ALF-causing *Phytophthora meadii* McRae. Infected leaf samples were collected at different times after inoculation, and RNA was extracted and subjected to Northern blot hybridization and reverse transcriptase polymerase chain reaction (RT-PCR). On hybridization with a 1.25 kb beta -glu probe, Northern blots showed a marked increase in beta -glu transcript levels in both clones 48 h after inoculation. However, compared with the susceptible RRIM 600 clone, the tolerant RRII 105 clone had a higher rate of increase and a more prolonged induction, with β-glu transcript levels remaining high for 4 days after inoculation. In RRIM 600, the mRNA levels decreased significantly 48 h after inoculation. On re-hybridization with an 18S rRNA probe, uniform signals were detected in all the lanes, indicating that an equal amount of total RNA was present in all samples. Similar results were obtained in relative quantitative RT-PCR experiments with the housekeeping actin gene as an internal control. Thus, although induction of the beta -glu gene occurred in both tolerant and susceptible clones, the predominant difference between clones was in the intensity and duration of the response. The tolerance of clone RRII 105 may be associated with the prolonged expression of the gene following infection. The antifungal activity of these hydrolase enzymes makes them rational candidates for over expression by genetic transformation to produce disease resistant crops.

Key words: Abnormal leaf fall; Genetic transformation; *Phytophthora meadii*

206. Thanseem, I., Joseph, A. and Thulaseedharan, A. (2005). Cloning of a pathogen inducible β-1, 3- glucanase cDNA from *Hevea brasiliensis* and its over expression in *E. coli*. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*,

6-8 November 2005, Cochin, India. (Comps. N.M.Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 475-484.

β-1, 3- glucanase are abundant, highly regulated hydrolytic enzymes widely distributed in plant kingdom. Many isoforms of plant glucanases with varying functions were reported. In the present study, a pathogen inducible isoform of β-1, 3- glucanase from rubber tree is being reported for the first time. Two-week-old leaves of *Hevea* clone RRII 105 were inoculated with Abnormal leaf fall causing *Phytophthora meadii* and RNA was isolated from the near necrotic zones of the infected samples by lithium choride precipitation. First strand cDNA was synthesized and sequence coding for the final mature β-glu was amplified using primers CGG GAT CCC AGG TAG GTG TTT GCT ATG G AND GGA ATT CCC AGT TCT TTT CTG CAC. The 963 bp glucanase gene fragment amplified was cloned unidirectional in the pET 32a+ expression system. The predicted II of the protein translated from the DNA sequences of the clone is 9.26. The major difference observed was the absence of a glycosylation site at Asn-27, which is present in other reported cDNA sequences of *Hevea* β-glu. Conditions were optimized for the IPTG induced over-expression of the gene in the *E. coli* strain BL21 (DE 3) in the soluble form. The purified recombinant *Hevea* b-glu was assayed for its anti-fungal activity against *Phytophthora*. Clear inhibition zones were developed around the filters soaked with the purified protein, when fungi were grown on PDA plates. This result clearly indicates the inhibitory action of purified enzyme.

Key words: *E. coli; Phytophthora meadii*

207. Vanitha, S., Jacob, C.K. and Jayarathnam, K. (1994). *In vitro* studies on biological control of *Phytophthora meadii* using *Trichoderma* spp. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 78-81.

An attempt was made to study the effect of antagonistic fungi, *Trichoderma viride*, *T. koningi* and *T. harzianum*, against *Phytophthora meadii* which causes Abnormal leaf fall disease in rubber (*Hevea brasiliensis*). *In vitro* screening of these antagonists showed that all inhibited growth of the pathogen. The antagonists were also found to penetrate the oospores of the fungus and cause their lysis.

Key words: Abnormal leaf fall; Antagonism; Biological control; *Phytophthora meadii*; *Trichoderma* spp.

208. Viswanathan, P.K., George, K.T. and Jacob,C.K. (2005). Crop loss in rubber due to Abnormal leaf fall: An analysis on the economic feasibility of plant protection measures in India. *Journal of Plant Protection Research*, **45**(4): 235-248.

The paper attempts to assess the extent of crop loss in rubber plantations in India, measured in terms of loss in latex and timber output and thereby to examine the comparative economics of plant protection measures against *Phytophthora* spp. induced Abnormal leaf fall (ALF). The specific objectives were: (a) to examine the extent of loss in latex and timber output in unsprayed plots vis-a-vis sprayed plots across prominent rubber clones; (b) estimate the value of loss in latex and timber output across clones between sprayed and unsprayed plots; (c) examine the comparative economics of plant protection measures in terms of the incremental costs and the incremental returns from sprayed plots across clones; and (d) reflect upon the policy imperatives with respect to region-specific research and development interventions on plant protection measures in India. The study brings out significant clonal differences in loss of latex and timber output in the absence of prophylactic spraying against ALF. The observed clonal differences with respect to feasibility of plant disease control measures indicate the need for region and clone-specific recommendations for plant protection measures in India instead of the currently followed unilateral prescription with due allowance to the costs and potential benefit accrued from the control measures. The study also highlighted the need for evolving interventions and agro-management/plant protection measures for minimizing the incidence of tree casualty in rubber plantation, as it amounts to loss of potential income from latex and timber from rubber plantations in India, dominated by the smallholder sector.

Key words: Abnormal leaf fall; Crop loss; Discounted cash flow analysis; Latex yield; *Phytophthora*; Timber yield

STEM DISEASES

209. Deka, H.K., Thapliyal, A.P., Mondal, G.C. and Kothandaraman, R. (1998). Pink disease of *Hevea*: A report from Meghalaya. *Rubber Board Bulletin*, **27**(3): 29-30.

Pink disease caused by *Corticium salmonicolor* affects the stem and branches of *Hevea* causing considerable loss of canopy, which retards growth and extends the period of immaturity. This disease has been reported from almost all rubber growing regions of Kerala and adjoining districts of Karnataka and Tamil Nadu. This paper reports the incidence of pink disease on two *Hevea* plants of PB 28/59 at the age of 5-6 years in North eastern India, particularly Meghalaya.

Key words: *Corticium salmonicolor*; Pink disease; Meghalaya

210. Edathil, T.T. and Pillay, P.N.R. (1976). Use of tetramethyl thiuram disulphide (Thride) for the control of pink disease of rubber. *Rubber Board Bulletin*, **13**(3): 43-47.

Several fungicides were subjected to laboratory tests employing paper disk bioassay method against *Corticium salmonicolor* causing pink disease of rubber. Complete growth inhibition of the pathogen was obtained with thride at 1000 ppm concentration, alone and incorporated in petroleum products. Petroleum products alone did not inhibit the growth of the pathogen in the laboratory test. Three concentrations of thiride-1500 ppm, 2000 ppm and 2500 ppm-incorporated in rubberkote, were painted around the affected portions of the infected plants in the field. Only one application was made without scraping the infected bark. Application of thride at 1500 and 2000 ppm concentrations incorporated in rubberkote resulted in 86 and 87% recovery, respectively. In the control treated with bordeaux paste only 60% recovery was obtained. Based on the results, 2000 ppm concentration of thride incorporated in rubberkote or any other petroleum product is recommended for the control of pink disease of rubber.

Key words: Pink disease; Tetramethyl thiuram disulphide

211. Edathil, T.T., George, M.K. and Pillay, P.N.R. (1979). Evaluation of some new fungicide formulations against *Corticium salmonicolor* causing pink disease of rubber. *In: Entomology, Microbiology, Nematology, Plant Pathology and Rodentology of Plantation Crops: Placrosym* II, 1979, Ootacamund, India. (Ed.C.S.Venkata Ram). Indian Society for Plantation Crops, Kasaragod, India, pp. 140-145.

The efficiency of 15 fungicides was tested in the laboratory against *Corticium salmonicolor* causing pink disease of rubber by poisoned food technique. Based on the initial results of this study Calixin, Thiride and Pancil T were selected for field trial. Calixin 4% and thiride 2000 ppm mixed with stabilized field rubber latex and Pancil T as such were painted around the affected portions of the plants in the field. Only one application was made after light scraping of the infected bark. Application of Calixin, Thiride and Pancil T resulted in 63, 70 and 87% recovery, respectively, in comparison to the control treated with Bordeaux paste, which showed only 57% recovery.

Key words: Fungicide; *Corticium salmonicolor*; Pink disease

212. Edathil, T.T. and Jacob, C.K. (1983). Control of pink disease of *Hevea* using tridemorph in ammoniated latex. *Pesticides*, **17**(12): 25-26.

Tridemorph a systemic fungicide incorporated in ammoniated latex was evaluated for the control of pink disease of *Hevea*. All the concentrations tried were effective *in vitro*. Two per cent tridemorph is recommended for field application.

Key words: Disease control; Pink disease

213. Edathil, T.T., Idicula, S.P. and Jacob, C.K. (1988). Field evaluation of fungicides to identify a substitute for organo-mercurials in the control of black stripe disease of rubber in India. *Indian Journal of Natural Rubber Research*, **1**(1): 42-47.

Investigations were carried out to identify an effective and alternative fungicide for organomercurial fungicides in the control of blackstripe disease of rubber. The high human toxicity of organo-mercurial fungicides and their possible withdrawal from the market necessitate the search for a substitute. Both captafol (Foltaf) and mancozeb (Dithane M-45) were found to be effective for the control of this disease. On economic consideration, Dithane M -45 at 0.75% ai appears better.

Key words: Bark rot; Fungicide evaluation; Human toxicity; *Phytophthora*; Plasticity retention index

214. Edathil, T.T., Idicula, S.P. and Krishnankutty, V. (1991). Efficacy of two carrier formulations in the control of pink disease of *Hevea* caused by *Corticium salmonicolor*: A comparative study. *Placrosym* VIII, 1988, Cochin, India. *Journal of Plantation Crops*, **18** (Supplement): 269-271.

Comparison of two existing carrier formulations used in the pink disease control operation *viz.* a petroleum compound (Sopkot) and Pidivyl china clay water compound after incorporating two effective fungicides (TMTD 7500 ppm and tridemorph 10,000 ppm) against *Corticium salmonicolor* causing pink disease in rubber trees was done by field testing on 3 year old, pink disease affected, rubber trees. The result indicated that the petroleum compound carrier formulation was superior to Pidivyl compound. Bordeaux paste treatment was not as effective as the treatments using carrier formulations. It was also confirmed that the early detection and treatment of the disease at cobweb mycelial stage ensure maximum recovery.

Key words: *Corticium salmonicolor*; Disease control; Pink disease

215. George, C.M. and Ananth, K.C. (1963-64). Further studies on the copper sulphate, lime and linseed oil paste used in the control of pink disease of rubber. *Rubber Board Bulletin*, **7**(4): 119-124.

From studies here described it is concluded that free linseed oil is seriously phytotoxic and, when used in Bordeaux paste, should be emulsified with water. The quantity of oil used in the paste should be 1 oz. for every pound of total solids present in the Bordeaux preparation.

Key words: Pink disease; Disease control

216. George, K.V., George, M.K. and Thankamma, L. (1968-69). A note on shoot splitting in *Hevea brasiliensis*. *Rubber Board Bulletin*, **10**: 33-37.

Splitting of tender green stems and petioles were observed in a severe form in different clones of rubber in budwood nurseries. The depth of the split varied from a mere cracking of the epidermis and a few layers of the cortex to deep wounding extending into the pith. The incidence was particularly high in RRIM 605 and

RRIM 623. The clone GT 1 was observed to be free from the disease. Anatomical studies showed no abnormal tissue formation during the early stages of the malady. No pathogenic fungi, bacteria or virus could be associated with the disease. No insect or animal pests could be observed to be responsible for this malady.

Key words: Shoot splitting

217. Jacob, C.K. and Edathil, T.T. (1986). New approaches of pink disease management in *Hevea*. *The Planter*, **62**: 463-467.

In the field experiments on the control of pink disease of *Hevea* caused by *Corticium salmonicolor*, propiconazole, a new systemic fungicide, was effective at a concentration of 1000 ppm and tridemorph at 10,000 ppm when a newly formulated carrier was used. Bordeaux paste also was equally effective. The merits of the new carrier are discussed. Investigations carried out to detect the appropriate time of treatment of pink disease revealed that early detection at cobweb mycelial stage ensures maximum recovery. In a survey, the branches of the five year old rubber tree above the third work were found to the most vulnerable loci for infection.

Key words: Pink disease; Disease control

218. Jacob, C.K., Edathil, T.T. and Idicula, S.P. (1995). Management of black stripe disease of *Hevea*. *Indian Journal of Natural Rubber Research*, **8**(1): 21-24.

Field experiments were conducted to evolve a schedule for application of non-mercurial fungicides for protection of tapping panels of *Hevea* trees from black stripe disease caused by *Phytophthora* spp. Mancozeb 0.375 per cent and phosphorous acid 0.08 per cent gave effective and economic protection when applied at weekly intervals.

Key words: Black stripe; Chemical control; *Phytophthora*

219. Jacob, C.K. and Idicula, S.P. (1997). Effect of fungicide spraying on pink disease incidence in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research*, **10**(1&2): 48-52.

An attempt was made to evaluate the effect of fungicide sprays to trunk and branches of *Hevea brasiliensis* on incidence of pink disease caused by *Corticium*

salmonicolor. Two rounds of spraying, with a knapsac sprayer with specially designed spray lance, the first in May before monsoons and next in August/ September, were compared with prophylactic and curative treatments with Bordeaux paste. During second and third year of plant growth, the disease incidence could be reduced when ammoniacal copper or Bordeaux mixture was sprayed. The percentage reduction in disease incidence was 40.4 and 35.4 for the treatments respectively when compared to curative Bordeaux paste application. Spraying of fungicides using modified mist blower during fourth year of growth proved to be difficult and ineffective. The economics of fungicide spraying and advantages in labour utilization are discussed.

Key words: *Corticium salmonicolor*; Fungicide; Pink disease; Spraying

220. Jain, P.M. (1991). *Evaluation of the incidence of pink disease in rubber plantations in Kanjirappally taluk,* Kerala state. Dissertation, PG Diploma in Natural Rubber Production, Kerala Agricultural University, Trichur, India, 28 p.

Key words: Pink disease; Rubber plantation

221. Joy, M. and Jacob, C.K. (2000). Dry rot disease management in *Hevea* using systemic fungicides. *In: Recent Advances in Plantation Crops Research: Placrosym* XIII, 16-18 December 1998, Coimbatore, Tamil Nadu, India. (Eds. N. Muraleedharan and R. Raj Kumar). Allied Publishers, New Delhi, India, pp. 412-414.

