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CROP LOSS DUE TO ABNORMAL LEAF FALL DISEASE OF RUBBER (*HEVEA BRASILIENSIS*) CAUSED BY *PHYTOPHTHORA* SPP.

C. Kuruvilla Jacob, E. Edwin Prem, M.J. Manju, Sabu P. Idicula and Thomson T. Edathil

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

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Evaluation of crop loss due to abnormal leaf fall disease caused by *Phytophthora* spp in rubber (*Hevea brasiliensis*) plantations of the clones RRIM 600, GT 1 and RRII 118 over 14 years revealed 31.66, 8.21 and 7.15 per cent loss respectively. No such loss was observed for the clone RRII 105 in the plantation in south western India. The mean leaf retention in clone RRIM 600 was only 14.32 per cent as against 54.82 in RRII 105. There was a significant and positive correlation between crop loss in the clone RRIM 600 and the leaf fall in the preceding two years. For RRII 105, the depression in yield during the disease season was compensated by the post wintering resurgence in crop production. The weather conditions had more pronounced effect on crop production in this clone than the disease incidence. The adverse effect of disease on the affected clones resulted in poor girthing and lower wood volume at felling. An increase in crop by 2 to 3 per cent compensates for the cost of spraying. Location specific recommendations of clones for disease avoidance could be a useful strategy for higher crop production.

Key words: Abnormal leaf fall, Clones, Crop loss, *Hevea brasiliensis*, Leaf disease *Phytophthora*, Wood volume.

INTRODUCTION

Abnormal leaf fall (ALF) disease caused by *Phytophthora* spp. is the most destructive disease of rubber in the traditional rubber-growing tract of South India necessitating crop protection every year (Edathil *et al.*, 2000). Early attempts to assess the crop loss due to this disease revealed losses of 37.68 to 50.46 per cent in the clones BD 5, Tjir 1 and Gl 1 (Ramakrishnan, 1960). Later, crop loss ranging from 9.27 to 15.75 per cent was observed in clones RRIM 600 and PB 86. (Jacob *et al.*, 1989). It was also observed that crop loss during the succeeding year of leaving an area unprotected exceeded that in the same year (Jayarathnam *et al.*, 1987). These estimations were based on short-term experiments extending only for one or two disease seasons/years and therefore could not estimate the carry-over effect of debilitation of trees due to the disease over several years on yield. This study was aimed at quantifying the overall crop loss in popular rubber clones widely cultivated in South India.

MATERIALS AND METHODS

The experimental clones consisted of three popular clones namely RRIM 600, RRII 105 and GT 1 planted in the Central

Correspondence: C. Kuruvilla Jacob (E-mail: kuruvilla@rubberboard.org.in)

Experiment Station (CES) of the Rubber Research Institute of India at Chethackal, Ranni in Kerala State, India during 1976 to 1978. A vigorously growing clone RRII 118 which was considered as a good clone for latex and timber production planted during 1978 was also included. Crop loss was assessed by comparison of paired plots (Wastie and Mainstone, 1968). Each clone was planted in two tapping blocks at a spacing of 4.8 x 4.8 m (nearly 300 trees/block). The tapping blocks were clearly marked with equal number of trees in each block, leaving two guard rows of trees in between the blocks. The experiment was initiated in 1988 and pre-treatment yield was recorded in all the clones under uniformly protected condition for one year to work out the potential yield of each block. The tapping blocks were maintained without any change (re-blocking) throughout the experimental period. Both the blocks received all the agro-management practices uniformly as per recommendation (Rubber Board, 2003). One tapper was allotted for each clone and the blocks were tapped half spiral on alternate days (1/2 S d/2), Sunday being holiday throughout the year and yield was recorded on every tapping day. The number of trees under tapping was recorded twice in a year and the yield per tree per tapping worked out.

For each clone, one block was sprayed against ALF while the other remained unsprayed throughout the period of experiment. The prophylactic spraying was done with oil-dispersible copper oxychloride (56%) dispersed in agricultural spray oil at 1:5 ratio at a dosage of 40 litres per hectare before the onset of monsoon, every year. Micron sprayer was used for spraying, covering every row of trees at a speed of about 2-3 km/h. Leaf retention was assessed by tagging four branches per tree from 10 trees in each block as described by Idicula *et al.*, (1989).

The trees were tapped on regular tapping panels without stimulation up to 2001-02 except for RRIM 600, which was on high level tapping during 2001-02. During 2002-03 all clones were under high level tapping. The potential yield of the unsprayed block was estimated annually on the basis of the pre treatment yield with yield in the sprayed block during the year as reference and the crop loss was estimated using the formulae given below.

