Section 1.6. Bibliography

BIBLIOGRAPHY ON SOUTH AMERICAN LEAF BLIGHT

INTRODUCTION

Research on SALB and the causal pathogen *Microcyclus ulei*, commenced in the 1960s mainly in the American universities and research institutions in Central America and Brazil. However, research on the disease intensified in the 1970s especially in Brazil. The Rubber Research Institute of Malaysia (RRIM) established a special unit based in Trinidad and Tobago in 1960s to 1970s. In 1980, the RRIM conducted research on SALB in Brazil. Several Brazilian institutions notably Instituto Agronomico do Norte (IAN) and Centro Nacional de Pesquisa de Seringueira and Dende (CNPSD) and CEPLAC also carried out research on SALB. France through CIRAD is also involved in research on SALB. The private sector also contributes to research on SALB. The Ford Motor Company carried some research when they were involved in the early cultivation of rubber in the Americas. Currently, Michelin conducts research on SALB especially at its plantation in Brazil.

This publication is a collection of articles on SALB and its causal agent *M. ulei* with a brief abstracts. The publication is a reference for plant pathologists and plant quarantine officers to gather information on SALB.

PUBLICATIONS

1. Albuquerque, P.E.P., Pereira, J.C.R. and Santos, A.F. dos. (1987). Efficiency of impaction of fungicides by thermal fogging in leaves of *Hevea* spp. *Revista Theobroma*, 17: 189-199.

   In Southeast Bahia, Brazil, Phytophthora leaf wither (*Phytophthora* spp.) and South American leaf blight (*Microcyclus ulei*) were the most destructive rubber (*Hevea* spp.) diseases. Leaf diseases are the limiting factor for a viable cultivated rubber. Disease control requires timely and rapid applications of fungicides for protection of young leaves and shoots appearing after the wintering season. The effectiveness of thermal fogging of copper in oil (0.9 1/ha) was tested. Copper in oil at recommended doses did not perform well as high zoospore germination (>80 percent) occurred and only few droplets of fungicides impacted on artificial targets (10 droplets per cm^2). Field observation and laboratory bio-assays showed that thermal fogging produced inconsistent results suggesting ineffective control.

2. Alencar, H., Peixoto, E. and Ferreira, H.I.S. (1975). Controle do mal das-folhas (*Microcyclus ulei*) da seringueira na Bahia. II. Relacao custo/beneficio da aplicacao aerea de fungicida, regiao de Itubera, 1972-73. *Revista Theobroma,* 5: 12-20.

   The cost benefit of aerial spraying of mancozeb using a Piper 235 aircraft to control *Microcyclus ulei* in a rubber plantation (clone IAN 873) was analysed. At the additional cost of Cr$400.00 per ha, net additional returns of Cr$3,000.00 per ha were obtained, implying a net return for the treatment of 825 percent. In order to check this excellent result, similar trials have to be carried out in plantations with different clones.

3. Almeida, H.A., Santana, S.O. and Sa, D.F. (1987). Edaphic-climatic zoning for rubber in southeast Bahia, with emphasis for incidence of the South American leaf blight. *Revista Theobroma*, 17: 111-123.

   A study on climate-soil-plant interactions was carried out to identify the agricultural limits for rubber cultivation. Climatic parameters such as rain-fall, air temperature, relative humidity, water deficit, water excess and hydric index and soil factors associated with agricultural characteristics (natural fertility, texture, drainage, effective depth and mechanization suitability) were used to

identify potential zones for rubber cultivation that is free from the South American Leaf Blight, a disease caused by *Microcyclus ulei* (P. Henn.) v. Arx. The results indicated that Southeast Bahia has: (1) a suitable area (10 000 km^2) for the expansion of the rubber crop; (2) two intermediate areas (24 000 km^2) classified as Marginal to Moderate and the Fully Suitable to Moderate; and (3) five unsuitable areas, comprising 54 000 km^2 characterized by hydric excess (Marginal area) and water deficit and/or thermic deficiency. Based on edaphic factors and climatic elements, an area of about 6 500 km^2 was suitable for rubber. There are areas with excellent or good edaphic-climatic conditions for rubber crop in Southeast Bahia.

4. Altson, R.A. (1924). Report of the assistant botanist and mycologist. *Report Department Science Agriculture British Guiana*, 1923, 39 pp.

   Infection by SALB had contributed to the abandonment of large cultivation of rubber.

5. Altson, R.A. (1955). South American leaf blight. *Journal Rubber Research Institute Malaysia,* 14: 338-354.

   This original article was published in 1948. The article draws attention to the importance of SALB to the rubber industry in Malaya. The defence measures against its introduction and means to deal with the disease once established were presented.

6. Anonymous (1914). Leaf diseases of *Hevea*. *Planters' Chronicle*, 9: 272-273.

   Dothidella ulei, Fusicladium macrosporum and *Passalora heveae* were reported on rubber leaves in South America.

7. Anonymous (1917). Plantation rubber in British Guiana. *India Rubber World,* 56: 552.

   Rubber plant in British Guiana was infected by *Fusicladium macrosporum*, *Hymenochaete noxia*, *Thyriduria tarda* and *Fomes semitostus*.

8. Anonymous (1941). South American leaf spot disease of *Hevea*. *Report Canal Zone Experimental Gardens*, 1940, p. 28-29.

   The outbreak of SALB coincided with the beginning of planting of rubber by Goodyear near Gatun Lake in 1935. The rubber planting materials originated either from Philippines or Panama Canal Zone where the first outbreak of SALB occurred in 1939. Many seedlings from Haiti were badly infected in an isolated site near Summit. These seedlings were apparently healthy in 1938.

9. Anonymous (1950). Natural rubber production in the western hemisphere. *World Crops,* 2: 75-77.

   The cooperative programme between USA and 12 Latin American countries to establish rubber production in the American tropics was documented. SALB is controlled by fungicides as well as top budding susceptible clone with a resistant crown.

10. Anonymous (1952). South American leaf blight. *Planters' Bulletin Rubber Research Institute Malaysia,* 3: 54-56.

    Measures against entry of SALB to Malaya were listed. These measures include introduction of legislation governing the importation of planting material, acquisition of resistant planting material, and development of measures to eradicate the disease should it enter into the country.

11. Anonymous (1953). South American leaf blight of rubber. *Planters' Bulletin Rubber Research Institute Malaysia,* 5: 35-38.

The symptoms of SALB with colour illustrations were presented and method of despatching suspected diseased specimen given.

12. Anonymous (1953). South American leaf blight. *Planter' Bulletin Rubber Research Institute Malaysia,* 5: 48.

    SALB was reported in the Republic of Honduras. Its spread to Central America from its source in the Amazon basin was believed to be through windborne spores.

13. Anonymous (1960). Secondary leaf fall and South American leaf blight. *Planters' Bulletin Rubber Research Institute Malaysia,* 46: 3-7.

    Symptoms of SALB were described to assist planters in the recognition of the disease.

14. Anonymous (1961). Jaarverslag 1960. *Meded. Landb. Proefst. Suriname* 25, 92 pp.

    Rubber plantings were kept free from *Dothidella ulei* by weekly fogging with 5 percent zineb.

15. Anonymous (1962). Plant quarantine announcements. *FAO Plant Protection Bulletin*, 9: 158-159.

    The article presents information on regulations governing importation of *Hevea* rubber to Malaya from South America.

16. Anonymous (1963). A note on *Hevea spruceana*. *Planters' Bulletin Rubber Research Institute Malaysia,* 67: 100-106.

    H. spruceana crown depressed growth and yield when crown budded onto *H. brasiliensis* trunk. However, as *H. spruceana* is resistant to SALB, it is valuable as a crown clone to overcome SALB.

17. Anonymous (1971). South American leaf blight: Precautions to be taken by visitors to and from Tropical America. *Planters' Bulletin Rubber Research Institute Malaysia,* 117: 333.

    Persons who visited SALB endemic countries should break their return journey in Europe or temperate North America. Precautions should be taken to ensure clothes and other personal belongings are free of *M. ulei*.

18. Anonymous (1972). South American leaf blight: measures against its introduction. *Planters' Bulletin Rubber Research Institute Malaysia,* 122: 161-164.

    SALB is still confined to South and Central America. The possible modes of entry into South East Asia and measures to prevent the introduction of SALB through planting materials and travellers were presented.

19. Anonymous (1976). Research on South American leaf blight at the Unit of the RRIM in Trinidad. *Planters' Bulletin Rubber Research Institute Malaysia,* 144: 69-72.

    The article presents research activities on SALB conducted by the Rubber Research Institute of Malaysia at the Unit in Trinidad and Tobago.

20. Anstead, R.O. (1919). *Hevea* leaf disease in Surinam. *Planters' Chronicle,* 14: 320-324.

    Occurrence of SALB caused by *Fusicladium macrosporum* was reported in Surinam, British Guiana and Brazil.

21. Araujo, A.E., Kalil, A.N. and Nobrega, M.B.M. (1997). Assessment of *Hevea* rubber tree genotypes to *Microcyclus ulei* to identify sources of horizontal resistance. *Acta Amazonica,* 27: 27-32.

The resistance of *Hevea* genotypes to *Microcyclus ulei* was evaluated. The latent period, lesion diameter, lesion type and reaction type were determined. Most of the clones are susceptible to at least one of *M. ulei* isolates. Genotypes that showed moderate resistance to one isolate were susceptible to other isolates. Clone Am/86/271 showed incomplete resistance characterized by longer latent period, smaller lesions and low sporulation. The genotypes evaluated were not suitable for breeding programmes for horizontal resistance.

22. Araujo, A.E., Kalil, A.N., Nobrega, M.B.M., Reis Sousa, N. and Dos Santos, J.W. (2001). Reaction of ten clones of *Hevea* (*Hevea benthamiana*) to three *Microcyclus ulei* isolates. *Acta Amazonica,* 31: 349-356.

Majority of the clones were resistant to the three isolates. Clones CNSAM 8218 and CNSAM 8219 were highly resistant. There was no interaction between clones and isolates for incubation period but interaction occurred between clones and isolates for lesion size. These clones exhibited characteristics of vertical resistance thus are not suitable as parents in breeding for horizontal resistance.

23. Aziz S.A.K. (1976). South American leaf blight: a proposed national and regional plan for emergency eradication. *ANRPC Technical Committee on SALB, 2nd Meeting, Bogor* 1976, 7 pp.

The article outlines measures against accidental introduction of SALB to the Far East.

24. Bancroft, C.K. (1913). A leaf disease of Para rubber. *Journal Bd Antic. British Guiana*, 7: 37-38.

SALB was found on nursery plants in British Guiana. The causal fungus was named *Passalora heveae* by G. Massee.

25. Bancroft, C.K. (1916). Report on the South American leaf disease of the Para rubber tree. *Journal Bd. Agric. British Guiana* 10: 13-23.

SALB was not a serious problem in British Guiana until 1916. The causal fungus *Fusicladium macrosporum* is propagated by three forms of spores.

26. Bancroft, C.K. (1916). Report on the Botanic Gardens and their work. *Report Department Science Agriculture British Guiana* 1915, 12 pp.

Several fungi were reported on *Hevea*. *Fusicladium macrosporum*, first recorded in 1909, occurred in all parts of the country.

27. Bancroft, C.K. (1917). The leaf disease of rubber: conditions in Surinam. *Journal Bd. Agric. British Guiana,* 10: 93-103.

SALB was more severe in Surinam than in British Guiana. There were 2 400 acres of *Hevea* and the epidemic occurred in 1914. Trees of all ages were attacked and died causing up to 1/3 losses in some holdings.

28. Bancroft, C.K. (1918). Disease in plants with special reference to fungi parasitic on crops in British Guiana. *Journal Bd. Agric. British Guiana*, 11: 47-57.

It was mentioned that *Melanopsammopsis ulei* occurred on *Hevea*.

29. Bancroft, C.K. (1919). Report on the Botanic Gardens. *Report Department Science Agriculture British Guiana*, 1917: 45-52.

Melanopsammopsis ulei was reported on rubber. SALB spread from indigenous rubber plants *(Hevea confusa)* in the forest.

30. Baptiste, E.D.C. (1961). Breeding of high yield and disease resistance in *Hevea*. *Proceedings Natural Rubber Research Conference, Kuala Lumpur,* 1960, p. 430-445.

The breeding and selection of *Dothidella*-resistant *Hevea* clones in Brazil was reviewed. The objective of breeding was to combine disease resistance with high yield from oriental clones using the backcross method of breeding. The susceptibility of clones to *Dothidella* and *Phytophthora* was presented. Examples on breakdown of disease resistance were presented and the importance and the need for diversification of highly resistant material for use in breeding were stressed. It was suggested that all natural rubber producing countries should co-operate and take joint action to implement projects with the assistance of an international body such as the FAO of the United Nations.

31. Begho, E.R., (1990). Biological characteristics of four races of *Microcyclus ulei*. *Indian Journal of Natural Rubber Research*, 3: 126-130.

The morphology of colonies and conidia, growth and sporulation of cultures, spore germination of eight isolates were presented.

32. Bekkedahl, N. (1945). Brazil's research for increased rubber production. *Science Month*, 61: 199-209.

Attempts at large scale *Hevea* cultivation were ruined by the endemic leaf blight caused by *Dothidella ulei*. Brazil possessed a wide selection of *Hevea brasiliensis* and other *Hevea* species. The leaf blight was controlled by crown budding.

33. Belgrave, W.N.C. (1921). Notes on the South American leaf disease of rubber. *Agriculture Bulletin Federated Malay States*, 9: 179-183.

The damage to *Hevea* caused by SALB in Surinam and British Guiana was reported. A visit in 1920 revealed that SALB was flourishing on nursery seedlings. Disease symptoms and the spore stages were described. In Guiana, wintering was not sharply defined as in Malaya; SALB may not therefore be severe in Malaya.

34. Belgrave, W.N.C. (1922). Notes on the South American leaf disease of rubber. *Tropical Agriculture,* 59: 109-113.

SALB was first attributed to *Fusicladium macrosporum*, later to *Passalora heveae* and finally to *Melanopsammopsis ulei*. It was present in Trinidad and British Guiana.

35. Bergamin Filho, A. (1982). Alternativas para o controle do mal das folhas da seringueira: uma revisao. *Summa Phytopathologia*, 8: 65-74.

Various possibilities to control *M. ulei* were discussed. It was concluded that horizontal resistance and chemical control proceeding artificial defoliation were the most promising alternatives to control SALB.

36. Bergamin Filho, A. (1984). Disease progress of South American leaf blight of rubber in different Brazilian region. *European Journal Forest Pathology*, 14: 386-391.

Abstract is not available.

37. Berger, P. (1992). Foliar phenolic compounds of the rubber tree and their implication in the resistance to *Colletotrichum gloeosporioides* and *Microcyclus ulei*. *Thesis, Universite de Montpellier 2 (France),* 235 pp. (In French).

Abstract is not available.

38. Bezerra, J.L., Castro, A.M.G., Vale, F.X.R., Rao, B.S., Souza, A.R., Araujo, A.C. and Neves, M.I. (1980). Controle quimico de *Microcyclus ulei* no Brasil atraves do PROMASE. Seminario Nacional da Seringueira, 3, 1980, Manaus. *Anais Brasilia, SUDHEVEA, 1980*, Vol. I, pp. 130-161.

Rubber plantations established after 1950 were planted with clones supposedly resistant to SALB. After an initial good promise the plantations faced disease problems within the first ten years after planting and some plantations were at the verge of being abandoned. In 1974, SUDHEVEA started a special programme (PROMASE) to rehabilitate the plantations to be economically productive. The plantations were sprayed with fungicides using helicopter to control SALB.

39. Blandin, J.J. (1941). Why rubber is coming home. *Agriculture America*, 1: 1-10.

SALB was one of the many problems encountered in starting a natural rubber industry in Central and South America. Research on the disease was initiated by Goodyear Plantations Co. in Costa Rica primarily to breed clones combining the high yield of Oriental clones with blight resistant South American clones.

40. Blazquez, C.H. (1959). Host-parasite relations of the fungus *Dothidella ulei* P. Henn. on *Hevea* rubber tree. *Ph.D. Thesis, University of Florida*, 97 pp.

Abstract presented in 40 and 41.

41. Blazquez, C.H. and Owen, J.H. (1957). Physiological studies of *Dothidella ulei*. *Phytopathology,* 47: 727-732.

D. ulei was grown successfully on an agar medium containing extract of 20 g rubber leaf and 2.5 g malt extract/l and on Difco LBA (23 g/l) + 200 mg quebrachitol. In semi-synthetic media containing vitamins and amino acids, the best growth was obtained in media with i-inositol + glutamine and nicotinic acid + glycine, and the highest conidial production was achieved with combination of riboflavin with glutamine, leucine, arginine or glycine. Both spermogonia and conidia formed on the fungal stroma. Conidial germination was best at pH 7-8 and at 24-28 ºC. Fungus cultured *in vitro* did not lose its pathogenicity to rubber.

42. Blazquez, C.H. and Owen, J.H. (1963). Histological studies of *Dothidella ulei* on susceptible and resistant *Hevea* clones. *Phytopathology*, 53: 58-65.

Growth of *D. ulei* in leaves of various stages of development was described: Black exudates were produced on stage 1 leaf (susceptible or resistant). Conidia germinating on resistant leaves produced abundant appressoria, but were few appressoria developed on susceptible leaf as the fungus penetrated directly into susceptible leaf. A yellow substance occurred in resistant tissue soon after penetration and also in old lesions in susceptible tissue. In highly resistant leaves (stages 1, 2 and 3) cells disorganisation occurred but no sporulation, stromatic mycelium or fructification were seen. Collapsed tissue was replaced by sclerenchyma-like cells with a positive tannin reaction; leaflets attained regular size and shape. On susceptible, mature leaves germination and penetration occurred, but the fungus did not develop further.

43. Bodkin, G.E. (1922). Report of economic biologist. *Report Department Science Agriculture British Guiana* 1920, 92 pp.

Rubber cultivation was abandoned as up to 95 percent of the trees were damaged by SALB. *Hevea confusa* and *H. guianensis* suffered to a lesser extent than *H. brasiliensis*. The ravages of the disease were particularly severe during protracted periods of heavy rainfall. Young leaflets shrivelled-up even hours after the buds burst. Even slightly infected trees decreased in yield. Every plantation had a few trees immune to the disease, but the reason for this was not known.

44. Bos, H. and McIndoe, K.G. (1965). Breeding of *Hevea* for resistance against *Dothidella ulei*. *Journal Rubber Research Institute Malaysia,* 19: 98-107.

A programme to breed *Hevea* clones resistant to SALB was initiated by the Firestone Plantations Company in 1949. Yield of introduced clones developed in Brazil were given. New crosses between susceptible and resistant clones were made in isolated seed gardens in Liberia. The progeny of these crosses were screened for resistance in Guatemala and Brazil. Yield of the resistant selections was tested in Liberia.

45. Brandes, E.W. (1943). Progress in hemisphere rubber plantation development. *India Rubber World,* 108: 143-145.

SALB, which caused the requiem for all early attempts to establish plantations in the Americas, was considered no longer a barrier to success. The disease can be controlled by protective measures. Cooperating with 14 Latin American countries and building on previous commercial work, the U.S. in 1940 began extensive expansion of the *Hevea* rubber industry, including establishment of experiment stations and nurseries and plant improvement by selection of wide varieties and breeding. Crown budding had controlled SALB.

46. Brandes, E.W. (1947). Progress towards an assured natural rubber supply. *India Rubber World,* 116: 491-497.

The efforts to establish *Hevea* plantations in Latin America by U.S. Government and Tire Companies were reported.

47. Brookson, C.W. (1956). Importation and development of new strains of *Hevea brasiliensis*. *Journal Rubber Research Institute Malaysia,* 14: 423-447.

Twenty-five selected *Hevea* clones and oil palm materials from Malaysia were exchanged for 25 *Hevea* clones resistant to *Dothidella ulei* with Brazil during 1953 to 1954. In the year 1951/l952, 1 614 seedlings of *H. brasiliensis, H. guianensis, H. benthamiana, H. spruceana* and *H. pauciflora* and their hybrids were also imported. Detail of the importation was described and a breeding programme and variety trials were established. The clonal material was exported to Ceylon, Indonesia and Indochina.

48. Camargo, A.P. de (1963). Possibilidades climaticas da cultura da seringueira em Sao Paulo. *Instituto Agronomico Campinas Boletim* 110, 24 pp.

It was mentioned that the climatic conditions in Sao Paulo is not favourable for the development of SALB.

49. Camargo, A.P. de, Cardoso, Rosa M.G. and Schmidt, N.C. (1967). Comportamento e ecologia do 'mal-das-folhas' da seringuiera nas condicoes climaticas do Planalto Paulista. *Bragantia*, 26: 1-17.

The development of SALB in relation to the phenology of the rubber plant grown in Sao Paulo was presented. During the four year study, susceptible clones planted in areas with low humidity were infected periodically. Infection generally occurred on leaf whorls that came out during January to May i.e. the period with most favourable humidity condition. Normally, only two to three whorls out of six whorls were infected per year. The whorls developing in September to December and plants planted on higher elevation in Sao Paolo were free of SALB.

50. Camargo, A.P. de, Schmidt, N.C. and Cardoso, Rosa M.G. (1975). South American leaf blight epidemics and rubber phenology in Sao Paulo. *Proceedings International Rubber Conference*, 1975, Kuala Lumpur, 3: 251-265.