Six systemic fungicides were evaluated for the control of dry rot (*Ustulina deusta*) disease of *Hevea brasiliensis*, cultivar 600 over three seasons in a high rainfall area. Rubber kote was used as carrier for the fungicides. Hexaconazole (0.02 a.i.) had consistently given effective control irrespective of the stage of the disease at the time of treatment. The systemic fungicides afforded better disease control when compared to the currently recommended contact fungicide (TMTD 0.75 a.i.).

Key words: Dry rot; Disease control; Fungicide

222. Kothandaraman, R. and Idicula, S.P. (2000). Stem diseases. *In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 297-308.

This chapter deals with the stem diseases of rubber. The factors favouring disease development and symptoms, the causal organism, its economic importance, clonal susceptibility and control measures of Pink disease, Black stripe, Patch canker, Dry rot, Mouldy rot and Bark necrosis are discussed in detail.

Key words: Bark necrosis; Black stripe; Dry rot; Mouldy rot; Patch canker; Pink disease

223. Mushrif, S.K., Prem, E.E. and Jacob, C.K. (2005). Control of patch canker disease on *Hevea brasiliensis*. *Natural Rubber Research*, **18**(2): 149-153.

Five systemic and contact fungicides incorporated in a petroleum wound dressing compound were evaluated for the control of patch canker disease caused by *Phytophthora* spp. in the *Hevea brasiliensis* clone PB 260 in comparison with Bordeaux paste. Among them, mancozeb, metalaxyl+mancozeb, phosphorous acid and thiophosphate were found to be effective. However, considering consistency of disease control and the cost of treatments mancozeb is the fungicide of choice for the control of the disease.

Key words: Disease control; Patch canker; *Phytophthora*

224. Mushrif, S.K., Prem, E.E., Idicula, S.P. and Jacob, C.K. (2005). Use of bacterial antagonists for biological control of shoot rot of *Hevea brasiliensis*. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 466-470.

Five bacterial antagonists (two *Bacillus* spp. and three *Pseudomonas* spp.) isolated from the rhizosphere soil and phylloplane were found effective antagonists of *Phytophthora* spp. the causal agent of shoot rot of rubber (*Hevea brasiliensis) in vitro*. All the antagonists were compatible with the fungicides carbendazim, mancozeb and metalaxyl MZ. *Bacillus* spp. showed higher efficacy in disease control when tested under glasshouse and field conditions.

Key words: Antagonism; *Bacillus* spp.; Biological control; Shoot rot

225. Pillay, P.N.R. (1968-69). Panel diseases of rubber. *Rubber Board Bulletin*, **10**(3&4): 141-146.

This paper describes on the different panel diseases of rubber, its symptom, the pathogen involved and control measures adopted. The diseases described are black stripe disease also called as black thread or bark rot caused by *Phytophthora palmivora*; patch canker or bark canker disease also caused by *P. palmivora* and *Pythium vexans*, mouldy rot caused by *Ceratocystis fimbriata* and brown bast.

Key words: Panel disease

226. Pillay, P.N.R. and George, M.K. (1980). Stem diseases. *In: Handbook of Natural Rubber Production in India.* (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 281-292.

This chapter deals with the different stem diseases. The pink disease is detailed under the following headings: the history and occurrence, influence of weather, symptoms, clonal susceptibility and control measures. For black stripe, patch canker, mouldy rot, dry rot and bark necrosis, the factors influencing disease, symptoms, causative organism and control measures are discussed in detail.

Key words: Black stripe; Dry rot; Pink disease

227. Pillay, P.N.R. and George, M.K. (1981). Pink disease of rubber. *Rubber Board Bulletin*, **16**(4): 8-10.

Key words: Pink disease

228. Pink disease. (1962). *Rubber Board Bulletin*, **6**(1): 29-31.

In South India, rubber plants 2-12 years of age are highly susceptible to pink disease, caused by the fungus *Pellicularia salmonicolor* (=*Corticium salmonicolor*). The disease is virulent during the rainy season. In the initial stages of infection, painting with Bordeaux mixture or Bordeaux paste is recommended. In the more advanced stages, the affected branch should first be sprayed with Bordeaux mixture and then cut at a point, about 45 cm below the diseased spot.The branches thus removed should be burnt immediately. The rest of the tree as well as the neighbouring trees should be sprayed with Bordeaux mixture. The cut surface should be painted with Bordeaux paste or any other suitable product.

Key words: *Corticium salmonicolor*; Pink disease; *Pellicularia salmonicolor*

229. Rajalakshmy, V.K., Joseph, A., Varghese, Y.A., Vanitha, S., Jayarathnam, K. and Sethuraj, M.R. (1994). Evaluation of *Hevea* clones against diseases. 1. Susceptibility to pink disease caused by *Corticium salmonicolor*. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 21-22.

Observations on the incidence of pink disease in trials laid out at Rubber Research Institute of India Experimental Station showed that clones RRII 208, PB 260, SCATC 93-114, PB 235, KRS 25, RRIM 703, RRII 118 and PCK 2 showed low disease incidence while clones PCK 1, RRIM 600, PB 217, Haiken 1 and PB 314 showed high incidence compared to clone RRII 105. Other clones included in the trials were moderate in their susceptibility to pink disease. It was also noticed that there was a high incidence of pink disease in the second and third year of planting. During the second year, the pathogen primarily attacked the main forking region but from the next year onwards infection on the first fork reduced and higher forks and branches were more and more infected. Percent disease incidence was more in the second and third year and gradually decreased thereafter.

Key words: Pink disease; *Corticium salmonicolor*; Clonal susceptibility

230. Ramakrishnan, T.S. (1963-64). Patch canker or bark canker caused by *Phytophthora palmivora* Butl. and *Pythium vexans de* Barry. *Rubber Board Bulletin*, **7**(1): 11-13.

A description of the occurrence, symptoms and treatment of patch canker of rubber in India. The disease is caused by *Phytophthora palmivora* or by *Pythium vexans*; it is prevalent in all rubber growing countries. It is especially infectious during the rainy seasons. Symptoms are exudation of discoloured latex or liquids from affected patches of the bark. Every part of the tree may be affected. Wounds by lightning, pruning or tapping often provide the gateway for infection. Several clones are noted for their susceptibility, especially those which are also susceptible to leaf fall caused by *Phytophthora*. Control is achieved by scraping away the affected tissue and treating the exposed bark with a water-borne fungicide. After drying, application of a wound-cover, generally a petrolatum product, is necessary.

Key words: Disease control; Fungicide; Patch canker; *Phytophthora palmivora*; *Pythium vexans*

231. Ramakrishnan, T.S. and Pillay, P.N.R. (1962). Pink disease of rubber caused by *Pellicularia salmonicolor* (Berk and Br.) Dastur (*Corticium salmonicolor* Berk and Br.). *Rubber Board Bulletin*, **5** (3): 120-126.

Pink disease in rubber was reported from Java in 1901. There are over 140 hosts plants for this fungus from different parts of the world. Young rubber within the age of 1-12 years is readily affected by this disease. The main stem or one or more branches may be affected and consequently the upper portion dies. Exudation of latex takes place from the affected bark. A pinkish growth of the fungus can be seen on the surface. The clone Tjir-1 and its clonal seedlings are very susceptible. The disease occurs during the rainy season. All factors, which contribute towards increasing the atmospheric humidity inside the plantation, favour the disease. The disease is of high importance during the pre-tapping years and in the early tapping years. The disease can be controlled by the application of efficient fungicides on the affected bark in the initial stages and pruning of dead branches. Bordeaux paste and the paste with linseed-oil have been very satisfactory.

Key words: Pink disease; *Pellicularia salmonicolor; Corticium salmonicolor*

232. Ramakrishnan, T.S. and Pillay, P.N.R. (1962). A new disease causing limb breakage in rubber. *Rubber Board Bulletin*, **5**(4): 213-214.

A new disease affecting the bigger limbs of mature rubber trees has been observed in some plantations in Mundakayam, India. A white fungus envelops the basal portions of one or more branches near the forks, gradually extending along the branch. Affected branches dry up in the course of 1 to 2 years. In the initial stage, it is advisable to scrape the affected bark lightly and to apply Bordeaux paste, after which prowax may be applied for quick regeneration. In case of advanced infection, it is advisable to cut the branch close to the stem and to apply Bordeaux paste on the cut surface. The causal fungus is probably a *Marasmius*.

Key words: Limb breakage; *Marasmius*

233. Ramakrishnan, T.S. and Pillay, P.N.R. (1962). Spearhead drying of bark above the bud union. *Rubber Board Bulletin*, **6**(2): 57-58.

In young rubber plantations in South India the snag of the budded stock often turns black and is invaded by several fungi including *Diplodia*. Under certain

conditions, the fungi grow down into the living part of the stock or up into the scion, the side of the scion facing the stock developing an extended spearhead-shaped dry patch, broader below and tapering to a point above. This may have serious consequences since the plants are liable to break or the tapping panel may be lost. The primary factor responsible for the development of snag rot is the heat of the sun. The damage may be prevented by proper pruning of the snag, treatment of the wound, and protection against the sun by shading or whitewashing.

Key words: *Diplodia*; Spearhead drying

234. Ramakrishnan, T.S. and Pillay, P.N.R. (1963). Black stripe, black thread or bark rot caused by *Phytophthora palmivora* Butl. (*Phytophthora faberi* Maubl. *P. meadii* McRae) *P. heveae* Thompson. *Rubber Board Bulletin*, **6**(3&4): 110-112.

A description is presented of black stripe disease of the rubber tapping panel, caused by the fungus *Phytophthora palmivora*. To control the disease, planters in South India are advised to stop tapping during the months of maximum rainfall. If tapping is continued during the wet season, an organomercurial fungicide such as 0.25% aretan or 0.6% ceresin should be applied to the panel by means of a brush or hand sprayer either on the day after tapping or on the day of tapping before removing the scrap. When the fungicide has dried, one of several preparations yielding a waterproof coating should be applied over it.

Key words: Black stripe; Bark rot; *Phytophthora palmivora*

235. Ramakrishnan, T.S. and Pillay, P.N.R. (1963). Mouldy rot caused by *Ceratocystis fimbriata* Ell & Halst (*Ceratostomella fimbriata)* (E & H) Elliot *Sphaeronema fimbriatum* (E&H) Sacc. *Rubber Board Bulletin*, **6**(3&4): 121-124.

The symptoms of the disease and the pathogen are described. Infected trees should not be tapped in the rainy season. The tapping area should be treated with a fungicide and covered with a waterproof seal.

Key words: Fungicide; Mouldy rot

236. Thankamma, L. (1988). Role of injection wounds on bark rot disease incidence in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research*, **1**(1): 48-50.

Rubber trees were pressure injected with 1 litre of streptomycin at 5 and 10 g/ tree, injected with water or sprayed with 4 litres Bordeaux mixture during Jul.-Aug. 1984. In November the trees were inoculated with culture discs of *Phytophthora meadii*. Significant control of bark rot occurred uniformly in the 3 treatments with injection-induced callusing.

Key words: Bark rot; Injection wound; *Phytophthora*

237. Thankamma, L., Marattukalam, J.G., Joseph, A., Potty, S.N. and George, K.T. (1994). Prophylactic premonsoon brush on application of Bordeaux paste for management of pink disease of the rubber tree caused by *Corticium salmonicolor*. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 105-111.

The severity of pink disease can be reduced by using a long handled brush to apply a premonsoon prophylactic application of Bordeaux paste, in 30 cm bands, to the parts of the tree from the ground to the forking region and the top-most brown portion of the stem. On average, severity is reduced to one eighth on two-year-old rubber plants and to one sixth on three-year-old plants using this prophylactic treatment in the second year compared to the respective curatively treated controls. The disease could be successfully managed at an additional cost of Rs.0.44 per plant. Disease severity was brought down to half of that in the curative control in the case of three-year-old plants not prophylactically treated with Bordeaux paste during their second year of growth.

Key words: Bordeaux mixture; *Corticium salmonicolor*; Pink disease

238. Thankamma, L., Marattukalam, J.G., Joseph, A., Potty, S.N. and George, K.T. (1995). Pink disease of rubber can be prevented. *Rubber Board Bulletin*, **27**(2): 35-38.

This general account of measures to be taken for the control of *Corticium salmonicolor* includes details of the conditions favouring disease incidence, time of appearance, clonal susceptibility, symptoms and the use of Bordeaux paste as a preventive or curative treatment.

Key words: Pink disease; Disease control

239. Vanitha, S. and Jacob, C.K. (1996). Collar rot disease of nursery rubber seedlings caused by *Pythium scleroteichum* drechsler. *Indian Journal of Natural Rubber Research*, **9**(1): 58-59.

A new collar rot disease of rubber was observed at Karikattoor, Kerala, India. The first symptoms appeared as sudden death of seedlings. On examination, diseased plants had water soaked lesions around the collar which later became dull brown and was followed by seedling death. The causal organism was isolated and subsequently identified as *P. scleroteichum.* The pathogen was subsequently shown to re-infect rubber seedlings. Spread of the disease was controlled by drenching nursery beds with either mancozeb or methoxy ethyl mercuric chloride. In a survey of affected beds, c. 34% of seedlings were affected by the pathogen.

Key words: Collar rot; *Pythium scleroteichum*; Seedling

TAPPING PANEL DRYNESS

240. Abraham, T., Mathew, J., Srinivas, P. and Jacob, C.K. (2006). Incidence of tapping panel dryness on popular rubber clones in Southern rubber growing region of India. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, pp. 55-63.

Tapping panel dryness (TPD) is widespread in all rubber growing countries and this syndrome is becoming a matter of serious concern. There are reports of varying intensities of TPD with regard to clone, age of the plant, stage and system of tapping etc. In order to assess the actual extent of TPD in medium and large holdings having different clones in different years of tapping, a study was made in clones RRII 105, RRIM 600, PB 28/59 and GT 1. The study showed that the number of trees having 75-100% TPD intensity increased and the number of TPD trees with lesser intensity of TPD remained more or less constant from the first to the last panel. This was due to the fact that trees with less than 75% TPD would be converted to more than 75% TPD during the course of time as the age of the tree and tapping progressed. The number of TPD trees decreased in the first year of every panel change but this immediately got reversed as tapping progressed in the new panel. It was found that TPD incidence was less in the UT system than in the normal system of tapping. When the TPD affected trees were tapped in the UT system of tapping, more than 30% of the trees showed varying degrees of

dryness after four months of tapping in all the clones. When the forward occurrence of TPD trees was studied, the number of TPD trees in clusters of two or more showed a remarkable increase compared to the single TPD trees as tapping progressed from BO 1 to BI 2. This is an indication that there is a chance of spread of TPD from one tree to the neighbouring tree and a pathogenic agent is likely to be involved.

