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IMPACT OF WHITE ROOT DISEASE INCIDENCE ON RUBBER INTERCROPPED WITH TEA OR CINNAMON

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The white root disease incidence on rubber

White root disease caused by *Rigidoporus microporus* (Fr.) Overeem, is the most cumbersome root disease in rubber plantations in many rubber growing countries including Sri Lanka. The fungal pathogen infects and kills mature and immature trees and subsequently spread towards the adjoining healthy trees within a short period if conditions are conducive. The fungus at the initial stage colonizes bark tissues of the collar region of young or mature trees disturbing the mobility of conducting tissues causing wilting, downward buckling.and yellowing of leaves. At latter stages, the fungus entirely colonises the bark tissues of the collar region resulting the tree death due to total rim-barking. The existence of the fungus on the collar region is simply identified by inspecting the collar area just below the soil layer or at latter stages by availability of bracket shaped orange-brown fructifications (Plate 1a). The fungus tends to grow upward towards the soil surface during prolonged wet weather and hence, infection may be visible even above the ground level.

Like other soil-borne micro-organisms, this pathogen also prefers top soils rich in organic matters and adequate oxygen concentrations to be survived in the absence of an adequate food source such as decaying root debris. Since, organic matters enhance the luxurious growth of the fungus through wet soil as visible mycelial threads, having a thick layer of organic matters under the cover crop on and around infected plants may enhance the growth of the fungus to adjoining healthy plants through soil. Therefore, immature fields should be properly cleaned when the disease is there in the field. In wet soils, the fungus thrives well and produces luxurious mycelial mats on the infected roots and the fate of the infected plant would quickly be the death. Generally, proper management practices such as maintaining sanitary conditions and plant health, fertilizer application etc. are critically important to maintain the plantation economically.

During the last two decades in Sri Lanka, the white root disease in rubber plantations has significantly increased causing heavy tree losses and lowering the plant density, subsequently making lands unproductive (Plate 1b). Usually the transmission of the white root disease from an infected tree to adjoining trees occurs easily in flat lands. It has recently been noted from results of a survey that, in a flat rubber land, a one white root disease infected tree has the potential to destroy about 55 - 80 trees in a period of 15 years. This figure can be as high as 80 - 135 trees, depending on factors such as location of the first infected point or on the initial number of infected points derived from the underlying inocula. However, in sloppy terrains, the disease may be transmitted easily from an infected tree to the adjoining two trees on the same platform and to the trees at the lower terrains. In a land with a slope of 20°-30°, the actual disease spread within 15 years was calculated as 20 trees with a potential up to 30 trees depending on the same above mentioned reasons (unpublished data of Plant Pathology & Microbiology Department). As such, the spread of the white root disease incidence in intercropped rubber lands can be much faster if intercropped plants also susceptible to the white root disease. Hence, this brief article discusses some facts on the importance of controlling the white root disease in tea and rubber intercropped lands during the early stages and emphasises the consequences if failed to do so.

Benefits of intercropping rubber lands

Intercropping techniques are invaluable tools in sustainable agricultural systems to increase the land use efficiency and to provide better economic returns. By intercropping agricultural lands not only the income from a unit area increases (Haymes & Lee, 1999; Feng *et al.*, 1982) but also improve the soil properties (Mapa, 1995; Vidhanaarachchi & Liyanage, 1998). In addition, due to the efficient land usage, the growth of the weed biomass in inter-row spaces is reduces (Bulson *et al.*, 1997), while due to low sole crop density, the pest and disease incidences, compared to the mono-crop also decreases (Deadman & Cook, 1997) provided the two crops do not serve as common hosts for pathogens. From the early periods of the introduction of rubber to Sri Lanka, intercropping in rubber lands was evident and at present, intercropping is a recommended practice that has been proposed to obtain an increased income from a unit area of the land during the immature period of rubber which may last up to 6-7 years depending on the rubber clone. However, due to limiting factors for both crops, intercropping may be done successfully in mid- or low-country, where the annual rain fall is high. When intercropping, providing a wider rubber row-space and orientation of rubber rows in the east-west direction, is important for interception of adequate sun light by the intercrop. Hence, the rubber tree stand in intercropped plantation is lower than when rubber is grown as a mono-crop. This tree loss is compensated and a profit can be gained by the additional income from the intercrop for a considerable period depending on the type of the intercrop. However, in case of growing tea (Plate 1c), cinnamon or other permanent tree crops, the additional benefits obtainable can be different.

