Developments in leaf disease epidemic management technology for rubber (*Hevea brasiliensis*) plantations in India.

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Abstract

Strategies have been designed to combat the epidemic leaf diseases caused by *Phytophthora* spp., *Oidium heveae* and *Corynespora cassiicola* in India on the basis of the research over several years. The clones susceptible to *Phytophthora* disease have systematically been replaced with the disease tolerant clone RRII 105, evolved through hybridization. Environmental factors that trigger *Phytophthora* disease development have been identified. The species of *Phytophthora* widely prevalent in India has been identified as *P. meadii*. As clones resistant to *O. heveae* are not available, the disease control depends mainly on chemical protection. The mechanism of tolerance of GT 1 to *Corynespora* leaf disease has been studied with a view to locate factors that could be transferred to susceptible high yielding clones. Among the *Corynespora* isolates, putative virulence-specific isolates could be identified. The virulence could be related to their efficacy of toxin production.

For the control of *Phytophthora*, prophylactic high volume spraying of Bordeaux mixture 1% has been in recommendation from very early days. As this method was costly, efforts were made to reduce the requirement of spray fluid and chemicals. Mechanisation of high volume spraying was also attempted to reduce labour and to increase coverage. Ground spraying with copper oxychloride dispersed in spray oil using micron sprayers was introduced for prolonged protection and better coverage. Refinements were made to reduce the weight of the sprayers and improve the efficacy of fungicide discharge and lightweight low volume sprayers were developed. Alternative fungicides for copper were also located. Aerial application of copper fungicide was attempted and the method gained wide popularity among large estates. Impact of continuous use of copper fungicides to soil microflora and fauna was observed to be negligible.

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Powdery mildew disease has been controlled by prophylactic dusting of sulphur. Alternative systemic fungicides were tried for powdery mildew disease control and integrated dusting schedules evolved.

Epidemics of *Corynespora* leaf disease occurred during 1996-98 for which control measures using high volume and low volume spraying as well as dusting of fungicides were evolved. Using these techniques, a campaign was launched for suppression of the pathogen during 1999. Subsequent surveys revealed considerable reduction in disease intensity and decline in spread of the disease.

In order to prevent the entry of South American Leaf Blight into India, quarantine regulations have been stipulated. Under these rules, import of rubber plant materials from Tropical America is prevented. Import of rubber plants from any other country is permitted only through the Rubber Research Institute of India and strict post-entry quarantine is prescribed. Although techniques for sudden defoliation of rubber have been evolved, the choice is for chemical control as rubber is mainly grown in homestead gardens interspersed with many other crop plants in the smallholdings.

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In India, rubber (*Hevea brasiliensis*) is traditionally grown in the warm humid tropical region between 8^0 to 12^0 N lying as a strip between the western side of the Western Ghats and the Arabian Sea, enjoying the monsoon type of climate. In the southern part of this region, the rainfall is around 2000 mm, well distributed between the South West and North East monsoons while towards north, the total precipitation is more than 3000 mm with South West monsoon being more prominent and the North East monsoon weak and unpredictable. The relative humidity during the peak monsoon period (June to August) remains above 90% accompanied by a warm climate with a temperature range of 22 to 30^0C. Although these environmental conditions are favourable for growth and yield of rubber trees, the plantations are predisposed to epidemic diseases like abnormal leaf fall (ALF) caused by *Phytophthora* spp., powdery mildew caused by *Oidium heveae* and Corynespora leaf disease caused by *Corynespora cassiicola*. Due to constraints in land availability for extension of rubber cultivation in the traditional region, the plantations are now established in the non-traditional regions with similar total annual rainfall but more unevenly distributed and with a distinct cold climate during the winter period (December to February). The non-traditional areas in northeastern India ($22^0 - 29.5^0$ N and $88^0 - 91.5^0$ E) are prone to powdery mildew disease epidemics.