The behaviour of South American leaf blight in relation to the phenology of the rubber tree was studied based on macro and micro climatic conditions in Sao Paolo. Young leaf flushes were infected from midsummer to mid autumn. In winter when the temperature was below 20 ºC, the lesion was generally non-sporulating. This behaviour along with complete defoliation during wintering season in late September contributed to low inoculum level in spring. Disease occurs in badly drained areas exposed to long lasting dew conditions. No SALB was observed in well drained areas and on upland areas. These areas may escape SALB.

51. Campanharo, W.E., Cecilio, R.A., Sperandio, H.V., Jesus-Junior, W.C. and Pezzopane, J.E.M. (2011). Modification of the climatic zoning of rubber trees for the Espirito Santo state, Brazil due to climatic change scenarios. *Scientia Forestalis Piracicaba*, 39: 105-116.

The potential impact of climate change on geographical distribution of rubber and *Microcyclus ulei* in Espirito Santo state, Brazil was presented. Espirito Santo climate is suitable for rubber cultivation in areas with little likelihood for South American leaf blight.

52. Cano, H.H., (1997). Physiological races of *Microcyclus ulei* in Mexico. *Proceedings Scientific Technological Meeting on Forestry, Agriculture and Husbandry Research in Vera Cruz State, Mexico,* 27-28 November 1997, p. 143-145.

53. Carefoot, G.L. and Sprott, E.R. (1969). Vulcan's victims: one life equals eight pounds. In "*Famine on the Wind - plant diseases and human history'*, p. 139-159.

The discovery of natural rubber and its usefulness led to the domestication of the crop. Central and South America would have become the world's leading producer of natural rubber, if not for SALB.

54. Carpenter, J.B. (1950). Plant pathological investigation in the United States. *Plant Disease Reporter, Supplement*, 191: 60-66.

Disease symptoms were described and measures to control the disease by fungicides or resistant clones in tropical America were presented.

55. Cayla, V. (1913). Maladis cryptogamiques des feuilles de 1' *Hevea* en Amerique. *Journal Agriculture Tropical,* 13: 186-188.

A review of the literature indicated that *Dothidella ulei* P. Henn., *Aposphaeria ulei* P. Henn. and *Fusicladium macrosporum* Kuyper were different forms of the same fungus. Trees in a water-logged situation were more severely attacked and cutting of diseased tissue was recommended as a remedial measure.

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

Spore germination varied from 90 percent in wet season to 10 percent in dry season. Germination of ascospore was consistently high. The survival period of the spores under various weather conditions was presented. Conidia in lesions survived longer at low temperature and under

desiccation (up to 25 weeks). Spore viability was shorter under high humidity. Ascospore from fallen leaves, probably, is the source of inoculum to initiate disease in a new season. Ascospore and also perithecia survived longer under dry condition. The diurnal spore release was also presented. More ascospores were trapped in the early morning or after a rain. No conidia were trapped during dry season but ascospores were trapped all year round. The degree of resistance of clones was proportional to lesion size on the leaves.

57. Chee, K.H. (1976b). Assessing susceptibility of *Hevea* clones to *Microcyclus ulei*. *Annals Applied Biology*, 84: 135-145.

Leaf disks of 7-day-old *Hevea* leaves floating on water produced lesions of varying sizes following inoculation with conidia of *M. ulei*. Based on 188 *Hevea* clones, lesion size on leaf disks correlated with leaf area infected in the field. Lesion size varied little with leaf age or inoculum level. Leaves treated with sodium hypochlorite and stored for three days could still be infected by desiccated conidia. The method is suitable for quick screening for resistance of rubber plants.

58. Chee, K.H. (1976c). South American leaf blight of *Hevea brasiliensis*: spore dispersal of *Microcyclus ulei*. *Annals Applied Biology*, 84: 147-152.

Trapping of ascospores and conidia of *M. ulei* among young trees of *H. brasiliensis* in Trinidad over a period of two years showed that ascospores occurred throughout the year whilst conidia were present only during the wet season. Peak ascospore concentrations occurred in August and November during the wet season. In dry weather, the number of ascospores increased during the night to a maximum at 06.00 hours, and decreased to a low level during the day. On rainy days heavy ascospore discharge also occurred during the day. Ascospore concentration decreased significantly after dawn on sunny days whilst on overcast days the concentration remained high most of the day. Conidia production was highest around 10.00 hours and decreased towards the evening, reaching a minimum at 07.00 hours.

59. Chee, K.H. (1976d). Factors affecting discharge, germination and viability of spores of *Microcyclus ulei*. *Transaction British Mycological Society*, 66: 499-504.

Ascospores of *M. ulei* are forcibly discharged in rapid succession when leaves are wetted at sub-ambient temperatures (14 ºC). Leaves which fall during wintering discharge ascospores readily after rain. Ascospores are released from green leaves throughout the dry season. Under moist conditions at 24 ºC, perithecia lose their viability after 12 days on green leaves and after 9 days on fallen brown leaves. At the optimum temperature (24 ºC), ascospores germinated in 2½ h in darkness and 6 h in light. Ascospores die at high humidity (>80 percent RH), but survived up to 15 days when kept dry in a desiccator. They were killed by 4 min exposure to ultra violet light. The percentage germination of fresh conidia was 10-90 percent whereas the percentage germination of ascospores was consistently high. The percentage germination of floating conidia and ascospores was higher than submerged spores. Conidia on sporulating lesions survived for several weeks at sub-zero temperatures or under desiccation. On glass slides, conidia survived for up to 16 weeks under desiccation and for 4 weeks at humidifies >65 percent. Conidial infection on leaf disks was most severe at 24 ºC and much less so at 28 ºC, suggesting that mean temperatures in Peninsular Malaysia are slightly above the optimum for SALB development.

60. Chee, K.H. (1977). Combating South American leaf blight of *Hevea* by plant breeding and other measures. *Planter, Kuala Lumpur*, 53: 287-296.

International co-operation in the enforcement of plant quarantine measures was presented. The potential of using various species of *Hevea* for breeding purposes was discussed. The performance of some progenies from crosses between high yielding and SALB resistant clones was presented. Thiophanate methyl and benomyl fungicides were effective in preventing infection as well as sporulation. The life cycle of the disease and the methods of control were illustrated diagrammatically.

61. Chee, K.H. (1978a). Evaluation of fungicides for control of South American leaf blight of *Hevea brasiliensis*. *Annals Applied Biology,* 90: 51-58.

Of 43 fungicides tested *in vitro,* 19 showed strong, seven moderate and 17 weak inhibitions of germination of conidia and ascospores of *Microcyclus ulei*. The formation of lesions on *Hevea brasiliensis* leaf discs was also suppressed by the first category of fungicides as well as by the five adjuvants tested. Ascospores release was inhibited following treatment of perithecia with urea, thiabendazole or alcoholic mercuric chloride at 10.0, 0.1, 1.0 g/l respectively; other fungicides had no such inhibitory effect.

In field trials, thiophanate methyl (0.07 percent a.i.) and benomyl (0.025 percent a.i.) were most effective, followed by chlorothalonil (0.15 percent a.i.) and mancozeb (0.32 percent a.i.) in controlling leaf infection. Benomyl suppressed conidial sporulation, whereas one application of thiophanate methyl (0.14 percent a.i.) to perithecia inhibited ascospore release; and when conidial lesions or pycnidia was treated with half of this concentration caused the perithecia formed subsequently to abort. Thiophanate methyl had promise to control and eliminate SALB and benomyl may be valuable in later rounds of spraying to control conidial sporulation. After six days of rain (2 mm for 17 min per day), water collected from sprayed leaves completely inhibited spore germination. However, inhibition markedly reduced after 6 days of heavy rain (over 8 mm for 24 min per day).

62. Chee, K.H. (1978b). South American leaf blight of *Hevea brasiliensis*: culture of *Microcyclus ulei*. *Transaction British Mycological Society*, 70: 341-344.

The best method of isolating *M. ulei* was to deposit fresh conidia on plain agar and then transfer it to potato sucrose agar (PSA). Some brands of agar inhibited growth and sporulation. Dried rubber leaf extract stimulated growth. Two morphological strains of *M. ulei* occurred amongst field isolations. The free sporulating strain appeared to be associated with resistant clones. One isolate produced ascospores. Plating laboratory-produced conidia produced three colony types. Variants with high degree of sporulation were obtained by successive sub-culturing of spores. Cultures from single conidium differed in mycelial growth and production of conidia and pycnospores. Single ascospore culture was uniform in appearance. The fungus grew best at 23 ºC, produced maximum conidia after three weeks, but optimum germination occurred with younger spores. Stromata were produced saprophytically on leaf disks bearing conidial lesions or pycnidia.

63. Chee, K.H. (1979). Movement of benomyl, thiophanate methyl and mancozeb on leaves of *Hevea brasiliensis* and their fungicidal action on *Microcyclus ulei*. *Proceedings Rubber Research Institute of Malaysia Planters' Conference, Kuala Lumpur*, p. 409-418.

The actions of three fungicides (benomyl, thiophanate methyl and mancozeb) were studied. Benomyl and thiophanate methyl were more persistent than mancozeb and moved into the cuticle more readily. Only the soluble form of benomyl could penetrate the lamina of 14-day old leaves. The three fungicides moved more readily through the abaxial cuticle or lamina. Conidial germination was not inhibited by the three fungicides at 5 μg/ml. In poison food test, mycelial growth was inhibited by benomyl and thiophanate methyl at 1 μg/ml and by mancozeb at 5 μg/ml. Conidia harvested from leaves sprayed with benomyl were less viable compared to conidia from leaves sprayed with thiophanate methyl or mancozeb.

64. Chee, K.H. (1980a). The suitability of environment conditions in Asia for the spread of South American leaf blight of *Hevea* rubber. *Planter, Kuala Lumpur*, 56: 445-454.

The article describes the role of spores in disease infection and their release and dispersal. The viability period of spores kept under various conditions were also presented. The weather conditions in Brazil and Trinidad and Tobago were compared with weather conditions in Malaysia

and Thailand. Based on the similarity of weather conditions, it was concluded that SALB would be severe in Malaysia and other neighbouring countries.

65. Chee, K.H. (1980b). Management of South American leaf blight. *Planter, Kuala Lumpur*, 56: 314-325.

Three approaches can be adopted to control SALB i.e. crown budding; breeding for disease resistant clones and application of fungicides. Crown budding using PA 31 as the crown showed promise. Emphasis on breeding should be to produce clones with horizontal resistance. The mechanics of fungicide control and the use of spray oils and surface active agents were discussed.

66. Chee, K.H. (1984). Improved control of South American leaf blight of *Hevea* in Brazil. *Journal Plant Protection in the Tropics,* 1: 1-7.

Three approaches to manage SALB were suggested i.e. crown budding, breeding for resistant clones and fungicide application. Breeding and selection should focus on breeding for clones with horizontal resistance. The aim of disease control is to reduce the amount of inoculum and also to reduce the rate of increase of disease. The theory related to the strategy was presented. When fungicides are used, there is a possibility of the pathogen developing resistance to a fungicide. This possibility was discussed. The effectiveness of fungicide can be increased with proper use of fungicide carriers and additives. Fogging of thiophanate methyl was effective on SALB. A disease control programme for SALB was presented.

67. Chee, K.H. (1985). An analysis of possible preventative measures against the introduction of South American leaf blight to Malaysia. *Regional Conference in Plant Quarantine Support for Agricultural Development, 1985, Kuala Lumpur, Malaysia,* p. 261-263.

Devastating consequences are likely to result if South American leaf blight (*Microcyclus ulei*) of *Hevea* rubber spreads to the Orient. Hence, high priority is given to erecting and maintaining effective quarantine barriers at the frontiers of SALB free regions. The conidia of *M. ulei* survived on commonly-used substances, such as cloth, polyethylene, glass, metal and paper, and in soil, for over a week. Travellers who have been to SALB-infected rubber-growing areas are recommended to pass through a temperate country and launder their clothing before returning. Soap solution at 40 mg/l as well as exposure to moist heat at 55 ºC or dry heat at 75 ºC for 30 min killed the conidia. Fumigation with formaldehyde (35 percent strength) at 100 ml/cu m was also effective. When the dosage is increased twice, it inhibited ascospore release. Ultra-violet light irradiation for 15 min killed most conidia, but all conidia were killed in the presence of low concentration of formaldehyde (50 ml/cu m). Plant quarantine officers, plant pathologists and rubber growers should know how to recognize the symptoms of SALB and a contingency plan should be ready to eradicate the disease should it occurs.

68. Chee, K.H. (1990). Present status of rubber diseases and their control. *Review of Plant Pathology*, 69: 423-430.

The major diseases of rubber, their distribution and economic importance and disease control methods were presented. SALB is a highly destructive disease. The merits and demerits of disease control by several methods including planting resistant clones, fungicide spraying, crown budding and planting rubber in escaped areas were discussed.

69. Chee, K.H., Darmono, T.W., Zhang, K.M. and Lieberei, R. (1985). Leaf development and spore production and germination after infection of *Hevea* leaves by *Microcyclus ulei*. *Journal Rubber Research Institute Malaysia,* 33: 124-137.

South American leaf blight (*M. ulei*) infection of *H. brasiliensis* caused a reduction of up to one-third in leaf size. The younger the leaf when infected the greater the reduction in leaf growth and the higher the percentage of leaf fall. Formation and size of conidial lesions, the degree of sporulation, the extent of stroma formation and leaf fall, differed among the ten clones examined. Abundant conidia but few stroma were produced on leaves of FX 985, FX 4163 and IAN 873, but the reverse occurred on clone FX 3864. Heavy stroma formation was not positively correlated with the degree of leaf fall among over 200 clones examined. Desiccated conidia after three months of storage were still capable of infecting *Hevea* leaves. Washing the conidia with water accelerated the production of germ-tube initials but did not lead to increased germ-tube growth. Shallow water was more favourable for development of germ-tube initials and germ-tubes. *Hevea* leaf diffusate from susceptible clones stimulated conidial germination, while that from resistant clones inhibited it. Viable conidia were stainable by acid fuchsin in acetic acid. The highest rate of germination of conidia was obtained from fourteen-day-old leaves and those produced during the months with least rain. Two-celled conidia germinated better than one-celled ones, which were produced in greater numbers during dry weather. Conidia removed by tapping lesion gave a higher rate of germination than conidia harvested by brushing or conidia produced at lower relative humidity instead of at saturation.

70. Chee, K.H., Darmono, T.W. and Santos, A.F. dos. (1986). Laboratory screening of fungicides using cellulose film and leaf discs against South American leaf blight pathogen, *Microcyclus ulei*. *Journal Natural Rubber Research*, 1: 98-103.

Cellulose film coated with fungicide was suitable to replace agar medium in laboratory screening of fungicides against *Microcyclus ulei*. It revealed the fungicidal, fungistatic and residue effects of the chemical examined. Discs of young *Hevea* leaves sprayed with a fungicide and inoculated with conidia also gave a good estimate of the effectiveness and curative property of fungicides. The effectiveness of chlorothalonil, mancozeb, tridemorph, dithianon, benomyl, triforine, triadimefon, carbendazim and thiophanate methyl on South American leaf blight was compared.

71. Chee, K.H. and Holliday, P. (1986). South American leaf blight of *Hevea* rubber. *Monograph No. 13, Malaysian Rubber Board,* 50 pp.

The monograph reviews the South American leaf blight (SALB) disease and the causal pathogen *M. ulei*. The review covers the pathogen especially its morphology, life history and the methods to culture the fungus. The economic importance of SALB, distribution and host range were also covered. The monograph also describes the symptoms, epidemiology of SALB and measures to control the disease.

72. Chee, K.H. and Wastie, R. L. (1980). The status and future prospects of rubber diseases in Tropical America. *Plant Pathology*, 59: 541-548.

The status of rubber diseases in the New World was reviewed. The most important disease in Brazil is South American leaf blight (*Microcyclus ulei*). With the exception of leaf wither and black stripe caused by *Phytophthora palmivora* in Bahia and possible target leaf spot (*Thanatephorus cucumeris*) in Manaus, other diseases are of minor importance. *Erinnyis ello* is the most serious insect pest. Research areas on SALB were suggested.

73. Chee, K.H., Zhang, K.M. and Darmono, T.W. (1986). The occurrence of eight races of *Microcyclus ulei* on *Hevea* rubber in Bahia, Brazil.*Transaction British Mycological Society,* 87: 15-21.

Conidia of *Microcyclus ulei* from infected leaves of 12 clones of *H. brasiliensis* and its hybrids with *H. benthamiana* were used to inoculate leaf disks of 19 selected clones of diverse genetic background. Eight physiologic races of *M. ulei* were distinguished. Races 1 and 2 have previously been recorded only from Central America whereas races 4, 5 and 6 (previously 4A, 4B and 4C) have been reported from Amazonas, Belem, and Bahia respectively. The new races 7, 8 and 9 are described, and a set of six clones (IAN 710, IAN 717, FX 2261, FX 985, FX 2804 and FX 25) is proposed for differentiating the eight races.

74. Commonwealth Mycological Institute (1975). Distribution maps of plant diseases, No. 27.

The disease was present in North America (Mexico); Central America and the Caribbean (Costa Rica, Guatemala, Honduras, Nicaragua, Panama, Trinidad and Tobago); and South America (Bolivia, Brazil, Colombia, French Guiana, Guyana, Peru, Surinam and Venezuela).

75. Compagnon, M.P. (1971). Note on the *Dothidella ulei* in Brazil. Mimeograph, 3 pp.

Clones FX 3810, FX 3925 and FX 3899 were resistant to SALB in most situations. Clones FX 25, FX 2261, FX 2804, FX 3864, IAN 873 and IAN 717 were variable in resistance depending on localities possibly connected to the occurrence of fungus races, climatic conditions and the phenology of the clones, an inherent character subject to modification by attacks of disease and growing conditions.

76. Compagnon, M.P. (1976). Note on the influence of climatic conditions on the spread of SALB. Mimeograph, 8 pp.

The severity of SALB in various localities in South America was related to the local climatic conditions. SALB has reached Haiti and evidence suggests it was brought over by wind and rain from Guiana and Trinidad. A similar explanation was given regarding a newly infected site in Venezuela. A new SALB-free planting in Guadeloupe provides a valuable site to confirm the above observation should SALB eventually reach Guadeloupe.

77. Compagnon, M.P. (1976). Review on progress and spread of SALB. *ANRPC Technical Committee on SALB 2nd Meeting, Bogor,* 1976, Mimeograph, 16 pp.

The geographical range of SALB has expanded since it was last mapped in 1970. The disease occurred a few months or a few years after rubber was planted and wind/rain was responsible for its spread. The current disease situation in Mexico, Guatemala, Haiti, Trinidad, Venezuela, Guiana and Brazil was discussed. Disease control by suppressing the 'over winter' ascospores was suggested but a fungicide for this purpose is yet to be found. Dithane M 45, benomyl, and thiophanate methyl are effective in controlling the infection. Application of fungicide by fogging appears promising. Crown budding *Hevea brasiliensis* with certain *H. pauciflora* clones did not seem to suppress yield.

78. Cuellar, A.S., Rodriguez, L.C.G. and Diaz, J.C. (2010). Incidence and severity of *Microcyclus ulei* in a collection of rubber tree in the Colombian Amazonia. *Ingeniarias and Amazonia*, 3: 93-104.

In Colombia, planting of IAN 873, IAN 710 and FX 3864 are widespread. However, these clones increasingly were infected by SALB. The susceptibility of 12 rubber clones to SALB was assessed. The incidence of SALB was influenced by rainfall regime and not by genotypes. However, rainfall and genotypes influenced severity of disease. More tolerant clones were MDF 180, FDR 5597, IAN 717 and FX 4098.

79. Darmono, T.W. and Chee, K.H. (1985). Reaction of *Hevea* clones to races of *Microcyclus ulei* in Brazil. *Journal Rubber Research Institute Malaysia*, 33: 1-8.

The resistance of over 100 progenies of *Hevea* species and their hybrids to SALB was tested in the laboratory. Clone MDX 42 was resistant while FX 2261 and FX 3864 were less susceptible to five races of *M. ulei*. FX 2261 was susceptible only to Race 1; clone FX 985 to Race 7 and Race 9 whereas FX 3864 was infected by all races of *M. ulei*.

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

The article describes the historical development of rubber cultivation in South America. In the event of SALB being introduced, it would wipe out the rubber industry in Asia.

81. Delamadi, L.C., Neto, D.C. and Rocha, V.F. (2009). Avaliacao do potencial do uso de Dicyma pulvinata no controle biologico mal-das-folhas (*Microcyclus ulei*) de seringueira (*Hevea brasiliensis*). *Ciencia Florestal*, 19: 183-193.

Matto Grosso state is a major producer of rubber with 45 727 ha in 2002. The occurrence of South American leaf blight, a major disease of rubber, is a factor limiting expansion in rubber cultivation. A promising option, biological control, could overcome the problem. This study evaluates the potential of *Dicyma pulvinata* to control *Microcyclus ulei* in comparison with chemical control. The studies were conducted in the field and green house. Three concentrations of *D. pulvinata*, benomyl, and mancozeb were evaluated. In the field, good control was obtained with application of *D. pulvinata* at 8.1×10^6 and 1.25×10^7 conidia/ml. In the greenhouse, better results were obtained with 2.025×10^7 and 3.037×10^7 conidia/ml.

82. Demmon, E.L. (1942). Rubber production opportunities in the American tropics. *Journal Forestry*, 40: 207-210.

Hevea may be grown successfully in many parts of Latin America. The main difficulty is SALB. Yields in Central and South America compare favourably with those of plantations in the Far East.

83. Denis, C., Troispoux, V., and Pinard, F. (2001). The South American leaf blight of the rubber tree due to *Microcyclus ulei*. *Phytoma la Defense des Vegetaux*, 535: 37-40.