Rubber trees in intercropped plantation can be more vigorous and the yield from individual trees may also be higher than from that of the mono-crop itself due to immense tree girth, light interception and humidity (Yogaratnam & Iqbal, 1998). This observation has to be discussed in a critical level using all the supportive data and observations, and therefore, more research may be necessary for drawing conclusions. In addition, during the first 3-4 years after normal field planting, some varieties of tea bushes are known to be susceptible to severe prolonged drought conditions (Karunaratne *et al.*, 1999) causing enormous losses to the stand. However, intercropped tea bushes have been reported to withstand severe drought conditions successfully (De Zoysa, 1993) maintaining the stand unaffected. In addition, growing different types of crops in the same land may be defined as multi-cropping, which is also a valuable tool for sustainable agriculture, since this system would promote the soil structure and its nutrient status, increase the number of beneficial microbial population.

When rubber is intercropped with tea, an enhanced root contact may be observed between rubber and tea due to high root competition for space and nutrients. This may be a one reason for higher white root disease transmission along the rubber tree rows (Plate 1d). Therefore, in the case of the white root disease incidence in intercropped lands, quick attention is essential to manage the problem easily. Negligence of the incidence may lead to unpleasant consequence of loosing both crops (Plate 1d).

Tea is also prone to white root disease at any stage of its growth (Plate 1e), although the juvenile stage is highly susceptible and tends to die within a very short period after the infection (Arulpragasam, 1986). Mature tea bushes can withstand the white root disease infection up to a certain period, while transmitting the pathogen quickly to the adjoining bushes via laterals (Plate 1f). It has been noted that on many occasions, the infection spread from the collar region towards the laterals. It points to the possibility that tea bush may also be infected by mycelial strands running through the thick litter layer beneath tea bushes. Possible reasons can be the high moisture retaining nature due to the thick litter layer and this condition enhances formation of such mycelial strands, which are actively involved in finding new host tea roots.

Since, tea is planted at 120 cm × 60 cm in intercropped lands, the pathogen would be able to make a steady network within the plantation (Plate 1f) concomitantly transmitting to rubber tree rows as well. Therefore, growers must take immediate action when the disease is observed early in tea or in rubber. It may be quite difficult to blindly inspect roots of tea bushes for the disease, but the grower should take the history of rubber lands into consideration particularly those infested by white root disease pathogen previously. When maintaining field records, growers should have field maps for each clearing indicating the status of the white root disease for the sake of the next plantation and such information would be useful for the proper upkeep of the subsequent clearings. Following the recommended techniques on pre-planting practices in white root disease infected areas is important. If tea is to be planted in an area, which was previously under rubber, with a history of white root disease, it will not be difficult to be vigilant on new tea plants grown in the same area. Therefore, it should be a matter of priority to inspect tea and rubber plants in the diseased patches for new infections at regular intervals during the first two years which is the critical period for infections. It may also be possible to suppress the pathogen underground by applying sulphur to soil. This can be done by sprinkling sulphur to soil in between rubber trees or perhaps in between tea bushes, in consultation with Tea Research Institute (TRI). Application of a systemic fungicide to tea may not be advisable, since leaves are harvested for human consumption and accumulation of residues in leaves may be a problem. However, a localized application of Hexaconazole to infected bushes may be effective against the tea root infection by *R. microporus* (personal communication with TRI), although the effect of the fungicide on the quality of tea has not been investigated yet. If the disease has not been properly controlled at the correct time, growers will have to overcome more difficult situations as the disease would spread rapidly when root network is developed underneath, and the disease would spread not only within the tea itself, but also to the rubber trees or vice versa.