Severity of epidemics

The impact of the incidence of these epidemics on the crop production has been estimated. It was observed that abnormal leaf fall disease causes annual crop loss of 9.27 to 15.75 per cent in susceptible clones if left unprotected during one monsoon season and this effect is carried forward to the next year even if the trees are prophylactically protected during the subsequent year (Jacob *et al.*, 1989). The plugging indices of trees in unsprayed plots were higher and the DRC of latex low, indicating a direct impact on latex metabolism. Among the clones, which were recommended for large-scale planting in India, RRIM 600 was observed to be severely affected (Table 1) and suffered heavy crop loss (Table 2) due to ALF.

Table 1. Leaf retention at the end of monsoon period

Clone	1997-98		1998-99		1999-2000		2000-01		2001-02	
	S	US	S	US	S	US	S	US	S	US
RRIM 600	50.17	20.09	55.62	7.96	42.11	14.87	52.97	3.89	50.34	28.02
RRII 105	73.29	48.52	72.77	39.14	71.02	69.61	83.27	55.58	64.28	52.83
GT 1	75.21	28.54	53.46	20.67	57.13	32.88	75.20	48.80	58.74	41.54

S = Sprayed   US unsprayed

Table 2. Crop loss due to ALF in clones recommended for large-scale planting

Clone	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02
RRIM 600	16.53	16.69	15.39	43.56	25.67	25.44
RRII 105	21.14	--	--	--	--	--
GT 1	12.23	--	--	4.71	20.36	17.68

The crop loss due to powdery mildew disease (Table 3) in the southern region of the traditional rubber growing tract varied between 20 to 32 per cent in the clone PB 86 and 13.5 to 28.5 per cent in RRIM 600 (Jacob *et al.*, 1992). In the North East India (non-traditional region) the crop loss was 28.5 percent in the clone RRIM 600 (Mondal and Jacob, 2002). The growth (girth increment) of the trees was also found to be higher when protected against the disease in both the regions.

Table 3. Crop loss due to powdery mildew

Region	Clone	Crop loss (%)
Kanyakumari (traditional)	PB 86	20.0 - 32.0
"	RRIM 600	13.5 – 28.5
Nagrakata (non-traditional)	RRIM 600	28.5

Corynespora leaf disease epidemics was confined to the northern region of the traditional rubber growing area. In a survey conducted during 1999 in Dakshina Kannada District (Table 4), 47 to 100 per cent of the holdings in different *taluks* (regions) were infected and the disease severity ranged from 30 to 66 per cent (Manju *et al.*, 2001). The impact of the disease on crop was not assessed, as most of the affected plantations were young areas being brought under tapping.

Table 4. Incidence and severity of Corynespora leaf disease in Dakshina Kannada (1999)

Taluks (regions)	Infected (%)	Intensity (%)
Kundapur	46.67	31.14
Belthangady	54.54	29.83
Puthur	100.00	58.56
Sullia	100.00	58.96
Madikeri	81.82	53.11
Subramanya	100.00	60.00

Management of epidemics

The prevalence of disease susceptible host in large stretches of cultivated land under favourable environment for disease development and presence of large inoculum load of the pathogen are the conditions that favour epidemics. Manipulation of any of these factors can limit the rate of development of epidemic diseases.

(a) Host factors

Since abnormal leaf fall disease was considered as the most damaging epidemic in India, attempts to develop clones resistant to this pathogen through hybridisation was initiated soon after the Rubber Research Institute was established. The parents selected for breeding were those with high yield and high degree of disease tolerance so that these characters could be combined. The clone RRII 105 is one of the clones so developed (by crossing Tjir 1 and Gl 1) which exhibited a high degree of disease tolerance (inherited from Gl 1) and high yield. This clone was released for planting in 1980 after several years of experimental evaluation. With strong extension support and wide publicity through media the Rubber Board of India encouraged planting of this clone and over a period of 20 years it occupied more than 85 per cent of the planted area under rubber in India. Although the area under rubber cultivation showed several-fold increase during this period, the consumption of fungicides remained rather steady indicating low disease incidence. The higher leaf retention in the absence of epidemics resulted in better crop production. The average productivity of Indian rubber plantations is now the highest in the world being 1592 kg/ha (Table 5).

