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Control of White Root Disease in Immature Rubber with Three Systemic Fungicides

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Three series of experiments were laid down on 18 month to 30 month old PB260 to evaluate the effectiveness of Bayfidan (triadimenol), Bayleton (triadimefon) and Tilt (propiconazole) against the disease.

The results indicated that treatment success depended on severity of infection at time of fungicide application, rate and type of fungicides applied and method and frequency of disease inspection.

The degree of infection at the collar appeared critical to treatment success. When disease infection advanced beyond the severe stage with concomitant yellowish foliage symptoms, all three fungicides were ineffective against the disease. Conversely, when infection had not crossed the severe stage, trees could be 'saved' by application of Tilt at 7.5 ml, Bayleton at 15–20 g and Bayfidan at 20 ml when infection was severe and 10 g Bayleton, 10 ml Bayfidan and Tilt also at 7½ ml when infection was slight to moderate.

Collar inspection resulted in much higher treatment success than foliar inspection as infected trees could be detected at a much earlier stage. Most diseased trees detected by foliar inspection were beyond 'saving' as infection had advanced beyond the severe stage.

Reinfection of disease appeared about six to ten months after treatment on a small percentage of previously infected trees. These were however successfully controlled by reapplication of fungicides at the previous rates.

It may not be necessary to carry out prophylactic treatment on non-infected border trees if infected trees have been treated with fungicide.

Growth rates of treated trees which had recovered returned to normal about nine months later.

White root disease caused by *Rigidoporus lignosus* is one of the three major root diseases of rubber. It is still an outstanding problem particularly during the immature phase of the crop (Tan, 1990).

Normal estate treatment of the disease consists of removing the soil to expose the tree collar and lateral roots. This is followed by surgical removal of the infected areas and application of a protectant fungicide. The non-diseased neighbouring trees on either side of the infected tree are also prophylactically treated with collar protectant after exposing the tree in the same manner. Isolation trenches are also constructed on both sides of the infected tree as additional precaution against spread of the disease (Wong, 1991).

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Although effective, the above estate practice is laborious and can also be costly. In 1985, Basuki (1985) reported the use of sulphur in reducing disease incidence. Tran (1985) also reported successful treatment of the disease with the use of Calixin (triademorph), a systemic fungicide with soil drenching. With the advent of chemicals, treatment of the disease had become much simplified.

New chemicals have entered the market and recently Ng and Yap (1990) and Tan (1990) reported much higher success with several new systemic fungicides than Calixin, using the same soil drench method. These fungicides include Bayfidan 250 EC (triadimenol), Bayleton 25WP (triademefon), Tilt 250 EC (propiconazole), Folicur (terbuconazole), Anvil (hexaconazole) and Systane (myclobutanil).

This paper reports results of several trials on use of the fungicides, Bayfidan, Bayleton and Tilt against white root disease. Aspects related to control of the disease which were also investigated, including method and frequency of disease inspection, reinfection of disease and prophylactic treatment of border trees are also reported.

MATERIALS AND METHODS

The trials may be grouped into three series. The first and third series of trials basically evaluated effectiveness of the fungicides against the disease while the second series of trials checked the influence of frequency of collar and foliar inspections on incidence and severity of infection of the disease.

Trial sites

Details of trial sites are summarised in *Table 1.*

Owing to the steep terrain, the method of clearing of the previous stand in most of the trials was by chainsaw followed by poisoning of stumps.

Selection of treatment trees

First series trials. Treatment trees consisted of trees infected with the disease and also non-infected neighbours of infected trees in trials RPD89/1 and RPD89/2.

Infected trees were identified by collar inspection carried out at trimonthly intervals.

Second series trials. These trials were conducted to check the incidence and severity of disease infection obtained from collar and foliar inspections carried out at intervals ranging from one to three months. Prior to commencement of the trials, root disease inspection in the areas was carried out at trimonthly intervals.

To obtain three sections in the field which would conform to one to three monthly intervals of disease inspection, three sections covering about 5 ha each were marked out and designated as sections A, B and C. The schedule of root disease inspection given in *Table 2* was followed.

Infected trees detected at each inspection round within each section were given a different colour code to differentiate new infection from the previous infection. Infected trees detected at the end of the fourth month for sections A and C and fifth month for section B were used as treatment trees in the third series trials. All infected trees detected earlier were treated according to normal estate practice.