Key words: Forward occurrence; Panel change; Tapping panel dryness

241. Abraham, T., Mathew, J., Ramachandran, P., Philip, S., Jacob, C.K. and Nair, R.B. (2009). Tapping panel dryness in *Hevea brasiliensis*: Symptoms suggesting a possible pathogen involved. *Indian Phytopathology,* **62** (3): MEZ.31.

Despite decades of research, the etiology of tapping panel dryness in *Hevea brasiliensis* remains ambiguous. Different reports relate it to physiological disorders but none of them were conclusive on the actual cause. A large scale study was conducted on 1,20,000 trees on the symptoms and pattern of occurrence of TPD. The symptoms of browning, cracking and deformation of the bark are similar to those observed in many of the diseases caused by pathogens. We have identified the symptoms of cracking, necrosis and bulging on the roots also, distant from the tapping cut suspecting a pathogen to be involved. In healthy trees 92 per cent of the trees showed normal flow of latex from the roots, whereas in partially dry trees it was 25 per cent and in fully dry trees it was only 9 per cent. When the occurrence of TPD in adjoining trees was studied the number of TPD trees in clusters of two or more showed a remarkable increase from less than six in BO 1 panel to more than 22 in B1 2 out of 100 trees in all the locations studied as the tapping progressed compared to the number of single TPD trees which remained almost in the same level. This is an indication that there is a chance of spread of TPD from one tree to the neighboring tree and a pathogenic microbial agent is likely to be involved. Our investigations on the common pathogens so far could not establish any association of fungi, bacteria, protozoa or phytoplasma in TPD. However, a consistent association of a viroid like low molecular weight RNA in the TPD affected trees was observed and detailed studies are in progress.

Key words: Pathogen; Tapping panel dryness

242. Das, G., Raj, S. and Dey, S.K. (2005). Seasonal variations in the occurrence of TPD under the agroclimatic condition of North East India. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 68-73.

Four prominent seasons are prevalent in North East India. They are summer, rainy, post rainy and cold seasons. The extent of occurrence of TPD was periodically determined during these seasons. The trees were tapped under 1/2Sd/2 7d/7 and 1/2Sd/3 7d/7 with or without tapping rest during winter. The study showed that TPD was more serious in the winter season than in the other seasons. A period of tapping rest for a few weeks during winter considerably decreased the progression of TPD in the other seasons. The highest yield was observed for both the tapping frequencies during the post-monsoon period. With tapping rest in winter, the yield in summer and monsoon seasons increased compared to the control without rest. The fact that low winter temperature adversely affects the performance of the rubber tree is discussed.

Key words: Cold temperature; Seasonal variation; Tapping panel dryness; Tapping rest; Tapping frequency; Yield

243. Deka, H.K., Mathew, J., Abraham, T. and Jacob, C.K. (2005). Incidence of TPD syndrome in North East India: A preliminary report. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 509-513.

A total of 31 small rubber holdings were covered in a survey in North East India to assess the incidence of TPD syndrome. TPD was observed to occur in all the holdings irrespective of age and clone. In Assam the highest incidence of TPD was observed in RRII 105 and minimum in West Bengal, whereas in clone RRIM 600 the TPD incidence was highest in West Bengal and minimum in Tripura. Not much difference was observed on the occurrence of TPD in clone RRIM 600 and RRII 105 in relation to BO I and BO II panel. More TPD incidence was noticed in the plants having the girth range 51-70 cm. No definite trend in the incidence of the syndrome was observed with age of the trees and years of exploitation.

Key words: Tapping panel dryness; North East India

244. Deka, H.K., Mathew, J., Abraham, T. and Jacob, C.K. (2006). Characterisation of TPD in different clones of *Hevea* in CUT panel. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 64-67.

Occurrence of TPD on basal panel of rubber *(Hevea brasiliensis)* trees and their present status under CUT panel is discussed in this study. The incidence of TPD varied considerably with clone and year of tapping. Nearly 25% of the total trees with TPD in the basal panel continued to be TPD affected in the CUT panel also. Nearly 40% of the trees, which were healthy in the basal panel continued to be healthy in CUT panel. There was considerable variations in the remaining 35% of the trees. Some of the trees which were healthy in the basal panel became affected by TPD in the CUT panel while a few basal panel affected trees did not show TPD symptom in the CUT. The present study clearly indicates that although some of the TPD affected plants in the basal panel yield latex in CUT, the change over to CUT has only limited benefits in the management of TPD. It also emphasises that once a tree is severely affected by TPD, it remains as TPD even when tapping is done in CUT panel.

Key words: Controlled upward tapping; Tapping panel dryness

245. Gogoi, N. K., Mandal, S., Datta, B., Mazumder, A., Dey, S. K. and Mathew, J. (2010). Tapping panel dryness of rubber: Prevalence, incidence and severity in different panel and season in Tripura. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp. 189-190.

Tapping panel dryness (TPD) syndrome is a serious disorder of rubber (*Hevea brasiliensis*) resulting in considerable yield loss. This syndrome is generally observed in rubber plantations of Tripura but information on various aspects of its occurrence is rather scanty. Therefore, a field survey was conducted in 43 rubber holdings of west and south Tripura districts comprising 4484 plants, in order to understand the occurrence, severity and seasonal variation of TPD in rubber plantations of Tripura. The 43 rubber holdings were distributed in 12 different locations. Trees under various stages of tapping from first year in the BO1 panel to the third year in BI 2 panel were closely monitored during winter season (December-January) of 2007 to summer (April-May) of 2009. Across the surveyed

locations and seasons, average incidence of TPD (e"50% panel dryness) was observed to be 8.68 %. Incidence of TPD was observed to vary from place to place. Maximum mean TPD of 13% was observed at Kariamura II followed by Mirza (12.91%), Promodnagar (11.32%) and Rangamala (11.05%). The lowest incidence was observed at Baghmara recording 1.94% TPD, followed by Dariabagma (2.94%). The lowest mean TPD of 7.52% was observed in BO 1 panel and the highest mean TPD of 19.61 % was observed in BI 2 panel. Variation in TPD incidence was observed for six consecutive seasons. Incidence of TPD was observed maximum (16.61%) during winter season of 2009 and minimum (9.06 %) during summer season of 2008. TPD intensity was observed to increase from summer to winter season. A tapping rest of around two months from middle of February to middle of April observed to lower TPD marginally in subsequent summer season compared to that in previous winter season. Clustered occurrence of TPD trees corresponding to the direction of tapping was observed. Fifteen trees were observed to dry in a single row in few places. Increase in clustered form of TPD was observed more than single incidence of TPD during the survey period from winter, 2007 to winter, 2008-09. In general, TPD in rubber plantation of Tripura was observed to vary from place to place, over the seasons and years of exploitation, however a definite and uniform trend was not observed in all the observed locations in this present study.

Key words: Incidence; Season; Severity; Tapping panel dryness; Tripura

246. Latha, N. and Jose, M. (2005). *Tapping panel dryness: An annotated bibliography.* Rubber Research Institute of India, Kottayam, India, 95 p.

This bibliography consists of literature on brown bast, bark dryness, stimulation methods, TPD control and related areas of tapping panel dryness. It covers literature published from 1917 onwards with abstracts. Bibliography is supported with a Key word Index and Author Index.

Key words: Bibliography; Tapping panel dryness

247. Latha, N. and Jose, M. (2006). A bibliography on tapping panel dryness. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 261-295.

This chapter covers a list of 402 publications on TPD, including brown bast, bark necrosis, bark dryness, phloem necrosis and related aspects affecting rubber plantations. At different times in different countries, TPD has been known by these different names. It covers literature published from 1917 – 2006 (May).

Key words: Bibliography; Tapping panel dryness

248. Mathew, J., Abraham, T., Jacob, C.K. and Reghu, C.P. (2006). Tapping panel dryness: The symptoms. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 28-44.

The very first visible symptom in a TPD affected tree is the cessation of latex flow and drying of the tapping panel. The panel could be fully, partially or intermittently dry. In order to express the intensity of TPD, a score was developed based on the percentage of dry area. A panel with 0-25% dryness would be low, 26-50% medium, 51-75% high and 76-100% very high intensity of TPD. Though no foliar symptoms were observed, various secondary external symptoms were evident in the trunk of the affected trees. Variations in symptoms were seen with respect to the clones and their age. The external symptoms were more prominent in the virgin than in the renewed panels. Generally, splitting/cracking of the bark along and below the tapping panel was observed in most of the clones. However, trees without this phenomenon were also seen. Necrotic patches could be seen below the cracking which were more on the basal portion near the bud union. Inter and intraclonal variations in these symptoms were observed irrespective of the regions. Clones RRII 105, Tjir 1, PB 260, PB 217 and RRIM 600 exhibited the cracking and splitting of bark below and even on the opposite side of the tapping panel in certain cases. Trunk abnormalities like formation of burrs, nodules, thickening etc. were seen in the advanced stages in RRII 105. Clone PB 28/59 showed a special symptom of bark sloughing where the splitted bark peals off up to the cambium. Scaling of bark, occasionally, even at the young age of third year was seen in clone RRIM 605. Such trees with bark scaling later turned to be TPD affected. Clone PB 235 did not show any specific external symptoms. Generally, upper panels did not show prominent external symptoms.

Key words: Bark scaling; Bark sloughing; Burr formation; Cracking; Symptoms; Tapping panel dryness

249. Mathew, J., Abraham, T., Phillipose, J., Prem, E.E., Jacob, C.K., Ramachandran, P. and Varma, A. (2006). Investigations on the probable biotic etiology of TPD: Screening for common plant pathogens. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 175-182.

Past investigations on the biotic etiology of TPD have not brought out any conclusive evidence. In order to reinvestigate the possible association of known pathogens, attempts were made to isolate the causative organism, if any, from the affected tissues. No pathogenic organisms, namely, fungi, bacteria, protozoa, phytoplasma, bacteria-like organisms (BLO) or Rickettssia- like organisms (RLO) could be isolated. In another experiment, remission of TPD symptoms was not observed in spite of pressure injection with tetracycline, penicillin flagyl or carbendazim continuously for one year in partially affected trees, which again indirectly proved that phytoplasma, bacteria, protozoa or fungi were not associated with TPD. Moreover, untapped trees which received these chemicals prophylactically for one year also expressed the symptoms of TPD when tapping was initiated. Intensity of TPD in the partially affected trees was found to steadily increase in majority of trees despite the injections. Our results clearly indicate lack of association of common disease causing organisms with the syndrome.

Key words: Biotic etiology; Common pathogens; Pressure injection; Tapping panel dryness

250. Mathew, J., Abraham, T., Ramachandran, P. and Jacob, C. K. (2008). Tapping panel dryness: An enigmatic disorder. *IPS-MEZ Annual Meeting & National Symposium on Advances in Microbial Diversity and Disease Management for Sustainable Crop Production,* 13-15 October 2008, College of Forestry and Hill Agriculture, Ranichauri, Uttarakhand, Souvenir and Abstracts, pp. 73-74.

Tapping panel dryness of *Hevea brasiliensis* is a syndrome with unidentified etiology observed in all rubber growing countries and is a matter of serious concern. It has been observed that the loss incurred due to TPD in rubber production over the years is on the increase as the yield of all the high yielding clones falls below their potential yield. Incidence of TPD increases with age of the tree and year of tapping. Various physiological factors were attributed towards the cause of TPD, but none of them was conclusive. There exist scanty reports in literature on the

involvement of biotic agents with this disorder. TPD can neither be cured nor prevented with the presently available knowledge and technology. Once a tree succumbs to the disorder it may remain that condition for the rest of its life. Good agronomic practices, quality tapping practices and judicious stimulant application are some healthy practices that can be adopted to reduce the incidence of TPD. Early detection of TPD symptoms, resting and controlled upward tapping are some of the best possible ways to manage the TPD affected trees, and get some yield.

Key words: Tapping panel dryness

251. Mathew, J., Abraham, T., Ramachandran, P. and Malathi, V.G. (2009). Tapping panel dryness of *Hevea brasiliensis*: An overview. *5th International Conference on Plant Pathology in the Globalized Era*, 10-13 November 2009, New Delhi, India, pp. 150.

Tapping panel dryness (TPD) of *Hevea brasiliensis* is a matter of serious concern in all rubber plantations as the etiology is unknown and the loss incurred over the years is on the increase. Tapping panel of the TPD affected trees shows the characteristic symptom of dryness. Other external symptoms including cracking, bulging and necrosis of the bark vary from tree to tree and clone. The root system below the dry bark is also usually affected. TPD incidence increases with age of the tree and year of tapping. The number of trees with very high TPD trees with very high TPD intensity shows an increasing trend from opening to end of tapping state. Generally, once a pane is fully affected, the other panels also get affected. Although the spatial distribution of TPD trees initially is at random, the number of TPD trees, in clusters of two or more showed a remarkable increase compared to the single TPD trees, from the first year of tapping to the last. Different studies shows physiological factors such as stress resulting from tapping, alternate respiration, peroxidative damage due to various reactive oxygen species (ROS), ethylene etc. as the cause of TPD. However, attempts on prediction of onset of TPD by testing the physiological parameters of the latex have not been successful as they were consequence rather than cause. Anatomical abnormalities resembled those of virus infected woody plants. Detection of ricketssia like organism (RLO) in TPD trees was reported from China and was cured by the application of tetracycline. But possible involvement of fungi, phytoplasma, bacteria and virus using various methods could not find their involvement in TPD. Detection of pathogens using R-PAGE has shown the association of LMW RNA bands during

immature period showed TPD upon opening for tapping. There are also reports which ruled out the involvement of virus/double stranded RNA/viroid. TPD can neither be cured nor prevented with the presently available knowledge and technology.

Key words: Tapping panel dryness

252. Philip, S., Abraham, T., Zachariah, C.A., Chacko, N., Mathew, J., Jacob, C.K. and Ramachandran, P. (2006). Use of PCR technique for characterising the LMW RNA isolated from TPD affected rubber plants. *In: Tapping Panel Dryness of Rubber Trees* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 189-192.