The girth of the trees and bole height were recorded from every third tree in each row at the close of the experiment and the wood volume estimated (Viswanathan *et al.*, 2003).

$$\text{Potential yield in unsprayed block} = \text{Yield in sprayed block} \times \frac{\text{Pre-treatment yield in unsprayed block}}{\text{Pre-treatment yield in sprayed block}}$$

$$\text{Percentage crop loss in unsprayed block} = \frac{\text{Potential yield} - \text{Realised yield}}{\text{Potential yield}} \times 100$$

RESULTS AND DISCUSSION

The incidence of abnormal leaf fall was observed in varying intensities every year during June to October. The disease incidence, as reflected by the leaf retention in the sprayed and unsprayed plots of all the four clones, is presented in Table 1. It is evident that the sprayed plots retained more foliage in all the clones. The disease incidence was severe in the clone RRIM 600 while it was the least in RRII 105 and moderate in the other two clones. The unsprayed plot of RRII 105 retained 54.82 per cent leaves while it was lower for the other clones with RRIM 600 recording only 14.32 per cent.

The yield recorded in the experimental blocks is presented in Table 2. It was observed that the yield from the sprayed block in the clones RRIM 600, RRII 105 and RRII 118 was higher while it was lower for GT 1. However the gross yield could not clearly reveal the crop loss, due to the variations in other factors that contribute to yield. The number of tapping trees varied from year to year. The variation was due to loss of tapping trees by natural calamities like wind damage and also due to the occurrence of tapping panel dryness. The mean number of tapping trees was much lower for the sprayed blocks of GT 1 compared to unsprayed (Table 3). There was also variation in the number of tapping days for each block. Hence, the yield per tree per tapping was worked out for each tapping year. The realised and potential yields of the trees per tapping along with the corresponding crop loss are presented in Table 4. There was an overall crop loss of 31.66 per cent in the unsprayed plot of RRIM 600. The crop loss in the clones GT 1 and RRII 118 was 8.21 and 7.15 per cent respectively while there was no overall crop loss in the clone RRII 105.

The monthly variation in the yielding pattern of the clones during 1991 to 2001 is presented in Figure 1. It can be observed that the yield in the unsprayed plot of RRIM 600 remained much below that of the sprayed, irrespective of the seasons indicating profound influence of disease on the

Table 1. **Leaf retention (%) in experimental plots**

Year	RRIM 600		RRII 105		GT 1		RRII 118	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
1989-90	10.84	10.84	—	—	—	—	—	—
1990-91	69.96	38.86	88.97	73.62	—	—	—	—
1991-92	58.63	4.77	83.83	69.25	94.78	44.54	60.67	24.35
1992-93	44.13	4.38	71.23	64.62	85.46	51.28	77.07	53.4
1993-94	41.31	10.69	68.52	26.65	76.83	46.65	60.09	15.71
1994-95	65.27	13.01	80.98	63.25	75.09	58.88	82.75	67.42
1995-96	49.67	19.16	83.03	66.78	78.37	61.20	76.97	44.72
1996-97	29.70	17.37	66.15	43.63	60.90	55.69	60.90	59.33
1997-98	50.17	20.09	73.29	48.52	75.21	28.54	84.39	54.43
1998-99	55.62	7.96	72.77	39.14	53.46	20.67	59.11	18.85
1999-00	42.11	14.87	71.02	69.61	57.13	32.88	80.79	72.49
2000-01	52.97	3.89	83.27	55.58	75.2	48.80	71.49	71.05
2001-02	50.34	28.02	64.28	52.83	58.74	41.54	73.37	48.28
2002-03	32.94	6.55	67.08	39.42	65.81	39.74	69.94	43.46
Mean	51.47	14.32	74.96	54.82	71.42	44.2	71.46	47.79

Table 2. **Gross yield (kg) of clones under sprayed and unsprayed conditions**

Year	RRIM 600		RRII 105		GT 1		RRII 118	
(June-May)	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
1989-90	2212	1671	2435	1890	1440	1441	1510	1601
1990-91	1976	1584	2897	3472	1735	2405	1815	1816
1991-92	1944	1618	2271	2489	1499	2188	1789	1721
1992-93	1562	1396	1689	1852	1059	1637	1479	1489
1993-94	2292	1815	1963	1866	1343	1906	1737	1670
1994-95	1580	1124	1993	2034	1699	2281	1717	1465
1995-96	1247	1006	1596	1580	1064	1313	1051	920
1996-97	1169	1283	1759	1610	1063	1499	1091	991
1997-98	2361	1930	1547	1286	1226	1483	1191	1019
1998-99	1767	1383	1931	1887	1640	2030	1414	1253
1999-00	1923	1936	1353	1172	1081	1400	1378	1388
2000-01	1823	2170	1402	1213	1340	1349	1356	1293
2001-02	4392	4585	1337	1028	1220	764	1356	1022
2002-03	3826	3687	4127	4126	4919	5126	5783	5654
Mean	2148.14	1942	2021.43	1964.64	1594.86	1915.86	1761.93	1664.43