We have recently investigated the severity of white root disease incidence in an experimental field (established in a mid country plantation) with a view to comparing the rate of white root disease transmission during a period of 14 years, after planting tea and rubber. This particular area was previously under rubber, which has been infested by white root disease. After clearing the site including the white root disease infected site, rubber has been planted in single rows with the distances of 8×27 feet or at 8×40 feet in intercropping areas, while rubber only was planted at 12×18 feet. Tea has been planted with the distances of 2 feet in rows and 4 feet between rows leaving 8 feet apart from rubber rows.

Nineteen white root disease infected patches were observed (Table 1) in a total area of 1.25 ha with intercropping. In majority of white root disease infected intercropping patches, two rows of tea bushes were affected from infected rubber trees. However, in few cases, the infection had been transmitted up to five tea rows, in contrary to the respective rubber row and the actual transmission of infection towards tea rows may be calculated as 10-14 feet from the rubber row. In some infected patches, the number of infected tea rows has been up to 3-5 (Fig. 1) and the distance is about 14-18 feet. In those infected patches, irrespective of treatments provided for infected rubber trees, a considerable number of trees were found dead due to the infection.

The white root disease infection has not been observed in four blocks planted with rubber only. Only in one instance, that the marginal rubber row of a rubber block was infected from tea bushes of the adjoining intercropping block. This is a very good indication to overview the whole picture with the emphasis of the phenomena of intercropping towards the enhanced disease transmission. Tea is known to have contributed towards greatly increasing the area under the disease infection. However, it should also be taken into the consideration that, there were casualties of tea bushes due to live-wood termite (LWT) infestation or due to some other causes, among the total dead tea bushes all along the area (Table 2).

Vacancies due to termite attack in tea area were roughly calculated by measuring the average percentage of casualties due to termites, in 4 randomly located tea blocks (28 ft^2) consisting 8 tea bushes in each plot. Percentage values of each block were averaged with the standard error of means (SEM). In this calculation, it was ensured to avoid areas affected with the white root disease by root inspection and assess the casualties due to LWT. In tea only plots, an average of 24.2±3.9 % casualties due to LWT or other causes were observed, while that of intercropping area was 32.7±0.7% (Table 2). Therefore, about 24% or 32% of the total WRD affected area in tea only or intercropped (blocks respectively, may be subtracted to rectify the error, because within the WRD affected area, it may be possible to have casualties due to LWT or other causes occasionally.

The loss of tea bushes in tea-only area due to the white root disease was found to be in a range of 0.1-27% (average is 14.2±3.4%), while that of tea rubber intercropping area was 25.6±0.3%. The higher percentage loss in intercropped area may be due to synergistic effect of the two cropping systems with a higher root biomass from both crops. Therefore, the total loss of tea bushes in tea-only areas due to all reasons was about 35%, while that of intercropping area was about 58%. During the 14 year period under investigation, the total tea area affected due to the disease was about 0.42 ha, while affected area under rubber in the intercropping area has been calculated as 0.244 ha. The total affected rubber area in rubber-only plots is only 0.0143 ha, which is significantly less, compared to the affected rubber area in the intercropped rubber area (0.244 ha). The total area affected due to the disease is about 0.664 ha under tea and rubber. There was no clear effect of spacing between rubber rows for the spread of the disease in rubber intercropped areas. The actual total number of white root disease infected tea bushes was difficult to be determined by inspecting them individually, since there is a possibility for tea bushes to be partially infected on lateral roots without external symptoms. Therefore, the actual total disease infected area should be higher if partially infected area is also added and thus it would have come around 0.42 ha, which is about 34% of the total area. Obviously, this loss of 34% of the area is too high to be ignored.

Plate 1: **a**, Fructifications on a rubber log in the intercropping area, **b**, unproductive land area in a rubber plantation due to white root disease incidence, **c**, Intercropping rubber with tea, **d**, white root disease transmission along the rubber and tea rows, **e**, white root disease infection on tea, **f**, network of rubber and tea roots enhances the disease transmission from one crop to an other (arrows indicate the growth of the pathogen towards the collar of the tea bush and a crossing over of a tea root by a lateral root from rubber).