South American leaf blight plays a major role in the reduction of rubber production in South America. The disease causes severe defoliation and death of trees. CIRAD conducts research on the disease in French Guiana on host pathogen interaction especially on resistance.

84. Deslandes, J.A. (1944). Observacoes fitopatologicos na Amazonia. *Boletim fitossanitario Ministerio Agricultur, Rio de Janeiro*, 1: 197-242.

Dothidella ulei was found on the dead branches of *Hevea*.

85. Djikman, M.J. (1951). *Hevea*, thirty years of research in the Far East. Miami Press, 329 pp.

SALB was a major consideration in the selection for resistance to diseases. It was mentioned that other workers observed that occasional trees in abandoned plantations in British Guiana were resistant to SALB.

86. Duarte, H.L.R., Albuquerque, F.C., Pinheiro, E. and Begeer, J.J. (1973). Control of wilting of foliage of rubber plants *(Microcyclus ulei)* through aerial spraying. Mimeograph, 9 pp.

Several fungicides (Benlate 0.6 kg/ha or 0.3 kg/ha, Dithane M45 0.6 kg/ha) were applied from the air. The percentage of leaves infected by SALB after treatment was 12 percent (Benlate 0.6 kg/ha), 25 percent (0.3 kg/ha or 77 percent (Dithane M45).

87. Ducke, A. (1946). Novas contribuicoes para o conhecimento das seringueiras da Amazonia Brasileira. *Boletim Tecnico Instituto Agronomico do* Norte, No. 10, 24 pp.

The number of *Hevea* species previously described was reduced from 24 to 12. Only nine species were recognised i.e. *H. guianensis, H. benthamiana*, *H. brasiliensis, H. viridis*, *H. pauciflora*, *H. comporum, H. spruceana* and *H. minor*.

88. Edathil, T.T. (1986). South American leaf blight: a potential threat to the natural rubber industry in Asia and Africa. *Tropical Pest Management*, 32: 296-303.

South American leaf blight (SALB) caused by the fungus *Microcyclus ulei* (P. Henn.) von Arx is the main limiting factor to the development of the natural rubber (*Hevea brasiliensis*) industry in South and Central America. It also poses a great danger to the rubber grown extensively in Africa and South East Asia. Disease distribution, epidemiology and spore viability, the risks of its entry into Asia and Africa and its possible behaviour in these countries were reviewed. Application of defoliants and fungicides, breeding for resistance and crown budding of high yielding panel clones with leaf blight-resistant crowns are measures to control SALB. As the existing quarantine regulations were inadequate, more rigorous measures are needed.

89. Feldman, F., Junqueira N.T.V. and Lieberei, R. (1989). Utilization of VA-mycorrhiza as a factor in integrated plant protection. *Agriculture, Ecosystem Environment*, 29: 131-38.

VA-mycorrhiza infected rubber trees were more resistant to South American leaf blight. Lesion size and spore production were significantly lowered in VAM inoculated plants, but the number of lesions remained unchanged. This suggests that the resistance response of the plant was influenced by VAM and demonstrates that enhanced resistance is not due to inhibition of penetration or early growing phases of the pathogen but was due to modification of late resistance responses. The increase in resistance by VAM inoculation is an important means to control the epidemiological development of the leaf disease. The chemical control measures are combined with plant management, breeding and use of hyperparasites in an integrated control system.

90. Feldman, F., Idczak, E., Martins, G., Nunes, J., Gasparotto, L., Preisenger, H., Moraes, V.H.F. and Lieberei, R. (1995). Recultivation of fallow low lying areas in Central Amazonica with equilibrated polycultures: Response of useful plants to monoculture with VA-mycorrhizal fungi. *Angewandte Botanik*, 69: 111-118.

Severity of leaf diseases caused by *M. ulei* and *Thanatephorus cucumeris* was not altered significantly by mycorrhizal treatment.

91. Fernando, E.B. and Ismail Hashim (1986). Reactions of oriental *Hevea* clones to isolates of *Microcyclus ulei* and response of isolates to fungicides. *Journal of Rubber Research Institute of Sri Lanka*, 66: 14-21.

The resistance of oriental clones especially those bred in Sri Lanka were tested against *M. ulei*. The responses of races of *M. ulei* to specific fungicides were presented.

92. Fernando, D.M and Liyanage, A. de S. (1975). *Hevea* breeding for leaf and panel disease resistant in Sri Lanka. *Proceedings International Rubber Conference, 1975, Kuala Lumpur*, Vol. III, pp. 236-246.

Preliminary studies on breeding for resistance to SALB were reported. The source of resistance for the breeding programme was from introduced clones such as FX 4098, FX 516, IAN 3434, IAN 2750, IAN 873 and IAN 710. These clones had been crossed with Sri Lankan clones. The initial yield of some of the progenies was presented.

93. Fernando, D.M and Liyanage, A. de S. (1980). South American leaf blight studies on *Hevea brasiliensis* selection in Sri Lanka. *Journal Rubber Research Institute Sri Lanka*, 57: 41-47.

The resistance of selected Sri Lankan clones to SALB was presented. Clones RRIC 119, RRIC 115, RRIC 117 and 6004 exhibited high degree of resistane but only RRIC 117 had favourable latex yield. Clones RRIC 121 and RRIC 130 had better yield and were also resistant to SALB.

94. Figari, A. (1965). Sustancias fenolicas toxicas al hongo *Dothidella ulei* en hojas de clones de *Hevea brasiliensis*. *Turrialba*, 15: 103-110.

Inhibition of conidial germination was greater in aqueous leaf extract of the resistant clone IAN 710 than in extract of the susceptible clone GA-1126. The toxic substance appeared as a yellow spot on chromatograms and was possibly a flavonol. Other phenolic compounds such as chlorogenic acid, caffeic acid and catechol were also highly toxic to *D. ulei*.

95. Fox, R.A. (1965). International plant protection and the FAO. *Research Archives Rubber Research Institute Malaysia,* 51, 25 pp.

The regional plant protection agreement established under the FAO. International Plant Protection Convention of 1951 was summarised. The Plant Protection Committee for S.E. Asia and the Pacific region recommended measures on movement of *Hevea* to safeguard against the introduction of SALB.

96. Furtado, E.L., Cardoso, R.M.G., Oliveira, D.A. and Rolim, R.R. (1991). Systemic fungicide effects on lifecycle of *Microcyclus ulei*, agent of South American leaf blight. *Summa Phytopatologica*, 17: 238-245.

97. Furtado, E.L., Menten, J.O.M., Carualho, J.C., Godoy Junior, G. (1995). Ergosterol synthesis inhibitors fungicides for South American leaf blight control. *Fitopatologia Brasileira,* 20: 203-207.

Abstract is not available.

98. Furtado, E.L., Menten, J.O.M. and Passos, J.R. (2008). South American leaf blight intensity evaluated on six clones of young and adult rubber trees in Vale do Ribeira region, Sao Paolo state, Brazil. *Tropical Plant Pathology,* 33: 130-137.

Rubber trees present different intensity of symptoms depending on their age. Evaluation of the intensity of symptoms on six clones of one and eight years old plants showed that young trees of clones FX 3864, IAN 717, RRIM 600, IAN 873 and mature trees of clones RRIM 600, IAN 717 and FX 3864 were severely infected. Mature IAN 873 was less severely infected as their leaf change was uniform and leaf refoliation occurred during the weather conditions not favourable to disease thus avoiding the disease.

99. Furtado, E.L., Sambugaro, R. and Mattos, C.R.R. (2004). SALB management. *IRRDB/Michelin/CIRAD International Workshop on SALB*, 2004, Bahia, Brazil, Mimeograph, pp. 7.

Various methods to control SALB were discussed. Various clones were recommended for planting in areas with different climatic conditions. Susceptible clones (RRIM 600, PB 235, PR 255, IAN 873) were recommended for disease escaped areas. In areas with more suitable climatic conditions for SALB, the above clones should be crown budded with *H. pauciflora* hybrids. Biological control of SALB with *Dicyma pulvinata* was effective. SALB can be controlled with various old and newer fungicides.

100. Garcia, D. (2004). Breeding CMB (CIRAD-Michelin-Brazil) clones. *IRRDB/Michelin/CIRAD International Workshop on SALB*, 2004, Bahia, Brazil, Mimeograph, pp. 3.

The SALB resistance breeding programme was presented. The genetic source of resistance was from the more resistant Wickham Amazonian clones. 212 clones were selected for further evaluation and 11 clones were evaluated under controlled condition.

101. Garcia, D., Cazaux, E., Rivano F. and D'Auzac, J. (1995). Chemical and structural barriers to *Microcyclus ulei*, the agent of South American leaf blight in *Heve*a spp. *European Journal of Forest Pathology*, 25: 282-292.

Six hours after inoculation, intense blue fluorescent light was emitted from the infection site. The speed of appearance of the discoloration correlated with degree of resistance of the clones i.e. faster in more resistant clones. This substance may be the coumarin scopoletin. Lignin accumulation also occurred following penetration of resistant clones. Accumulation of scopoletin and lignin was linked to resistance.

102. Garcia, D., LeGuen, V., Mattos, C.R.R. Gonsalves, P.S. and Clement Demange (2002). Relationship between yield and some structural traits of the laticiferous system in *Hevea* clones resistant to South American leaf blight. *Crop Breeding and Applied Biotechnology*, 2: 307-318.

Latex yield and six anatomical bark traits (average yield, girth, bark thickness, latex vessels ring number, density of latex vessel rings, diameter of latex vessels and average distance between latex vessel rings) were measured in a five year old clonal trial. There were considerable genetic variations between clones for average yield, bark thickness and number of latex vessel rings. The correlation between average yield and number of latex vessel rings was significant. Several SALB resistant clones with good yields were selected.

103. Garcia, D., Mattos, C.R.R., Clement-Demange, A. and LeGuen, V. (2004). Genetic parameter estimations of three traits used to evaluate South American leaf blight (SALB) in rubber tree. *Crop Breeding and Applied Biotechnology*, 2: 453-462.

Disease severity, sporulation density and stromata density were evaluated in the field on one to three year old trees. Results from small scale clone trials were better than seedling trials for individual values. There was high correlation between the three parameters.

104. Garcia, D., Mattos, C.R.R., Goncalves, P. S. and LeGuen, V. (2004). Selection of rubber clones for resistance to South American leaf blight and latex yield in the germplasm of Michelin Plantation of Bahia, Brazil. *Journal of Rubber Research*, 7: 188-198.

SALB is a threat to rubber cultivation in Asia and Africa which produced more than 98 percent of world's natural rubber. The performance of 36 clones from the Michelin Plantation in Bahia, Brazil was evaluated. Several clones were resistant to SALB and also high yielding. Clones MDX 624, FDR 5788, CD 1130, MDX 607, CDC 312, FDR 5665, FDR 5802 and CD 1174 were selected for further evaluation.

105. Garcia, D., Sanier, C. Macheix, J.J. and D'Auzac, J. (1995). Accumulation of scopoletin *in Hevea brasiliensis* infected by *Microcyclus ulei* and evaluation of its fungitoxicity to three leaf pathogens of rubber tree. *Physiological and Molecular Plant Pathology,* 47: 213-223.

Accumulation of a coumarin, scopoletin, occurred at the infection site of leaves inoculated with *M. ulei*. The degree of resistance of clones was related to the rapidity and intensity of scopoletin accumulation. In immune clones and clones with partial resistance, early accumulation of scopoletin occurred and lasted for more than 48 h. The level of partial resistance was positively correlated with scopoletin concentration. *In vitro* test indicated that scopoletin at 2 mm strongly inhibited germtube elongation and conidium germination. At 24 h after inoculation, conidia germination and number of infection sites were lower in resistant clones. Scopoletin was also toxic to *Colletotrichum gloeoeporioides* and *Corynespora cassiicola* but required higher concentration than for *M. ulei* to totally inhibit germination and germtube elongation.

106. Garcia, D., Troispoux, V., Grange, N., Rivano, F. and D'Auzac, J. (1999). Evaluation of the resistance of 36 *Hevea* clones to *Microcyclus ulei* and relation to their capacity to accumulate scopoletin and lignin. *European Journal of Forest Pathology*, 29: 323-338.

Thirty six *Hevea* clones were inoculated and components of resistance (latent period, infectious period, lesion size, percent leaf area damaged, lesion number, spore production, and stroma

generation period) were compared. Clones could be differentiated based on these parameters. Components with high correlation were spore production, size of lesion, number of lesion and percent leaf area damaged. Stroma generation period was slightly correlated with all the other components. Latent period and infectious period were lightly correlated with lesion size and lesion size was slightly correlated with lesion density. For disease screening purposes, the important components of resistance were spore production and percent leaf area damaged. Scopoletin production also correlated strongly with resistance.

107. Gasparotto, L., Albuquerque, P.E.P., D'Antona, O. de J., Ribeiro, I.A., Rodrigues, F.M. and Lim, T.M. (1985). Reabilitacao de seringais de cultivo na Amazonia. *EMBRAPA-CNPSD Boletim de Pesquisa*, 1, 30 pp.

Integrated Pest Management combining weed control, fertilizer application and fungicide spraying was evaluated to rehabilitate a rubber area seriously affected by SALB. One year before fungicide application, weed control and fertilizer application was carried out to boost growth of trees. During refoliation the following season, fungicide (mancozeb, thiophanate methyl and triadimephon) treatment was carried out. Spraying of the three fungicides improved canopy retention. However, only mancozeb was effective when applied by fogging.

108. Gasparotto, L. and Junqueira, N.T.V. (1994). Ecophysiological variability of *Microcyclus ulei*, causal agent of rubber tree leaf blight. *Fitopatologia Brasileira,* 18: 22-28.

The minimum period of leaf wetness required to cause infection and the effect of temperature on infection, incubation period, generation period, size of lesion and sporulation of six *Microcyclus ulei* isolates from different regions of Brazil were evaluated. At 24 ºC, the *M. ulei* isolate from Manicore-AM required only 3 hr of leaf wetness for infection while both the isolates from Manaus-AM and Viana-ES required 4 hr of wetness. On the other hand, the isolates from Itubera-BA and Registro-SP required 8 hr for infection. All isolate had similar effects of temperature on infection except the Viana isolate which infected and produced conidia at 16 ºC. These findings indicate the existence of ecotypes or ecological races of *M. ulei* able to cause disease under climatic conditions unfavorable for disease development.

109. Gasparotto, L, Zambolim, L., Maffia, L., Vale F.X.R., and Junqueira N.T.V. (1989b). Epidemiologia do mal das folhas da seringueira. I. Ponte Nova-MG. *Fitopatologia Brasiliera*, 14: 65-70.

110. Gasparotto, L, Zambolim, L., Ventura, J.A., Costa, H., Vale F.X.R., and Maffia, L. (1991). Epidemiologia do mal das folhas da seringueira no estado do Espirito Santo. *Fitopatologia Brasileira*, 14: 65-70.

111. Gasparotto, L., Zambolim, L. Junqueira N.T.V., Maffia, L.A. and Vale F.X.R. (1991). Epidemiology of South American Leaf blight of rubber tree: Manaus Region. *Fitopatologia Brasileira,* 16: 18-21.

Abstract is not available.

112. Gasparotto, L., Zambolim, L., Ribeiro do Vale, F.X. and Junqueira N.T.V. (1989). Effect of temperature and humidity on the infection of the rubber tree (*Hevea* spp.) by *Microcyclus ulei*. *Fitopatologia Brasileira,* 14: 38-41.

113. Giesemann, A., Biehl, B. and Lieberei, R. (1986). Identification of scopoletin as a phytoalexin of rubber tree *Hevea brasiliensis*. *Journal Phytopathology,* 117: 373-376.

Various fungi induced formation of a blue fluorescent substance, a phytoalexin, in rubber leaves. This substance was identified as scopoletin by chromatographic and spectrophotometric methods.

114. Gilman, G.A. (1963). Some problems associated with the culture of *Dothidella ulei*. *Thesis for Diploma in Tropical Agriculture, University of the West Indies,* 42 pp.

Mannose at 20 g/l was optimum for the growth of *D. ulei*. A mixture of mercuric chloride and propylene oxide was most effective for disinfecting rubber seeds.

115. Goncalves, J.R.C. (1967). Observacoes sobre resistencia de clones de seringueira a *Dothidella ulei*. *Boletim Informativo IPEAN 120*. Mimeograph, 2 pp.

The susceptibility of rubber clones to SALB was determined in different localities in Brazil based on the number of stroma produced, lesion development and sporulation.

116. Goncalves, J.R.C. (1968). The resistance of FX and IAN rubber clones to leaf disease in Brazil. *Tropical Agriculture Trinidad*, 45: 331-336.

The degree of resistance of rubber clones to leaf diseases in the Brazilian states of Amazonas, Para, Acre, Mato Grosso and Bahia were reported based on observation in clonal gardens and plantations. FX 3925 (one parent is F4542) was resistant to SALB. Clones IAN 710, IAN 713 and FX 2261 were susceptible.

117. Goncalves, J.R.C. (1970). Resistancia de clones de seringueira provenientes do Brasil e da America Central a 'Isolares' de *Dothidella ulei* sob condicoes de Cosa de Vidro. *Instituto Pesquisas e Experimentacao Agropecuarias do Norte Fito-tecnia*, 4: 27-43.

FX and IAN clones from Brazil and MDF, MDX and P clones from Central America were inoculated with four isolates of *D. ulei*. None of the clones was immune. The Brazilian isolates appeared to belong to Race 4. Observations were made on sporulation and viability of the fungus.

118. Goncalves, P. de S. (1968). The resistance of FX and IAN clones to leaf disease in Brazil. *Tropical Agriculture*, 45: 331-336.

119. Goncalves, P. de S., Fernando, D.M. and Rossetti, A.G. (1980). A nursery progeny test of SALB resistant hybrids of inter-specific crosses of *Hevea*. *Journal Rubber Research Institute Sri Lanka*, 67: 13-21.

Abstract is not available.

120. Goncalves, P. de S., Paiva, J.R. de and Souza, R.A. de (1983). Retrospectiva e atualidade do melhoramento genetico da seringueira (*Hevea* spp.) no Brasil e em paises Asiaticos. *Serie Documentos No. 2, EMBRAPA*, Brazil, 69 pp.

The history of rubber cultivation in Brazil was presented. The taxonomy of *Hevea*, method of *Hevea* breeding and the history and development of *Hevea* breeding in South East Asia and Brazil were also presented.

121. Grant, T.J. (1946). Cooperative rubber research in Costa Rica. *Agriculture America*, 6: 47-50.

SALB was detected in 1935. SALB was prevalent on the Atlantic slope at an elevation of 2 000 feet where humid weather and dew periods were long. Plants from Africa and Philippine were very susceptible. However, plants from South America were resistant.

122. Griffon, E. and Maublanc, A. (1913). Sur quelques champignons parasites des plantes tropicals. *Bull. Soc. mycol. Fr.*, 29: 244-249.

Dothidella ulei was recorded on *Hevea brasiliensis* in Brazil.

123. Guyot, J., Condina, V., Doare, F., Cilas, C.C. and Sache, I.I.(2010). Segmentation applied to weather-disease relationships in South American leaf blight of the rubber tree. *European Journal of Plant Pathology*, 126: 349-362.

South American leaf blight is managed by planting rubber in areas not conducive to the disease. However, knowledge on effects of climate on the disease is lacking. This knowledge would assist in identifying zones in Asia and Africa with high risks to the disease. Using the segmentation method, it is possible to list climatic factors that influence disease severity.

124. Guyot, J. and Doare, F. (2010). Obtaining isolates of *Microcyclus ulei*, a fungus pathogenic to rubber trees, from ascospores. *Journal of Plant Pathology*, 92: 765-768.

A technique was developed to isolate the fungus using ascospores in the stroma. The stroma was crushed and the ascospores were used in inoculation studies and successfully caused infection.

125. Guyot, J., Sache, I.I. and Cilas, C.C. (2008). Influence of host resistance and phenology on South American leaf blight of the rubber tree with special consideration of temporal dynamics. European Journal of Plant Pathology, 120: 111-124.

South American leaf blight is responsible to the insignificant rubber production in South America and is a threat to Asia and Africa. Clonal resistance influences disease severity, asexual sporulation, stroma density and disease dynamics at the leaflet level. Latent period and infection period were longer on more resistant clones. Stroma density was dependent on disease severity. The period of leaflet development also influenced disease development and the shorter the period, the less severe is the disease.

126. Hagen, J., Gasparotto, L., Moraes, V.H.F., and Lieberei, R. (2003). Reactions of cassava leaves to *Microcyclus ulei*, causal agent of South American leaf blight of rubber trees. *Fitopatologia Brasileira*, 28: 477-480.

Young cassava leaves inoculated with conidia induced formation of blue fluorescent compounds in the inoculation site causing leaf distortion and sometimes abscission. Restricted fungal growth developed but no sporulation occurred.

127. Hargis, O.D., Stakman, E.C., Johnson, K.E., La Rue, C.D., Sorensen, H.G. and Whally, W.G. (1946). Cooperative inter-American plantation rubber development, Colombia. *U.S.D.A. Washington D.C.* 1940.

SALB was present in the Leticia area and conditions of damp weather during eight months of the year were extremely favourable to its development. Many small seedlings however were absolutely disease free. The material would seem to possess an unusual degree of disease resistance.

128. Harrison, J.B. (1922). Report of the Department of Science and Agriculture for 1920. *Report Department Science and Agriculture British Guiana* 120, 35 pp.

Conditions affecting the development and spread of SALB were described.

129. Hennings, P. (1904). Fungi Amazonici II. *Hedwigia*, 43: 242-273.

New species: *Aposphaeria ulei, Dothidella ulei*.