yield. The correlation between leaf retention in the preceding two years and yield in the succeeding year was high (0.683) and significant for RRIM 600. The confidence interval (95%) worked out for the yield loss in this clone was between 38.72 and 24 per cent. For the clone RRII 105, the yield (per tree/per tapping) during the disease season (June-October) remained lower in the unsprayed plot but the trees recovered thereafter with the new flush after wintering in December and the yield remained high till the next disease season, thus compensating the loss due to disease. This clone showed wide variation in crop loss in different years indicating that the effect of weather on the yield was more pronounced than the effect of disease. With the retention of about 55 per cent leaves, the trees could recover the adverse effect of leaf fall. No definite trend was observed in the monthly yield for GT 1. However the yield of unsprayed plots of RRII 118 remained lower compared to the sprayed though the difference was not as pronounced as in RRIM 600.

The length of the tapping cut depends upon the girth of the rubber trees which in turn affects the yield. The girth is an indication of growth of the trees as well. As the leaves are the source of photosynthates for growth, the low leaf retention leads to poor girth. This is evident from the girth of trees presented in Table 5. Girth in turn affects the volume of wood. The adverse effect of abnormal leaf fall disease on girth increment of clones RRIM 600 and PB 86 has already been reported (Jacob *et al.*, 1989). Similar effect of powdery mildew disease which also causes defoliation and loss of canopy has also been reported (Wastie and Mainstone, 1968; Jacob *et al.*, 1992; Mondal and Jacob, 2002).

The control of abnormal leaf fall disease can be achieved by micron spraying of copper oxychloride as evident from the present study. This involves an annual expenditure of Rs. 2470/ hectare as per the cost of inputs during 2003. At the average price of Rs.50.40 for RSS 4 grade rubber realised during 2003, the expenditure on micron spraying can be compensated by an

Table 3. **Number of tapping days and tapping trees (1989-2003)**

Year (June-May)	RRIM 600 Tapping trees Sprayed	RRIM 600 Tapping trees Unsprayed	RRIM 600 Tapping days Sprayed	RRIM 600 Tapping days Unsprayed	RRII 105 Tapping trees Sprayed	RRII 105 Tapping trees Unsprayed	RRII 105 Tapping days Sprayed	RRII 105 Tapping days Unsprayed	GT 1 Tapping trees Sprayed	GT 1 Tapping trees Unsprayed	GT 1 Tapping days Sprayed	GT 1 Tapping days Unsprayed	RRII 118 Tapping trees Sprayed	RRII 118 Tapping trees Unsprayed	RRII 118 Tapping days Sprayed	RRII 118 Tapping days Unsprayed
1989-90	229	221	149	152	222	225	149	152	218	257	149	152	231	251	149	152
1990-91	163	193	152	153	189	193	152	153	193	257	152	153	211	262	152	153
1991-92	193	252	152	153	162	190	152	153	186	245	152	153	222	274	152	153
1992-93	189	192	121	124	146	155	121	124	171	242	121	124	206	242	121	124
1993-94	242	258	152	150	141	139	150	149	170	242	150	149	201	243	150	149
1994-95	153	183	138	142	132	167	138	142	188	241	138	142	183	206	138	142
1995-96	198	215	152	152	179	163	152	152	175	224	152	152	170	192	152	152
1996-97	88	96	146	149	131	149	146	149	170	248	145	149	157	138	146	149
1997-98	240	190	144	151	190	140	151	151	155	210	149	147	190	230	144	149
1998-99	204	218	145	145	172	124	145	142	197	180	140	143	205	220	152	152
1999-00	167	247	145	148	153	109	145	143	184	216	139	146	220	207	125	145
2000-01	183	268	148	147	178	144	148	147	184	216	148	151	220	207	151	148
2001-02	273	321	124	124	178	144	117	120	184	216	120	118	220	207	120	110
2002-03	281	301	145	148	201	197	151	153	236	285	147	146	256	269	148	145
Mean	200.21	225.36	143.79	145.57	169.57	159.93	144.07	145	186.5	234.21	143	144.64	206.57	224.86	142.86	144.5