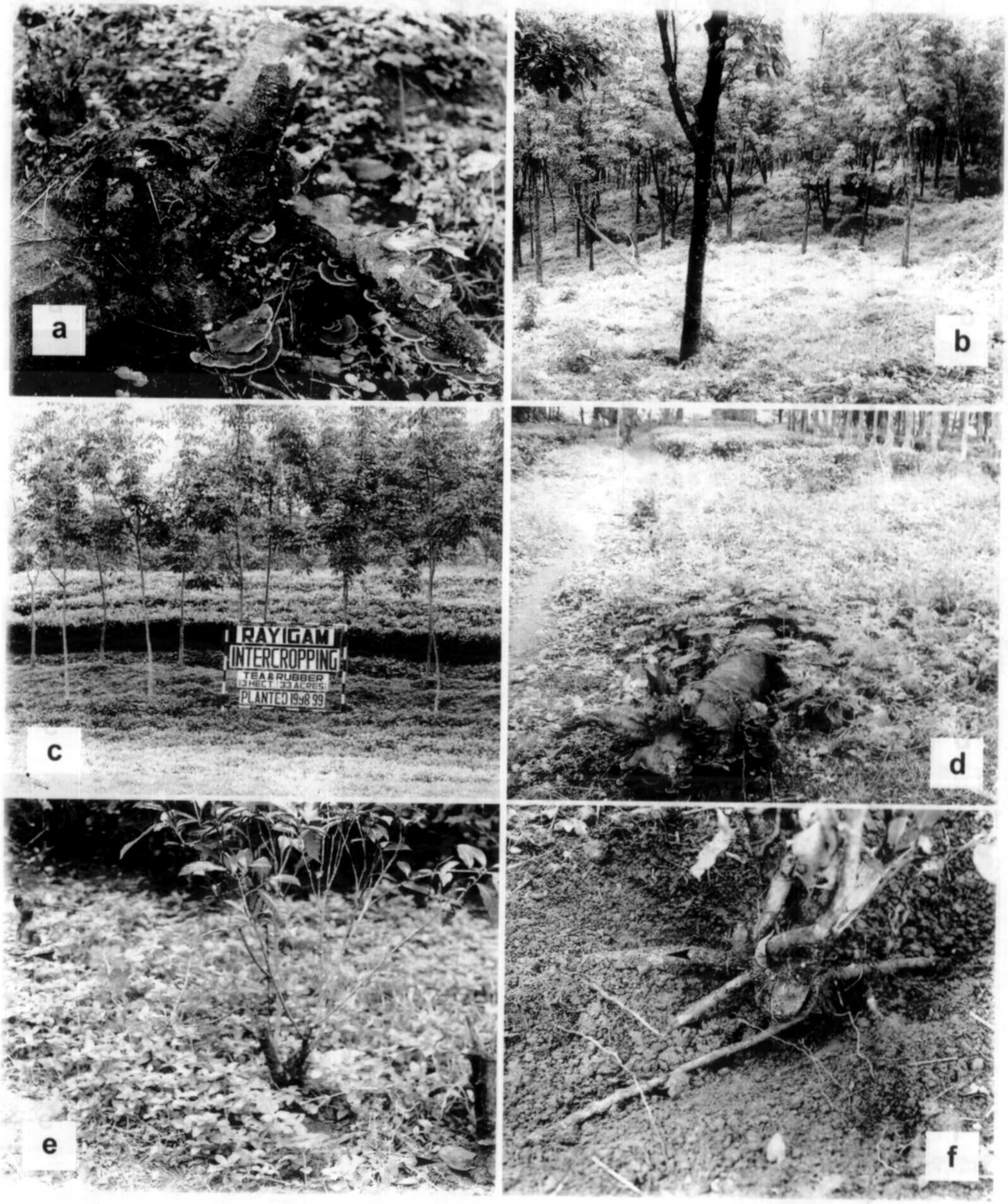

a
b
RAYIGAM
INTERCROPPING
TEA & RUBBER
13 HECT. 33 ACRES
PLANTED 1998/99
c
d
e
f

Table 1. *Summary of the white root disease incidence in an area of 1.25 ha which covers a tea × rubber intercropping experiment with different spacing parameters*