Presence of nucleic acid similar in electrophoretic mobility to a viroid-like LMW-RNA was found consistently associated with TPD affected trees using electrophoretic analysis. Viroid specific primers were designed, cDNA was synthesized and specific PCR of amplified cDNA was done. The cDNA amplified by random primers produced a band of ~360 bp in all TPD affected plants. After obtaining the sequence data, probes will be developed which can be utilized for nucleic acid hybridization studies, which is a technique widely, used in the detection of viroids.

Key words: LMW-RNA; RT-PCR; Tapping panel dryness; Viroid

253. Pushpadas, M.V. (1995). Brown bast disease of rubber trees. *Rubber Board Bulletin*, **27**(2): 32-34.

The symptoms, causes, mechanism and prevention/cure of brown bast a disorder of rubber trees now known as tapping panel dryness are discussed.

Key words: Brown bast; Rubber disease; Tapping panel dryness

254. Pushpadas, M. V., Nair, M.K., Krishnakumari, M. and Karthikakuttyamma, M. (1975). Brown bast and nutrition: A case study. *Rubber Board Bulletin*, **12**(3): 83-88.

GG1 seedlings planted in 1966 in an estate in Kerala, were fertilized during its immature phase using NPK mixtures having a high proportion of potassium and phosphorus in relation to nitrogen. When the trees were brought under tapping on a s/2 d/3 system in September 1971, an unusually high yield, two to three times

the normal, was obtained and late-dripping was also noticed. Within a few months, incidence of brown bast became evident. It would appear from the manorial history and the results of analysis of soil, leaf and latex samples that unbalanced nutrition of the tree may be responsible for the unhealthy symptoms. The study shows that high intensity of tapping or frequency of the wounding process *per se* is not the cause of the type of brown bast observed in the estate. The process of long duration of flow or withdrawal of a large quantity of latex resulting in the loss of a critical quantity of materials from the trees in a relatively short period appears to be a pre-condition for the development of this type of brown bast.

Key words: Brown bast; Nutrition

255. Ramachandran, P., Mathur, S., Francis, L., Varma, A., Mathew, J., Mathew, N. M. and Sethuraj, M.R. (2000). Evidence for association of a viroid with tapping panel dryness syndrome of rubber (*Hevea brasiliensis). Plant Disease,* **84**(10): 1155.

Tapping panel dryness (TPD) is one of the most destructive maladies affecting rubber plantations and is becoming a matter of serious concern. Reduced latex yield leading to total drying of the tapping panel is the obvious symptom. The cause of TPD syndrome is unknown but has been mostly attributed to abiotic causes. In India, the high yielding commercial clone RRII 105 is affected by TPD, leading to enormous losses. We have observed that TPD-affected trees show symptoms of bark scaling, cracking, drying, necrotic streaking, and browning of internal bark leading to the decay of internal tissues. Often prominent abnormal bulges on the lower part of tree trunks occur where the first panel begins to dry. Investigations on TPD-affected rubber samples did not reveal the association of fungus, bacterium, virus, or a protozoan. Total nucleic acid extracts purified from leaf, bark tissues of affected samples, and analyzed by polyacrylamide gel electrophoresis under denaturing conditions of low salt and high temperature showed the presence of nucleic acids similar in electrophoretic mobility to low molecular weight (LMW) RNA, of ~359 nucleotides such as potato spindle tuber viroid (PSTVd). The LMW nucleic acid detected from TPD-affected samples was found to be RNA based on its sensitivity to RNase and insensitivity to DNase, phenol, and heat treatments. The LMW RNA was purified and cloned in a PUC 19-derived vector by using primers specific to PSTVd (1). The cloned DNA, when

random labelled and used as probe reacted specifically to nucleic acid extracts from TPD-affected rubber trees but not from healthy tissue in dot-blot hybridization assays. Based on the above findings, a viroid etiology for TPD syndrome is proposed.

Key words: Etiology; Gel electrophoresis; Tapping panel dryness

256. Ramachandran, P., Varma, A., Ahlawat, Y.S., Mathew, J., Sethuraj, M.R., Mathew, N.M., Abraham, T., Philip, S. and Jacob, C.K. (2006). Detection of a low molecular weight viroid-like RNA in *Hevea brasiliensis*. *In: Tapping Panel Dryness of Rubber Trees*. (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 183-188.

Despite decades of research, the etiology of TPD remains ambiguous. Systematic field investigations using therapeutants have ruled out bacteria, fungi, RLO, phytoplasma and protozoa as causal organisms. A low molecular weight (LMW) RNA similar to viroid RNA was isolated from TPD affected samples of rubber trees. Viroids, which are LMW RNA, are the most recent plant pathogens discovered in the last century and are known to incite serious maladies in important fruit and plantation crops. The diagnostic procedures for detection of these pathogens are of very recent origin and hence not tested by most laboratories. In the present study, a modified reverse polyacrylamide gel electrophoresis (R-PAGE) procedure was standardized. It was found that a viroid-like LMW RNA was associated with seedlings, untapped trees and trees in the very year and subsequent years of tapping. This is for the first time that a biotic agent is found consistently associated with the syndrome. The technology developed in the present study was useful to demonstrate the onset of TPD in untapped trees and also helped in assessing TPD distribution in different plantations.

Key words: LMW-RNA; R-PAGE; Tapping panel dryness; Viroid

257. Ramachandran, P., Malathi, V.G., Kumar, A., Mathew, J. and Abraham, T. (2009). Molecular investigations on etiological agent of tapping panel dryness disease of rubber. *5th International Conference on Plant Pathology in the Globalized Era*, 10-13 November 2009, New Delhi, India, pp. 42.

Key words: Etiological agent; Tapping panel dryness

258. Ramakrishnan, T.S. and Pillay, P.N.R. (1963-64). Brown bast. *Rubber Board Bulletin*, **7**(2&3): 61-63.

The symptoms are described of a physiological disorder affecting the tapping cut and bark. Clones GI 1, BD 5, 10, CH 30, CH 31, AVROS 255, and RRIM 628 are particularly susceptible to the disorder, and high-yielding clones are more prone than low-yielding ones. When more than 10% of the plantation is affected the length of the cut and the frequency of tapping should be reduced. Affected trees should be rested for 3-6 months according to the severity of the disorder, and the damaged bark removed. Injection of copper sulphate at 6-monthly intervals into affected trees is reported as giving some control but the response varied from tree to tree.

Key words: Brown bast; Clone; Fungicide

259. Sethuraj, M. R. (2006). A collection of thoughts and ideas on tapping panel dryness syndrome. *In: Tapping Panel Dryness of Rubber Trees.* (Eds. James Jacob, R. Krishnakumar and N.M. Mathew). Rubber Research Institute of India, Kottayam, India, pp. 252-257.

Key words: Genetic basis; Pathological basis; Tapping intensity; Tapping panel dryness; Stimulation

ROOT DISEASES

260. Deka, H. K., Mondal, G. C. and Thapliyal, A.P. (2006). Purple root disease of *Hevea*: A report from Meghalaya. *Rubber Board Bulletin*, **28**(2): 12-14.

The purple root disease caused by *Helicobasidium compactum* Boedijin has been considered as an important plant disease and was reported from many parts of the world. Symptoms of the occurrence of this disease in one and two year old seedling nursery at District Development Centre, Jenggitchakgre, and about the control measures are described.

Key words: Purple root; Meghalaya

261. George, M.K. and Edathil, T.T. (1979). *Phytophthora* sp. and *Oidium* sp. as hyper parasites on *Loranthus* sp. a phaneorgamic parasite of rubber. *In: Entomology, Microbiology, Nematology, Plant Pathology and Rodentology of Plantation Crops: Placrosym* II, 1979, Ootacamund, India. (Ed. C.S.Venkata Ram). Indian Society for Plantation Crops, Kasaragod, India, pp. 159-162.

Loranthus is an occasional parasite on rubber *Phytophthora* sp. and *Oidium* sp. were observed as hyperparasites on *Loranthus* sp. During southwest monsoon period of June, July and August and the refoliation period of December-January, respectively. *Phytophthora* has been isolated from the infected materials and identified as *P. meadii.* Cross inoculation studies under laboratory conditions, proved that *Loranthus* sp. is an alternative host of *Phytophthora meadii* infecting rubber. In the cross inoculation studies with *Oidium heveae* collected from rubber and *Loranthus* under field conditions, proved that *Loranthus* is also an alternative host of *Oidium heveae* causing powdery mildew disease of rubber.

Key words: *Oidium heveae; Phytophthora*

262. Idicula, S.P., Prem, E.E., Manju, M.J., Mushrif, S.K. and Jacob, C.K. (2002). Purple root disease and its control in rubber plantations. *Placrosym* XV, 2002, Mysore, India. (Eds. K. Sreedharan, P.K. Vinod Kumar, Jayarama and Basavaraja M. Chaluki). Central Coffee Research Institute, Karnataka, India, pp. 609-612.

Purple root disease of *Hevea brasiliensis* caused by *Helicobasidium compactum* Boedijin has recently been reported from India. Experiments were conducted in a badly infected seedling nursery and on polybag plants to identify effective and economic control measures for the disease. Efficacy of fungicides viz. tridemorph, propiconazole, hexaconazole and thiram was evaluated. The survival of plant in the fungicide-treated nursery beds and recovery in polybags (at initial stage of infection) were significant. The budded stumps at advanced stage of infection survived around 50% when grown in polybags after fungicide treatment. Recovery was better when chemical treatment was done at initial stage. All fungicide treatments were on par in their efficacy. Hexaconazole (0.01) and thiram (0.75%) were the cheapest fungicides effective in controlling purple root disease.

Key words: Purple root; Rubber plantation

263. Idicula, S.P., Rajalakshmy, V.K., Joseph, A., Manju, M.J., Prem, E.E. and Edathil, T.T. (2002). Management of root disease caused by *Phellinus noxius* and *Poria vincta* in rubber plantations. *National Symposium on Crop Protection and WTO: An Indian Perspective*, 22-25 January 2002, Central Plantation Crops Research Institute, Kasaragod, India.

Key words: Rubber plantation; Root disease; Disease control; *Phellinus noxius*

264. Jacob, C.K., Joseph, A. and Jayarathnam, K. (1991). Biological control of brown root disease of *Hevea* by introduction of fungal antagonists. *National Seminar on Biological Control in Plantation Crops*, 27-28 June 1991, Kottayam, India.

Key words: Brown root; Biological control

265. Jacob, C.K., Joseph, A. and Jayarathnam, K. (1991). Effect of fungal antagonists on *Phellinus noxius* causing brown root disease of *Hevea*. *Indian Journal of Natural Rubber Research*, **4**(2): 142-145.

Among isolates from rubber rhizosphere soil *Trichoderma harzianum* was the most effective antagonist in preliminary tests against *P. noxius* in dual cultures. When rubber seedlings were grown in soil infested with *P. noxius*, introduction of the antagonists into the rhizosphere improved growth. Plant height in treatments with *T. viride* and *T. hamatum* was greater than that of the uninoculated controls. Lesions of the pathogen were present on the roots on inoculated control plants. After 4 months populations of the antagonists in all treatments were higher than in the uninoculated control.

Key words: Brown root; *Phellinus noxius*

266. Mondal, G.C. and Deka, H.K. (2004). Purple root disease of *Hevea brasiliensis* seedlings in nursery: A report from Assam and Meghalaya. *Placrosym* XVI, 2004, Kasaragod, India. *Journal of Plantation Crops*, **32**(Supplement): 391-394.

The outbreak of purple root disease caused by *Helicobasidium compactum* Boedijin was observed on *Hevea brasiliensis* seedlings in nursery for the first time in Meghalaya in 1998 and in Assam during 2002 in North East India. High incidence of purple root disease (54.0%) was observed in seedling nursery at DDC,

Jenggitchakgre, Tura in Meghalaya, which led to yellowing of leaves and caused a heavy loss of stands of the affected plants (95.5%). The development of spongy, resupinate, purple coloured typical fruiting body girdling the collar region of *Hevea* was found in nursery seedlings as well as on the collar region of alternate host plant (*Eupatorium odoratum*) growing nearby. A field trial was conducted on one year old seedlings of *Hevea* in nursery during 2000-01 at DDC, Jenggitchakgre (a highly susceptible pocket) for evaluation of fungicides (carbendazim and mancozeb) for the control of purple root disease. The incidence of purple root disease was significantly reduced (17.5%) by drenching with carbendazim (0.1%). The treatment with carbendazim (0.1% ai) was superior to mancozeb (0.75% ai) for the control of purple root disease of *Hevea* seedlings in nursery. The untreated control had 54% infection.

Key words: Disease control; *Helicobasidium compactum*; Purple root; Nursery; Assam; Meghalaya

267. Rajalakshmy, V.K. (1980). Root diseases. *In: Handbook of Natural Rubber Production in India.* (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 295-304.

This chapter deals with the different root diseases. The various root diseases are Brown root disease, White root disease, Red root disease, Dry root rot, Stinking root rot, Poria root rot, Black root disease and Armillaria root rot. The symptoms of the disease, the causative organism and spread of the disease as well as the control measures for each disease is mentioned in detail.

Key words: Black root; Brown root; Red root; White root

268. Rajalakshmy, V.K. and Pillay, P.N.R. (1978). Poria root disease of rubber in India. *Indian Phytopathology*, **31**: 199-202.

Root disease of *Hevea braşiliensis* caused by *Poria vincta* (Berk.) Cke. Var *cinerea* (Bres.) Setliff was observed on rubber plants in India. Cultural characters of the pathogen were studied and pathogenicity established by artificial inoculation tests.

Key words: Pathogenicity; *Poria vincta*; Root disease

269. Rajalakshmy, V.K. and Arthassery, S. (1994). *In vitro* screening of selected fungicides against *Phellinus noxius* and *Poria vincta*. *Indian Journal of Natural Rubber Research*, **7**(1): 63-64.

In lab. tests using 12 fungicides and 1 antibiotic, TMTD [thiram], propiconazole, triadimefon and tridemorph were effective in inhibiting growth of these root pathogens of *Hevea brasiliensis.*

Key words: Fungicide; *Phellinus noxius*; *Poria vincta*

270. Rajalakshmy, V.K. and Joseph, A. (1994). Purple root disease of rubber: A new report for India. *Indian Journal of Natural Rubber Research*, **7**(2): 75-78.

The occurrence of purple root disease caused by *Helicobasidium compactum Boedijin* is reported for the first time on rubber in India. The attack is mainly on nursery plants occasionally leading to their mortality. The presence of distinct fruiting bodies girdling the collar region, purple-coloured fungal growth on the root surface and adventitious root formation were the distinguishing features of the disease.