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

Information on SALB and the causal fungus was reviewed. Disease spread and effects of the disease in tropical America were presented. Measures to prevent and combat the possibility of spread to Asia, particularly Malaysia were suggested.

131. Ho, C.Y., Tan, H., Ong, S.H., Sultan, M.O and Abdul Ghani, M.N. (1977). Breeding and selection strategies at the Rubber Research Institute of Malaysia. *Workshop on International Collaboration in Hevea Breeding, Kuala Lumpur*, Mimeograph, 13 p.

The problems hindering rapid *Hevea* improvement in the East were outlined. The RRIM breeding and selection strategies to alleviate these problems were presented. These include broadening the genetic base for field resistance to diseases particularly to SALB. Field or horizontal resistance is more stable against SALB than vertical or major gene resistance. Combining horizontal resistance with the 'early or off-seasonal wintering' or 'non-wintering' character is advantageous for 'disease escape'. Clone RRIM 600 and PR 107 appear to possess field resistance.

132. Hoedt, T.G.E. (1953). Opmerkingen over *Hevea*-selectie in Z.O. Azie en Latijns Amerika in verband methet optreden van *Dothidella ulei*. *Archive Rubberculture*, 30: 1-37.

The genetic factor for resistance to *D. ulei* may be present in the progenies of the Wickham seeds which have been used in all the rubber plantings of South East Asia. For instance, AVROS 1301 was highly resistant. A study of the fundamental reason for the resistance of different *Hevea* species and clones was suggested.

133. Hoedt, T.G.E. (1961). *Dothidella ulei* and the selection and breeding of *Hevea*. *Proceedings Natural Rubber Research Conference,* 1960, Kuala Lumpur, pp. 446-452.

The spread of *D. ulei* and its relation to climatic conditions were discussed. Disease control by fungicide spraying and the use of resistant planting material was also discussed. The yield of Brazilian and Far Eastern clones was compared.

134. Holliday, P. (1969). Dispersal of conidia of *Dothidella ulei* from *Hevea brasiliensis*. *Annals Applied Biology*, 63: 435-447.

Conidial production was maximum at 10.00 hours and minimum at night or in the early morning. Transient increases occurred after rain. On wet days almost equal numbers of conidia were dispersed between 10.00 hours and 12.00 hours. Large increases occurred following rain between 09.00 and 13.00 hours but no such increase occurred following rain after 13.00 hours. Twice the number of conidia was trapped on sunny days than on overcast days. The morning maximum spore caught was more pronounced on windy as compared to calm days. Conidial sporulation was low on drier days and sporulation was abundant on wetter days.

135. Holliday, P. (1970). *Microcyclus ulei* in *'IMI Description of Fungi and Bacteria', No. 23, Sheet 225, Cab International, U.K.*

The symptom of the disease caused by *M. ulei* was described and information on disease transmission, geographical distribution and hosts was also presented. *M. ulei* infects only *Hevea* species (*H. brasiliensis, H. benthamiana, H. guianensis* and *H. spruceana*). It infects young foliar parts of the plant i.e. young leaves, petioles, stems, inflorescences, flowers and fruits. The disease is spread by windborne conidia.

136. Holliday, P. (1970). South American leaf blight *(Microcyclus ulei)* of *Hevea brasiliensis*. *Phytopathological Papers No.12*, Commonwealth Mycological Institute, England, 31 pp.

The information on SALB was reviewed in considerable detail. It covers subjects on hosts, disease identification, fungal morphology, economic significance, distribution and disease spread, disease symptoms, life history and biology of the pathogen and disease control.

137. Honig, P., Vollema, J.S. and Kortleven, J. (1947). Selectie van *Hevea*. *Chron. Natur.,* 103: 63-67.

Cooperation between United States Department of Agriculture and Surinam over testing of American clones resistant to SALB was reported.

138. Hutchinson, F.W. (1958). Defoliation of *Hevea brasiliensis* by aerial spraying. *Journal Rubber Research Institute Malaysia,* 15: 241-274.

Defoliation of old rubber leaves was recommended as a measure to eradicate SALB. A defoliant, n-butyl 2, 4, 5-T sprayed from the air (5 percent (8 percent acid equivalent) in 3 gallon gasoline/ acre) was effective to defoliate the rubber trees. After one application, treated trees remained leafless for 4-6 weeks. Concentration was not critical in defoliation, but had marked effect upon the rate and amount of refoliation.

139. Ismail Hashim (1978). Histological and biochemical studies on South American leaf blight of *Hevea* species. Ph. D. Thesis, University of the West Indies, Trinidad and Tobago.

The development of the fungus in leaves from resistant and susceptible clones was presented. The activities of selected enzymes were presented and their possible roles in disease resistance were suggested. The anatomy of leaf abscission of infected leaves was compared with abscission caused by other factors.

140. Ismail Hashim (1979). Possible mechanism of *Hevea* resistance to South American leaf Blight. *ANRPC SALB Technical Committee Meeting*, 1979, Chiang Mai, Thailand.

The possible mechanism of resistance of *Hevea* to SALB was presented. The mechanism of resistance may be biochemical in nature. For certain clones, resistance may be linked to hypersensitivity. The roles and relationship of phenolic compounds and certain enzymes with resistance were presented.

141. Ismail Hashim (1979). South American leaf blight: Recent advances. *Planters' Bulletin Rubber Research Institute Malaysia*, 158: 20-24.

The methods to control SALB with fungicides and resistant clones were reviewed. The host parasite relation of *M. ulei* with *Hevea* was also presented.

142. Ismail Hashim (1980). Clonal characteristics and susceptibility of *Hevea brasiliensis* to *Microcyclus ulei*. *Proceedings Second South East Asian Symposium of Plant Diseases*, 1980, Bangkok, Thailand, 12 pp.

Clones of *Hevea brasiliensis* varied in their susceptibility to *Microcyclus ulei*. Host response to infection of susceptible and resistant clones and the anatomy of resistant and susceptible clones was presented. The clones differ in content of cuticular wax, total phenols and activities of certain enzymes but the contents did not correlate with resistance of clones. Conidia germinated readily on resistant and susceptible clones but the conidia developing appressoria were more numerous on resistant clones as compared to susceptible clones. Lesion formation and sporulation occurred earlier on susceptible clones than on resistant clones. The occurrence of cell collapse in some resistant clones inhibited disease spread. Following infection, the increase in activities of IAA oxidase and peroxidase was higher and occurred earlier in resistant clones as compared to susceptible clones.

143. Ismail Hashim (1983). Biology and economic importance of South American leaf blight of *Hevea* rubber. In '*Exotic Plant Quarantine Pests and Procedures for introduction of Plant Materials*,' ASEAN PLANTI, pp. 27-34.

The article describes the disease symptoms, the spores of *M. ulei*, the physiological races, spore production, liberation and the viability period of the spores. Information on methods of disease control was also covered.

144. Ismail Hashim (1986). Induced resistance of *Hevea* to South American leaf blight by incompatible races of *Microcyclus ulei*. *Journal Natural Rubber Research,* 1: 195-201.

Inoculation of leaf discs of *Hevea* by an isolate of *Microcyclus ulei* incompatible to a *Hevea* clone induced resistance to subsequent infection by a compatible race. Simultaneous inoculation of compatible and incompatible races reduced the size of lesions but not their numbers. Inoculation of an incompatible race 24-hour prior to inoculation of a compatible race reduced both the number and size of lesions. The reduction was proportional to the concentration of the incompatible race inoculum. On intact leaves, inoculation of a compatible race prior to an incompatible race reduced the number of lesions and the conidia produced.

145. Ismail Hashim (1988). Detection and characterisation of benomyl resistant strains of *Microcyclus ulei*. *Journal Natural Rubber Research,* 3: 155-162.

Benomyl resistant isolates of *Microcyclus ulei* were detected by inoculating potato sucrose agar medium amended with 1 mg/l benomyl. Race 6 and to a lesser extent Race 2 of the fungus had a higher frequency of yielding benomyl resistant isolates. Resistant isolates developed longer germtubes on benomyl-treated cellophane and required higher concentrations of benomyl to control infection. Benomyl resistant isolates were also cross-resistant to thiophanate methyl and carbendazim. Sporulation of a benomyl resistant isolate was not significantly reduced by the presence of low concentrations of benomyl or a benomyl sensitive isolate.

146. Ismail Hashim and Almeida, L.C.C. de (1987). Identification of races *and in vitro* sporulation of *Microcyclus ulei*. *Journal Natural Rubber Research,* 2: 111-117.

Culture characteristics viz. colony appearance, growth habits and *in vitro* sporulation of pure isolates of *Microcyclus ulei* from different *Hevea* clones were studied. The physiologic races of these isolates were identified by inoculating leaf discs and differential clones grown in polyethylene bags. The isolates could be classified into two morphological groups and four physiologic races i.e. Races 2, 4, 5 and 6. Generally, results of leaf discs were similar to those of plants in polyethylene bags.

147. Ismail Hashim and Aziz, S.A.K. (1983). South American leaf blight – Further measures against its introduction. *Planters' Bulletin Rubber Research Institute Malaysia,* 177: 128-132.

The quarantine measures to exclude the introduction of SALB into Malaysia were described. Travellers originating from SALB endemic areas are advised to take special precautions including breaking their return journey in temperate North America or Europe. In the event of an outbreak of SALB, a disease eradication procedure involving spraying of fungicide and defoliant will be undertaken.

148. Ismail Hashim, Chee, K.H. and Duncan, E.J. (1978). Reaction of *Hevea* leaves to infection with *Microcyclus ulei*. *Journal Rubber Research Institute Malaysia,* 26: 67-75.

The germination rate and length of the germ tube of conidia of *M. ulei* were similar on *Hevea* clones of different susceptibility at 12 h after inoculation but hyphal growth was slower on resistant leaves after 18 h. Appressoria were observed within 3-6 h on leaves of resistant clones and 12 h on susceptible ones. Penetration of the epidermis occurred within 12 h on both resistant and susceptible material, but internal spread was prevented in resistant leaves due to collapse of the epidermal and sub-epidermal cells. On less resistant clones, this collapse was delayed, and in susceptible clones was confined to the epidermis.

149. Ismail Hashim, Chee, K.H. and Wilson, L.A. (1980). The relationship of phenols and oxidative enzymes with resistance of *Hevea* to South American leaf blight. *Phytopathologische Zeitschrift,* 97: 332-345.

There was no direct correlation between total content of phenolic compounds in healthy *Hevea* and their degree of resistance to South American leaf blight (*Microcyclus ulei*). However, quercetin seemed to be higher in leaves from resistant clones. Total phenolic compounds and orthodihydroxyphenol contents in diseased resistant leaves were not significantly different from those in diseased susceptible leaves. IAA oxidase and peroxidase activities were generally higher in susceptible leaves and these enzymes increased with infection giving greater increases, and earlier detection, after infection of resistant leaves. Presence of growth substances reduced lesion size which could be related to increased peroxidase activities.

150. Ismail Hashim, Chee, K.H., Wilson, L.A. and Duncan, E.J. (1980). A comparison of abscission of rubber (*Hevea brasiliensis*) leaves infected with *Microcyclus ulei* with leaf abscission induced by ethylene treatment, deblading and senescence. *Annals Botany*, 45: 681-691.

Studies on the histology and on effects of growth substances and phenols as well as changes in activities of pectinmeythl esterase indicated that the mechanism of abscission of *Hevea* leaflets infected with *Microcyclus ulei* differed from the mechanism of abscission of debladed, ethylene treated and senescent leaves. An abscission layer which was formed during abscission of debladed, ethylene-treated and senescent leaves was absent during abscission of heavily diseased leaves. The ratio of pectinmethyl esterase activities in tissues distal to the abscission zone to activities in tissues proximal to the zone decreased in debladed and ethylene treated leaves but such decreases were not detected during abscission of *Hevea* leaves infected with *M. ulei*.

151. Ismail Hashim and Lim, T.M. (1983). Screening for defoliants of *Hevea* rubber leaves. *ANRPC SALB Technical Committee Meeting,* 1983, Kotayam, India, 6 pp.

Triclopyr at 250 g/ha was effective in defoliating mature rubber leaves. Triclopyr was recommended as an alternative defoliant to 2, 4, 5-T for emergency eradication of SALB.

152. Ismail Hashim and Pereira, J.C.R. (1986). Influence of resistance of *Hevea* on deveploment of *Microcyclus ulei*. *Journal Natural Rubber Research*, 4: 212-218.

The histological development of Race 2 of *Microcyclus ulei* and the components of resistance of 13 *Hevea* clones of various levels of resistance were compared. At least two mechanisms of resistance were observed. On the highly resistant clones, colony development was arrested early and sometimes host cell collapse occurred. On the marginally resistant clones, resistance arrested the development of some lesions while increasing the latent period and reducing the amount of conidia produced on others. On some marginally resistant clones (FX 4098 and FX 3864) and the susceptible clone SL 26, host cell collapse also occurred. *Hevea* clones with partial resistance to *M. ulei* could be selected by determining latent period and conidia production.

153. Ismail Hashim and Pereira, J.C.R. (1989). Lesion size, latent period and sporulation on leaf discs as indicators of resistance of *Hevea* to *Microcyclus ulei*. *Journal Natural Rubber Research*, 4: 56-65.

There were clonal differences in the rate of development of mycelium and appearance of lesions, size of lesions, latent period and the quantity of conidia produced on discs of *Hevea* leaves. There was a positive correlation between conidial production and lesion size, and negative correlation existed between conidial production and latent period and lesion size and latent period. Latent period and sporulation are also important components for assessment of resistance. Clones GT 711, RRIM 501, CNS AM 7701, SIAL 842 and SIAL 263 developed relatively smaller lesions, had longer latent periods and reduced sporulation. On these clones, the differences in lesion size were significant between clones but not between races of *Microcyclus ulei*. However, differences in conidial production between clones, races and the interaction between clones and races were significant.

154. Ismail Hashim, Wilson, L.A. and Chee, K.H. (1978). Regulation of indole acetic acid (IAA) oxidase activities in *Hevea* leaves by naturally occurring phenolics. *Journal Rubber Research Institute Malaysia,* 26: 105-111.

Indole acetic acid (IAA) oxidase activities of preparations from *Hevea* leaves were stimulated by 2, 4-dichlorophenol as well as by naturally occurring phenolics, p-coumaric acid, scopoletin, 4-methylumbelliferone and chlorogenic acid. Kaempferol and quercetin which had been associated with resistance to SALB were shown to function both as cofactors and as competitive inhibitors of *Hevea* leaf IAA oxidase. The contribution of these findings to the understanding of pathogenicity of SALB was discussed.

155. Jayasinghe, C.K. (1992). South American leaf blight: Likelihood behaviour in Sri Lanka and strategies in management. *Bulletin of the Rubber Research Institute of Sri Lanka*, 29: 21-26.

Abstract is not available.

156. Jayasekera, N.E.M. and Fernando, D.M. (1977). *Hevea* introduction (non-Wickham) into Sri Lanka. *Workshop on International Collaboration on Hevea Breeding, Kuala Lumpur*, Mimeograph, 4 pp.

Dothidella resistant clones of Latin American origin (F, FX, IAN) were introduced into Sri Lanka between 1955 and 1959. Clones with possible *Oidium* resistance include the *H. benthamiana* clone F 4542 and its progeny FX 590, FX 614, IAN 45-717, IAN 3793, IAN 3828, FX637 and FX 3810. Crosses of the introduced clones 2473, 6004, 5329 and 8798 were resistant to SALB; the latter clone was a cross between *H. spruceana* and LCB 1320.

157. John, C.K., Aziz S.A.K. and Subramaniam, S. (1976). South American leaf blight – an overview. *RRISL International Rubber Conference,* 1976, Sri Lanka, 16 pp.

A review covering dispersal of *Microcyclus* spores, possible introduction and behaviour in Asia, preventive measures and eradication, crown budding and chemical control and on breeding for disease resistance which is considered the most important. The Ford Motor Company breeding programme in Brazil had produced several promising clones such as FX 25, FX 3899 and FX 3164, while a similar effort by the Firestone Rubber Company in Liberia and Guatemala had created numerous resistant clones in their MDF and MDX series. Breeding for SALB resistance in Asia was primarily carried out by the Rubber Research Institutes in Malaysia and Sri Lanka. *Hevea brasiliensis* from Madre de Dios and *H. benthamiana* from Rio Negro were useful as sources of resistance against SALB.

158. Johnston, A. (1941). The Ford rubber plantations I. *India Rubber World,* 104: 35-38.

The effort of the Ford Motor Co. to establish rubber plantations in Brazil from 1927 to 1941 was documented. Eastern clones were introduced for source of high yield, and crown budding was considered the ultimate solution to the SALB problem.

159. Junior, J.H. (2010). Mal das folhas da seringueira: Danamica de inoculo do patogeno, progreso e danos em tres condicoes topograficas. Thesis, Universidade Federal do Vicosa, 91 pp.

The dynamics of the conidia and ascospores release, host phenology and disease progress, effects of tree height on disease severity and leaf production on tree growth were assessed. Ascospore and conidia were trapped throughout the period of study (18 months). Concentration of ascospores was higher at night but the conidia in the air were more during the day. Weather variables affect conidia concentration. Lower spore concentration in the air and less severe disease occurred on the hill tops disease was more severe in the lowland. Thus altitude affected disease severity. Yield was reduced by 47.7 percent in the lowland and leaf density reduced by 50.1 percent.

160. Junqueira, N.T.V. (1991). Controle biologico do mal das folhas da seringueira, Mimeograph, pp. 115-129.

The efficiency of mycoparasite *Dicyma pulvinata* and *Acremonium strictum* for biological control of *Microcyclus ulei* was evaluated. *A. strictum* was tested only under controled environmental-conditions. The control of *M. ulei* by *D. pulvinata* was satisfactory in plantations with intercalary lines of *Hevea* clones varying in resistance to this pathogen. Under controlled environmental conditions, both mycoparasites were able to colonize stromata and conidial phase of *M. ulei*. Recommendations for the utilization of these mycoparasites for integrated control of rubber tree leaf blight were presented.

161. Junqueira N.T.V., Alfenas A.C., Chaves, G.M., Zambolim L. and Gasparotto, L. (1987). Isoenzyme patterns of *Microcyclus ulei* isolates differing in virulence. *Fitopatologia Brasileira,* 12: 208-214.

Protein and isoenzyme patterns of *Microcyclus ulei* isolates differing in virulence were analysed on polyacrilamide gel electrophoresis. Gels were stained for α and β esterase (EST), malate dehydrogenase (MDH), lactate dehydrogenase (LDH), β-glucosidase (GLU), polyphenoloxidase (PPO), alcohol dehydrogenase (ADH), alkaline phosphatase (AP), tetrazolium oxidase (TO), hexokinase (HK) and peroxidase (PO). Better visualization of bands of enzyme activity was obtained by treating the stained gels with acetone. Electrophoretic data were compared to the virulence of the isolates. Isolates were classified into three groups according to their virulence. EST, LDH and PO patterns differentiated 6, 5 and 4 isolates, respectively. On the other hand, MDH and HK differentiated onIy 2 and 3 isolates, respectively. GLU, PPO, ADH and AP showed very low enzyme activity. The HM^{I} isolate was avirulent to all tested clones, nonsporulating, and displayed different isoenzyme patterns in comparison to the other isolates. Virulence of *M. ulei* isolates correlated with their isoenzyme patterns. It was concluded that the electrophoretic analysis of enzymes may be usefull to identify and characterize isolates of *M. ulei* varying in their degrees of virulence.

162. Junqueira, N.T.V., Chaves, G.M., Zambolin, L., Gasparotto, L. and Alfenas, A.C. (1986). Variabilidade fisiologica de *Microcyclus ulei* (Physiological variability of *Microcyclus ulei*). *Fitopatologia Brasileira*, 11: 823-833

The physiological variability of 16 isolates of *M. ulei* collected from rubber plantations in different regions of Brazil was studied by inoculations of different clones. At 15 days after inoculation, the diameter of lesions and sporulation was determined. The isolates showed a great physiological variation. Three groups of isolates of *M. ulei* were determined and were designated as Groups I, II and III. Isolates of Group I sporulated on all clones carrying the genes of F 4242 (*H. benthamiana*) and in the majority of clones of *H. brasiliensis*, but did not sporulate on clones MDF 180 and FX 985 (*H. brasiliensis).* Isolates of Group II sporulated on all or in the majority of clones of *H. brasiliensis*, including clones MDF 180 and FX 985, and on some clones with genes from F 4542. Isolates of Group III sporulated on the majority of clones with genes of F 4542 and on the majority of clones of *H. brasiliensis*.

163. Junqueira N.T.V., Chaves G.M., Zambolim L., Alfenas, A.C. and Gasparotto, L. (1988). Reaction of rubber tree clones to various isolates of *Microcyclus ulei*. *Pesquisa Agropecuaria Brasileira*, 23: 877-893.

The reactions of 33 clones of *Hevea* to various *M. ulei* isolates collected from rubber plantations in different regions of Brazil were studied. Isolates were inoculated with a suspension of conidia (2×10^5 conidia/ml). The clonal reaction varied with isolates and clones. Most of the clones showed complete resistance to some of the isolates, but the same clones were susceptible or highly susceptible to other isolates. Some clones showed complete resistance and varying levels of incomplete resistance. The latent period and the diameter of lesions may be related to *Hevea* resistance to *M. ulei*, but these two parameters are not sufficient to explain this resistance. The contribution of various other resistance components is needed. The most important component of resistance was "sporulation on lesions". The incubation period and number of lesions are not good parameters for analysing the rubber tree resistance to *M. ulei*.

