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EVALUATION OF MODERN *HEVEA BRASILIENSIS* CLONES AGAINST POWDERY MILDEW AND ABNORMAL LEAF FALL DISEASES

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Abnormal leaf fall (ALF) disease caused by *Phytophthora* spp. and powdery mildew disease caused by *Oidium heveae* are the most economically important diseases of rubber (*Hevea brasiliensis*) in India. Severe incidence of these diseases adversely affects the growth and yield of the plants. Since the incidence and intensity of the disease vary among clones, an attempt was made to evaluate the response of modern *Hevea* clones against ALF and powdery mildew diseases. Twenty clones of *H. brasiliensis* including the newly recommended RRII 400 series clones were evaluated against powdery mildew disease in comparison with the popular clone RRII 105 in two large-scale trials (Trial I & II) at Central Experiment Station, Chethackal in Central Kerala. Trial 1 included twelve clones and Trial II ten clones, replicated six and three times respectively, with sixteen trees per plot. Observations on powdery mildew disease was carried out for three consecutive years at the peak time of disease season. Disease assessment was carried out on a 0-5 scale according to the intensity of infection on the leaves and mean intensity per plot was calculated. Wintering pattern and leaf stage at the time of assessment for each clone was also carried out. Similarly five promising 400 series clones *viz.* RRII 414, RRII 430, RRII 417, RRII 422 and RRII 429 were evaluated for ALF disease severity in comparison with RRII 105 in the 1982 small-scale trial at Rubber Research Institute of India for three consecutive years. Leaf retention after the disease season was assessed as per standard procedures. The results indicated that, in general all the clones were susceptible to powdery mildew disease with more than 50 per cent disease intensity. Significant variation in disease intensity was observed between clones and across years. Mean disease intensity was found to be significantly low for the clones RRII 55 and RRII 422 though RRII 55 was on par with RRII 105 and RRII 407. Variations in disease intensity were correlated to variations in the time of wintering of clones and prevailing climatic conditions in different years. Evaluations of clones for ALF disease revealed no significant variation in leaf retention among the five clones and were on par with RRII 105, a clone relatively tolerant to ALF disease. The lowest leaf retention was recorded in RRII 422.

Keywords: Abnormal leaf fall (ALF) disease, Disease assessment, Disease intensity, Disease resistance, Leaf retention, Powdery mildew disease

INTRODUCTION

Abnormal leaf fall (ALF) disease caused by *Phytophthora* spp. and powdery mildew disease caused by *Oidium heveae* are the most important diseases of rubber in India. Severe incidence of these diseases adversely affects the growth and yield of the plants. An yield loss of 38 to 56 per cent due to ALF was

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reported when the trees are left unsprayed for one disease season (Ramakrishnan, 1960). Jacob *et al.* (1989) reported an yield loss of 9 to 16 per cent due to this disease in high yielding clones. The cumulative crop loss due to ALF was reported to be 30 to 50 per cent (Pillay *et al.*, 1980). Wastie and Mainstone (1968) have reported a crop loss of 8.1 per cent in the clone PB 5/51 over the period of nine months in Malaysia and an increase in bark renewal and girth increment in trees protected against powdery mildew. In India, yield loss of 8 to 32 per cent has been reported in clones PB 86, RRIM 600 and RRII 105 susceptible to powdery mildew disease and this reduction in yield was noticed throughout the year (Jacob *et al.*, 1992; Mondal and Jacob, 2002). Clonal variation to these diseases has been observed by many authors. Clones PB 86, PB 235, PB 260, PB 28/59, RRIM 600 and RRIM 703 were found to be susceptible to ALF disease whereas, the clones RRII 105, PB 217 and GT 1 were observed to be relatively tolerant (Edathil *et al.*, 2000). High degree of disease resistance has been reported in the clone LCB 870 in Sri Lanka and Fx 516, RRII 33 and F 4542 in India (Edathil *et al.*, 2000). All the rubber clones cultivated in India were observed to be susceptible to powdery mildew disease. The clones Tjir 1, Tjir 16, BD 5, BD 10, PB 5/139, PB 6/9, PB 6/50, AVROS 49, and PLB 84 & 81 were reported to have severe damage due to powdery mildew disease (Ramakrishnan and Pillay, 1962). The clones PB 5/51, RRIM 605, RRII 105, RRII 118, RRII 308, RRII 300, PR 261, PB 217, PB 235, PB 280 and PB 311 were also susceptible. However, PB 86, GT 1, Gl 1, PB 5/139, RRIM 703, RRII 208, PB 341, RRIM 600, PB 311, SCATC 88- 3, SCATC 93-114, Haiken 1, RRII 429, RRII 417 and RRIC 100 showed some tolerance (Mondal *et al.*, 2005).