Key words: *Helicobasidium compactum;* Purple root

271. Rajalakshmy, V.K. and Jayarathnam, K. (2000). Root diseases and non-microbial maladies. *In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 309-324.

This chapter deals with the root diseases and non-microbial diseases. Regarding the root diseases, the disease development and symptoms, causal organism and control measures for White root disease, Red root disease, Dry root rot, Stinking root rot, Poria root rot, Black root disease, Purple root disease and Armillaria root rot are discussed in detail. The different non-microbial maladies such as sunscorch, drought, wind damage, cold damage, lightning damage, fire damage, hailstorm, water logging, chemical toxicity, fasciation, woody nodules, self pruning, stem bleeding and phanerogamic parasites are discussed in detail.

Key words: Root disease; Brown root; White root; Purple root; Black root; Non parasitic malady; Sunscorch; Wind damage; Lightning damage; Fire damage; Hailstorm; Water logging; Chemical toxicity; Fasciation; Self pruning

272. Ramakrishnan, T.S. and Pillay, P.N.R. (1961-62). Collar rot, dry rot or charcoal rot. *Rubber Board Bulletin*, **5**: 88-91.

Ustulina infects different parts of *Hevea brasiliensis* resulting in different types of damage. Collar rot is the common form of infection, which commences under the accumulated mass of blackened latex pads at the base of the trees. From the collar region the damage may progress upwards to a distance and also into the tap root and main lateral roots. Systematic and sustained efforts should be taken to prevent damage caused by the disease. Dead stumps and logs should not be allowed to lie in the plantation. Accumulation of latex pads at the base of the trees should be avoided. Organomercurials are found to be suitable disinfectants.

Key words: Collar rot; Dry rot

273. Ramakrishnan, T.S. and Pillay, P.N.R. (1962-63). Brown root disease. *Rubber Board Bulletin*, **6**(1): 8-11.

Brown root disease of rubber caused by *Fomes noxius* was recently found in India to occur in nurseries as well as in the field. Planters are advised to eradicate severely diseased nursery plants and to pour a dilute solution of an organomercury fungicide down the stems of the remaining plants.

Key words: Brown root; Disease control

NON-MICROBIAL MALADIES

274. Hegden, M.L.R. (1998). Wind damage in rubber plantations: Preventive methods. *Rubber Board Bulletin*, **27**(3): 35-36.

Wind damage is a serious problem of rubber plantations. This paper explains wind damage in older plantations under four heads *viz.* uprooting, trunk breaking, branch snapping and slanting of trees. Further, excessive fertilizer application should be avoided, pruning of canopy to maintain a regular canopy balance may be attempted, wind belts may be planted along the border of the plantation and insuring the rubber plantations are essential to prevent rubber loss due to wind damage in rubber plantations.

Key words: Wind damage; Rubber plantation

275. Mondal, G.C., Jose, V.T., Jayarathnam, K. and Sinha, R.R. (1995). Occurrence of *Hypomeces squamosus* (*Coleoptera curculionidae*) on *Hevea* rubber: A new record from India. *Indian Journal of Natural Rubber Research*, **8**(2): 91-93.

Infestation of the leaves of budwood nursery plants of *Hevea brasiliensis* by the weevil *Hypomeces squamosus* F. was noticed for the first time at Sarutari farm, Assam in March, 1989. The infestation index was recorded for three consecutive years from 1990. Highest infestation index and maximum number of weevils per plant were observed in the month of April.

Key words: Disease control; *Hypomeces squamosus*(F); Infestation index

276. Thankamma, L. (1990). Dodder menace: A threat to rubber plantations. *Rubber Board Bulletin*, **26**(2): 2, 27.

Infestations of dodder (*Cuscuta* sp.) on rubber (*Hevea brasiliensis*) and its cover crop *Pueraria phaseoloides* are discussed briefly. Methods for *Cuscuta* control are given.

Key words: Dodder; Rubber plantation

277. Thankamma, L. and Marattukalam, J.G. (1995). Dodder (*Cuscuta campestris* Yuncker) infestation in rubber plantations. *Rubber Board Bulletin*, **27**(2): 15-18.

Extensive parasitic infestation on *Pueraria phaseoloides* by *Cuscuta campestris*, and its sporadic infestation of *Hevea brasiliensis* and *Mucuna bracteata* in India is reported. Information is presented on *C. campestris* seed germination, anatomy, and pest status and control measures.

Key words: Dodder; Rubber plantation

PESTS/ PEST MANAGEMENT

278. Jayarathnam, K. (1966-68). Termite control in rubber plantations. *Rubber Board Bulletin*, **9**(4): 33-40.

A comparative efficacy of five insecticides, *viz.* Heptachlor, dieldrin, aldrin, chlordane and BHC at different concentrations and formulations was tested against the attack of termite *Odontotermes obesus* in rubber. The results showed that effective control of termite can be achieved for a period of one year by drenching soil at the collar region of plants or trees with heptachlor 0.125% followed by Dieldrin 0.06%. The cost of insecticides required for treating 150 trees is approximately Rs. 8/- in the case of heptachlor and Rs. 5.50 in the case of dieldrin.

Key words: Rubber plantation; Termite control

279. Jayarathnam, K. (1980). Pests in rubber plantations. *In: Handbook of Natural Rubber Production in India*. (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 315-323.

Pests of rubber are not many and their occurrence is sporadic and localized. However, there are a few pests, which become serious at times and cause considerable damage. This chapter details on the pests in rubber plantations namely the insect pests: root grubs, gallery making caterpillar, termites, scale insects, mealy bugs and insects attacking rubber wood. Certain non-insect invertebrates namely slugs, snails and mites are also discussed. Among the vertebrates, rats, porcupines, wild pigs, elephants, monkeys and deers are also pests of rubber plantation. A mention about the pests of cover crops and pests affecting personnel in rubber estates are also discussed.

Key words: Insect; Pest; Rubber plantation; Slug; Snail; Termite control

280. Jayarathnam, K. (1986). New approaches in disease and pest management in natural rubber. *Rubber Board Bulletin*, **21**(3): 5-7.

Integrated control approach leading to disease and pest management is found to be the best approach, as total eradication of the inimical organism is not aimed, but only the suppression of the intensity of attack below the economic levels of damage. By such an action, a small population of the natural enemies of the

pathogens and pests could survive and continue to suppress the population of noxious organisms.

Key words: Disease control; Pest control

281. Jayarathnam, K. (1992). Pests. *In: Natural Rubber: Biology, Cultivation and Technology.* (Eds. M.R. Sethuraj and N.M. Mathew). Elsevier Science Publishers, Amsterdam, pp. 360-369.

Key words: Mite; Non insect pest; Pest control; Root grub; Slug; Snail; Termite control

282. Jayarathnam, K. and Rajendran, T.P. (1979). Control of the snail *Cryptosona bistrialis* attacking *Hevea brasiliensis. In: Entomology, Microbiology, Nematology, Plant Pathology and Rodentology of Plantation Crops: Placrosym* II, 1979, Ootacamund, India. (Ed. C.S. Venkata Ram). Indian Society for Plantation Crops, Kasaragod, India, pp. 237-242.

Slugs and snails are the important non-insect invertebrate pests of *Hevea brasiliensis.* They damage young plants and feed on latex from tapped trees. Only a fraction of the high population of these molluscs in the field attack rubber. A field trial was conducted in a snail infested immature rubber area with Temik 10G, a good contact poison of molluscs formulated in India, and Metaldehyde, to find out an effective control measure for the snails that visit young rubber plants. From the results, it is recommended that for practical control of snails attacking young rubber plants 5 grams of Temik 10G per plant may be broadcasted around the base of plants at the dormant bud stage of terminal shoot. Repeated application is necessary when the granules disintegrate completely.

Key words: *Cryptosona bistrialis;* Pest control

283. Jayarathnam, K. and Nehru, C.R. (1980). Control of root grubs in rubber nursery. *International Rubber Conference*, 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

Root grubs of the species *Holotrichia serrata, H. rufoflava, H. fissa* and *Anomala varians* attack rubber plants and cause considerable loss in rubber nurseries

adjoining virgin forest areas, the most predominant among the four species is *H. serrata*. The larval stage of this species lasts from June to December and this stage alone damages rubber plants. In young plants of upto three months' growth the grubs completely feed on the root and in older plants, they feed on the bark of taproot resulting in wilting and death. Such plants are rendered useless for transplanting. In planted areas, they were not found to cause death to the rubber plants, as they do not depend on rubber plants alone for food. A field trial was conducted in a rubber nursery for the control of grubs with ten insecticidal treatments and a control, in a randomized block design. The granules and emulsion concentrate of seven insecticides were applied along with the seeds while sowing whereas the dusts were incorporated into the soil before sowing at the time of preparation of beds. Only one application of insecticides was carried out in the month of August. The efficacy of the treatments was evaluated as the reduction in the number of plants damaged due to root grubs and rendered useless for transplanting. The results indicate that Sevidol 4.4G 10 kg/ha, Sevin 4G 10 kg/ha, Ekalux 5G 10 kg/ha, BHC 10 per cent 100 kg/ha, Temik 10G 10kg/ha and Temik 10G 20 kg/ha are on par in reducing the number of plants damaged due to the grubs and are significantly more efficient than control. Sevidol 4G 10 kg/ha alone is significantly superior to Thiodan E.C. 0.05 per cent and Dasanit 5G 10 kg/ha in reducing the number of plants damaged due to the grubs, whereas all other insecticide treatments including DDT 10 per cent 100 kg/ha and BPMC 4G 10 kg/ha are on par. The highest percentage of damaged plants (51.56) was in control and the lowest is Sevidol 4G (22.81).

Key words: Root grub; Rubber nursery

284. Jayarathnam, K. and Nehru, C.R. (1984). White grubs and their management in rubber nursery. *Pesticides*, **18**(1): 27-29.

In India, the larvae of *Holotrichia serrata*, *H. rufoflava* and *H. fissa* are known to cause severe root damage to rubber seedlings in the nursery and to render them unfit for transplanting. In field control tests at Karikattoor in Kerala State, granular formulations of Sevin (carbaryl), Sevidol (carbaryl with lindane), Temik (aldicarb) or Ekalux (quinalphos), all at 20 kg/ha, either applied together with the seed at sowing or broadcast before sowing, were compared, together with a 10% dust of BHC (HCH) that was broadcast only. HCH dust at 100 kg/ha was effective at low

pest densities, and higher application rates were unnecessary. Broadcasting was generally more effective than sowing with the seed for all the other insecticides tested, the carbaryl-based products gave slightly better control than aldicarb and quinalphos, but the difference was not significant.

Key words: Pest control; Rubber nursery; White grub

285. Jayarathnam, K., Nehru, C.R. and Jose, V.T. (1991). Field evaluation of some newer insecticides against bark feeding caterpillar *Aetherastis circulata* infesting rubber. *Indian Journal of Natural Rubber Research*, **4**(2): 131-133.

Effectiveness of five insecticidal dusts (carbaryl, fenvalerate, HCH, methyl parathion and quinalphos) was evaluated against the bark-feeding caterpillar, *Aetherastis circulata* Meyr. feeding on the bark of *Hevea brasiliensis*. All the insecticidal applications were significantly superior to control. Fenvalerate, methyl parathion and quinalphos proved to be more effective in relative performance. The most effective and low toxic fenvalerate is recommended for the control of this pest.

Key words: *Aetherastis circulata*; Fenvalerate; Insecticide; Methyl parathion; Pest control; Quinalphos

286. Jose, V.T., Nehru, C.R. and Jayarathnam, K. (1989). Effect of bordeaux paste as a repellent of slugs (*Mariaella dussumieri). Indian Journal of Natural Rubber Research*, **2**(1): 70-71.

Results indicated that Bordeaux paste (10%) applied as a band on the stem of the young rubber plants functioned as an effective slug repellant.

Key words: Bordeaux mixture; Pest; Repellent; Slug; Snail

287. Jose, V.T., Nehru, C.R. and Jayarathnam, K. (1996). Management of slugs and snails on young rubber. *Indian Journal of Natural Rubber Research*, **9**(1): 32-35.

Aldicarb granules and Snailkill (2.5% metaldehyde) applied as broadcast (20g/ plant) and aldicarb 0.01 per cent slurry with maida proved to be molluscicidal when applied to young rubber plants. Bordeaux paste showed repellent activity for 45 days.

Key words: *Mariaella dussumieri; Cryptosona bistrialis*; Slug; Snail; Molluscicide

288. Jose, V.T., Thankamony, S. and Kothandaraman, R. (2000). Control of bark feeding caterpillar *Aetherastis circulata* Meyr. infesting rubber with insecticidal dusts. *In: Recent Advances in Plantation Crops Research: Placrosym* XIII, 16-18 December 1998, Coimbatore, Tamil Nadu, India. (Eds. N. Muraleedharan and R. Raj Kumar). Allied Publishers, New Delhi, India, pp. 352-354.

The bark feeding caterpillar, *Aetherastis circlata* Meyer. inflicted severe injury to rubber trees at Velimalai estate in Kanyakumari district of Tamil Nadu. Dust formulations of three insecticides *viz.* endosulfan 4D, fenvalarate 0.4D and methyl parathion 2D were evaluated. Pretreatment population during 1995-96 was 15 to 18 caterpillars and in 1996-97 it was five to six per tree upto a height of 1.5 m. Severity of infestation was brought down by three rounds of dusting to a level of one to four in 1995-96 and one to three after one round of dusting in 1996-97. Methyl parathion 2D at 10 kg per ha achieved 92.6 per cent control after three rounds of dusting during 1995-96. Application of fenvalarate 0.4D at 10 kg per ha had resulted in 86.55 and 74.71 per cent control during the two years. Dusting with methyl parathion 2D at 10 kg was the most cost effective treatment.

Key words: Bark feeding caterpillar; Pest control

289. Jose, V.T. and Thankamony, S. (2005). Cricket (*Gryllacrys sp.*) damage to rain guards on rubber trees under tapping and their management. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 499-501.

The crickets (*Gryllacrys* sp.), *Orthoptera, Cryllacrididae* are very destructive to the polythene rain guards of tapping rubber trees. Because of the semi circular cut inflicted by the cricket, water leaks in leading to panel rot. Experiments showed that the application of insecticides such as malathion, neem oil 0.010% and fenvalerate 0.02% along the tapping panel once in a week reduce the attack. Phorate (2g/litre) and neem oil (direct) were also effective treatments when applied on the interior of the polythene rain guards. Direct application of used engine oil, maroti oil, cashew kernel oil on the interior periphery of the polythene were more effective than neem oil, turpentine and castor oil in reducing the damage. Blue,

red and yellow coloured rain guards were observed to be less affected while clear transparent ones were severely damaged.