164. Junqueira, N.T.V., Chaves, G.M., Zambolim, L., Romeiro, R.S. and Gasparotto, L. (1987). Isolation, culture and sporulation of *Microcyclus ulei*, causative agent of South American leaf blight of *Hevea* rubber trees. *Revista Ceres*, 31: 322-331.

This study was undertaken to evaluate several culture media to enhance spore production of *Microcyclus ulei*. Media were incubated in Erlenmeyer flasks at 24 ºC under an alternate regime of light periods (1 hr under a 40 W, fluorescent light, at 2000 lux, daylight, followed by 3 hr in the dark, repeated three times in the first 9 hr), followed by 15 hr in complete darkness. Each medium was inoculated with a mixture of mycelia and conidia harvested from a twelve-day old *M. ulei* culture. Maximum yield of conidia was obtained from a twelve-day old culture medium containing 6 g neopeptone, 10 g sucrose, 2 g KH_2P0_4, 1 g $MgS0_4.7H_20$, 20 g agar, and 2 ml of 'Panvit', a complex of mineral salts, vitamins and amino acids. Another culture medium with a per liter composition of 10 g sucrose, 2 g $K_2HP0_4.7H_20$, 0.25 percent w/v potato, 13 g of 'Bonzo' dog food and 1.5 ml of 'Panvit' also gave a good yield of conidia.

165. Junqueira, N.T.V. and Gasparotto, L. (1991). Controle biologico de fungos estromaticos causados de doencas foliares em seringueira. In 'Bettiol, W., ed., *Controle Biologicos de Doencas de Plantas'*, EMBRAPA-CNPDA, Brazil, Document 15, p. 307-331.

The effectiveness of *Dicyma pulvinata* to control *Microcyclus ulei* was experimented. *D. pulvinata* was isolated using potato dextrose agar supplemented with chloramphenicol (100 ppm). Spores produced in the laboratory were used to treat *M. ulei* on one year old rubber plants. The colonization of stromas of *M. ulei* by *D. pulvinata* varied with season. *D. pulvinata* successfully reduced the incidence of *M. ulei* in an area with polyclonal clones with heterogenous genetic lines. However, it did not reduce incidence in a monoclonal planting of IAN 717. This may be due to the ability of *D. pulvinata* to survive in a polyclonal area as leaves were present continuosly as compared to an area planted with a single clone.

166. Junqueira, N.T.V., Gasparotto, L.; Kalil Filho, A.N.; Lieberei, R. and Lima, M.I.P.M. (1989). Identificacao de fontes da resistencia ao *Microcyclus ulei*, agente causal do mal das folhas da seringueira. *Fitopatologia Brasileira*, 14: 147.

167. Junqueira, N.T.V., Lieberei, R., Kalil Filho, A.N. and Lima, M.I.P.M. (1990). Components of partial resistance in *Hevea* clones to rubber tree leaf blight, caused by *Microcyclus ulei*. *Fitopatologia Brasileira*, 15: 211-214.

Several components of resistance that reduced the rate of rubber tree leaf blight were evaluated. The components evaluated (susceptible leaf period, fungal pathogen generation period, number of fungal generations per leaf flush, lesion diameter and the spore production on the lesions) differed strongly among various clones of *Hevea*. These biological, plant inherent factors are suitable for use in controlling epidemic development of SALB. The utilization of these factors for rubber tree breeding for SALB resistance to *Microcyclus ulei* is discussed.

168. Junqueira, N.T.V., Lima, M.I.P.M., Gasparotto, L. and Luiz, A.J.B. (1992). Integrated control of rubber tree leaf blight, association between genetic resistance and chemical control. *Pesquisa Agropecuaria Brasileira*, 27: 1027-1034.

The efficiency of chemical control of leaf blight (*Microcyclus ulei*) on rubber tree clones varying in partial resistance to this disease was studied. In the field, leaf flushes were weekly sprayed once, twice, thrice or four times with a mixture of thiophanate methyl (0.125 percent) + triadimephon (0.025 percent) + methamidophos (0.06 percent). The first fungicide spraying was carried out during bud burst (A_2/A_3 leaf stage). The response to chemical control was proportional to the resistance level of the *Hevea* clones. The influence of each component of partial resistance on the effectiveness of chemical control of leaf blight was discussed.

169. Junqueira, N.T.V., Mevenkamp, G, Lieberei, R. and Normando, M.C.S. (1991). Resistance activation in rubber tree to leaf blight (*Microcyclus ulei*) by non-and weakly-pathogenic fungi. *Fitopatologia Brasileira*, 16: 268-270.

Conidia of *Periconia manihoticola* and *Corynespora cassiicola* (weak *Hevea* pathogens in Brazil), *Hansfordia pulvinata* (*Hevea* non-pathogen) and avirulent *Mycrocyclus ulei* isolates when inoculated in young *Hevea* leaves 24-hour before the challenge inoculation of a virulent *M. ulei* isolate, led to a distinct, but transient, resistance activation against the biotrophic leaf pathogen *M. ulei*. On pre-inoculated leaves, the *M. ulei* generation period was markedly enhanced while lesion diameter and spore production per lesion was reduced.

170. Junqueira, N.T.V., Moraes, V.H.F., Lieberei, R. and Gasparotto, L. (1993). Induced polyploidy potential for improving resistance in *Hevea* clones to Rubber Tree Leaf Blight. *Fitopatologia Brasileira*, 18: 12-18.

Components of resistance that reduce the epidemic rate of rubber tree leaf blight, were evaluated on colchicine-induced polyploids (CIP) *Hevea* clones and on their respective natural diploids after inoculation of virulent *Microcyclus ulei* isolates to the diploid clones. Some CIP clones presented high level of resistance in comparison to their susceptible diploid clones, whereas other CIP clones were susceptible. The polyploid plant inherent factors controlling resistance to *M. ulei* and the potential of induced polyploidy for control of SALB were discussed.

171. Junqueira N.T.V., Zambolim L., Chaves G.M., and Gasparotto, L. (1986). Sporulation *in vitro* and viability of conidia and pathogenicity of *Microcyclus ulei*. *Fitopatologia Brasileira*, 11: 667-682.

172. Kajornchaiyakul, P., Chee, K.H., Darmono, T.W., and Almeida, L.C. de (1984). Effect of humidity and temperature on the development of South American leaf blight (*Microcyclus ulei*) of *Hevea brasiliensis*. *Journal Rubber Research Institute Malaysia*, 32: 217-223.

Dry conidia of *M. ulei* require 6-8 hr of high humidity after deposition to infect young leaves of *H. brasiliensis*. After inoculation high disease intensity was observed on plants incubated at 19-22 ºC or 23-25 ºC, but little infection occurred at 26-29 ºC and none at 30-32 ºC. Lesion development was optimum at 23-25 ºC. Conidial sporulation occurred, between 19 and 28º C and was increased by high humidity, especially in the range 23-25 ºC.

173. Kalil-Filho, A.N., Lama M.A., Mestriner, M.A. and Del-Lama, M.A. (1995). Association between iso-enzymatic phenotypes and resistance to the fungus *Microcyclus ulei* in rubber tree clones. *Brazilian Journal of Genetics*, 18: 511-516.

Starch gel electrophoresis was done on 78 rubber clones. Seven enzymatic systems were studied. Association between specific enzymatic phenotypes and resistance indicates that selection for resistance is possible using these markers.

174. Kalil-Filho, A.N. and Junqueira, N.T.V. (2001). Correlacao fenotipicas entre vigor e resistencia ao mal das folhas no hibrido IAN 6158 × FX 985 da seringueira. *Communicado Tecnico*, 67, 4 pp.

Characteristics associated with vigour and resistance were evaluated. Phenotypic correlation existed in one of the progenies. Low positive (0.26) or negative correlation were obtained between vigour and resistance. These characters must be considered separately in breeding programmes.

175. Klippert, W.E. (1941). The cultivation of *Hevea* rubber in tropical America. *Chronicle Botany*, 6: 199-200.

The transfer of the industry from America to the Far East was the result of the successful method of cultivation in the Far East and also the presence of SALB in the Americas. Satisfactory progress is being achieved to bring back the rubber industry to western hemisphere.

176. Kuyper, J. (1912). Een *Fusicladium*-ziekte on *Hevea*. *Meded. Dep. Landb. Suriname*, 28: 1-10.

The causal fungus of SALB was described as *Fusicladium macrosporum*. The disease was not serious but was widespread in Suriname and in plantations and 'virgin' forest 38 m from the coast. *H. guianensis* was infected. Breading for disease resistance was discussed.

177. Kuyper, J. (1913). *Fusicladium* leaf disease of *Hevea* in Surinam. In Rubber disease: a warning. *J. Bd. Agric. British Guiana*, 6: 103-104.

Symptoms on leaves and leaf stalks were described. The causal fungus was named *Fusicladium macrosporum*. The fungus was difficult to culture. *Hevea guianensis* was also infected. Six-year-old trees were infected and killed.

178. Langdon, K.R. (1963). Culture and pathogenicity of *Dothidella ulei*. *Ph.D. Thesis, University of Florida,* 35 pp.

The subject of the thesis is described in the two papers below.

179. Langdon, K.R. (1965). Relative resistance or susceptibility of several clones of *Hevea brasiliensis* and *H. brasiliensis* x *H. benthamiana* to two races of *Dothidella ulei*. *Plant Disease Reporter,* 49: 12-14.

Hevea clones with F 4542 (*H. benthamiana*) parentage were more susceptible to Race 2 of *D. ulei* from Costa Rica than to Race 1 from Guatemala whereas those without F 4542 parentage were equally resistant or susceptible to both races.

180. Langdon, K.R. (1966). Development of a new medium for culturing *Dothidella ulei* in quantity. *Phytopathology*, 56: 564-565.

PDA with peptone, phytone, malt extracts (5 g/1) and yeast extract (0.5 g/l) supported best growth. The pathogen also grow on a basal medium containing 1 g NH_4NO_3; 0.3 g KH_2PO_4; 0.3 g $MgSO_4.7H_20$; 0.005 g $FeSO_4.7H_2O$ and 10 g glucose/1 and growth promoting substances - *Hevea* leaves, peptone or phytone. Sporulating cultures may be maintained by sub-culturing every 3 months; and virulence by passage through hosts every 6-12 months.

181. Langford, M.H. (1943). Fungicidal control of South American leaf blight of *Hevea* rubber trees. *Circular United States Department of Agriculture*, 686, 20 pp.

SALB could be economically controlled by weekly spraying with insoluble copper (basic copper sulphate, copper silicate, copper phosphate, copper oxychloride, cuprous oxide) or dusting with wettable sulphur, with the addition of a spreader (casein, wheat flour). Spraying high yielding, susceptible trees and top budding with resistant crowns is practical.

182. Langford, M.H. (1944). Science fights for healthy *Hevea*. *Agriculture America*, 4: 151-153, 158.

SALB was controlled using fungicides, crown budding and resistant clones.

183. Langford, M.H. (1945). South American leaf blight of *Hevea* rubber trees. *Technical Bulletin U.S. Department of Agriculture*, 882, 31 pp.

A report on the influence of environmental factors on severity of leaf blight severity and on resistance of *Hevea* plants obtained from many parts of the world. A technique for testing *Hevea* clones for resistance to SALB was described, and a system of classifying resistance or susceptibility was presented and illustrated.

184. Langford, M.H. (1946). Regional differences in resistance of *Hevea* selections to South American leaf blight. *Phytopathology*, 36: 686 (Abstract).

Hevea clones were grown in Costa Rica, Panama, Trinidad, Brazil and Peru. Clones that were highly susceptible in some areas were infected slightly or not at all in other areas.

185. Langford, M.H. (1953). *Hevea* diseases of the Amazon Valley. *Boletim Tecnico Instituto Agronomico do Norte*, 27: 1-28.

One of the diseases described was SALB which infected the leaves and could kill the plant. It was the most destructive disease in the Amazon Valley. Spraying of protective fungicides and planting of resistant clones were the means to control the disease.

186. Langford, M.H. (1957). The status of *Hevea* rubber planting material for use in tropical America. *Turrialba*, 7: 10-110.

Top budding SALB resistant crowns to susceptible panel clones did not depress yield significantly. However, the climatic conditions of a few areas in Latin America (notably the Pacific side of Guatemala) make it possible to grow blight-susceptible, oriental clones with their own crowns. The following blight resistant clones were mentioned to perform satisfactorily in Mexico, Central America and northern South America: FX 2261, IAN 873, IAN 717, FX 2187, IAN 710, IAN 713, FX 1042 and FX 25. The first four clones were also more resistant to *Phytophthora*.

187. Langford, M.H. (1960). A new strain of leaf blight on rubber trees in Costa Rica. Mimeograph, 2 pp.

Two new strains of *Dothidella ulei* were reported. One appeared in Brazil in 1946, attacking *Hevea brasiliensis* clones such as F 409 and F 1619 which were previously resistant to SALB. The other strain occurred in Costa Rica in 1959 attacking progeny of F 4542, originally a blight resistant *H. benthamiana* selection.

188. Langford, M.H. (1961). A new strain of leaf blight on rubber trees in Costa Rica (second report). Mimeograph, 2 pp.

Occurrence of a new strain of *M. ulei* in Costa Rica was reported. Clones that derived their resistance from sources other than F 4542 (such as IAN 500, 710, 713, 873, 833, 893 and FX 25) were more heavily attacked by the new strain than by previously existing strains.

189. Langford, M.H. and Echeverri, H. (1953). Control of South American leaf blight by use of a new fungicide. *Turrialba,* 3: 102-105.

Dithane Z 78 (zinc ethylene bisdithiocarbamate) applied every 8 days gave better control than the standard insoluble copper fungicide applied every 4 days. Parzate (same a.i. as Dithane) at

5-day intervals also gives excellent control and reduced infection to <1 percent. Both fungicides produced larger leaves and more vigorous growth than the copper sprays.

190. Langford, M.H. and Osores, A. (1965). Enfermedades del jebe y recomendaciones para su control. *Boletim Tecnico S I P A*, 63: 1-16.

Nine important diseases of *Hevea* in Peru (including SALB) were described under symptoms and method of control.

191. Langford, M.H. and Townsend, C.H.T. (1954). Control of South American leaf blight of *Hevea* rubber trees. *Plant Disease Reporter, Supplement*, 225: 42-48.

A review on selection of resistant clones, control with fungicides, top budding, breeding programme, specialisation of the fungus and long distance spread of the disease.

192. Lamont, N., Freeman, W.G., Warner, A. and Rogers, C.S. (1917). Rubber cultivation in Trinidad and Tobago. *Bulletin Department Agriculture Trinidad and Tobago*, 16: 95-152.

The only disease affecting *Hevea* in the region was SALB.

193. La Rue, C.D. (1926). The *Hevea* rubber tree in the Amazon Valley. *Bulletin United States Department of Agriculture,* No. 1422, 69 p.

The possibility of the introduction of SALB into the Orient exists. Best means of control is to plant resistant varieties. There is a need to introduce new species of *Hevea*. An account of trees yielding rubber and their geographical distribution in the Amazon Valley was presented.

194. Lebai-Juri, M., Bahari, I., Lieberei, R. and Omar, M. (1997). The effects of X-rays, UV, temperature and sterilants on the survival of fungal conidia, *Microcyclus ulei*, a blight of *Hevea* rubber. *Tropical Science,* 37: 92-98.

Contrary to earlier work where tap water was sufficient to induce germination, the conidia strains used in this study required nutrient to germinate. Radio-sensitivities (D_{10}) of conidia irradiated in air-equilibrium, oxygen and nitrogen-saturated tap water were 263, 119 and 333 Gy respectively. Conidia were inactivated by 60 min UV exposure, but temperatures of -74 ºC and -28 ºC failed to arrest germination. Commercial disinfectant arrested germination of conidia.

195. LeGuen, V. (2008). Exploration de la diversite des resistances genetique a la maladie sud americaine des feules de l/*hevea* par centographie et genetique d'association au sein population naturelles, Theses, Universite Montpellier, 184 pp.

Genetic mapping carried out on a resistant progeny revealed two major resistant genes. Analysis of genotypes indicated three main clusters corresponding to the three source states of Brazil. Genetic association with SALB resistant traits was located.

196. LeGuen, V., Garcia, D., Doare, F. And Mattos, C.R.R. (2011). A rubber tree's durable resistance to *Microcyclus ulei* is conferred by a qualitative gene and a major quantitative resistance factor. *Tree Genetics and Genomes*, 7: 877-889.

The components of genetic resistance from *Hevea* clone MDF 180 was determined by QTL mapping. The resistance of progenies from crosses between MDF 180 with and a susceptible clone was assessed following controlled inoculations by three races of *Microcyclus ulei* and also in the field. No resistant QTL was obtained from the susceptible clone. However, a qualitative gene responsible for resistance was isolated. The qualitative resistance gene was denominated M15md and was located in the linkage group g15. Four minor resistance QTLs were also identified.

197. LeGuen, V., Garcia, D., Mattos, C.R.R., Doare, F. Lespinasse, O.G. and Seguin, M. (2000). Bypassing of a polygenic *Microcyclus ulei* resistance in rubber tree analysed by QTL detection. *New Phytologist*, 173: 335-345.

Interval mapping and a non-parametric test were used to detect resistance QTLs. Eight significant QTLs were detected but only one contributed to partial resistance against a highly pathogenic isolate. No QTL was detected against the most pathogenic isolate of *M. ulei*. Unexpectedly, a single isolate can completely bypass partial resistance.

198. LeGuen, V., Garcia, D., Mattos, C.R.R. and Clement Demange (1995). Evaluation of field resistance to *Microcyclus ulei* of a collection of Amazonian rubber tree (*Hevea brasiliensis*) germplasm. *Crop Breeding and Applied Biotechnology*, 2: 141-146.

A collection of *Hevea* progenies from the IRRDB 1981 Expedition was assessed. 81 progenies originating from Matto Grosso were susceptible to SALB. More progenies from Acre and Rondonia were resistant to SALB. The resistance of progenies from Matto Grosso was unstable.

199. LeGuen, V., Guyot, J., Mattos, C.R.R., Seguin, M. and Garcia, D. (2008). Long lasting rubber tree resistance to *Microcyclus ulei* characterized by reduced conidial emission and absence of teleomorph. *Crop Protection*, 27: 1498-1503.

The resistance of MDF 180 to South American leaf blight (SALB) was studied. The clone produced sporulating lesions when inoculated but at moderate intensity thus depicting partial resistance. The teleomorph stage was never observed on this clone either following inoculations or in the field. Since this clone was resistant to SALB for more than 30 years, its resistance is durable. The yield of this clone is not high enough for commercial planting but this clone is suitable for SALB resistance breeding.

200. LeGuen, V., Lespinasse, O.G. and Rodier-Goud, M. (2003). Molecular mapping of genes conferring field resistance to South American leaf blight (*Microcyclus ulei*). *Theoretical Applied Genetics*, 108: 160-167.

The resistance of 192 progenies of plants in the field was scored based on resistance type (RT), presence of stromata (ST), and the level of attack (AT). The search for QTL was performed using the Kruskall-Wallis's tests. One major QTL located on linkage group G13 was detected on the RO38 map was responsible for 36-89 percent variance of resistance. This QTL was called M13-1bn. Other minor QTLs were also detected.

201. LeGuen, V., Rodier-Goud, M., Troispoux, V., Xiong, T.C., Brottier, P., Billot, C. and Seguin, M. (2004). Characterisation of polymorphic microsatellite markers for *Microcyclus ulei*, causal agent of South American leaf blight. *Molecular Ecology Notes*, 4: 122-124.

The process to design 11 microsatellite markers was described and the usefulness of the microsatellite markers was evaluated. Nine of the markers were polymorphic among six isolates from Brazil and four markers were polymorphic among four *M. ulei* isolates from French Guiana.

202. Lespinasse, D., Grivet, L., Troispoux, V., Rodier-Goud, M., Pinard, F. and Seguin, M. (2000). Identification of QTLs involved in the resistance to South American leaf blight (*Microcyclus ulei*) in the rubber tree. *Theoretical and Applied Genetics*, 100: 975-984.

Quantitative trait loci (QTLs) for resistance were mapped using 195 F1 progenies of PB 260 × RO 38. The response of the progenies was evaluated in controlled conditions following artificial defoliation with five isolates of *M. ulei*. All isolates infected PB 260 and four isolates did not infect RO 38 and one isolate infected RO 38 on lesser degree. The search for QTLs was performed using the Krunskal-Wallis method. Eight QTLs for resistance were identified on the RO 38 map.

Only one QTL was identified on the PB 260 map. A common QTL was detected for the five isolates. Two QTLs were common for complete resistance to four fungal strains. Perspectives for breeding for horizontal resistance were discussed.

203. Lespinasse, D., Rodier-Goud, M., Grivet, L. and Leconte, A. (2000). A saturated linkage map of rubber tree (*Hevea* spp.) based on RFLP, AFLP, microsatellites and isozyme markers. *Theoretical and Applied Genetics*, 100: 127-138.

The first genetic map of *Hevea* was presented based on 106 F1 progenies of PB 260 x RO 38. Homologous linkage groups between the two parental maps were merged and 717 loci formed the map including 301 RFLPs, 388 AFLPs, 18 microsatellites and 10 isozymes. *Hevea* origin and genome organisation was discussed.

204. Lesser, T. and Rodriguez, L.A. (1944). *Dothidella ulei* en Venezuela. *Boln. Soc. Venez. Cienc. Mat.*, 10: 117-119.