Table 5. Productivity in relation to cultivation of tolerant clone (RRII 105)

Year	Area under rubber (ha)	Approximate area under clone RRII 105 (%)	Productivity kg/ha
1980	2,84,166	<1	788
1990	4, 75, 083	78	1076
2000	5, 62670 ~~3, 99, 901~~	89	1576
2003	~~4, 07, 953~~ 5, 69670	91	1592

The study of host defense to the pathogen and the identification of genetic factors that contribute to such defense shall be beneficial in exploiting them in future breeding programmes.

The involvement of PR proteins in the host defense against *Phytophthora* has been indicated (Narasimhan *et al.*, 2000). Attempts have been made to locate markers linked to resistance (Licy *et al.*, 2000). Attempts made to locate sources of resistance in the 1981 IRRDB germplasm collection have been successful and seven resistant accessions have been identified.

Although crown budding of rubber clones showing high yield with resistant crowns like F 4542, Fx 516 and RRII 33 were successful on experimental scale (Pillai *et al.*, 1986) this technique did not gain popularity due to difficulty in the establishment and delay in maturity of crown budded plants.

Powdery mildew resistant clones useful for breeding programmes could not be identified and the disease remains as a constraint for crop production in the conducive environments. The germplasm available at RRII is being screened for locating resistance.

Corynespora epidemic occurred in India only during 1998-99 and screening of clones and germplasm are under way. The clone GT 1 is observed to have high degree of field tolerance while RRII 105 is susceptible. The host-pathogen inter-relationship in these two clones has been compared and the triggering of the production of PR proteins in the non-compatible host-pathogen relation has been observed. Production of three prominent β

1, 3 glucanase isozyme bands (Philip *et al.*, 2001a) were detected on infection of *Corynespora* in clone GT1 (Figure 1). The activity of peroxidase, polyphenol oxidase and phenylanaline ammonia lyase was also found to be higher. Esterases were observed to play a role in the initial recognition and establishment of the pathogen on the host (Philip *et al.*, 2001). Attempts are being made to study the genetics of host-pathogen interaction with a view to modify them and reduce disease incidence in high yielding clones.

(b) Environmental factors

The optimum climatic conditions for the out break of abnormal leaf fall disease has been identified (Table 6) and attempts were made to make the prediction more accurate and as earlier as possible to warn growers in advance for undertaking protective measures. But as forewarning earlier than a fortnight has not yet been successful, prophylactic protective measures are routinely taken up, since large areas cannot be sprayed in a short time.

Table 6. Disease forecast systems for abnormal leaf fall disease

Weather parameters	Forecast by	
	Pillai *et al* (1980)	Jayarathnam *et al* (1987)
Rainfall		
Per day (mm)	--	1.0
Total (mm)	250-300	>112
Duration (days)	7-10	4-5
Temperature		
Maximum (^{0}C)	26-30	29-31
Minimum (^{0}C)	22-25	22-23
Relative humidity		
Maximum (%)	98	93
Mean (%)	--	80
Sunshine		
Mean (h/day)	No intermittent hot sunshine	2.4
Forecast	Immediate commencement	9-15 days from first overcast day

Although presence of dew and drizzle and prolonged leaf wetness has been pointed out as predisposing factors for incidence of powdery mildew disease during the refoliation period following wintering (Ramakrishnan and Pillai, 1962; Liyanage and Jacob, 1992) the critical limits have not yet been worked out.

The occurrence of Corynespora leaf disease epidemic in the disease-prone region was observed to start by second fortnight of February attain a peak by second fortnight of March to Mid-April and recede thereafter (Manju *et al.*, 2002). The comparison of weather parameters revealed only a slight increase in temperature and sunshine to be associated with the disease. Assuming that the critical factor involved may be the inoculum, spore load is being monitored by installing spore trap.