Key words: Biological control; Cricket damage; Insecticide

290. Jose, V.T. and Thankamony, S. (2005). Menace of mooply beetles (*Lyprops curticollis* Frm.) near rubber plantations and their control. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 531-533.

The mooply beetles (*Lyprops curticollis* Frm. *Coleoptera: Lagriidae*) create a lot of menace to the public residing near rubber plantations in South India. The grubs of these beetles were found under the ground litter actively feeding upon fallen semi dried silky green rubber leaves and emerging as adults by March. After the onset of rains in April, the beetles fly enmass towards houses and aggregate on roof and walls. Insecticides such as deltamethrin 0.0056% gave 99% mortality after three days of spraying. Other comparable insecticides were cypermethrin 0.025%, fenvalarate 0.02% and chlorpyriphos 0.05% which gave 76-84% mortality. An entomogenous fungus, *Beauveria bassiana* was found to infect and kill the grubs and adults. Sometimes the grubs crawl on to the rubber trees and fall into the latex in collection cups, spoiling it by coagulation.

Key words: Beetles control; Insecticide; Mooply beetle; Pest; Rubber plantation

291. Jose, V.T. and Thankamony, S. (2005). Borer beetle control on rubber trees using insecticides. *Natural Rubber Research*, **18**(1): 63-66.

Borer beetle infestation was observed on partially dried bark of standing rubber trees. Swabbing of a mixture of carbaryl (0.5%) + quinalphos (0.25%) on the beetle infested region of the bark three times at an interval of one week was highly effective and resulted in 99 per cent control when observed after two months.

Key words: Borer beetle; Insecticide; Pest control

292. Jose, V. T. and Thankamony, S. (2010). Control of bark feeding caterpillars on rubber with insecticide combination. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts, pp. 187-188.

Among the insect pests of rubber, the bark feeding caterpillar *Aetherastis circulata* is emerging as the most serious pests of mature trees in India. The caterpillars build galleries all over the trunk region with chewed bark, faeces and silk and live inside the gallery. They feed initially on the dead bark on all parts of the trunk and branches and latex oozes out from the points where they feed deeper. During 2004 – 06 and 2006 – 07 the incidence of bark feeding caterpillar was very severe in Cheruvally and Kodumon estates. So field experiments were conducted in these estates using insecticides, biopesticides and combination of insecticides. In Cheruvally estate, the field was laid out using insecticides and bio pesticides. The insecticides used were chlorpyriphos, lamdacyhalothrin, deltamethrin, fenvalarate, spray, fenvalarate dust and an entomopathogen, *viz. Beauveria bassiana* and Dipel (Bt). *B. bassiana* and Dipel (Bt) were tried in different concentrations. But in Kodumon estate, the insecticides were used singly and in combinations. All the experiments were laid out in completely randomized design with suitable controls. Each treatment was replicated four times. The spraying was done with a back pack sprayer. The effect of treatment was evaluated based on the pre-treatment and post treatment number of caterpillars upto a height of 1 meter. Comparative efficacy of insecticides, bio pesticides and insecticide combinations in controlling bark feeding caterpillar was evaluated. Among the different insecticides used at Cheruvally estate, deltamethrin 0.0056% showed 86.47% control of bark feeding caterpillar followed by cypermethrin (84.74%) lamdacyhalothrin (79.69%) and fenvalarate (66.38%). The insecticide combination trial at Kodumon estate indicated that spraying combination of fenvalarate 0.02% and carbaryl 0.01% indicated 94.78% control of bark feeding caterpillar followed by quinalphos 0.05% and carbaryl 0.1%. The results have shown that the insecticide combinations were more effective than single insecticides and bio-pesticides.

Key words: *Aetherastis circulata;* Bio-pesticide control; Insecticide combinations

293. Mathew, J., Abraham, T., Jose, V.T., Mondal, G. C., Raj, S. and Sailajadevi, T. (2010). Prevalence of pests and diseases of *Hevea brasiliensis* in India - Past and present. *International Workshop on Climate Change and Rubber Cultivation: R & D Priorities*, 28-30 July 2010, Rubber Research Institute of India, Kottayam, India, pp. 90-92.

Key words: Pest

294. Mondal, G.C., Sethuraj, M.R., Sinha, R.R. and Potty, S.N. (1994). Pests and diseases of rubber in North East India. *Indian Journal of Hill Farming*, **7**(1): 41-50.

Leaf diseases of rubber caused by *Corynespora cassiicola* and *Guignardia heveae* (leaf spot), *Bipolaris heveae* (bird's eye spot), *Colletotrichum gloeosporioides* [*Glomerella cingulata*](leaf anthracnose), *Oidium heveae* and *Gloeosporium alborubrum* [*G. cingulata*] (secondary leaf fall) were recorded in all the plantations visited in Northeast India. High intensities of *Gloeosporium* and *Oidium* leaf fall occurred in all stages of growth of rubber plants in most of the locations and caused repeated defoliation and die-back. High incidence of *Oidium* was also observed on flowers causing whither and drop off. Abnormal leaf fall disease caused by *Phytophthora botryosa* was noticed in a few plantations in Tripura in 1988. High intensity of pod rot caused by *Phytophthora* and *Gloeosporium* was found in most of the plantations in Assam, Tripura and Meghalaya. Low incidence of pink disease (*Corticium salmonicolor*), bark canker *(Phytophthora* sp.) and brown root rot (*Phellinus noxius*) were noticed in a few plantations of Assam and Tripura. Mild attack of termites, slugs, snails and caterpillars were also observed in some plantations. Severe infestations of scale insects (*Saissetia nigra* [*Parasaissetia nigra*]) was found in most of the plantations in Assam and Tripura and caused severe damage of plants in some of the cases.

Key words: Pest; Rubber disease; North East India

295. Nehru, C.R. (1982-83). Highlights on the diseases and pests of rubber. *Rubber Board Bulletin*, **18**(4): 5-6.

Key words: Pest; Rubber disease

296. Nehru, C.R. (1991). *Studies on the bioecology, behaviour and control of Holotrichia serrata F. infesting rubber seedlings*. Ph.D. Thesis, University of Kerala, Trivandrum, India, 265 p.

Key words: *Holotrichia serrata*; Pest control; Rubber seedling

297. Nehru, C.R., Jayarathnam, K. and Pillay, P.N.R. (1983). Incidence of bark feeding caterpillar *Aetherastis circulata* Meyer on rubber (*Hevea brasiliensis* Muell. Arg.). *Indian Journal of Plant Protection*, **11**(1&2): 150.

A field trial was carried out in Kerala, India in 1983 to evaluate the effectiveness of dusts containing 10% BHC [HCH], 2% parathion-methyl, 5% malathion and 5% carbaryl applied at 15 kg/ha against larvae of *Aetherastis circulata* feeding on the bark of rubber. Parathion-methyl was the most effective treatment, reducing the larval population by 98.5%, while carbaryl, HCH and malathion reduced the population by 95.6, 7.1 and 74.3% respectively. No fresh damage by the pest was observed 30 days after treatment. On the basis of the results, parathion-methyl is recommended for control of the pest.

Key words: *Aetherastis circulata*; Pest

298. Nehru, C.R. and Jayarathnam, K. (1987). Evaluation of insecticides against bark feeding caterpillar *Aetherastis circulata* (Meyr.) infesting rubber. *Placrosym* VI, 1984, Kottayam, India. (Ed. M.R. Sethuraj). Oxford and IBH, New Delhi, India, pp. 209-214.

The comparative efficacy of five insecticidal dusts namely, BHC, carbaryl, malathion, methyl parathion and phosalone was evaluated against the bark-feeding caterpillar, *Aetherastis circulata* Meyr. infesting rubber (*Hevea brasiliensis* Muell. Arg.) All the insecticidal treatments were significantly superior to control after seven and 14 days of dusting. Methyl parathion, carbaryl and phosalone proved to be most effective in relative performance.

Key words: *Aetherastis circulata;* Bark feeding caterpillar

299. Nehru, C.R. and Jayarathnam, K. (1988). Control of white grub (*Holotrichia serrata* F.) attacking rubber at the nursery stage in India. *Indian Journal of Natural Rubber Research*, **1**(1): 38-41.

In a 2-year field experiment, seven insecticides *viz.* carbofuran 3G, phorate 10G, carbaryl 5D, HCH 10D, carbaryl 4G, phosalone 4D and carbaryl + lindane (sevidol)4: 4G broadcast at the time of sowing were evaluated for their relative effectiveness in controlling white grub infesting rubber seedlings in the nursery. Among the insecticides tested, phorate 10G followed by carbaryl + lindane (sevidol) 4: 4G was proved to be very effective in managing the population of white grub in rubber nursery below the economic threshold. The treated plots recorded the lowest grub population and highest plant survival.

Key words: *Holotrichia serrata*; Phorate 10G; Carbofuran 3G; White grub

300. Nehru, C.R., Jayarathnam, K. and Karnavar, G.K. (1991). Application of an entomopathogenic fungus, *Beauveria brongniartii* (Sacc.) Petch for control of the adult chafer beetle, *Holotrichia serrata* Fabricius (Coleoptera: *Scarabaeidae*). *National Seminar on Biological Control in Plantation Crops*, 27-28 June 1991, Kottayam, India, pp. 13.

Key words: *Beauveria brongniartii*; *Holotrichia serrata*

301. Nehru, C.R., Jayarathnam, K. and Karnavar, G.K. (1991). Application of entomopathogenic fungus *Beauveria brongniartii* for management of chafer beetle of the white grub *Holotrichia serrata* infesting rubber seedlings. *Indian Journal of Natural Rubber Research*, **4**(2): 123-125.

The infectivity of the entomopathogenic fungus *Beauveria brongniartii* to adult beetles, which are responsible for the abundance and distribution of white grubs (*H. serrata*) in rubber nurseries, is reported. Longevity of the adult beetles of both sexes infected with *B. brongniartii* was significantly less than that of the uninfected ones. The results indicated that *B. brongniartii* spreads from contaminated adults to healthy ones through mating contact. Release of the contaminated adults in the nursery was effective for biological suppression of *H. serrata*.

Key words: *Beauveria brongniartii*; *Holotrichia serrata*; Rubber nursery

302. Nehru, C.R., Thankamony, S. and Jayarathnam, K. (1991). Occurrence of root-knot nematode *Meloidogyne incognita* as a pest of rubber (*Hevea brasiliensis*) seedlings. *Indian Journal of Natural Rubber Research*, **4**(1): 77-78.

Nursery screening on the occurrence and infestation of plant parasitic nematodes was conducted and reported root-knot nematode, *Meloidogyne incognita* as a pest of rubber. The infested seedlings showed symptoms of wilting and dwarfing as well as discolouration and shedding of leaves. Severe attack causes the death of seedlings.

Key words: *Meloidogyne incognita*; Pest; Seedling

303. Nehru, C.R. and Jayarathnam, K. (1993). Evaluation of biological and chemical control strategies against the white grubs (*Holotrichia serrata*) infesting rubber seedlings. *Indian Journal of Natural Rubber Research*, **6**(1&2): 159-162.

In recent years, white grubs have become a major pest problem throughout the world and are known to cause severe damage to a variety of crops including rubber. The losses inflicted by this pest are so high that now in India the white grub has been declared as a national pest. White grubs of the species *Holotrichia serrata*, *H. rufoflava*, *H. fissa* and *Anomala varians* are the serious pests of rubber causing severe damage to seedlings in nurseries and rendering them unfit for transplanting. The most predominant and serious among the four species is *H. serrata*. The peak period of occurrence of the pest in the field is from June to December, when the grubs of different instars would cause serious damage to rubber seedlings. The damage in general is more severe when the voracious third instant grubs are abundant in the nursery. In endemic areas, the estimated quantum of losses inflicted by this major pest to nursery seedlings ranges from 65 to 68 per cent. In a field experiment, a comparative evaluation of biological and chemical control strategies was attempted during 1989-90, using randomized block design with eleven treatments and a control, replicated four times. Each plot measured 9.30 m^2 consisting of 100 seedlings. The spores of *Beauveria brongniartii* and *B. bassiana* were broadcast and incorporated into the soil at the rate of 1 x 10^9 spores/g of soil with sheep manure. Doom dust (*Bacillus popilliae*) was broadcast into the soil at the rate of 2 g per plot with sterile soil. Isofenphos 5G, phorate 10G, carbaryl + lindane (sevidol) 4:4G, carboruran 3G and carbaryl

4G were applied at 25 kg/ha as granules whereas aldrin 5D, carbaryl 5D and HCH 10D were applied at 100 kg/ha as dusts at first instar stage of the grubs. All the insecticides were broadcast and incorporated into the soil at the time of sowing. Mean percentage survival of the seedlings in treated plots was recorded. Grub population was assessed after 4, 8, 12 and 16 weeks from 10 pits per plot in 30 cm^3 soil between rows and the average worked out. The data recorded were subjected to statistical analysis and the mean percentage survival of plants is presented. The results reveal that all the biological control treatments were significantly superior to the untreated check in protecting rubber seedlings from white grubs. However, in both the years the application of entomopathogenic fungus *viz. Beauveria brongniartii* spores @ 1 X 10^9 spores/g of soil proved to be the best treatment which gave the highest plant survival (92.56 to 94.25 per cent) by reducing the white grub damage and its effectiveness did not differ significantly from the application of *B. bassiana*. Among the other treatments, the most effective treatment was application of *B. popilliae* followed by the application of isofenphos 5G, phorate 10G and carbaryl + lindane (sevidol) 4:4G all being on par in both the years. The untreated control plots recorded the lowest plant survival (7.50 to 9.31 per cent) and highest grub population during both the years. No reinfestation of grubs was observed in plots broadcast with entomopathogens even after six months.

Key words: Biological control; *Holotrichia serrata*; White grub

304. Nehru, C.R. and Thankamony, S. (2000). Pests in rubber plantations. *In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 347-368.

This chapter deals with the insect pests and non-insect pests. Among the insect pests of rubber, white grubs, bark-feeding caterpillars, termites, scale insects and mealy bugs, leaf feeding caterpillars, certain other insect pests, rubber wood-boring beetles, insect pests of cover crops and pests affecting plantation workers are discussed. Among the non-insect pests, both invertebrate pests - slugs and snails, mites, nematodes and vertebrate pests – rats, porcupine and others are discussed.