SALB was discovered on *Hevea* in Caripito, Venezuela. Disease symptoms, life history of the pathogen, mode of dissemination and environmental factors affecting disease development were described.

205. Lems, G. (1963). Verleden, heden en toekomst van de rubber culture. *Suriname Landbouw*, 11: 19-26.

The rubber industry in the colony was interrupted after the outbreak of SALB in about 1900. Attempt to restart the industry by replanting with resistant clones was described. The resistant clone IAN 45-17 was used in breeding programme.

206. Lieberei, R. (1986). Cyanogenesis of *Hevea brasiliensis* during infection with *Microcyclus ulei*. *Journal Phytopathology,* 115: 134-146.

Eight *Hevea* species were shown to be cyanogenic. They liberated HCN following mechanical tissue injury. Infection of *Hevea* leaves by *Microcyclus ulei* leads to a large reduction of hydrocyanic acid potential, while only small amounts of HCN were set free from the leaves into the atmosphere. HCN production by infected leaves followed a reproducible pattern with a maximum between 40 and 60 hours after infection. During the entire process of infection, free HCN can be detected in the leaves. High amounts of HCN were liberated from leaves of susceptible clones whereas only very little HCN was released from resistant clones. During *Hevea* infection with *M. ulei*, cyanogenesis does not lead to control of the fungal pathogen but impairment of the resistance reaction.

207. Lieberei, R. (1988). Relationship of cyanogenic capacity (HCNc) of the rubber tree *Hevea brasiliensis* to susceptibility to *Microcyclus ulei*, the agent causing South American leaf blight. *Journal Phytopathology,* 122: 54-67.

A high capacity for hydrogen cyanide liberation following infection was correlated with the susceptibility of rubber leaves to *M. ulei* infection.

208. Lieberei, R. (2000). Physiological characteristics of *Microcyclus ulei*, a fungal pathogen of the cyanogenic host *Hevea brasiliensis*. *Journal of Applied Botany and Food Quality*, 80: 63-68.

HCN was liberated from lesions during the development of fungus in the *Hevea* leaf tissues. Despite high liberation of HCN, the fungus developed hyphae. The reaction of *M. ulei* to HCN and the biochemical properties of β-glucosidase were reported.

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

Hevea contributes to the economies of many producing countries and especially to small farmers worldwide. SALB disease affects the development of the crop in South and Central America. The disease is still restricted to its continent of origin, but the risk of spreading around the world increases with transcontinental airline connection. There is an urgent need to develop control measures. All control efforts since 1910 failed even with new systemic fungicides and modern application methods. New areas of studies were suggested.

210. Lieberei, R., Biehl, B., Giesemann, A. and Junqueira N.T.V. (1989). Cyanogenesis inhibits active defense reactions in plants. *Plant Physiology*, 90: 33-36.

HCN was liberated from infected tissues following infection of the cyanogenic rubber tree (*Hevea brasiliensis* Muell. Arg.). HCN interferes with plant host and fungal pathogen. It inhibited active defence responses which were dependent on biosynthetic processes.

211. Lieberei, R., Junqueira, N.T.V. and Feldmann, F. (1989). Integrated disease control in rubber plantations in South America. *Proceedings Integrated Pest Management in Tropical and Subtropical Cropping System,* 1989, Germany, p. 445-456.

Rubber tree cultivation in South America is threatened by many factors and diseases. The most important factor retarding successful development of natural rubber industry in South America is SALB caused by *M. ulei*. This disease cannot be controlled by chemicals due to application problems. This paper reports on studies to find tolerant plant material, biological control procedures and plant management systems for successful establishment of rubber plantation. It was mentioned that *Hansfordia pulvinata* was effective for biological control of *M. ulei*.

212. Lieberei, R., Schrader, A., Biehl, B., and Chee, K.H. (1983). Effect of cyanide on *Microcyclus ulei* cultures. *Journal Rubber Research Institute Malaysia,* 31: 227-235

The influence of cyanide on cultures of *Microcyclus ulei*, a pathogen of the cyanogenic host *Hevea brasiliensis* was tested under laboratory conditions. Low cyanide concentrations promoted conidial germination and mycelial growth, while high concentrations inhibited fungal development and sporulation. Application of cyanide to young sporulating mycelia caused severe cessation of mycelial growth, indicating a higher sensitivity during this developmental stage.

213. Lim, T.M. (1982). Fogging as a technique for controlling rubber leaf diseases in Malaysia and Brazil. *Planter, Kuala Lumpur*, 58: 197-212.

In Malaysia, *Oidium heveae, Colletotrichum gloeosporioides* and *Phytophthora botryosa* annually cause severe defoliation of susceptible cultivars resulting in loss of tree vigour and latex yield The discovery of oil-based fungicidal formulation and the availability of powerful fogging machines, led to the successful development of ground thermal fogging as a novel, efficient and most economical method of applying fungicides to tall, mature rubber trees. Fogging tridemorph-in-oil thrice at 0.5 kg/ha/round at seven to ten day intervals gave better control of *O. heveae* than four to five weekly rounds of sulphur dusting especially when treatments meet with rainy weather. Against *P. botryosa*, pre-monsoon fog of captafol-in-oil at 1.7 kg/ha or copper-in-oil at 1.2 kg/ha effectively reduced leaf fall. Fogging of captafol-in-oil at 0.6 kg/ha/round or chlorothalonil-in-oil was effective against *Colletotrichum*, and fogging of the defoliant thidiazuron to hasten wintering was promising to avoid leaf diseases. Fogging covers 100 to 150 ha/day, a rate of spray five times faster than existing ground machines, resulting in 70 percent savings in application cost. SALB is the destructive leaf disease affecting rubber in the states of Bahia, Para, Amazonas, Acre and Sao Paulo of Brazil. Aerial spraying of benomyl (0.1 kg/ha) followed by mancozeb 91.6 kg/ha) and then thiophanate-methyl (0.2 kg/ha), in oil/water carrier, and ground fogging of the same fungicides in oil gave satisfactory control of the disease. Infection and defoliation caused *Pellicularia filamentosa* and *Catacauma huberi* reduced the benefit of control of SALB. Therefore fogging of fungicides effective against these diseases would be beneficial.

214. Lima, M.P.I.M., Gasparotto, L., Araujo, A.L. and Dos Santos, A.R. (1992). Surto do mal das folhas (*Microcyclus ulei*) em seringal enxertado com copa do clone IAN 6158 em Manaus. *Fitopatologia Brasileira,* 17: 192.

215. Lindsay, W.R. (1941). South American leaf disease of *Hevea*. *Annual Report Canal Zone Experiment Gardens*, 1939/40, p. 28-29.

SALB was unknown in Panama prior to 1935 but it appeared soon after the introduction of *H. brasiliensis* in experimental plantings, although the sources from which the introduced stocks derived were free from the disease. As *H. brasiliensis* does not occur in the native state in Panama, it was suggested that the fungus may occur there, on other indigenous trees.

216. Lins, A.C.R. and Brito, P.F.A. (1981). Avaliacao de 7 clones de seringueira quanto ao 'mal-das-folhas na micro-regiao Alta Purus-Acre'. *Fitopatologia Brasiliera*, 6: 509, 513.

Evaluation of clones IAN 717, IAN 873, FX 3899, FX 3810, FX 3864, FX 2261 and PFB 5 indicated that the most promising clones were FX 3899, IAN 717, PFB 5 and FX 3810. Clone FX 2261 was most susceptible and PFB 5 was most resistant to SALB.

217. Liyanage, A. de S. (1981). Long distance transport and deposition of spores of *Microcyclus ulei* in Tropical America – a possibility. *Bulletin Rubber Research Institute Sri Lanka*, 16: 3-8.

There was strong circumstantial evidence that the spread of SALB from the Amazon basin to the surrounding areas was through long distance dissemination and deposition of *M. ulei* spores. A scheme was suggested to confirm the evidence.

218. Liyanage A. de S. and Chee, K.H. (1981). The occurrence of a virulent strain of *Microcyclus ulei* on *Hevea* Rubber in Trinidad. *Journal Rubber Research Institute Sri Lanka,* 58: 73-78.

In Trinidad, many hitherto resistant *Hevea* clones were infected by *Microcyclus ulei* in recent years. A laboratory test of 37 rubber clones of diverse genetic backgrounds showed that conidial inoculum from a newly affected clone was more virulent than the previously existing fungus strain. The occurrence of more virulent strains rather than appearance of new physiologic races of *M. ulei* were responsible for the infection of resistant clones.

219. Mainstone, B.J., McManaman, G. and Begeer, J.J. (1977). Aerial spraying against South American leaf blight of rubber. *Planter's Bulletin Rubber Research Institute Malaysia,* 148: 15-26.

Several fungicides were applied aerially using an aeroplane to control SALB in a rubber plantation at Guama (Para). Better results were obtained when non-toxic low volatility spray oil was included in the spray mixture. Poor result was obtained in the trial at Una (Bahia) and this was attributed to poor timing of commencement of spray. In addition, the rates used there were too low and, spray oils were not used, and the spray interval was too long. However, ground applications did control SALB in Una and resulted in better canopies and higher latex yield relative to untreated controls.

220. Marassi, A. (1951). *Hevea brasiliensis*. *Riv. Aqric. Subtrop.*, 45: 176-178.

The *Hevea* development programme in Tingo Maria, Peru was presented. This included selection and propagation of material of high yield and resistance to SALB and other leaf diseases. Material from Costa Rica, Honduras, Haiti and Mexico, Fordlandia and Belterra (Brazil), Leticia (Colombia) and from the Peruvian forest was established to produce lines resistant to SALB.

221. Martains, E.M.F., Moraes, W.B.C., Cardosa, P.M.G. and Kuc, J. (1970). Purification and identification a substance connected with resistance in rubber (*Hevea brasiliensis*). *Biologico*, 36: 112-114.

The article reports on the methods used to isolate, purify and identify the substance developing in rubber leaves in response to infection by *M. ulei*. This substance was identified as kaempferol-3-rhamnodiglucoside. The substance strongly inhibited germination of conidia of *M. ulei*.

222. Martin, W.J. (1947). Diseases of the *Hevea* rubber tree in Mexico during 1943-46. *Plant Disease Reporter,* 31: 155-158.

SALB of *Hevea* caused by *Dothidella ulei* was included among leaf diseases and fungi recorded.

223. Martin, W.J. (1948). The occurrence of South American leaf blight of *Hevea* rubber trees in Mexico. *Phytopathology*, 32: 157-158.

SALB of *Hevea* was discovered in Southern Mexico in 1946 and subsequently the disease was found in most of the *Hevea* plantings in Mexico. The pathogen was probably introduced into Mexico through *Hevea* planting material introduced and planted about 1910. *Hevea* plantings in Guatemala, Honduras, El Salvador, Nicaragua, Haiti and the Dominican Republic apparently were still blight-free.

224. Matthews, G.A. (1976). Fungicide application for the control of South American leaf blight of *Hevea brasiliensis*. Mimeograph, 29 p.

SALB is a major cause of low yield of rubber in South America. The critical period for disease control is during refoliation following ‘wintering’. Fungicide sprays are recommended by sequential aerial application using 40-60 μm droplets during the refoliation period. This control technique has to be integrated with selection of resistant clones, use of fertilizer and insect control.

225. Mattos, C.R.R. (1999). Culture media containing green coconut water for sporulation of *Microcyclus ulei*. *Fitopatologia Brasilieira*, 24: 470.

Coconut water added to modified culture medium of Junqueira increased conidia production by 12 times.

226. Mattos, C.R.R. (2004). Crown grafting – a way of fighting the *Microcyclus ulei* - The experience at the Michelin Bahia Plantation. IRRDB/MICHELIN/CIRAD International Workshop on SALB, 2004, Bahia, Brazil, 3 pp.

227. Mattos, C.R.R., Garcia, D., Pinard, F., LeGuen, V. (2007). Variability of *Microcyclus ulei* from South East Bahia. *Fitopatologia Brasileira*, 28: 502-507.

South American leaf blight is the cause of poor rubber development in Brazil. Inoculation with 50 isolates of *M. ulei* on 12 rubber clones produced 36 variations of disease reactions. The intensity of sporulation varied between clones and isolates. Twenty one isolates were virulent on more than nine *Hevea* clones while no isolate was virulent on all the clones.

228. McRae, W. (1920). The Surinam or South American leaf disease. *Planters’ Chronicle*, 15: 303-305.

SALB caused by *Fusicladium macrosporum* put an end to rubber cultivation in Surinam.

229. Medeiros, A.G. (1973). Tecnica simples para isolar *Microcyclus ulei* (P. Henn.) v. Arx, fungo responsavel pela 'Queima sul-Americana' das folhas da seringueira. *Revista Theobroma*, 3: 57-76.

A technique for isolating *M. ulei* was described. A small block of agar was used to pick up the conidia from leaf lesions and then transfer to potato dextrose agar (PDA) media slants.

230. Medeiros, A.C. (1975). Novos conceitos tecnicos sobre controle quimico do 'mal-das-folhas' da seringueira. *Boletim Tecnico CEPEC-CEPLAC,* 35, 20 pp.

The life cycle of *Microcyclus ulei* consists of two months for stroma formation, two months for asci development and one month for ascospore maturation and discharge. The annual leaf change occurred gradually about five months for FX 25 and all year round for IAN 717. A new approach to disease control aims at disrupting the disease cycle by four rounds of fungicides i.e. two rounds during formation of stroma and two rounds during formation of young leaves. Artificial defoliation should be adopted to defoliate leaves before normal leaf change season.

231. Mello, D.F., Mello, S.C.M., Mattos, C.R.R. and Cardoso, S.E.A. (2008). Compatibility of *Dicyma pulvinata* with pesticides and biocontrol efficiency of South American leaf blight of rubber tree under field conditions. *Pesquisa Agropecuaria Brasileira*, 43: 179-185.

The fungus was incompatible with benomyl, carbendazim, mancozeb, propiconazole and endosulfan. Two isolates of *D. pulvinata* (CEN 62 and CEN 93) were as effective as propiconazole + mancozeb on the control of South American leaf blight.

232. Mello, S.C.M. de (2004). *Dicyma pulvinata*, a biological control agent for South American leaf blight (*Microcyclus ulei*). *IRRDB/Michelin/CIRAD International Workshop on SALB*, 2004, Bahia, Brazil, Mimeograph, pp. 5.

Aspects related to genetic and morphological variability, pathogen and antagonist interaction, production of conidial biomass and biological activity were presented.

233. Mello, S.C.M., Estevenato, C.E., Brauna, L.M., Capdeville, G., Queroz, P.R. and Lima, L.C. (2008). Antagonistic process of *Dicyma pulvinata* against *Fusicladium macrosporum* on rubber tree. *Tropical Plant Pathology*, 33: 5-11.

The interaction between *D. pulvinata* and F. *macrosporum* was studied using E.M. *D. pulvinata* parasitized the spores of *F. macrosporum* 24 h after inoculation causing the spores to disintegrate. The antagonist completely overgrew the pathogen and sporulated 6-7 days after inoculation. *D. pulvinata* also produced hydrolytic enzymes which could contribute to the parasitisation.

234. Mello, S.C.M, Santos, F., Silva, M. da J.B.T. (2006). *Dycima pulvinata* isolates colonizing *Microcyclus ulei* stromata in rubber. *Pesquisa Agropecuaria Brasileira*, 41: 359-364.

D. pulvinata is an efficient biocontrol agent of *Microcyclus ulei*. 52 isolates of the fungus were obtained in a survey of rubber plantations in several states of Brazil

235. Menten, J.O.M., Pereira, W.S.P., Godoy, Junior, G. And Cardoso, M. (1990). Two new fungicides for the control of South American leaf blight of the rubber tree. *Summa Phytopatologica*, 16: 275-278.

236. Miller, J.W. (1965). Biology of *Dothidella ulei*. I. *In vitro* production of toxin. II. Differential clones of *Hevea* for identifying races of the fungus. *Ph.D. Thesis University of Florida*, 19 pp.

M. ulei produced toxin in culture medium. Inoculation of leaflets with culture filtrate or mycelial

extract produced small flecks. No flecks developed on leaflets injected with boiled extract or filtrate. A set of differential clones (IAN 717, FX 3925, IAN 710 or IAN 713, MDF 180 and P 122) was used to differentiate four races of *M. ulei*.

237. Miller, J.W. (1966). In vitro production of toxin by *Dothidella ulei*. *Phytogathology,* 56: 718-719.

Fungus-free aqueous extracts and sterile culture filtrates of *D. ulei* caused leaf symptoms in inoculated seedlings similar to those produced by the fungus, indicating the presence of a toxin. Symptoms did not appear when filtrates had been boiled for 1 h or dialysed against water for 96 hr.

238. Miller, J.W. (1966). Differential clones of *Hevea* for identifying races of *Dothidella ulei*. *PIant Disease Reporter*, 50: 187-190.

Races 1, 2, 3 and 4 of *D. ulei* were differentiated using five *Hevea* clones. IAN 717 was highly resistant to races 1 and 4 but susceptible to 2 and 3. FX 3925 was susceptible to race 2 and resistant to race 3. IAN 710 or IAN 713 and P 122 were moderately resistant to races 1, 2 and 3. All clones were resistant to race l.

239. Moncure, R.C. (1946). Agricultural collaboration in Nicaragua. *Agriculture America,* 6: 10-11.

Eastern Nicaragua was one of the few areas in the Western Hemisphere free of SALB then.

240. Moraes, V.H. F., Moraes L.A.C. (2008). Effects of SALB resistant budded crowns on the yield and physiological parameters of *Hevea* latex (may be deleted).

The reported cases of yield reduction had discouraged a more intensive research on the use of SALB resistant budded crowns in Brazil. A strong depressive effect of *H. pauciflora* crowns budded on FX 3899 was found to be related to a lower Mg content affecting the latex regeneration, though an increase of the bursting index and a reduction of the duration of flow were also recorded. In an earlier yield test, the crown/trunk combinations Px/CNS AM 7905, Px/FX 985 and CBA1/ FX 985 displayed a relatively high yield. This was due to prolonged flow and latex regeneration, which was correlated to the inorganic phosphorus content. Except for FX 3899 with *H. pauciflora* crowns (low Mg), a normal response to stimulation with etephon was obtained. In both mature (FX 3899) and young trees, *H. pauciflora* budded crowns caused a significant increase of the thiols content. This deserves further studies in connection with resistance to bark dryness. The rise in R-SH did not correspond with increased membrane stability. The effects on sucrose, pH and total solids were discussed.

241. Moraes, V.H. F., Moraes L.A.C. (2008). Performance of rubber tree crown clones resistant to South American leaf blight. *Pesquisa Agropecuaria Brasileira*, 43: 1495-1500.

The performance of 18 South American leaf blight resistant clones used as crowns was evaluated. Eight hybrid clones of *Hevea pauciflora* × *H. rigidifolia* and two clones of *H. pauciflora* were used as crowns on IAN 7905. The crowns of *H. pauciflora* × *H. guaianensis* induced fastest girth increment. *H. rigidifolia* is resistant to *Leptopharsa heveae* and should be investigated as crown. Clones CPAA C01, 06, 13, 15, 16 and 45 are potentially high yielding.

242. Moraes, L.A.C., Moreira, A., Fontes, J.R.A., Cordeiro, E.R. and Moraes, V.H.F. (2011). Assessment of rubber tree panels under crowns resistant to South American leaf blight. *Pesquisa Agropecuaria Brasileira*, 46: 466-473.

The performance of 18 South American leaf blight (SALB) resistant clones (*H. pauciflora* × *H. guaianensis*) used as crowns was evaluated. Within the first three years of evaluation, panel clones IAN 2878, IAN 2903, CNS AM7905, CNS AM 7905P1 and PB 28/59 produced the highest

latex yield. Clones IAN 6158, IAN 6590 and IAN 6515 should not be recommended for crown budding. Higher potassium and copper foliar content in panel clones were associated with higher yield. Crown budding is an effective technology to manage SALB in its endemic areas.

243. Muller, E. and Von Arx, J.A. (1962). Die gattungen der didymosporem Pyrenomyceten. *Beitr. Kryptog. Flora Schweiz*, ll: 373.

The authors transferred the SALB causal fungus *Dothidella* or *Melanopsammopsis* to the genus *Microcyclus* Saccardo.

244. Neto, B.F., Furtado, E.L., Cardoso, R.M.G., Oliveira, D.A. and Roloim, R.R. (1991). Systemic fungicide effects on lifecycle of *Microcyclus ulei*, agent of South American leaf blight. *Summa Phytopatologica*, 17: 238-245.

245. Oliveira, D. De A., Cardoso, R.M.G., Brignane Neto, F., Furtado, E.L. and Rolim, P.R.R. (1986). Sanity index and number of plants by plot in function of *Microcyclus ulei* incidence in nursery of *Hevea brasiliensis*. *Fitopatologia Brasileira*, 11: 847-855.

246. Ong, S.H. (1980). Breeding for disease resistance. *Hevea breeding Course, Lecture notes,* pp. 1-13.

The best yielding progenies produced from crosses between oriental clones (RRIM 600, RRIM 623, Tjir 1, PB 86 and LCB 1320) with introduced South American clones (FX 25, F 351 and FB 3363) were screened against SALB.

247. Ong, S.H., Tan, A.M. and Chee, K.H. (1977). Breeding for resistance against *Hevea* leaf diseases. *Workshop on International Collaboration in Hevea Breeding, Kuala Lumpur*, Mimeograph, 9 pp.