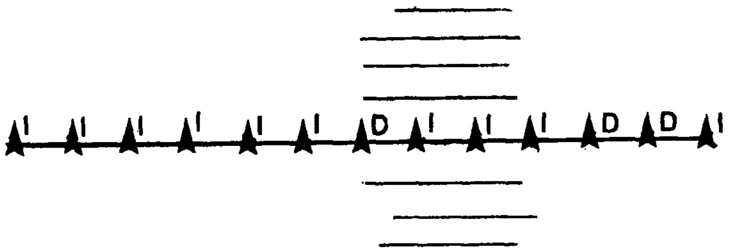
Plot No	Intercropping design	Patch No	Rubber				Tea			
			dead	Infected	Total	Area (ha)	dead	infected	total	Area (ha)
2	8×27 feet (rubber)	1	6	2	8		24	13	37	
	(tea)	2	2	4	6		10	8	18	
		3	5	3	8		89	2	91	
		4	7	6	13	0.016	186	26	212	0.03
7	8×27 feet (rubber)	10	2	8	10		15	13	28	
	(tea)	11	2	8	10		22	5	27	
		12	4	3	7		59	29	88	
		13	3	9	12	0.18	59	27	86	0.02
23	8×27 feet (rubber) (tea)	19	11	4	15	0.007	137	32	169	0.013
3	8×40 feet (rubber)	5	7	3	10		0	0	0	
	(tea)	6	9	7	16	0.012	88	5	93	0.007
5	8×40 feet (rubber)	8	11	2	13		188	13	201	
	(tea)	9	6	6	12	0.0114	79	21	100	0.023
14	8×40 feet (rubber)	14	5	2	7		63	45	108	
	(tea)	15	3	0	3	0.0045	16	16	32	0.011
16	8×40 feet (rubber) (tea)	16	10	3	13	0.006	122	45	167	0.013
22	8×40 feet (rubber)	17	6	2	8		41	41	82	
	(tea)	18	7	1	8	0.0072	100	43	143	0.02
4	12×18 feet (rubber only)	7	3	4	7	0.0143	-	-	-	-

The total rubber area affected is 0.244 ha from intercropped area, while 0.0143 ha is affected in rubber mono-crop area. Tea has been planted at 2 × 4 feet in all plots.

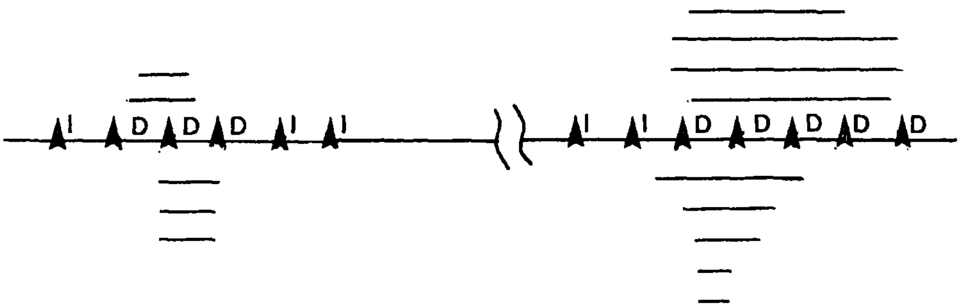
Table 2. *Present status of tea in different experimental blocks showing percentage losses of tea bushes due to different reasons*

Block (Tea)	Initial No.	Total loss (%)	% loss due to		Blocks Inter-cropped	Initial No.	Total loss (%)	% loss due to	
			LWT/other	WRD				LWT/other	WRD
1	1710	22	21.9±7	0.1	2	1020	60	47	13
8	1673	58	31.2±4.2	27	3	1300	44	39	5
13	1318	51	28.1±3.6	22.9	5	1192	67	11	56
21	1810	17	15.6±3.6	1.4	6	1070	62	56	6
total	6511	χ =37±11.8	χ =24.2±3.9		7	810	50	47	3
		0.18 ha	0.117 ha	0.06 ha	9	1400	63	16.6	46.4
					10	1354	61	61	-
					12	1020	67	19.2	48
					14	1218	52	50	2
					15	1020	78	-	
					16	1105	47	47	-
					18	1185	47	42	5
					20	1324	66	50	16
					22	1483	44	43	1
					23	1221	60	25	35
					24	1085	54	34	20
						18807	χ =57.6±1.4	χ =32.7±0.7	χ =25.6±0.3
						1.4 ha	0.81 ha	0.45 ha	0.36 ha