Key words: Insect; Non insect pest; Nematode; Pest; White grub

305. Pillay, P.N.R. (1968). Pests of rubber in India. *Pesticides Annual* 1968, pp. 87.

Key words: Pest

306. Pillay, P.N.R. (1980). Non parasitic maladies. *In: Handbook of Natural Rubber Production in India.* (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 307-312.

Non-parasitic maladies are those, which are not caused by any pathogen. These include wind damage, sun scorch, lightning damage, fire damage, chemical toxicity, self pruning, fasciation and woody nodules. Each of these non-parasitic malady is mentioned in detail in the chapter.

Key words: Chemical toxicity; Sun scorch; Wind damage

307. Rajendran, T.P. and Jayarathnam, K. (1977). On the occurrence and effect of nematode infestation in rubber plantation. *Indian Journal of Nematology*, **7**(1): 82-83.

Key words: Nematode

308. Ramakrishnan, T.S. and Pillay, P.N.R. (1961-62). Scale insects (*Saissetia nigra* Nietn and *Pulvinaria maxima* Green). *Rubber Board Bulletin*, **5**(4): 209-212.

Scale insects cause some damage to young rubber plants in different districts of India. The most common species is the black scale (*Saissetia nigra*); *Pulvinaria maxima* is another important species. Natural control of these insects is brought about by predators, parasitic insects, and two entomogenous fungi, *Hypocrella reineckiana and Cephalosporium lecani.* Oil emulsions have given satisfactory control of light infestations. Also used are albolineum, dieldrex and parathion (0.25%).

Key words: *Cephalosporium lecani; Hypocrella reineckiana; Pulvinaria maxima; Saissetia nigra*; Scale insect

309. Ramakrishnan, T.S. and Pillay, P.N.R. (1962-63). Report of the first year of trials in increasing yield from existing plantations of rubber. *Rubber Board Bulletin*, **6**(2): 79-87.

Results of fertilizer application, sulphur dusting (against *Oidium*), and stimulation in rubber in various districts of southern India. In general the combined treatments resulted in high yield responses. Thus the production of medium-aged plantations can be substantially increased at a low cost; this will partly meet the increased demand for rubber in the country. When stimulation is practised, the use of a fungicide to protect the panel and the bark is to be recommended.

Key words: Rubber plantation; Yield

310. Ramakrishnan, T.S. and Pillay, P.N.R. (1962-63). Snails and slugs. *Rubber Board Bulletin*, **6**(1): 26-28.

Snails and slugs have been observed in several districts of South India causing damage to young rubber plants. The following methods of control are discussed: 1) collection by handpicking and destroying which is very efficient, and 2) spreading poison bait. Recommended is a mixture containing one part of metaldehyde, two parts of rive bran, six parts of slaked lime and six parts of cement kneaded with water and then made into small briquettes or balls. These are distributed on the ground among the plants. Spraying parathion or dieldrex over the parts frequented by these animals is also reported to be efficacious.

Key words: Slug; Snail

311. Ramakrishnan, T.S. and Pillay, P.N.R. (1963). Slugs and snails. *Rubber Board Bulletin*, **6**(3&4): 134.

Foliar application of the mixture of zinc sulphate and lime solution is effective for the control of zinc deficiency in young rubber plants. The infestation of slugs and snails in rubber plants can be prevented by painting eight inches of stem above the soil with dieldrex 18 E.C. (1 in 400) or by dusting 10% gammaxene in young shoots.

Key words: Slug; Snail

312. Ramakrishnan, T.S. and Pillay, P.N.R. (1963-64). Brown root disease in nurseries. *Rubber Board Bulletin*, **7**(2&3): 67-69.

Symptoms produced in *Hevea* seedlings by *Fomes noxius* are described. Control measures include the eradication of severely damaged plants followed by repeated drenching of the soil with solutions of Aretan (1 in 400) or Ceresan (1 in 160).

Key words: Brown root; Nursery

313. Ramakrishnan, T.S. and Pillay, P.N.R. (1963-64). Cockchafer grubs. *Rubber Board Bulletin*, **7**(2&3): 76-78.

The larvae of several cockchafer species attack the roots of rubber and cover crops in India and other S.E. Asian countries. Nurseries and young trees in the field are most liable to be attacked. Some degree of control is exercised by the entomophagous fungus *Metarrhizium anisopliae*. Chemical control is possible by drenching the soil with 0.1% DDT or 0.4 BHC at a rate of 30 1/100 sq.m; 0.5% aldrin or 0.25% dieldrin are even better because of their more persistent action. Ultraviolet light has been successfully used in Malaya to trap the adults.

Key words: Cock chafer grub

314. Rao, K. N., Jose, V. T., Gupta, C. and Edathil, T. T. (2005). Termite menace to rubber cultivation in Orissa. *Rubber Board Bulletin*, **28**(1): 6-9.

Key words: Rubber cultivation; Termite; Orissa

315. Thankamony, S., Nehru, C.R. and Jayarathnam, K. (1989). Preliminary observations on reaction of leguminous cover crops to root-knot nematode. *Indian Journal of Natural Rubber Research*, **2**(1): 68-69.

In this short scientific report the preliminary observations on reaction of leguminous cover crops to root-knot nematode is reported. Various cover crops were screened for resistance against the root-knot nematode *Meloidogyne incognita*. The results revealed that *Mucuna bracteata* exhibited high resistance.

Key words: Leguminous cover crop; Root knot nematode

316. Thankamony, S., Nehru, C.R. and Jayarathnam, K. (1996). Frequency of occurrence and distribution of plant parasitic nematodes in rubber nursery soils. *Indian Journal of Natural Rubber Research*, **9**(1): 60-62.

A systematic survey undertaken in ten rubber nurseries in Kerala and Tamil Nadu indicated that presence of plant parasitic nematodes in varying number. Major nematode genera encountered include *Meloidogyne, Helicotylenchus, Hemicriconemoides, Aphelenchus* and *Tylenchus. Meloidogyne* spp. was recorded as the most prominent parasitic nematode with high frequency of occurrence and population density followed by *Helicotylenchus* and *Hemicriconemoides* spp. *Aphelenchus* spp. and *Tylenchus* spp. which were present in small number was considered as minor nematodes.

Key words: Plant parasitic nematode; Rubber nursery; Soil

317. Thankamony, S., Jose, V.T. and Kothandaraman, R. (1997). Evaluation of pesticides for control of root-knot nematode infestation of rubber (*Hevea brasiliensis*) seedlings. *Indian Journal of Natural Rubber Research*, **10**(1&2): 97-101.

The relative efficacy of some pesticides, *viz.* carbofuran 3 G (Furadan), phorate 10 G (Thiride), aldicarb 10 G (Temik) and sevidol 4:4 G at 6, 10 and 15 kg per ha applied twice for a period of six months against root-knot nematode, *Meloidogyne incognita* in rubber nursery were evaluated. In general, all the treated plants recorded significant increase in plant growth over untreated control. Carbofuran at 15 kg per ha recorded maximum plant growth followed by phorate and aldicarb at the same dosage. Carbofuran was also found to decrease the nematode infestation significantly at 15 kg per ha compared to respective doses of other chemicals. Thus application of carbofuran at 15 kg per hectare was found very effective for the release of nematode free seedlings from infested rubber nurseries.

Key words: Rubber seedling; Pesticide; Root knot nematode

318. Thankamony, S., Jose, V.T. and Kothandaraman, R. (1998). Evaluation of nematicidal properties of some plant materials against root-knot nematode, *Meloidogyne incognita* on *Pueraria phaseoloides*. *Rubber Board Bulletin*, **27**(3): 25-28.

Pot culture and laboratory studies were conducted to evaluate the nematicidal properties of *Pongamia glabra, Azadirachta indica, Mucuna bracteata* and mushroom compost against root-knot nematode *Meloidogyne incognita* on *Pueraria phaseoloides*. Among the materials tested, the incorporation of the leaves of *P. glabra* was proved to be effective in reducing the nematode infestation in the host and final soil nematode population followed by that of *A. indica, M. bracteata* and mushroom compost. In *in vitro* study also *P. glabra* was more effective in increasing the larval mortality followed by *A. indica* and *M. bracteata*. The per cent mortality increased with concentration and period of exposure.

Key words: *Meloidogyne incognita;* Nematicidal property; *Pueraria phaseoloides*; Planting material; Root knot nematode

319. Thankamony, S., Kothandaraman, R., Jacob, C.K. and Jose, V.T. (2002). Density and frequency of root-knot nematode, *Meloidogyne incognita* in rubber plantations. *Placrosym* XV, 2002, Mysore, India. (Eds. K.Sreedharan, P.K. Vinod Kumar, Jayarama and Basavaraja M. Chaluki). Central Coffee Research Institute, Karnataka, India, pp. 561-564.

Field experiments were conducted to evaluate a triazole fungicide, hexaconazole, for the management of powdery mildew disease of rubber (*Hevea brasiliensis*) caused by *Oidium heveae* Steinm. The experiment was conducted on a susceptible clone PB 5/51 in Cheruvally estate, Kottayam, Kerala and also in a disease-prone area on clone RRIM 600 in Vaikundam estate, Kanyakumari district, Tamil Nadu for seasons (1999 to 2002). Hexaconazole (2) dust was evaluated as such and in alternate schedule with sulphur and in combination with recommended sulphur fungicide and at three concentrations. Results indicated that application of hexaconazole (2) as such and in alternate schedule with sulphur was found to give better control. Combination of hexaconazole (2) and sulphur and hexaconazole (1) as such were observed to reduce powdery mildew disease. Alternate use of hexaconazole with sulphur is suggested to avoid the development of resistant strains.

Key words: *Meloidogyne incognita;* Plant parasitic nematode

320. Thankamony, S., Kothandaraman, R., Jacob, C.K. and Jose, V.T. (2005). Effect of different inoculum levels of *Meloidogyne incognita* on the growth and biochemical constituents of *Pueraria phaseoloides*. *In: Preprints of Papers. International Natural Rubber Conference, India 2005*, 6-8 November 2005, Cochin, India. (Comps. N.M. Mathew, *et al.*). Rubber Research Institute of India, Kottayam, India, pp. 526-531.

Pathogenicity of *Meloidogyne incognita* on *Pueraria phaseoloides* was tested by inoculating different levels of second stage juveniles (J2) of *Meloidogyne incognita*. Increase in the level of inoculum resulted in proportional decrease in plant growth and increase in root-knot disease on *P. phaseoloides*. Increase in the content of total phenols, ortho-dihydroxy phenols, reducing sugars, non-reducing sugars and amino nitrogen in the infected plant tissues was observed at 10, 100, 1000 and 10,000 levels of nematode inoculum. Low starch content was recorded in nematode inoculated plants.

Key words: *Meloidogyne incognita; Pueraria phaseoloides*

321. Thankamony, S., Kothandaraman, R., Jacob, C.K., Joseph, K. and Jose, V.T. (2005). Interaction between endomycorrhizal fungus *Glomus fasciculatum* and root-knot nematode, *Meloidogyne incognita* on *Pueraria phaseoloides*. *Natural Rubber Research*, **18**(2): 183-187.

Interactive relationship of the vesicular arbuscular mycorrhizae, *Glomus phaseoloides* was studied. Mycorrhizal association enhanced total biomass as well as fresh root weight of plants while the nematode infection reduced them. Mycorrhizal colonization percentage and spore count was more when VAM was inoculated alone or prior to nematode inoculation. The reproduction factor of *M. incognita* decrease in presence of mycorrhizae. The inoculation of VAM induced tolerance in *P. phaseoloides* to *M. incognita*.

Key words: *Meloidogyne incognita; Pueraria phaseoloides;* Vesicular Arubuscular Mycorrhizae

322. Thankamony, S., Kothandaraman, R., Jacob, C.K., Joseph, K. and Jose, V.T. (2009). Interaction of root knot nematode, *Meloidogyne incognita* and *Bradyrhizobium* sp. on *Pueraria phaseoloides*. *Natural Rubber Research*, **22**(1&2): 127-132.

The effect of interaction of root-knot nematode, *Meloidogyne incognita* and *Bradyrhizobium* sp. on growth, nodulation and nitrogen content in *Pueraria*

phaseoloides, a cover crop grown in rubber plantations, was studied in a pot – culture experiment by inoculating different inoculum levels of *M. incognita* and *Bradyrhizobium*. Significant reduction in nodulation due to nematode infestation was observed. Maximum gall formation was recorded in plants inoculated with nematode alone. Simultaneous inoculation of *Bradyrhizobium* and nematode or nematode inoculation after 10 days of bacterial inoculation reduced the adverse effect of nematode. Plant growth was increased by 5 to 13 per cent over control. Nitrogen content in the root and shoot of *P. phaseoloides* was considerably reduced by nematode inoculation at different inoculum levels. However, pre-inoculation of *Bradyrhizobium* could increase nitrogen content of the plants.

Key words: *Bradyrhizobium*; Interaction; *Meloidogyne incognita; Pueraria phaseoloides*

323. Thankamony, S. and Jose, V. T. (2010). Survey for entomopathogenic nematodes in rubber growing areas of Kerala. *In*: *Climate Change: Placrosym XIX*, 7-10 December 2010, Kottayam, India, Abstracts. pp.186-187.