(c). Pathogen factors

Four species of *Phytophthora* namely *P. palmivora*, *P. meadii*, *P. nicotianae* var. *parasitica* and *P.botryosa* have been reported as causal organism of ALF disease (Thankamma *et a*l., 1968; Edathil and George, 1976; 1980). Recent studies using molecular tools like rDNA RFLP (Philip *et al.*, 2004) have revealed that despite morphological variations all isolates of *Phytophthora* from the traditional rubber growing region belong to *P. meadii* (Fig. 3).

RAPD analysis of 20 isolates of *Corynespora cassiicola* from 16 different locations in the traditional rubber growing tracts clearly indicated the existence of at least seven different genotypes of *C. cassiicola* (Saha *et al.*, 2000). Putative virulence specific RAPD profile of *Corynespora* was identified among the isolates from the region where epidemic occurred. (Fig.4). Three more distinct RAPD patterns indicating additional genotypes were reported later (Saha *et al.*, 2002). The virulence of the pathogen isolates could be correlated to their capacity for toxin production (Joseph *et al.*, 2004).

(d) Chemical control of epidemics

The control of ALF disease has gained much attention from early days of rubber cultivation in India and prophylactic spraying of Bordeaux mixture (0.75 to 0.8 per cent) was recommended (Ashplant, 1928). Later, use of Bordeaux mixture (1%) was recommended and addition of 0.2 per cent Zn SO_4 was reported to increase its efficacy (Ramakrishnan and Pillai, 1961a). As spraying of Bordeaux mixture on mature rubber trees is rather a slow process and demanded large volumes of spray fluid and high labour input, attempts were made to evolve cost-effective spraying schedule. It was observed that the spray fluid requirement could be reduced form the recommended 5000 litres to 3000 litres by judicious and systematic application (Idicula *et al.*, 1989). Further experiments showed that the cost of Bordeaux mixture spraying could be reduced by adding 0.5 per cent Zn SO_4 to 0.5 per cent Bordeaux mixture (Table 7) without any adverse effect on its efficacy (Idicula *et al.*, 1994).

Table 7. Effect of fungicide on leaf retention

Fungicide	Leaf retention (%)			
	RRIM 600		RRII 105	
	Year 1	Year 2	Year 1	Year 2
Bordeaux mixture 1 %	63	50	72	70
Bordeaux mixture 0.5% + Zn SO_4 0.5%	62	65	70	72
Copper oxychloride (8 kg in 40 l oil/ha)	40	44	52	--
Unsprayed	--	--	10	27

The use of motorised high volume HDP sprayers instead of the rocking type of sprayers improved the efficacy of spraying as the spray fluid is discharged at high pressure through a specially designed spray gun and ensures good coverage of canopy from the ground for young and from the first forking region for mature trees. The daily task of high volume spraying could be doubled by this, thus reducing the cost.

In order to increase the efficacy and spread of prophylactic spraying, micron spraying of copper oxy chloride was attempted. A Micron 420 sprayer was initially used to spray oil dispersible copper oxychloride with mineral oil as carrier. The throw of this sprayer was about 25 m. But the machine was too heavy for four workers to carry in difficult terrains (Ramakrishnan and Pillai, 1962). Hence reduction in weight of the sprayer was attempted and research in collaboration with sprayer manufacturers resulted in indigenously manufactured duster-cum-sprayers. Further reduction in weight using fibreglass, plastic-moulded and aluminium parts resulted in the presently used micron sprayers (Fig. 5), which can easily be carried by four workers (Idicula and Jose, 2000). In order to further reduce the labour requirement, a smaller version of micron sprayer with lower engine capacity namely Minimicron was introduced. This had a throw of about 15 m only. Recent developmental efforts have evolved another sprayer, which can be carried as backpack by a single worker. As this sprayer has a throw of only 10 m it is useful only for young plantations. As a further modification to improve the fungicide discharge of micron sprayer, Micronair atomiser (Fig 6) was attached to the delivery end, which resulted in a higher, throw of fungicide and more leaf retention (Table 8).