The best yielding progenies of crosses between oriental clones (RRIM 501, RRIM 600, RRIM 623, Tjir 1, PB 5/51, PB 86 and LCB 1320) and resistant materials introduced from South America (FX 25, Ford 351, FB 3363) were screened for resistance to Gloeosporium leaf disease (GLD) and SALB. No clone was resistant to the two diseases. There was no association between resistance to GLD and SALB. A sizeable proportion, classified as moderately susceptible was likely to have field resistance to either GLD or SALB. A useful outcome of this programme was the production of a considerable number of clones which were superior to elite oriental selections in yield and vigour.

248. Ong, S.H., and Tan H. (1987). Utilization of *Hevea* genetic resources in the RRIM. *Malaysian Applied Biology,* 16: 145-155.

As the Wickham introduction has a narrow genetic base, new introductions of rubber from South America were made in 1950s, 1966 and 1981. The 1950s introduction was mainly low yielding. The introduced clones were crossed with local clones. The yield performance of the introduced clones and their progenies was presented.

249. Peralta, A.M., Furtado, E.L., Amorim, L., Menten J.O.M. and Bergamin-Filho, A. (1990). Breeding for resistance to South American leaf blight of *Hevea* rubber tree: review. *Summa Phytopathologica*, 16: 214-224.

Abstract is not available.

250. Pereira, J.L., Rao, B.S. and Ribeiro, J.L. (1980). Role of oil in fungicide formulations in the control of *Microcyclus ulei*. *Seminario Nacional da Seringueira E Simposio Internacional Sobre Borracha, 1980, Manaus, Anais,* Vol. 1, pp. 223-252.

Wettable powder formulations of fungicides used in the control of South American leaf blight of rubber (SALB) had been modified to include mineral oil in tank mix. Suitable water/oil formulations were investigated to obtain a reasonably stable tank mix with a minimum proportion of oil. This was done by first preparing a concentrated emulsion, and then diluted just before use. The role of oil in the technology of spray application and the effect of the water/oil/fungicide mix on disease control was assessed. This preliminary study suggested that oil-mixed sprays may not yield the beneficial effects attributed to them and their use should be urgently re-evaluated, especially in light of the very high cost of mineral oil.

251. Petch, T. (1914). The fungus diseases of *Hevea brasiliensis*. In *International Rubber Congress Batavia, Rubber Record*, 116-129.

The important *Hevea* root, stem and leaf diseases, including SALB were described.

252. Petch, T. (1921). The diseases and pests of the rubber tree. MacMillan, London, 278 p.

Description on symptoms of SALB, life cycle of the causal fungus which has numerous names and the damage on *Hevea* in Surinam, Guiana and Trinidad was presented.

253. Pinheiro, E. (1995). Reducing SALB risks – Cultivating rubber in 'escaped areas'. *Paper presented at a colloquium at the Rubber Research Institute of Malaysia*, 1995, 5 p.

M. ulei was prevalent in the humid areas and more than 50 strains of the fungus had been found. Efforts to control SALB by planting resistant clones and application of fungicides were not very successful. Crown budding may be more suitable. Planting of rubber in 'escaped areas' i.e. areas with 4-5 months of dry period (350 mm year and 60 percent RH). In Matto Grosso 'escaped areas', the clones planted were RRIM 600, RRIM 701, Gt 1, PB 235, PB 260, IAN 717, IAN 873 and IAN 3087. In the 'escaped areas' of Sao Paolo, RRIM 600, RRIM 614, PR 261, AVROS 1518, Gt 1 and PB 235 were planted.

254. Pinheiro, E. and Libonati, V.F. (1971). O emprego do *Hevea pauciflora* M.A. como fonte genetica de resistencia ao mal das folhas. *Polimeros*, 1: 31-39.

The history of breeding for SALB resistance was presented. The programme successfully introduced several promising clones in the IAN series. Unfortunately, the source of resistance was mainly from *H. banthamiana* especially F 4542. When a new race of *M. ulei* developed, most of these progenies were infected. Hybrids of *H. pauciflora* × *H. brasiliensis* were vigorous in growth and do not winter. Although the progenies were resistant to SALB, their yield was poor.

255. Pinheiro, E. and Lion, A. (1976). Perspectivas do emprego da *Hevea pauciflora* na enxertia de copa de seringueira. II. Seminario *Nacional da Seringueire, Rio Bianco, Acre*. Mimeograph, 11 pp.

Clones recommended for large-scale planting differ in their susceptibility to SALB. Crown budding offers a method of disease control. The method is so advanced that it is now used on a large scale. Some clones of *H. pauciflora* are outstanding in that it is disease resistant and when used as crowns improved stem girth. Promising yield was obtained. More research should be directed towards the use of *H. pauciflora* as crown clones and its susceptibility to other leaf and stem diseases.

256. Pita, F.A.D.O., Junqueira, N.T.V., Alfenas, A.C. and Cano, M.A.O. (1992). Phenolic regulation of resistance to *Microcyclus ulei* infection in *Hevea* progenies. *Pesquisa Agropecuaria Brasileira*, 25: 1193-1200.

Three *Hevea* clones (FX 25-moderately susceptible, FX 2804 – highly susceptible and P10 - resistant) with different levels of resistance to *M. ulei* were studied. Phenol, anthocyanin and chlorophyll contents were determined from inoculated and non-inoculated leaflets. Progenies FX 25 and FX 2804 had low phenol content, decreased levels of chlorophyll and heavy damage and sporulation. Progenies P10 had high levels of phenol and chlorophyll, compared to the control. It did not show any damage. The anthocyanin levels decreased in all progenies. *Hevea* resistance to *M. ulei* infection seems to be related to variations of leaf phenol content.

257. Polhamus, L.G. (1962). Rubber. Leonard Hill, London, 448 pp.

Investigation on *Hevea* species other than *H. brasiliensis* and international exchange of breeding material was recommended in the effort to combat SALB.

258. Rands. R.D. (1924). South American leaf disease of Para rubber. *Bulletin United States Department of Agriculture*, 1286, 18 pp.

P. Hennings described the causal fungus of SALB as *Dothidella ulei* from material collected in Acre by E. Ule in 1901-1902. Only the perfect and pycnospore stages were described. In 1910, A.W. Drost drew attention to SALB in Surinam. In 1911, Kuyper described the disease in Surinam and the conidial stage as *Fusicladium macrosporum*. In 1929, V. Cayla collected spores from Para and sent to Griffon and Maublanc who identified the fungus as *D. ulei* and the conidia as *Scolecotrichum*. In 1913, Bancroft reported the conidia as *Passalora heveae* by Massee. In 1914, Petch considered that only one fungus was responsible for these various diseases reported. In 1917, Stahel compared various collections, and concluded that only one fungus was involved and erected the new genus, *Melamnopsammopsis*. In 1917, Rorer thought SALB had been in Trinidad for several years but considered it less serious than in the Guianas because of less favourable weather. Since 1917, SALB had forced the abandonment of rubber in British Guiana and Surinam. The paper also describes the disease symptoms, spread, biologic and climatic factors affecting the disease and control stressing on plant quarantine.

259. Rands, R.D. (1942). *Hevea* rubber culture in Latin America, problems and procedures. *India Rubber World,* 106: 239-243.

A diagrammatic outline on the intergovernmental breeding and selection project for development of SALB resistant superior yielding clones was suggested. This involves crossings between the highly susceptible clones of the East with the most resistant and highest yielding Amazonian selections. For commercial plantings in SALB-free areas, a mixture of three groups of clones was recommended i.e. oriental clones which are tolerant to leaf blight; Latin American clones moderately resistant to leaf blight; and Brazilian Ford clones highly resistant to leaf blight. In areas infected with leaf blight, only the last group should be planted. Closely spaced plantings of a mixture of some half dozen clones from these different groups provide insurance against leaf blight. Alternative procedures were suggested for safe and immediate utilization of the first group of clones. These include top-budding with highly resistant seedling material and a rotational planting scheme.

260. Rands, R.D. (1946). Progress on tropical American rubber planting through disease control. *Phytopathology*, 36: 688 (Abstract).

Control of SALB by spraying or crown budding enabled the use of the high yielding oriental clones in tropical America. In 1944 more than 28 000 acres of high-yielding rubber had been planted. Further, breeding programmes produced thousand of first and second generation hybrids, some of which indicated superior yield and blight resistance.

261. Rands, R.O. and Brandes, E.W. (1945). Plants and plant science in Latin America. *Chronica Botanica Co., Waltham, Mass.*, 37: 182-201.

The use of selected clones resistant to *Dothidella ulei* and crossing of high yielding, susceptible eastern clones with resistant Amazon selections was recommended. The clones recommended for breeding purposes was listed.

262. Rao, B.S. (1972). Regional cooperation in measures against introduction and spread of South American leaf blight. *IRRBB Meeting, Medan* 1972, 7 pp.

Measures recommended against the introduction of SALB include strengthening plant quarantine, prompt action on disease eradication and establishment of country and regional committees entrusted with the duty to prevent the introduction and spread of SALB.

263. Rao, B.S. (1973a). Potential threat of South American leaf blight to the plantation rubber industry in the Southeast Asia and Pacific region. *FAO Plant Protection Bulletin*, 21: 107-113.

The symptoms of SALB, the possibility of introduction into South East Asia and Pacific region and the likely behaviour in the region were presented. SALB was predicted to be very destructive if it occurs in the region. Quarantine measures against the introduction and spread of SALB presented. An effective phytosanitary barrier is the only means to prevent introduction of SALB to the region. From its first appearance in a country, its spread to neighbouring territories would be rapid. Measures for its exclusion and preparedness are joint responsibility of rubber-growing countries.

264. Rao, B.S. (1973b). Some observations on South American leaf blight in South America. *Planter, Kuala Lumpur*, 49: 2-90.

All the commercially planted clones differ in their resistance to SALB in different locations in Brazil and Trinidad. Thus, disease screening should be carried out in many climatic regions and against diverse races of the fungus.

265. Rao, B.S. (1973c). South American leaf blight: chances of introduction and likely behaviour in Asia. *Quarterly Journal Rubber Research Institute Sri Lanka,* 50: 216-222.

The mechanism of dissemination of *Microcyclus ulei* was described with a view to assess the possibility of its spread outside tropical America. Should SALB be introduced to Asia, its importance in different localities was likely to vary, depending upon the intensity and distribution of rainfall. The epidemiology of the fungus suggests that it could behave more like *Colletotrichum gloeosporioides* leaf disease.

266. Rao, B.S., Ribeiro, J.O., Bezerra, J.L. and Ribeiro do Vale, F.X. (1980). New approaches to control of the major leaf diseases of rubber in Bahia. *III Seminario Nacional De Seringueira, 1980, Manaus, Brazil,* 15 pp.

Considerable effort and expenditure were incurred each year for spraying fungicides to obtain some measure of control of the most destructive leaf diseases caused by *Microcyclus ulei* and *Phytophthora palmivora*. Fungicides that were effective against both diseases were screened. The possibility of adopting simpler and cheaper disease control techniques i.e. by disease avoidance following artificial defoliation, improving tree vigour by manuring, and integration with limited fungicidal application was discussed. More flexible alternatives to the aerial spraying were considered for chemical control.

267. Rivano, F. (1992). South American Leaf Blight; Study in natural and controlled conditions of the partial resistance components to *Microcyclus ulei*. *Ph.D. Thesis, Universite de Paris-Sud, Orsay (France)*, 257 pp.

Abstract is not available

268. Rivano, F. (1997). La maladie sud-americaine des feuilles de l'*heveae* I. Variabilite du pouvoir pathogene de *Microcyclus ulei*. *Plantations, recherche, developpement,* Mai-Juin, pp. 104-110.

South American leaf blight caused by *Microcyclus ulei* remains the main obstacle to the development of rubber, cultivations in Latin America. As early as 1960, *M. ulei* overcame the resistance derived from inter-specific crosses. Studies of variability in clonal responses to SALB were conducted in French Guiana using 10 different clones and 16 *M. ulei* isolates. This study revealed the existence of seven virulence factors and 12 races of *M. ulei*.

269. Rivano, F. (1997). La maladie sud-americaine des feuilles de L'hevea II. Evaluation precoce de la resistance des clones. *Plantation, recherche, developpement,* 4: 187-194.

The resistance to SALB of 31 *Hevea* clones from Asia, Africa and Latin America was evaluated in a small scale trial in French Guiana. Several components of general resistance were evaluated. The tests revealed that the clones could be divided into three groups according to their SALB resistance and origin. Some clones were selected for a breeding programme for improving resistance, and also for further testing in a SALB zone. A methodology for early evaluation of *Hevea* resistance to leaf diseases, particularly *M. ulei*, was proposed.

270. Rivano, F. (2004). Rubber growing in Latin America: a new challenge. *IRRDB/Michelin/CIRAD International Workshop on SALB*, 2004, Bahia, Brazil, Mimeograph, 6 pp.

Rubber cultivation in Latin American countries (Mexico, Guatemala, Colombia, Ecuador, Peru) was reviewed with respect to SALB. In these countries, rubber was mainly cultivated by smallholders and production was below national demand. The major disease management strategies in these countries were planting resistant clones and planting in disease escaped areas.

271. Rivano, F., Malena, M., Victor, C. and Christian, C. (2010). Assessing resistance of rubber tree clones to *Microcyclus ulei* in large scale clone trial in Ecuador: a less time consuming field methods. *European Journal of Plant Pathology*, 126: 541-552.

The resistance of eight rubber clones was evaluated. Three months after planting, the plants were observed for 12 months to assess disease severity, sporulation intensity on young leaves and severity and density of stroma on mature leaves. These variables were correlated. Sporulation density on young leaves and stroma density on mature leaves is sufficient to score resistance level of clones.

272. Rivano, F., Mattos, C.R.R., LeGuen, V., Guyot, J. and Garcia, D. (2010). Is the production of rubber from *Hevea* really threatened?. *Workshop on the Future of Natural Rubber, 14-15 October, 2010.*

273. Rivano, F., Soto, S. and Sanchez J. (1996). *L'heveaculture au Guatemala*. *Plantations, recherche, developpement*, Novembre-Decembre, 1996, pp. 389-393.

In Guatemala, the rubber areas of about 35 000 ha were mainly in the Pacific zone. There was mild occurrence of SALB on the Pacific Coast due to the suitable climate. In the Southern region and along the Atlantic Coast, SALB was severe throughout the year. Oriental clones were severely infected by SALB in these regions.

274. Rocha, H.M., Aitken, W.M. and Vasconcelos, A.P. (1975). Control of South American leaf bllight (*Microcyclus ulei*) of the rubber tree in Bahia: Aerial spraying of fungicides in the region of Itubera. *Revista Theobroma,* 5: 3-11.

A trial on fungicidal control of *M. ulei* on clone IAN 873 in a rubber plantation was described. The fungicide was sprayed from the air using a Piper 235 fixed wing aircraft during the refoliation

period following wintering. Six sprayings at weekly intervals were given at a rate per spraying of about 2 kg/ha of mancozeb in 15 l spray emulsion. In view of the strongly sloping topography of the area concerned, the use of a more powerful aircraft or a helicopter might have improved the overall efficiency of the treatment.

275. Rocha, A.C.S., Garcia, D., Vetanabaro, A.P.T., Carneiro, R.T.O., Araujo, I.S., Mattos, C.R.R. and Goes-Netto, A. (2011). Foliar endophytic fungi from *Hevea brasiliensis* and their antagonism on *Microcyclus ulei*. *Fungal Diversity,* 47: 75-84.

Endophytic fungi were isolated from three rubber clones. Extracts of these fungi were tested for inhibition of germination of *M. ulei* conidia. Thirteen fungi were inhibitory to *M. ulei*. The inhibitory fungi were *Fusarium* sp., *Gibberella* sp., *Glomerella cingulata*, *Microsphaeropsis*, *Myrothecium* sp. and *Pestalotiopsis*.

276. Rocha, H.M., Medeiros, A.G. and Vasconcelos, A.P. (1973). Selecao de fungicidas para o controle de 'mal-das-folhas' *(Microcyclus ulei*) en condicoes de viveiro. *CEPEC Informe Tecnico 1972 and 1973*, p. 54.

Five fungicides (Benlate-0.07 percent a.i., Cercobin – 0.1 percent a.i., Dithane M 45 – 0.3 percent a.i., Tecto 60 – 0.1 percent a.i. and Kasumin - 0.1 percent a.i.) were tested in nursery for control of SALB. They were applied by a fogging machine at weekly at fortnightly or monthly intervals. Better control was obtained with Benlate, Cercobin and Dithane M 45. Benlate. Cercobin controlled the disease even with fortnightly or monthly applications.

277. Rocha, H.M., Medeiros, A.G. and Vasconcelos, A.P. (1978a). Comparacao de fungicidas para controle do 'mal-das'folhas' de seringueira. *Fitopatologia Brasiliera*, 31: 163-167.

Abstract is not available.

278. Rocha, H.M. and Vasconcelos Filho (1978). Epidemiology of the South American leaf blight of rubber in the region of Itubera, Bahia, Brazil. *Turrialba*, 28: 325-327.

The epidemiology of SALB was studied at Itubera region, Bahia, Brazil. Based on weekly counts of premature leaf fall, SALB may occur every month of the year with the highest incidence in September and October i.e. during the annual refoliation. Dispersion of conidia occurred between 07.00 hours and 14.00 hours, with a peak at noon. The highest number of conidia was collected from spore traps installed at one meter above the ground with south and west exposure during the period from September to December that coincided with the greatest density of new leaves on the trees. It was found that the highest areal spore count and premature leaf fall was highest at bottom of hills.

279. Rodrigues-Machado, R.F., Sena-Gomes, A.R., Rocha, H.M. and Vasconcelos, A.P. (1974). Programa especial de pulverizacao aerea de seringais na Bahia. *CEPLAC/SUDHEVEA*, Mimeograph, 18 pp.

The article reports on an aerial spraying programme on 61 plantations covering 3 992 ha in seven municipalities of Bahia. Dithane M 45 was applied to 1 858 ha by helicopter and to 631 ha by fixed-wing aircraft. Benlate was sprayed to 631 ha by helicopter. Disease control resulting from helicopter and aeroplane fungicide applications was similar. Benlate was more effective than Dithane M 45. In general, about 63 percent control was obtained. The cost of the operation was given.

280. Rogers, T.H. and Peterson, A.L. (1976). Control of South American leaf blight on a plantation scale in Brazil. *Proceedings International Rubber Conference,* 1975, Kuala Lumpur, Malaysia, 3: 266-277.

Preliminary results suggest that weekly aerial applications of Dithane M 45 at 2 kg/ha for six consecutive weeks during refoliation controlled the disease. Benlate was slightly less effective but this could be due to a longer interval (10 days) between sprays and the lower concentrations used (0.15-0.3 kg/ ha). Artificial defoliation prior to spraying fungicides was not beneficial. Improvement of canopy by manuring in conjunction with the spray was not apparent. Both fungicides increased flower production.

281. Romero, I.A.G., Aristizabal, F.A. and Castano, D.M. (2006). A review of *Microcyclus ulei* fungus, causal agent of South American leaf blight of rubber. *Revue Colombia Biotechnologia*, VIII: 50-59.

SALB is an important disease of rubber in Latin America and it was responsible for great economic loss. The fungus has wide variability suggesting great adaptability. Resistance is not well understood especially on its mechanism

282. Rossetti, Victoria (1959). Doencas da seringueira. *O. Biologico*, 25: 233-243.

Hevea diseases, including SALB were described under causal organism, symptoms and control.

283. Russell, J.A. (1942). Fordlandia and Belterra rubber plantations on the Tapajoz river, Brazil. *Economic Geoqraphy*, 18: 125-143.

Abstract is not available.

284. Rutgers, A.A.L. (1960). Bladziekte en kanker bij de *Hevea*. *Indische Mercuur, jaarg.,* 39: 1120.

The pathogen of SALB was named as *Melanopsammopsis heveae*.

285. Sambugaro, R. (2003). Caracterizacao anatomica foliar de clones de seringueira visando resistancia ao *Microcyclus ulei*. Thesis M.Sc., Universidade Estadual Paulista, 61 pp.

South American leaf blight is the main reason for a complete failure of rubber cultivation in Northern Brazil. The disease caused successive defoliation, reduced latex production and plant death. The histological development of the pathogen in different clones was presented. On PB 314, complete asexual and sexual stages developed while only conidia without ascospore stages occurred on MDF 180. On FX 2784, the thick abaxial epidermis conferred resistance.

286. Sambugaro, R. (2007). Estagios foliares, fenologia da seringueira e interacao com *Microcyclus ulei*. Thesis Ph.D., Universidade Estadual Paulista, 94 pp.

The relationship between tree phenology and weather patterns with SALB was studied. Uniform annual leaf changed reduced SALB. Weather conditions influenced the start of leaf change. A mathematical model on leaf change and SALB severity was presented

287. Sanier, C., Berger, P., Coupe, M., Macheix, J.J., Petat, J.M., Rivano, F., Sainst-Blanquat, A. de and D'Auzac, J. (1992). Relationship between Resistance to *Microcyclus ulei* and clonal foliar phenolics of rubber trees. *Journal of Natural Rubber Research*, 7: 38-59.

The relationship between resistance of *H. brasiliensis* to *M. ulei* and to certain foliar phenolics was studied. No qualitative differences were observed between the foliar phenolics of various clones of *H. brasiliensis* and *Hevea* hybrids. Except for clones PB 235 and PB 260, the total quantity of phenols and the proportion of flavans appeared to be related to resistance to *M. ulei* expressed as percentage of abscission. Some compounds seemed to be closely related to the percentage of abscission whereas others appeared to be correlated with resistance (kaempferol-3-rutinoside, 3'p-coumaroylquinic acid). Some phenols were present in resistant clones and others were found in susceptible clones. Likewise, the hydroxycinnamic derivatives (HDC)/flavonols ratio, the percentage of rutin in relation to total flavonols and the ratios of certain phenols (kaempferol-3-rutinoside: kaempferol-galactoside, rutin: kaempferol-galactoside) appeared in particular to be related to clonal resistance.