Though effective control measures are available for the control of these diseases, use of disease resistant clones is the most effective, economic and least hazardous measure of disease control. Information on disease response of different clones is essential for evolving management strategies. Hence, the present study was aimed at evaluating the powdery mildew disease intensity and ALF disease in the newly recommended clones.

MATERIALS AND METHODS

Twenty clones were evaluated against powdery mildew disease in comparison with RRII 105 in two large-scale trials (Trial I and Trial II) laid out at Central Experiment Station of RRII at Chethackal. Trial I included 12 clones, nine belong to RRII 400 series clones, one tetraploid and one derived from the compact canopy type and RRII 105 as control. Trial II included 10 clones, six being 400 series clones, one Prang Bazaar clone, two clones from the progeny of compact canopy type and the control RRII 105 (Table 1). The trials were laid out in Randomised Block Design with six replications in Trial I and 3 replications in Trial II. The plot size was 16 trees per plot. Observations on powdery mildew disease incidence were carried out for three consecutive years from 2001-2003. Disease assessment was done on leaf samples collected from five trees per plot. Five leaves each from the terminal whorls of five branches were observed in each tree. The leaves were graded according to their intensity of infection (% leaf area affected) on a 0-5 scale *viz.*, 0-(no disease), 1-(1-10 %), 2-(11-25 %), 3-(26-50 %), 4-(51-75 %) and 5-(> 75% with leaf fall). The mean score per plot was calculated and expressed as per cent disease intensity (Horsfall and Heuberger, 1942). The data collected during

Table 1. **Pedigree of clones evaluated**

Trial I		Trial II	
Clone	Pedigree	Clone	Pedigree
RRII 402	RRII 105 x RRIC 100	RRII 410	GT 1 x RRIC 100
RRII 403	"	RRII 422	RRII 105 x RRIC 100
RRII 407	"	RRII 427	"
RRII 414	"	RRII 430	"
RRII 417	"	RRII 434	RRII 105 x PR 107
RRII 429	"	RRII 454	GT 1 x RRIC 100
RRII 446	GT 1 x RRIC 100	RRII 52	Normal morphotype progeny
RRII 449	"	RRII53	"
RRII 453	"	PB 330	PB 5/51 x PB 32/36
RRII 54	Normal morphotype progeny from compact canopy type	RRII 105	Tjir 1 x Gl-1
RRII 55	Tetraploid (2n = 72)		

different years were statistically analysed. Wintering pattern and the stages of leaf in each clone at the time of disease assessment were also recorded.

Similarly five promising RRII 400 series clones *viz.* RRII 414, RRII 430, RRII 417, RRII 422 and RRII 429 were evaluated for abnormal leaf fall disease under unsprayed condition in comparison with RRII 105 in the 1982 small-scale trial at Rubber Research Institute of India. Observations on leaf retention were recorded for three consecutive years from 2006-2008. Leaf retention was assessed by the leaf count method (Idicula *et al.*, 1986) and by visual assessment at the end of disease season for all the years.