Table 8. Comparison of micron and Micronair atomisers

Treatment	Particle size (μ)	Throw height (m)	Leaf retention % (RRIM 600)	
			Pudukad	CES
Micronair	130x127	33	66.91	55.75
Micron	200x160	25	38.03	36.05
Control (unsprayed)	--	--	13.06	03.89

For large estates, as the spraying has to be completed in a fortnight as close to the monsoon as possible, micron spraying may not be feasible. Kershaw (1962) experimented aerial application of copper oxychloride dispersed in spray oil using helicopter (Fig. 7) and found it effective. In experiments to compare different methods of application of COC namely aerial and micron spraying with Bordeaux mixture 1% spraying, Idicula *et al.* (1989) observed that the different techniques are comparable in efficacy of disease control.

Improvements in spray oil also gained research attention. It was observed that spray oil having 72 USR was as efficient and non-phytotoxic as those with 90 USR and the former being cheaper, was recommended. Comparing different formulation of copper oxychloride, Idicula *et al.* (1989) reported that oil-dispersible powder formulation having 56% COC has several advantages particularly of shelf life and miscibility in comparison to oil-based paste with 40% active ingredient. Oil-dispersible mancozeb 70% was also observed to be effective (Table 9) for the control of ALF disease when sprayed aerially or using micron sprayers (Jacob *et al.*, 2001).

Table 9. Effect of spraying mancozeb on leaf retention

Treatment	Dose (kg/ha)	Leaf retention (%)		
		RRIM 600	GT 1	PB 235
Mancozeb 70%	5.0	45.39	62.58	57.87
COC 56%	8.0	62.57	75.21	55.59
Unsprayed	--	11.26	35.29	20.72

One of the important questions raised against spraying copper fungicides in rubber plantation is the possibility of accumulation of copper in the soil and its adverse effect on the soil ecosystems. This aspect was studied in detail by analysing the copper content in the soils from rubber plantations from several locations in the traditional rubber growing tract of India. The study revealed that the level of copper in the soil, inspection of the age of plantation and years of continuous spraying, was not toxic and within the normal range (up to 100 ppm). This could be due to run off losses in the rains, metal chelation and complexation of copper by the rich organic matter added to soil though wintering of rubber acting as a buffer (Rajendran *et al.*, 1999a). It was observed in another study that the soil copper content in sprayed plantations lowered to pre-spraying levels within six months after spraying (Mushrif, S.K. Personal communication). When plantations which were continuously sprayed for up to 30 years were compared with virgin land nearby, no appreciable charge in soil microflora (*Azotobacter*, *Beijerinckia*, bacteria, fungi, actinomycetes) and fauna (invertebrates, nematodes) could be observed (Rajendran *et al.*, 1999b).

Powdery mildew disease epidemic has been controlled by application of fine sulphur dust (70%) mixed with talc as carrier using micron duster. Three to four rounds of dusting at appropriate intervals using a dosage of 11-16 kg/ha during the susceptible refoliation period was recommended (Ramakrishnan and Pillai, 1962). As the leaves are in the process of expansion while dusting is done, some of portions of the lamina could not be protected with the contact fungicide. To address this problem dust formulations of systemic fungicides like tridemorph, carbendazim and hexazonazole (Table 10) were tried (Jacob *et al.*, 1996; Prem *et al.*, 2002). Alternate or mixed application of the systemic fungicide with sulphur dust was observed to afford better protection and is safer in terms of development of resistance in the pathogen.

Table 10. Powdery mildew disease control (Clone PB 5/51)

Treatment	Dose (Kg/ha)	Disease incidence (%)
Hexaconazole 2%	7.0	10.4
Hexaconazole + Sulphur	3.5 + 6.0	8.7
Sulphur	12.0	16.0

Table11. Percentage disease index under different schedules of dusting in clone RRIM 600

Treatment rounds	Disease index
Tridemorph – Sulphur - Sulphur	30.45
Carbendazim – Sulphur – Sulphur	28.95
Tridemorph – Tridemorph – Sulphur	21.90
Carbendazim- Carbendazim- Sulphur	23.75
Sulphur – Sulphur - Sulphur	48.45
CD (P=0.05)	13.30