Table 4. **Yield (grams/tree/tapping) and crop loss**

Year (June-May)	RRIM 600 Sprayed	RRIM 600 Unsprayed Realised	RRIM 600 Unsprayed Potential	RRIM 600 Crop loss (%)	RRII 105 Sprayed	RRII 105 Unsprayed Realised	RRII 105 Unsprayed Potential	RRII 105 Crop loss (%)	GT 1 Sprayed	GT 1 Unsprayed Realised	GT 1 Unsprayed Potential	GT 1 Crop loss %	RRII 118 Sprayed	RRII 118 Unsprayed Realised	RRII 118 Unsprayed Potential	RRII 118 Crop loss %
1989-90	64.83	49.74	76.62	35.07	73.62	55.26	73.62	24.94	35.10	36.91	37.05	0.38	43.89	41.97	40.59	-3.37
1990-91	79.73	53.66	94.23	43.04	100.85	117.58	100.85	-16.58	59.14	61.17	62.43	2.01	56.57	45.29	52.33	13.45
1991-92	66.25	41.96	78.29	46.41	92.23	85.62	92.23	7.16	53.02	58.36	55.97	4.27	53.02	41.04	49.04	16.32
1992-93	68.31	58.62	80.73	27.38	95.60	96.34	95.60	-0.77	51.16	54.54	54.01	-0.99	59.34	49.61	54.88	9.62
1993-94	62.30	47.81	73.62	35.05	91.60	89.49	91.60	2.29	51.98	52.50	54.87	4.31	56.85	45.82	52.59	12.87
1994-95	74.81	43.26	88.41	51.06	109.41	85.78	109.41	21.59	65.47	66.65	69.10	4.08	69.70	50.07	62.87	20.36
1995-96	41.44	37.80	48.98	37.15	58.67	63.77	58.67	-8.69	40.02	38.56	42.25	8.67	46.60	31.51	37.62	16.24
1996-97	90.89	89.66	107.41	16.53	91.91	74.28	91.91	21.14	43.10	40.50	45.49	12.23	47.60	48.10	44.03	-9.24
1997-98	68.32	67.26	80.74	16.69	53.90	60.85	53.90	-12.89	53.08	48.04	56.02	14.24	43.51	29.72	40.24	26.14
1998-99	59.71	43.75	70.57	15.39	77.41	107.16	77.41	-38.43	59.47	78.87	62.77	-25.64	45.36	37.48	41.96	10.67
1999-00	79.34	52.91	93.76	43.56	60.98	75.13	69.98	-23.20	42.22	44.35	44.56	4.71	50.09	46.23	46.33	2.16
2000-01	65.53	55.07	74.08	25.67	53.15	57.29	53.15	-7.78	49.18	41.34	51.91	20.36	40.82	42.22	37.76	-11.81
2001-02	129.70	115.17	153.28	24.86	64.21	70.62	64.21	-9.98	55.27	30.00	58.34	48.58	51.36	44.88	47.51	5.53
2002-03	93.92	82.75	110.99	25.44	135.97	136.04	135.97	-0.05	141.78	123.19	149.65	17.68	152.62	144.94	141.70	-2.28
Mean	74.65	59.96	87.98	31.66	82.82	83.94	83.47	-2.95	57.14	55.36	60.32	8.21	58.38	49.92	53.53	7.15