RESULTS AND DISCUSSION

In general, all the clones studied were susceptible to powdery mildew disease. Mean per cent disease intensity clearly indicated moderate to very severe disease in both the trials. The disease intensity was varying among clones and across years. In Trial I, RRII 105 recorded significantly low disease in 2001 followed by RRII 55 which was on par with RRII 407, RRII 402 and RRII 403. In 2002, the clone RRII 55 recorded 64 per cent disease intensity and was significantly lower to all other clones except RRII 414. Other clones recorded more than 84 per cent disease intensity and were significantly higher than RRII 55. In 2003, RRII 407 recorded low disease intensity and was on par with RRII 105, RRII 55, RRII 403 and RRII 402. Mean disease intensity also was low in the clone RRII 55 which was on par with RRII 105 and RRII 407. The clone RRII 449 recorded the highest disease intensity during the year 2001 with 98 per cent PDI and was on par with the clones RRII 54, RRII 453, RRII 417, RRII 414 and RRII 429. The clone RRII 446 recorded highest disease intensity and was on par with all the clones except RRII 414 and RRII 105 in 2002 and with clones RRII 449, RRII 54 and RRII 453 in 2003. The clones RRII 446, RRII 449, RRII 54 and RRII 453 were consistent with high disease intensity in all the three years (Table 2).

Table 2. **Powdery mildew disease- Per cent disease intensity (Trial I)**

Clone	Year			Mean
	2001	2002	2003	
RRII 54	93.4	89.3	80.6	89.6
RRII 105	47.9	91.4	43.2	60.8
RRII 407	69.5	84.9	39.9	64.8
RRII 449	98.4	97.1	84.5	94.0
RRII 403	72.2	95.4	45.4	71.3
RRII 414	82.4	70.2	62.5	71.7
RRII 402	76.4	93.5	54.5	74.8
RRII 429	82.2	94.0	63.3	79.8
RRII 446	95.6	98.9	97.8	97.8
RRII 453	92.8	97.6	85.4	91.9
RRII 417	93.2	85.7	75.2	84.7
RRII 55	69.2	64.3	45.9	59.8
Mean	81.2	87.3	65.3	
CD for mean years			-	4.89
CD for interaction between years			-	16.96
CD for mean clones			-	9.24
CD for interaction between clones			-	16.64

Table 3. **Powdery mildew disease - Per cent disease intensity (Trial II)**

Clone	Year			Mean
	2001	2002	2003	
RRII 434	96.5	97.8	92.6	95.7
RRII 427	84.4	95.8	48.6	75.9
RRII 53	76.2	86.2	68.4	76.9
RRII 422	74.7	66.3	33.6	58.2
RRII 105	77.3	81.1	65.8	74.7
PB 330	85.0	94.8	77.9	85.9
RRII 410	95.5	99.1	89.3	94.8
RRII 52	71.6	83.6	65.3	73.5
RRII 430	94.4	97.5	79.8	90.6
RRII 454	97.9	96.3	83.4	92.5
Mean	85.3	90.4	71.4	
CD for mean years			-	3.94
CD for interaction between years			-	12.47
CD for mean treatments			-	7.9
CD for interaction between treatments			-	12.88

In Trial II during 2001, lowest disease intensity was noticed for the clone RRII 52 and was on par with RRII 422, RRII 105 and RRII 53. In 2002 and 2003, the clone RRII 422 recorded significantly low disease intensity. The mean disease intensity also showed that RRII 422 is significantly lower to all other clones. The clones RRII 434, RRII 410, RRII 430 and RRII 454 recorded significantly high disease intensity in all the three years (Table 3). Disease intensity was significantly high during 2002 and low during 2003.

The clone RRII 105 exhibited moderate disease intensity during 2001 (47.9%) and 2003 (43%) in Trial I. Similarly the clones RRII 55 and RRII 422 in general exhibited comparatively low disease intensity in all the three years and were significantly lower to all other clones in 2002 and 2003. However, the inherent susceptibility of these clones was evident from the high PDI value obtained during 2001 and 2002 for the clones RRII 55 (69.2% and 64.3%) and RRII 422 (75% and 66 %) and RRII 105 during 2002 (91%). Rajalakshmy *et al.* (1997) and Mondal *et al.* (2005) reported the high disease intensity of the clone RRII 105. The low disease intensity of the clones could be attributed to their early wintering habit. Time of wintering and stages of the leaf greatly influence the intensity of the disease. Early wintering trees usually escape the disease and late wintering trees are severely affected. Observations on the wintering pattern showed that in these clones wintering was early and the leaves were almost mature when the disease started by the middle of February and could escape the disease (Table 4). Suryakumar *et al.* (2002) and Vinod *et al.* (2004) reported the early wintering habit of the clone RRII 105.