The incidence of Corynespora disease in mature plantation in large areas was observed for the first time in Karnataka in the northern part of the traditional rubber-growing tract during 1996 (Rajalakshmi and Kothandaraman, 1996). Experiments were initiated immediately and control measures using water-dispersible (Manju *et al*, 2000) oil-dispersible and dust (Manju *et al.*, 2002) fungicide formulations were evolved (Table 12, 13 and 14). Based on the results observed up to 1998, an epidemic control strategy was evolved. In 1999, an area of more than 10, 000 hectares in the northern region observed to be infected were sprayed under the direct supervision of the scientists and extension officers. As these plantations are smallholdings, a campaign had to be organised to explain the threat of the epidemics to the farmers and get them involved in the disease eradication programme. Bordeaux mixture 1% or mancozeb 0.2% were used as high volume spray in young plantations while in mature areas oil-dispersible copper oxychloride was used as low volume spray using micron sprayers. The spread of the disease to the southern regions (where more than 80% of the planted area is under the susceptible clone RRII 105) could successfully be prevented by this operation. The disease incidence in the sprayed areas was also on the decline (Table 15) as evidenced by the subsequent surveys (Manju *et al.*, 2001). The Rubber Research Institute of India established a field research laboratory within the epidemic affected area and evolved the disease control strategies, which were effectively used in the epidemic eradication programme. Timely intervention utilising scientific and technical know-how along with strong extension back up with co-operation of the farmers could contain the Corynespora leaf disease epidemic in India.

Table 12. Efficacy of water-based fungicides in Corynespora leaf fall disease control

Treatment	Dose (kg/ha)	Disease intensity (%)					
		1998		1999		2000	
		Initial	Final	Initial	Final	Initial	Final
Mancozeb(75% WP)	0.25	48.40	19.30	50.70	20.20	45.60	14.90
Carbendazim (50% WP)	0.10	47.40	20.10	48.60	22.50	44.40	17.60
Water dispersible COC (50% WP)	0.25	47.70	26.60	51.50	27.10	41.80	25.60
Bordeaux mixture	1.00	48.60	30.60	49.20	32.70	44.50	28.00
Untreated control	--	49.50	45.80	49.50	44.80	41.40	39.20
LSD (P=0.05)		3.61	3.66	4.12	3.37	5.99	3.74

Table 13. Effect of oil-dispersible fungicides in CLF disease control

Treatment	Dose (kg/ha)	Disease intensity (%)					
		1998		1999		2000	
		Initial	Final	Initial	Final	Initial	Final
Mancozeb(75% powder)	7	50.00	22.17	51.50	24.45	43.50	19.20
COC (56% powder)	8	50.00	29.60	56.20	32.30	44.50	28.00
Untreated control	--	52.00	48.40	56.00	53.40	43.00	42.50
LSD (P=0.05)		2.18	6.16	5.06	4.78	2.14	2.65

Table 14. Effect of dust fungicides in CLF disease control

Treatment	Dose (kg/ha)	Disease intensity (%)					
		1998		1999		2000	
		Initial	Final	Initial	Final	Initial	Final
Hexaconazole 2%	9	57.00	15.90	56.00	11.50	44.50	15.30
Carbendazim 1.5%	9	55.30	23.20	55.30	18.50	--	--
Tridemorph 1.5%	9	53.00	31.90	50.80	27.30	--	--
Untreated control	--	52.00	48.40	56.00	53.40	43.00	42.50
LSD (P=0.05)		5.95	5.69	7.08	4.88	--	--

Table 15. Intensity of Corynespora leaf fall disease

Location	Disease intensity (%)		
	1998	1999	2000
Karnataka			
Kundapur	26.42	31.14	17.45
Belthangady	24.85	29.83	15.82
Puttur	36.00	58.56	32.87
Sullia	40.46	58.96	34.20
Madikeri	32.50	53.11	31.64
Subramanya	52.26	66.00	36.56
Kerala			
Kanhangad	45.42	61.35	38.80
Nileshwar	NS	NS	18.00
Hosdurg	NS	NS	23.80