288. Santos, A.F. dos and Pereira, J.C.R. (1985). Efficiency of fungicides in the control of *Microcyclus ulei in vitro* and *in vivo*. *Revista Theobroma*, 15: 185-190.

The efficiency of fungicides on *M. ulei* was presented. The protective fungicides, clorotalonil and mancozeb, were effective in inhibiting germination of conidia. Tests in rubber nursery showed that *M. ulei* was controled efficiently with triadimefon (0.015 percent), clorotalonil (0.3 percent), mancozeb (0.32 percent), triforine (0.0285 and 0.038 percent), bitertanol (0.015 and 0.03 percent) and fenarimol (0.0011 and 0.0023 percent).

289. Santos, A.F. dos and Pereira, J.C.R. (1986a). Evaluation of systemic fungicides in the control of *Microcyclus ulei*. *Fitopatologia Brasileira*, 11: 171-176.

The efficiency of some systemic fungicides in the control of South American leaf blight of rubber was determined on clone FX 3899. Several fungicides (triadimephon, triforine, methyl thiophanate, benomyl, carbendazim, tridemorph and fenarimol) at a concentration below 0.2 percent were applied at seven or 14 days intervals in a clonal nursery at Una, Bahia. The more effective fungicides were triadimephon and triforine as they reduced the number of lesions and stroma.

290. Santos, A.F. dos and Pereira, J.C.R. (1986b). Evaluation of protective and systemic fungicides and their mixtures in the control of *Microcyclus ulei*. *Revista Theobroma*, 16: 141-147.

The effectiveness of systemic (triadimephon, triphorine, benomyl and methyl thiophanate) and protective (mancozeb and clorothalonil) fungicides for the control of SALB was determined in a nursery. The fungicides were applied weekly, alone or in mixtures, using a knapsack compression sprayer. Triadimephon, triphorine, mancozeb and clorothalonil, applied alone or mixtures, controlled *M. ulei* efficiently even in dosages smaller than the conventional.

291. Schultes, R.E. (1956)/0. The Amazon Indian and evolution in *Hevea* and related genera. *Journal Arnold Arboretum*, 37: 125-148.

The morphological and physiological characteristics of the various *Hevea* species were described. Information on *Hevea* resistant to SALB presented.

292. Schultes. R.E. and Uribe, H.A. (1974). The future of rubber growing in Colombia. *Agriculture America*, 8: 127-130.

The *Hevea* population highly resistant to SALB known in the Amazon was discovered in the Leticia area in Colombia. In Peru, clones selected based on high yield in the forest could still be improved by breeding.

293. Seibert, R.J. (1947). A study of *Hevea* (with its economic aspects) in the Republic of Peru. *Ann. Mo. bot. Gdn*, 34: 261-352.

It was noted that SALB resistant strains of *H. brasiliensis* were found in the Acre territory of Brazil, in the Leticia region of Columbia on the Peruvian border and in the north-eastern region of Madre de Dios of Peru. A number of clones from these areas have inherent characteristics of combined superior yield and high resistance.

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

Although disease avoidance is effective in reducing yield loss, its effectiveness depends on the ability to map low risk areas. Two GIS systems (CLIMEX and ArcView) were used to map areas with SALB risks. According to CLIMEX, the potential SALB areas occur in all continents within 24 N to 25 S. Areas in Asia, Africa, Northern Australia and several Pacific islands are suitable for SALB. The GISs are also useful in identifying low risk areas for SALB.

295. Silva, L.G., Moraes, W.B., Jesus Junior, W.C. and Souza, A.F. (2009). Effects of climatic conditions on the development of South American leaf blight in the south region of the Espirito Santo state. *Proceedings VI Congresso Brasileiro de Agroecologia, Curitiba, Brazil*, 2009, p. 470-473.

The study involved 18 clones and the factors determined were number of infected leaves and disease severity. The susceptible clones showed highest correlation with climatic variables especially average temperature and maximum and minimum temperature and relative humidity. Temperature of 23-28 ºC and relative humidity above 80 percent were favourable for enhancement of disease.

296. Simmonds, N.W. (1982). Some ideas on botanical research on rubber. *Tropical Agriculture (Trinidad),* 59: 2-8.

Several ideas related to rubber yield as an aspect of growth and partition, relation between tapping cost and yield, and the predictive capacity of variety trials were presented. In addition, vertical and horizontal resistance to airborne fungal diseases was briefly reviewed. The former (roughly equivalent to major-gene resistance) is unreliable and the latter much to be preferred. Some horizontal resistance to SALB was known to be present.

297. Simmonds, N.W. (1990). Breeding horizontal resistance to South American leaf blight of rubber. *Journal Natural Rubber Research*, 5: 102-113.

A scheme to breed polygenic (horizontal) resistance to SALB of rubber was proposed. It was based on biometrical genetic principles and analogy with successful HR to diverse diseases in other crops. There was already some experimental evidence of the existence of low level of HR to SALB in rubber and fairly rapid response per generation could be expected. The objectives should be concentrated on breeding resistant crown clones and the work must be done in SALB areas.

298. Sinulingga (1996). Pesticide application for control of *Microcyclus ulei* in rubber plant. *Warta Pusat Penilitian Karet*, 15: 40-47.

South American leaf blight caused by *Microcyclus ulei* is a disease causing great hindrance to rubber cultivation. Infection caused leaf defoliation and sometimes death of trees. Disease management was by application of fungicides or artificial defoliation. Effective fungicides were thiophanate methyl, benomyl, chlorothalonil, mancozeb, triadimefon, triforine and bitertanol. Many spraying applicators can be used, however, aerial spraying or fogging are most appropriate due to fast spread of the disease.

299. Situmorang, A. Boerhendhy, I. and Lasminingsih, M. (1996). Physiological races of *Microcyclus ulei* and developments for their control. *Warta Pusat Penilitian Karet*, 15: 29-39.

Microcyclus ulei, the causal agent for South American leaf blight, had developed nine physiological races that could overcome resistance of all clones except MDX 96, *H. benthamiana* and *H. pauciflora*. Some races are postulated to be adaptable to Indonesian conditions. Some methods to reduce the occurrence of new races of *M. ulei* were suggested.

300. Soepadmo, E. (1975). *Microcyclus ulei* – Bahaya laten bagi industri karet alam di Indonesia. *Menara Perkebunan*, 43: 303-304.

The article reviews the symptoms of disease, disease spread and lists quarantine measures and other actions to address the problem of SALB. These actions include monitoring of international air travel, breeding for resistant clones and disease eradication.

301. Sorensen, H.C. (1942). Crown budding for healthy *Hevea*. *Agriculture America*, 2: 191-193.

The method of bud grafting disease-resistant crowns to the high yielding trunks was described. The crown budded trees could resist SALB.

302. Sorensen, H.G. (1945). Colombia's plantation rubber programme. *Agriculture America,* 5: 106-108.

Resistant material could be obtained from the Amazon Valley (Acre Territory) but usually a certain percentage of the seedlings were infected. The seedlings from Leticia, Colombia were resistant as not a single plant lost its leaves due to SALB. Seedlings of *Hevea spruceana* obtained from Manaus did not make a good rootstock. Some of the buddings were dormant for months before they began to sprout. In the Far East, hybrids of *H. spruceana* and *H. brasiliensis* produced 15 to 32 percent more yield than *H. brasiliensis*.

303. Spaulding, P. (1961). Foreign diseases of forests of the world. *Agriculture Handbook U.S. Department Agric*. 197, 361 p.

The *Hevea* species attacked by SALB in the various South and Central American countries were listed.

304. Stahel, G. (1915). De *Hevea*-bladziekte van Zuid-Amerika. *Meded. Dep. Landb. Suriname* 1, 3 p.

The perfect stage of the SALB causal fungus was named *Melanopsammopsis heveae*.

305. Stahel, G. (1916). Control of the South American *Hevea* leaf disease. *Tropical Agriculture*, 47: 369-370.

Abstract is not available.

306. Stahel, G. (1917). De Zuid-Amerikaansche hevea-bladziekte veroorzaakt door *Melanopsammopsis ulei* nov. gen. Meded. *Dep. Landb. Suriname*, 34, 111 pp.

This publication describes in detail the causal fungus of SALB and the histology of the infected tissue. The factors affecting spore germination, geographical distribution of SALB and methods of control by artificial defoliation (disease escape) and by 'smoking' to reduce the period of leaf wetness were presented.

307. Stahel, G. (1927). The South American *Hevea* leaf disease in Surinam. *India Rubber World*, 76: 251-252.

A brief account of the destruction caused by SALB in the rubber plantations of Dutch Guiana was presented. From 1915 onwards infection was so heavy that branches and trunks of five to eight years old trees were destroyed, while occasionally the whole tree succumbed to the disease. The disease was most serious in the interior of the country where rainfall was very much heavier than near the coast. The conidia of the pathogen required 10 to 12 hours moisture on the leaves for to effect penetration of the tissues.

308. Stevenson, J.A. (1935). The South American leaf disease of Para rubber invades Central America. *Plant Disease Reporter*, 19: 308.

A specimen of *Hevea* rubber received from Costa Rica showed typical symptoms of both the conidial and pycnidial stages of *Dothidella ulei*, apparently not previously recorded from the country.

309. Subramaniam, S. (1969). Performance of recent introductions of *Hevea* in Malaysia. *Journal Rubber Research Institute Malaysia*, 21: 11-18.

A few *Hevea* collections from Brazil were introduced into Malaysia. Illegitimate progeny of FX 25 was the best population for yield and vigour. *H. benthamiana* from Rio Negro and *H. brasiliensis* from Madre de Dios gave low yields compared with modern oriental selections. However, they were better than the original Wickham material. Nevertheless they provide good sources of genes for resistance to *Dothidella*.

310. Subramaniam, S. (1970). Performance of *Dothidella*-resistant *Hevea* clones in Malaysia. *Journal Rubber Research Institute Malaysia*, 23: 39-46.

All the *Dothidella*-resistant clones imported into Malaysia were bred in South America. The performance of the primary and secondary clones tested in Malaya was reported. Clones F 351, FX 25 and FX 2784 were found to be promising as parents in a breeding programme aimed at combining high yield with resistance to *Dothidella*.

311. Subramaniam, S. (1972). Breeding for disease resistance against SALB in *Hevea*. *Symposium on International Corporation in Hevea Breeding, 1972, Kuala Lumpur*, Preprint 10, 4 pp.

Material from Madre de Dios and Rio Negro were resistant to SALB. These and other resistant Brazilian clones had been crossed with high yielding susceptible oriental clones. International cooperation in *Hevea* breeding and testing for SALB resistance was proposed.

312. Tavares, E.T., Tigano, M.S., Sueli, C.M.M., Martins, I. and Cordeiro, C.M.T. (2003). Molecular characterization of Brazilian *Dicyma pulvinata* isolates. *Fitopatologia Brasileira,* 29: 148-154.

Forty nine isolates of *D. pulvinata* were compared by morphological traits using RFLP, RAPD and AFLP analyses. Isolates from *M. ulei* were closely related. Among isolates of *D. pulvinata* from *M. ulei*, a significant pair wise distance was obtained for all markers between isolates from different SALB regions.

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

An account of plant diseases that have potential international importance but were limited to a few countries or a continent was presented. SALB was considered under 'highly threatening plant diseases'. The earlier effort to reduce the introduction of SALB into Asia was lauded.

314. Tollenaar, D. (1954). *Dothidella ulei* en de rubberculture op het westelijk halfrond en in Z.O. Azei *Bergcultures*, 23: 55-93.

After visiting all the major rubber plantations in Latin America except Brazil, it was concluded that rubber cannot be profitably grown in these countries due to SALB. The devastating effect of SALB in the countries visited was confirmed. In Trinidad, an estate close to the sea was relatively free of infection. In Costa Rica, breeding for resistance to SALB and *Phytophthora* together with trial on crown budding were carried out. Clones recommended for crowns were FX 25, FX 645, FX 516, IAN 45-717 and IAN 45-443, the last two being also resistant to *Phytophthora*. Preventive measures against possible introduction of SALB to S.E. Asia require international cooperation in exchange of resistant planting material.

315. Tollenaar, D. (1959). Rubber growing in Brazil in view of the difficulties caused by South American leaf blight (*Dothidella ulei*). *Netherlands Journal of Agriculture,* 7: 173-189.

As a measure to combat SALB, Brazil should plant three categories of clones i.e. highly resistant clones such as FX 25, FX 3844, IAN 710 and IAN 873; tolerant but high yielding eastern clones such as PB 86 and AVROS 1301; and seedlings of selfed PB 86 and AVROS 1301, which showed some measure of resistance. Crown budding was not recommended because of its depressing effect on yield. The biology of the fungus in relation to the host and climatic conditions was discussed.

316. Townsend, C.H.T. (1960). Progress in developing superior *Hevea* clones in Brazil. *Economic Botany*, 14: 189-196.

The Ford Motor Company's *Hevea* breeding programme attempted to combine high yield with SALB resistance characters. It describes the geographical distribution of *Hevea* spp., sources of SALB resistance, life history of *Dothidella ulei*, chemical control and methods in *Hevea* breeding and selection.

317. Tysdale, H.M. and Rands, R.D. (1953). Breeding for disease resistance and higher rubber yield in *Hevea*, guayule and kok-saghyz. *Agronomy J*ournal, 45: 234-243.

Eastern clones of *H. brasiliensis* cannot be used in South and Central America, their natural home, because of their susceptibility to SALB. The U.S. Department of Agriculture cooperated with 11 Latin-American Republics to produce disease-resistant, high yielding rubber clones. The disease was controlled by the use of the three-component tree. The most disease resistant selections were from crosses between *H. brasiliensis and H. benthamiana*, the latter being a species of low rubber production. Back crossing of the resistant segregates to high-yielding *H. brasiliensis* produced clones with disease resistance and improved yield.

318. Ule, E. (1950). Kautschukgewinnung und Kantschukhendel am Amazonen strome. *Tropenpflanzer, Beihefte*, 6: 1-71.

Thirteen *Hevea* species were described and fungi associated with them listed. Ule was the first collector of specimens of SALB.

319. Valois, A.C.C. (1983). Character expression in rubber trees and obtainment of clones with production and resistance to South American leaf blight. *Pesquisa Agropecuaria Brasileira*, 18: 1015-1020.

Abstract is not available.

320. Van Heusden, W.C. (1953). De Zuid-Amerikaanse bladziekte van *Hevea brasiliensis, Dothidella ulei* P. Hennings. *Bergcultures*, 22: 236.

A description of the primary and secondary stages of infection of SALB was presented.

321. Van Heusden, W.C. (1963). De Zuid-Amerikaanse bladziekte (*Dothidella ulei*) een brendende kwestie. *Bergcultures*, 22: 171-177.

The chances of SALB establishing in South East Asia are ever present. Defence measures worked out in Malaya and Ceylon were the enforcement of plant quarantine, early detection of the disease, establishment of eradication procedures and breeding for SALB resistance. All these measures should be implemented on an international level.

322. Vincens, F. (1920). *Hevea* seed – the Surinam leaf disease. *Planters' Chronicle,* 15: 277-278.

Hevea seed from South America should be excluded on account of the prevalence of leaf disease.

323. Wastie, R.L. (1975). Disease of rubber and their control. *PANS,* 21: 268-289.

324. Wastie, R.L. (1986). Disease resistance in rubber. *Plant Protection Bulletin,* 34: 193-99.

Breeding work conducted in Central and South America against SALB had relied on vertical resistance (VR) and not horizontal resistance (HR). This resulted with serious breakdown of resistance. By better knowing the race structure of the pathogen, and using HR instead of VR, further progress in breeding is possible.

325. Waite, S.H. and Dunlap, V.C. (1952). South American leaf blight on *Hevea* rubber. *Plant Disease Reporter,* 36: 368.

The article is the first record of the occurrence of SALB in Honduras. The disease later appeared in Guatemala. Later SALB occurred in all the commercial rubber growing areas in Central America.

326. Weir, J.R. (1926). A pathological survey of the Para rubber tree *(Hevea brasiliensis*) in the Amazon Valley. *Bulletin United States Department of Agriculture,* 1380, 129 pp.

Part of this book deals with SALB under the following headings: histological development, hosts, life history of the fungus, control, protection, exclusion, eradication, immunization and the disease in the forest.

327. Weir, J.R. (1929). The South American leaf blight and disease resistant rubber. *Journal Rubber Research Institute of Malaysia,* 1: 91-97.

Suitable environmental conditions as well as the contiguous rubber areas are conducive for the spread of SALB in the country. The most important strategy of disease control is breeding for disease resistance.

328. Whalley, W.G. (1946). Rubber, heritage of the American tropics. *Scientific Monthly,* 62: 21-31.

Rubber cultivation in Brazil, particularly the effort of Ford Motor Company in 1928, was hampered by SALB. The disease could be held in check by spraying with copper and grafting with resistant clones.

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

No major genes for resistance occurred in 116 clones resistant to *Dothidella ulei*. Several *Dothidella* resistant clones were also resistant to *Phytophthora palmivora*.

330. Wirjomidjojo, R. (1962). First report on performance of *Dothidella ulei* resistant clones in Experimental Garden, Tjiomas. *Menara Perkebunan*, 31: 181-185.

Dothidella-resistant clones (F, FB and FX) were imported from abroad in 1955 by the Research Institute for Estate Crops in Bogor. They were planted out as a collection in the Experimental Garden Tjiomas for breeding and crown-budding purposes. The imported clones when used as crowns had negative impact on growth and yield of the eastern clones.

331. Wycherley, P.R. (1968). Breeding of *Hevea*. *Planters' Bulletin Rubber Research Institute Malaysia,* 99: 159-170.

Resistance to leaf diseases is rapidly decreasing in *Hevea* in S.E. Asia due to genetical erosion. This can be corrected by imports of *Hevea* species from the neotropics. Some SALB resistant clones had been imported and should be used in the breeding programme to upgrade low yielding material.

332. Wycherley, P.R. (1968). Introduction of *Hevea* to the Orient. *Planter, Kuala Lumpur*, 44: 1-11.

The introduction of *Hevea* rubber to the orient by Henry Wickham and the early history of establishment of the crop in Malaya were documented. Introductions after Wickham contained rubber progenies resistant to SALB.

333. Wycherley, P.R. (1977). Motivation of *Hevea* germplasm collection and conservation. *Workshop on International Collaboration in Hevea Breeding, Kuala Lumpur*, Mimeograph, 5 pp.

The loss of genetic reserves in the wild was recognised. Motives for genetic conservation by breeders of *Hevea* were classified as specific, general and innovative. Priorities may be allocated according to these categories or according to the threats to the wild resource. An example of limited specific objective of breeding for resistance to SALB was that collection should concentrate on known sources of resistance to the disease and in areas climatically favourable to the virulent expression of SALB in nature.

334. Zhang, K.M. and Chee, K.H. (1985). Distinguishing *Hevea* clones resistant to races of *Microcyclus ulei* by means of leaf diffusate. *Journal Rubber Research Institute Malaysia*, 33: 105-108.

Leaves of *Hevea* clones were induced to produce diffusate by inoculating them with *Colletotrichum gloeosporioides* and *Phytophthora sp*. The diffusate exerted different degrees of inhibition of conidial germination of four physiologic races of *Microcyclus ulei*. Resistance or susceptibility of the test clones to SALB was segregated based on the degree of inhibition.

335. Zhang, K.M., Chee, K.H. and Darmono, T.W. (1986). Survival of South American leaf blight on different substances and recommendations on phytosanitary measures. *Planter, Kuala Lumpur*, 62: 128-133.

Spores of *Microcyclus ulei*, the causative agent of South American leaf blight of *Hevea* rubber survived best on infected leaves and cloth, less so on polyethylene, artificial leather and glass, and least germination was from conidia deposited on metal and paper in tests over seven days. The spores placed in soil for ten days remained viable. The gaseous phase of formalin at 91 ml/ cu cm or a 35 percent solution) inhibited ascospore release, and also killed the conidia after 15 minutes exposure. Conidia still germinated (5-10 percent) after 15 minutes ultra violet (254 nm) irradiation, but not when simultaneously exposed to 0.5 ml per cu cm of formalin. Conidia did not germinate in 40 mg per litre of soap powder solution. They were killed after 30 minutes exposure at 75 ºC or at 55 ºC in a moist enclosure. Air travellers were advised to bathe and launder their used clothes with soap powder during an intermediate stopover in a temperate SALB free country. At the point of entry into Southeast Asia, personal effects would need to be exposed to heat (75 ºC) or moist heat (55 ºC and 100 percent RH), or to ultra violet irradiation in combination with ‘fumigation’ with formalin in order to kill all conidia.

336. Zhang, K.M. and Chee, K.H. (1986). Differential sensitivities of physiologic races of *Microcyclus ulei* to fungicides. *Journal Natural Rubber Research,* 1: 25-29.

The effectiveness of benomyl, thiophanate methyl, chlorothalonil to Races 4, 6, 7, and 8 of *Microcyclus ulei* were evaluated by measuring inhibition of conidial germination, infection of leaf disks and field spraying. Races 6 and 8 were less sensitive to benomyl and thiophanate methyl than Races 4 and 7. Spraying benomyl (25 mg and 50 mg per litre) in the nursery gave satisfactory control of South American leaf blight on clones FX 2261 and FX 985 infected by Races 4 and 7 respectively, but not FX 3864 and FX 2804 infected by Races 6 and 8 respectively.