Table 4. **Wintering status of the clones during the first week of January 2002**

Wintering characteristics	Clone
Green leaves (yet to show symptoms of wintering)	RRII 446, RRII 453, RRII 54, RRII 449, RRII 434 RRII 454, RRII 410, RRII 430
Fully yellowing, no leaf shedding	RRII 429, RRII 414, RRII 417, PB 330
Yellowing and leaf shedding initiated	RRII 407, RRII 402, RRII 403, RRII 427
Wintering almost completed/refoliation initiated	RRII 105, RRII 55, RRII 422

The high disease intensity of these clones might be due to the early outbreak of the disease under conducive climatic condition during 2001 and 2002 when the leaves of these clones were at the most vulnerable stage. In Trial II, RRII 105 recorded high disease intensity compared to Trial I. In Trial I, the leaves of RRII 105 in some replications matured early and hence recorded low disease intensity. Rajalakshmy *et al.* (1997) reported that the fertility of the soil and soil moisture content affect wintering and rapidity of the growth of the leaves after wintering and this in turn influence the disease intensity. The clones RRII 446, RRII 54, RRII 449, RRII 453 in Trial I and the clones RRII 454, RRII 430, RRII 410 and RRII 434 in Trial II recorded significantly high disease intensity in all the three years. It can be attributed to the late wintering habit of these clones. The leaves of these clones were green during first week of January while the leaves of the early wintering clones were at the initial stage of wintering (yellowing stage) or at refoliating stage (Table 4). The wintering and refoliation was late by two weeks in these clones and the leaves were at the most susceptible stage *i.e.*, copper bronze/light green stage when climatic conditions were favourable for infection. The late wintering habit of these clones might have inherited from one of their parents GT 1 or PR 107 (Table 1). Vinod *et al.* (2004) reported the slow wintering habit of these clones with young leaves for a considerable long period. Our observations also showed slow wintering habit and long refoliation period of GT 1 and PR 107 at CES Chethackal.

The intensity of the disease significantly varied in different years. In general, disease intensity was high during 2001 and 2002 and low in 2003. The climatic factors have great influence on the incidence and severity of powdery mildew disease. In the present study, the high disease intensity in 2001 and 2002 coincided with the afternoon humidity of more than 50 per cent and sunshine hours with less than seven hours (Fig.1). Morning humidity was above 80 per cent and most of the days it was more than 90 per cent. Sunshine hours were less than seven hours for eight days in 2001 and twelve days (with two days without any sunshine) in 2002 during the refoliation period from last week of January to second week of February. Eight days were cloudy/partially cloudy during 2002. Rainfall was recorded for six days in 2001 and four days in 2002 and these cloudy and rainy days were observed during first week of February (Fig.1). This might have contributed for the high disease intensity in 2001 and 2002. However, during 2003 only one day recorded sunshine hours less than eight with no rainfall and hence low disease intensity. Prevalence of mist, dew, cloudy days and light showers during refoliation period