NS – Not surveyed

Prevention of South American Leaf Blight

Prevention of introduction of South American Leaf Blight to India is carried out through quarantine regulations. The revised quarantine regulations have been imposed by the Government of India on 18th November 2003 through an extra ordinary gazette notification. These rules prevent import of plants and plant products into India without a valid permit issued by the Ministry of Agriculture. Under Schedule IV appended to this order, import of rubber plant seed, budwood and other propagation materials from Tropical America including nearby islands and part of Mexico is prohibited (Table 16). The Director, Rubber Research Institute of India is the only authority authorised to import rubber seed, saplings, budwood and other plant materials under conditions of post-entry quarantine for a period of one year and phytosanitary certificate from the country of origin is mandatory for such imports as stipulated under Schedule V of this order (Table 17). The permitted point of entry of plant materials is notified under this order. The order stipulates post-entry inspection of consignments by plant quarantine officers, laboratory testing, fumigation and disinfection as pre-conditions for clearance for entry and authorises the

Plant Quarantine Officer to order deportation or destruction of the consignment in the event of non-compliance with restrictions and conditions specified in the order.

In case of an accidental introduction of SALB India has vast experience and necessary equipment for epidemic disease management in rubber which will become useful in eradication. The rubber estates have several years of experience in aerial as well as ground spraying. The small growers are organised under nearly 2000 Rubber Producers' Societies (RPS) many of which own and operate ground-spraying equipment. The Rubber Board has a wide extension network with 50 zonal /regional offices and 170 field offices and the extension officers work in close liaison with the farmers and the RPS. As even the very smallholdings are under strict supervision and management, occurrence of any disease does not go unnoticed or unattended. Artificial defoliation is possible with chemicals like ethephon (Idicula *et al.*, 2004). But as most of the rubber is grown in homestead plantations interspersed with other cultivated crops, wide use of defoliants may not be feasible. Physical and chemical destruction of inoculum and chemical protection of plantations will be the strategy of choice for India to combat South American Leaf Blight besides the quarantine measures in force. Wide variety of spray equipment including helicopters are available for use as and when necessity arises.

Table 16.

SCHEDULE – IV

[See clauses 3(2), 10(2) and 11(1)]

List of plants/planting materials and countries from where import is prohibited along with justifications

Serial Number	Plant species/variety	Categories of plant material	Prohibited from the countries	Justification for prohibition
11.	Rubber (*Hevea* spp.)	Seeds/plants/budwood and any other plant material	Tropical America (Area extending 231/2 degrees North land 231/2 degrees South of the equator (Tropics of Capicorn and Cancer) and includes adjacent islands and longitude 30 degree West land 120 degrees East including part of Mexico, North of the Tropic of Cancer)	Due to incidence of destructive South American Leaf Blight of Rubber (*Microcyclus ulei*)

Table 17.

SCHEDULE – V

[See clauses 3(3)(6) and (7) and 10(1)(2)(3) and 11(3)]

List of plants and plant materials import of which are restricted and permissible only by authorized institutions with additional declarations and subject to special conditions

Serial Number	Plant species/variety	Category of plants & plant material	Additional declarations required to be incorporated into Phytosanitary certificate	Special conditions of import	Authorised to import
12.	Rubber (*Hevea* spp.)	Seed/Saplings/ Budwood	Free from: (a) South American Leaf Blight (SALB) (*Microcyclus ulei* syn. *Dothidella ulei*) (b) Shot hole borer (*Xyleborus ferrugineus*)	(i) Post-entry quarantine for a period of one year. (ii) The consignment of seed and other planting material shall be treated with suitable systemic fungicide prior to despatch of the consignment at the country of origin and the treatment shall be endorsed on Phytosanitary Certificate	Shall only be permitted import by the Director, Rubber Institute, Kottayam, (Kerala).

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