Insect parasitic rhabditid nematodes of the genera *Steinernema* and *Heterorhabditids* possess tremendous potential as biological control agents for a range of insect pests of agricultural importance. Because of these useful attributes, numerous surveys were conducted worldwide and nematodes were recovered from numerous habitats. The objective of the present study was also to investigate the occurrence of entomopathogenic nematodes in rubber growing soils and to obtain locally adopted isolates for developing bio control programmes against pests of rubber, *Hevea brasiliensis*. A total of 345 soil samples were collected from ten districts, *viz*. Trivandrum, Kollam, Pathanamthitta, Kottayam, Ernakulam, Thrissur, Palakkad, Kozhikode, Malappuram and Idukki to find out the natural occurrence of entomopathogenic nematodes in rubber growing soils. The survey indicated the presence of entomopathogenic nematodes in rubber growing soils. Out of 345 composite samples examined, 73 samples (21%) yielded EPN, among these 61 soil samples (18%) collected from Trivandrum, Kottayam, Thrissur, Palakkad, Kozhikode and Malappuram regions yielded both *Heterorhabditids* and *Steinernema* spp. Twelve soil samples (3%) collected from Kollam, Pathanamthitta,

Ernakulam and Idukki regions showed the presence of *Heterorhabditid* spp. alone. Bioassays were carried out by soil baiting technique using fifth instar larvae of greater wax moth, *Galleria mellonella* under laboratory conditions (Bedding and Akhurst,1975). Mortality of the larvae was observed at 24h interval for ten days. The dead larvae were washed with 4% sodium hypochlorite solution, followed by distilled water and placed on white trap in BOD incubator at 30° C to collect infective juveniles (ijls). The genus identification was carried out based on the colour of the cadavers. The galleria larvae infested with *Steinernema* spp. became flaccid and their colour changed from white to yellow brown, in case of *Heterorhabditids*, the colour changed from white to brownish red or brick red. Laboratory and field evaluation of EPN against bark feeding caterpillar, *A. circulata* infesting rubber plants were also conducted. The results of the laboratory study showed 84% mortality of 2nd instar larvae of *A. circulata* when it was inoculated with EPN @ 360 ijls/5 larvae within 24 hours followed by 88% and 92% mortality of 3rd and 4th instar larvae respectively. 100% mortality was recorded at 48 h of exposure. The multiplication rate was found to reduce at lowest as well as highest inoculums levels. No significant effect was noticed on the field application of EPN against bark feeding caterpillar, *A. circulata*.

Key words: Entomopathogenic nematode; Soil survey

PLANT PROTECTION EQUIPMENT

324. Edathil, T.T. (1980). Plant protection equipments. *In: Handbook of Natural Rubber Production in India.* (Ed. P.N. Radhakrishna Pillay). Rubber Research Institute of India, Kottayam, India, pp. 327-333.

As various diseases and pests ravage rubber plants, it is necessary to use many plant protection equipments for their control. Those used in rubber plantations include sprayers, dusters, fogging equipments and pressure injectors. A detailed description on the different high volume sprayers such as: rocker sprayer, knap-sack sprayer and DSP (double suction pump) sprayer, low volume sprayers, such as mini micron sprayer, micron sprayer and aerial spraying is mentioned in this chapter. Similarly, details on the hand operated duster and power-driven duster are provided regarding plunger type duster, crank

Key words: Duster; Fogging equipment; Pressure injector; Sprayer

325. Idicula, S.P. (2006). Equipment for Corynespora leaf disease control. *In: Corynespora leaf disease of Hevea brasiliensis: Strategies for Management.* (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 158-168.

The success of disease control using chemicals depends much on its delivery to the targets. This chapter deals with the different types of equipments used for Corynespora leaf disease control. The sprayers (manually operated sprayers and power operated sprayers), dusters (manually-operated dusters and power operated dusters) as well as fogging machines used in rubber plantations are discussed in detail with illustrations.

Key words: Corynespora leaf fall; Fogging equipment; Plant protection equipment

326. Idicula, S.P. and Jose, V.T. (2000). Plant protection equipment and chemicals. *In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, India, pp. 347-368.

This chapter deals with the different plant protection equipment namely sprayers – (manually-operated sprayers and power-operated sprayers), dusters (manually-

operated dusters and power-operated dusters), fogging equipment, pressure injectors and electric fencing. The different chemicals used for plant protection are also discussed. In the section on fungicides, its classification, formulations, adjuvants, commonly-used fungicides and carriers for fungicides are discussed. Regarding pesticides, the commonly-used insecticides, molluscicides and rodenticides are discussed.

Key words: Duster; Fungicide; Pesticide; Rubber plantation; Spraying

327. Jacob, C.K., Prem, E.E. and Idicula, S.P. (2004). Improvement in the efficacy of micron sprayer used for spraying in rubber plantations. *Proceedings of ICAR National Symposium on Input Use Efficiency in Agriculture: Issues and Strategies*, 25-27 November 2004, Kerala Agricultural University, Trichur, India, pp. 33-34.

Key words: Abnormal leaf fall; Copper fungicide; Micron sprayer; Rubber plantation

328. Jose, V.T. and Vijayan, K. (2006). Maintenance of plant protection equipment. *In: A Laboratory Manual for International Training on Strategies for Management of Corynespora Leaf Fall Disease of Hevea brasiliensis.* (Eds. C. Kuruvilla Jacob, P. Srinivas and C. Bindu Roy). Rubber Research Institute of India, Kottayam, India, pp. 50-58.

Plant protection equipment, if given proper care and maintenance may offer a very long service life. Some of the important aspects of care and upkeep for different types of plant protection equipment are discussed in this chapter.

Key words: Maintenance; Plant protection equipment

329. Thankamma, L., Rajendran, T.P. and Mani, J.P. (1979). A pressure machine for injecting rubber trees. *In: Entomology, Microbiology, Nematology, Plant Pathology and Rodentology of Plantation Crops: Placrosym* II, 1979, Ootacamund, India. (Ed. C.S.Venkata Ram). Indian Society for Plantation Crops, Kasaragod, India, pp. 181-189.

A pressure machine suitable for injecting aqueous chemical solutions into rubber trees has been assembled and the method of injection standardized. This method of administering chemicals into trees is more acceptable than other methods like spraying or soil application, as only a minimum amount of chemical is required, the injected fluid is picked up by transpiration stream and systematically translocated throughout the plant and is confined within the treated tree itself. More over entry of prescribed dosage is assured and treatment schedule can be followed regardless of wind and rain. This method, besides being economically advantageous, avoids the environmental pollution hazards inherent in other methods of application. It is useful for injecting large volumes of relatively dilute solutions.

Key words: Plant protection equipment; Pressure injector

MICROBIOLOGY

330. Joseph, K., Kothandaraman, R. and Mathew, J. (1988). Actinomycetes population of rubber growing soils and its antagonistic activity against *Phytophthora meadii* (McRae). *Indian Journal of Natural Rubber Research*, **1**(1): 27-30.

The population of bacteria, fungi and actinomycetes in fifteen rubber growing soils was estimated. The occurrence of actinomycetes antagonistic to *Phytophthora meadii* (Mc Rae) and the extent of inhibitory activity were studied. In general, the population of bacteria was more than that of both fungi and actinomycetes and they varied widely in different soil samples. All soil samples, irrespective of the pH and microbial population, harboured actinomycetes antagonistic to *P. meadii* and majority of these isolates had inhibition zones upto 15 mm when tested by cross streak assay. In spite of the presence of such large number of actinomycetes antagonistic to *P. meadii* various diseases caused by this pathogen reoccurred every year.

Key words: Actinomycete; Antagonism; *Phytophthora meadii*

331. Joseph, K., Kothandaraman, R., Mathew, J. and Jayarathnam, K. (1991). A soil actinomycete antagonist to *Corticium salmonicolor*. The pathogen causing pink disease of rubber. *National Seminar on Biological Control in Plantation Crops*, 27-28 June 1991, Kottayam, India, pp.23.

Actinomycetes from the rhizosphere soils of five clones of rubber were tested against *Corticium salmonicolor*. One isolate produced an inhibition zone of 40 mm on the agar medium and caused lysis on the mycelium upto a distance of 20 mm from the inoculation point, in 72 h. Treatment of sterile *Hevea* twigs with the actinomycete also prevented growth of *C. salmonicolor*. The actinomycete survived in the bark of rubber trees for 1 month under field conditions. The application of actinomycete broth culture to infected trees showed promise for controlling pink disease.

Key words: Actinomycete; Biological control; *Corticium salmonicolor*; Pink disease

332. Joseph, K., Kothandaraman, R., Mathew, J. and Jayarathnam, K. (1991). A soil actinomycete antagonistic to *Corticium salmonicolor* causing pink disease of rubber. *Indian Journal of Natural Rubber Research*, 4(2): 126-130.

Actinomycetes from the rhizosphere soils of five clones of rubber were tested against *Corticium salmonicolor*. One isolate produced an inhibition zone of 40 mm on the agar medium and caused lysis on the mycelium upto a distance of 20 mm from the inoculation point, in 72 h. Treatment of sterile *Hevea* twigs with the actinomycete also prevented growth of *C. salmonicolor*. The actinomycete survived in the bark of rubber trees for 1 month under field conditions. The application of actinomycete broth culture to infected trees showed promise for controlling pink disease.

Key words: Actinomycete; Biological control; *Corticium salmonicolor;* Pink disease

333. Joseph, K., Mathew, J. and Kothandaraman, R. (1994). *In vitro* studies on the antagonistic effect of *Streptomyces lydicus* against *Phytophthora meadii*. *IRRDB Symposium on Diseases of Hevea*, 21-22 November 1994, Cochin, India, pp. 74-77.

An actinomycete identified as *Streptomyces lydicus* was tested for inhibition of *Phytophthora meadii* in agar medium and sterile soil. The actinomycete inhibited growth of *P. meadii* in various agar media and reduced the infective propagules in soil. Filter sterilized cultural filtrate and crude extract of antagonistic principle also showed inhibition of *P. meadii* and the test bacteria *Bacillus subtilis*.

Key words: Antagonism; *Phytophthora meadii; Streptomyces lydicus*

334. Kothandaraman, R. (1974). Role of soil bacteria on sporangial production of *Phytophthora meadii*. *IRRDB Scientific Symposium*, Part I, 26-28 September 1974, Cochin, India.

From soil extract, colonies of soil bacteria, which were observed to induce sporangial production in *P. meadii* were isolated. One of these isolates was identified as *Pseudomonas* sp. Sporangial production by *P. meadii* in unsterilised, steam sterilized and filter sterilized soil extract, in lima bean agar, steam sterilized tender shoot bits and surface sterilized fruits of rubber, was assessed in the presence and absence of *Pseudomonas* sp. High rate of sporangial production was observed when *P. meadii* was inoculated in unsterilised soil extract. In stem

sterilized and filter sterilized soil extract no sporangial production was noticed by *P. meadii* but abundant sporangial production was noticed in those media in the presence of *Pseudomonas* sp. In lima bean agar, surface sterilized fruits and steam sterilized shoot bits sporangial production was enhanced/induced by *Pseudomonas* sp. The possible role for soil bacteria, *Pseudomonas* sp. in the build up of primary inoculum potential required for the development and spread of Abnormal leaf fall disease of rubber was also discussed.

Key words: *Phytophthora meadii*; Soil bacteria

335. Kothandaraman, R. (1975). Abundant asexual sporulation of *Phytophthora* spp. on pods of *Phaseolus vulgaris*. *Rubber Board Bulletin*, **12**(4):135.

An alternate method of producing large quantity of sporangia from *Phytophthora* is necessary for artificial inoculation studies with the pathogen. This paper describes a methodology for producing abundant sporulation of the pathogen by artificial inoculation with culture bits on tender *Phaseolus vulgaris*. It was estimated that about 20 million sporangia were produced on an average sized bean.

Key words: *Phytophthora*; *Phaseolus vulgaris*

336. Kothandaraman, R., Joseph, K., Mathew, J. and Rajalakshmy, V.K. (1991). Actinomycete population in the rhizosphere of *Hevea* and its inhibitory effect on *Phellinus noxius*. *Indian Journal of Natural Rubber Research*, **4**(2): 150-152.

Brown root disease of rubber caused by *Phellinus noxius* has been reported from India and from other rubber growing countries. A preliminary study was carried out on the biological control of *P. noxius* by antagonistic actinomycetes present in rubber rhizosphere. Actinomycetes were isolated from the rhizosphere of five clones, *viz.* Fx 516, F 4542, RRIM 701, PR 107 and RRIM 600. The antagonistic activities were studied by dual culture. The population of the antagonists could not be correlated with the clonal susceptibility, as no information is available on susceptibility of these clones brown root disease. All the selected actinomycete inhibited the growth of *P. noxius* both in the soil and in the rubber wood pieces under sterile conditions.

Key words: Actinomycete; Antagonism; Brown root; *Phellinus noxius*

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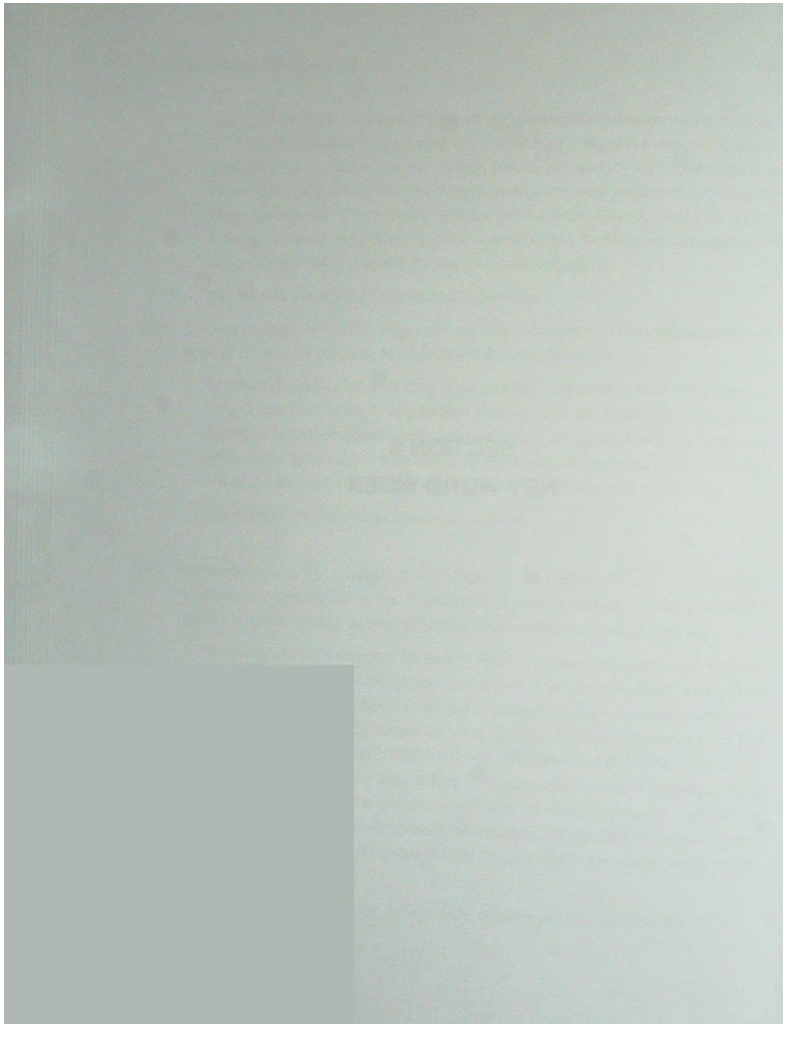

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