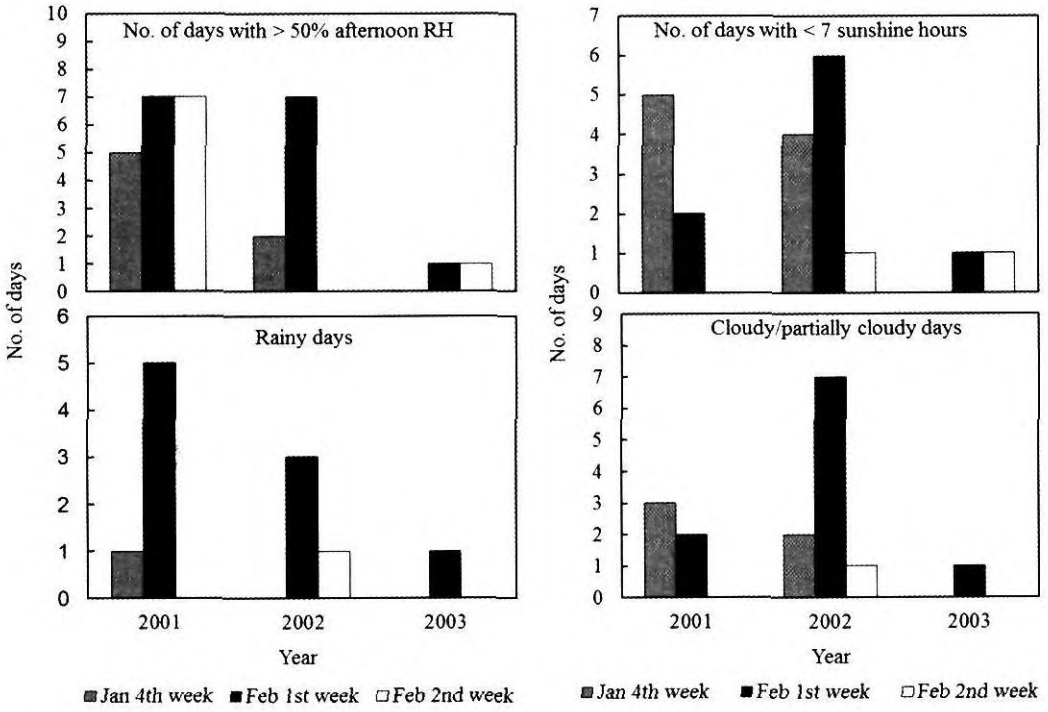

Fig. 1. Climatic factors during refoliation period from last week of January to second week of February

favours the disease development and bright sunny days are inimical to the development of the fungus (Edathil *et al.*, 2000).

Results of the evaluation of the clones for abnormal leaf fall disease indicated that the per cent leaf retention was at par for all the clones in years from 2006 to 2008 (Table 5). Both in leaf tagging method and visual scoring, the leaf retention was comparable. Though no significant variation

Table 5. **Leaf retention in RRII 400 series clones**

Clone	Per cent leaf retention							
	Leaf tagging method				Visual scoring			
	2006	2007	2008	Pooled mean	2006	2007	2008	Pooled mean
RRII 105	78.3	67.3	83.3	76.3	75.0	66.7	75.0	72.2
RRII 429	77.2	53.2	74.8	68.3	81.7	56.7	73.3	70.6
RRII 422	71.7	54.8	57.7	61.4	75.8	46.7	52.5	58.3
RRII 430	81.7	75.4	77.8	78.5	83.2	75.0	75.8	78.0
RRII 414	77.8	64.6	68.3	70.2	80.8	70.0	65.0	71.9
RRII 417	71.3	64.0	65.0	66.8	78.3	60.0	65.0	67.8
CD	NS	NS	NS	NS	NS	NS	NS	NS

in leaf retention was observed among clones, the mean PDI ranged from 61.4 to 78.5 per cent with the lowest leaf retention for RRII 422 and highest for *RRII 430*. *RRII 105*, a clone relatively tolerant to ALF recorded a mean leaf retention of 76 per cent and all other clones were comparable to RRII 105. Pillay *et al.* (1980) and Mushrif *et al.* (2004) reported that RRII 105 is having high leaf retention under similar prophylactic spraying compared to other susceptible clones. Edathil et *al.* (2000) reported that though this clone is relatively tolerant to ALF it is moderately affected by the disease if left unsprayed. In general, the leaf retention was low in 2007 which could be attributed to favourable climatic conditions for the incidence of the disease.

CONCLUSIONS

The present observations indicate that all clones studied here are susceptible to powdery mildew disease. Significant variation is observed among clones in the disease intensity and was greatly influenced by the wintering pattern of the clones and climatic condition prevailing at the area. Evaluation of clones for ALF disease revealed no significant variation in leaf retention among the five clones and was comparable with RRII 105, a clone relatively tolerant to ALF disease.

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