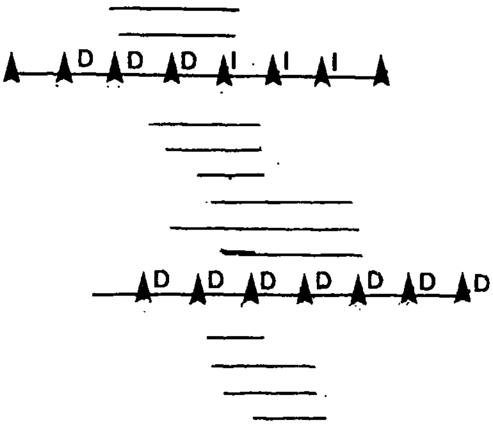
(LWT- Live wood termite, WRD- white root disease)



Plot No. 7, Patch No. 13, 3 rubber trees were dead and all 9 trees are still having infection, 3-4 tea rows are infected in both sides with 89 casualties and 51 having the disease infection.



Plot No. 14, Patches No 15 and 14, are located in the same rubber row with a distance from each other, 3 and 5 rubber trees are dead in two patches, while 5 trees are infected. Up to 5 tea rows are infected in patch 14.



Plot No. 16, Patch No. 16, two adjoining rubber rows including surrounding tea bushes are affected, 10 rubber trees are dead and 3 trees are infected.

Fig. 1. Sketches of some white root disease infected patches, 'A' marks along main lines represent rubber trees which are either dead (D) or infected (I), parallel lines proportionately indicate the affected tea area. Scale: 1 mm = 30 cm.

Though, cinnamon [*Cinnsmomum verum* (syn. *C. zeylanicum*)] has not been recorded as a host of *R. microporus* (Purseglove *et al.*, 1981), when intrecropped under rubber, cinnamon bushes are also prone to the white root disease caused by the same pathogen (Field observations from Kuruwita sub station). However, cinnamon withstands root infection by *R. microporus* for a prolonged period without a significant loss to the plant possibly due to the presence of highly fungitoxic phenolic substances such as camphor (60 %), cinnamaldehyde (4-8 %), eugenol (5 %) in the cinnamon root bark (Wijeratne *et al.*, 1974; Angmer *et al.*, 1972). The underneath root network of cinnamon has a much stronger structure than tea and hence, the pathogen would be more comfortable on thriving under the cinnamon intercrop.

Cacao (*Theobroma cacao*) was another perennial tree crop, which was successfully intercropped under rubber in preliminary trials conducted by the Rubber Research Institute of Sri Lanka with the collaboration of TRI and Minor Export Crop Research Institute. However, cacao is also prone to white root disease (Lass, 1985) spreading through root contact with an infected tree. In favourable conditions in wet soils rich in organic matter, the pathogen may send out long mycelial strands or runners that grow through the soil and along living tree roots. As intercropped lands are heavily crowded, these requirements are easily met and the disease can spread rapidly.

Conclusions

The data gathered from the field emphasise the importance of surveillance of the white root disease in intercropping lands. It does not mean that intercropping rubber lands would not be beneficial. Controlling the disease is a must commencing at the very early stage to avoid further difficulties when the disease has been spread eventually. It may be even worth to spend 5-10 labour days for the treatment of one or few infected trees, when compared to the tree losses that would incur at latter stages. For the control of the white root disease in rubber, a fungicide such as Hexaconazole (0.05 - 0.1% a. i. / ml) can be used as a drenching solution depending on the maturity of the crop, while affected tea or cinnamon bushes may also be treated similarly (Personal communications) in consultation with the TRI or the Department of Export Agriculture. When drenching the fungicide, it would be better to scrape-off the dead bark on the collar-trunk area (just above the ground level) to facilitate the absorption of the fungicide. Post-treatment collar inspection would highly be desirable to achieve better results if initial treatments fail.

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