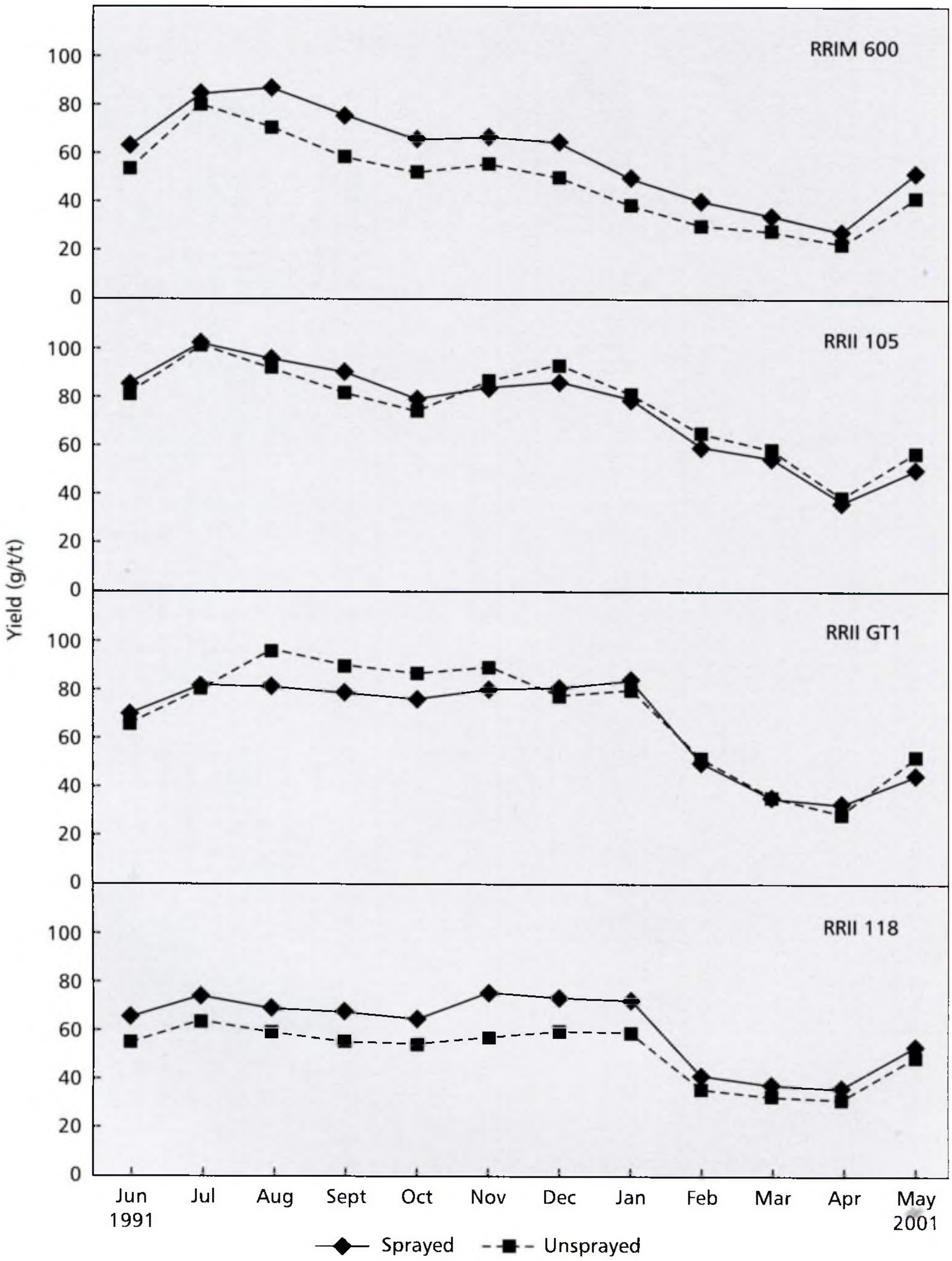

Fig. 1. Yield trend (June 1991 - March 2001)

Table 5. **Girth of trees and clear bole volume of wood at felling (2004)**

Clone	Treatment	Total number of trees	Mean girth (cm)	Mean wood volume m^3/tree
RRIM 600	Sprayed	234	119.34	0.42
	Unsprayed	300	102.31	0.37
RRII 105	Sprayed	219	114.80	0.31
	Unsprayed	169	98.78	0.38
GT 1	Sprayed	240	103.03	0.40
	Unsprayed	260	99.91	0.37
RRII 118	Sprayed	237	119.88	0.58
	Unsprayed	235	107.54	0.44

additional rubber crop of 49 kg/ha. At the yield potential recorded for the clones in the present study (at the experimental location) the crop increase required to compensate for the spraying cost is presented in Table 6. On this consideration, it will be quite economical to protect the clones RRIM 600, GT 1 and RRII 118. The additional income from increased wood volume will be another benefit of such protection. Considerable saving on cost of weeding in sprayed plots have also been reported (Jacob *et al.*, 1989).

This study also points to the need for environment specific clone recommendations. As observed in the present experimental area, the clone RRIM 600 may not be ideal for planting in the central zone of the traditional rubber growing region of India as it succumbs to ALF. Since RRII 105 could withstand the disease and compensate for crop loss in the succeeding disease-free season it may be the ideal clone for this region. Nevertheless, this clone may not perform similarly in all the rubber growing regions of South Western India. In areas where ALF is not reported, like the non-traditional rubber growing regions of India, RRIM 600 may yield better.

Table 6. **Crop increase required to compensate for the cost of spraying**

Clone	Crop increase required (%)
RRIM 600	2.28
RRII 105	2.42
GT 1	3.07
RRII 118	2.78

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