TABLE 1.
DETAILS OF TRIAL SITES

Trial series	*Trial no.*	*Location of site*	*Soil series/ slope*	*Method of clearing*	*Cultivar*	*Month/ year planted*	*Age of trees (mths)*	*Method of disease inspection*	*Inspection interval*
	RPD89/1	Kerling, Selangor	Seremban, 20' slope	Chainsaw, poisoning of stumps	PB260	Jun. '87	18	Collar	3 months
1st	RPD89/2	Kerling, Selangor	Seremban, 20' slope	Chainsaw, poisoning of stumps	PB260	Jun. '87	29	Collar	3 months
	RPD89/3	Kerling, Selangor	Seremban, 15-20' slope	Chainsaw, poisoning of stumps	PB260	Jun. '88	18	Collar	3 months
	RPD90/1	Kerling, Selangor	Seremban, 15-20' slope	Chainsaw, poisoning of stumps	PB260	Jun. '88	17	Collar	1-3 months
2nd	RPD90/2	Karak, Pahang	Pohoi, 15-20' slope	Poisoning of trees, destumping	PB260	Sept. '87	26	Foliar	1-3 months
	RPD90/3	Kerling Selangor	Seremban, 15-20' slope	Chainsaw, poisoning of stumps	PB260	Jun. '88	20-21	Collar	1-3 months
3rd	RPD90/4	Karak, Pahang	Pohoi, 15-20' slope	Poisoning of trees, destumping	PB260	Sept. '87	29-30	Foliar	1-3 months

TABLE 2.
SCHEDULE OF INSPECTION – EXERCISE 1 AND 2

Section	*Inspection interval*	*Month*				
		1st	*2nd*	*3rd*	*4th*	*5th*
A	Monthly	Inspection	Inspection	Inspection	Inspection	Nil
B	Bimonthly	Inspection	Nil	Inspection	Nil	Inspection
C	Trimonthly	Inspection	Nil	Nil	Inspection	Nil

Third series trials. Treatment trees for trials RPD90/3 and RPD90/4 consisted of all infected trees detected in the final round of inspection carried out in the second series trials.

Application of fungicide

All fungicides were diluted in water. In trials RPD89/1, RPD89/3 and RPD 90/1, the fungicides were diluted in 1 litre of water per tree and in trials RPD89/2 and RPD90/2, 2 litres of water per tree. Application of fungicides was carried out by drenching. A furrow of approximately 5–8 cm radius and 8–10 cm depth was constructed around the collar of the treatment tree and the test fungicide gradually poured on the tree collar directing the chemical at the mycelium. Excess chemical was allowed to seep into the soil before closing the furrow.

All neighbouring non-infected trees were also treated with fungicides in trial RPD89/1. In the other trials, neighbouring trees were left untreated.

Reapplication of fungicides

Treatment trees were reinspected for mycelial reinfection at the collar at two monthly intervals after the initial application of fungicides in all first and third series trials except RPD89/1. Where reinfection was detected, the same rate of fungicide as in the previous treatment was reapplied.

Measurements and assessment of treatment

Girth. Girth of all treatment trees was measured at a height of 150 cm from the ground at three monthly intervals.

Scoring of severity of disease infection

The degree of infection of all treatment trees was scored as follows:-

	Parameter	*Scoring of degree of infection*
a)	Colour of foliage	% yellowing/green
b)	Mycelial infection at collar.	nil/slight/moderate/ severe/very severe

Slight – less than 30 per cent mycelial coverage of collar
Moderate – 30–60 per cent mycelial coverage of collar
Severe – more than 60 per cent mycelial coverage of collar
Very severe – penetration of collar resulting in a darkish red to maroon colour of bark.

Scoring of infection at the pretreatment stage was undertaken after the collar had been drenched with fungicide. This resulted in good visibility of the mycelial ramification at the collar as soil sticking to the collar was washed off in the process.

Assessment of treatment success

Treatment success was assessed every three months in trial RPD89/1 without exposing the tree colour as follows:

	Parameter	*Assessment*
a)	Status of tree	Either surviving or dead
b)	Colour of foliage	% yellowing or green

In the other trials treatment success was assessed every two months. In addition to assessing tree status, and colour of foliage, collars were also exposed superficially for, examination of mycelial reinfection. If reinfection was detected, scoring was done as previously after reapplication of treatment.

RESULTS

First series trials

Effectiveness of fungicides against white root disease. Results of the first series trials are shown in *Table 3* and indicate the following:

All trees showing slight and moderate infection at the collar recovered after application of Bayfidan at 10 ml and 20 ml, Bayleton at 10 g and 20 g and Tilt at 10 ml and 20 ml in all three trials.

When collar infection was severe, all trees treated with Bayfidan at 10 ml did not survive in trial RPD89/1. Corresponding treatment success for Bayleton at 10 g was slightly higher with one out of three trees surviving in the same trial and five out of nine in trial RPD89/3. All trees treated with 10 ml Tilt survived in trial RPD89/3. Treatment success was higher when Bayfidan and Bayleton were applied at the higher rates of 20 ml and 20 g respectively. At these rates, most trees survived in trials RPD89/1 to RPD89/3. Tilt applied at 20 ml achieved 100 per cent success in trial RPD89/3.

When infection reached the very severe stage at the collar with concomitant yellowish foliage, treatment with all three fungicides was unsuccessful.

Second series trials

Incidence and severity of disease infection detected from collar inspection at three frequencies of inspection – trial RPD90/1. Results of trial RPD90/1 are given in *Table 4*. The number of trees with severe and very severe symptoms declined with each progressive inspection round for monthly and bimonthly inspections but increased for trimonthly inspections.

In the final inspection round, incidence of disease infection was lowest for monthly and highest for trimonthly inspection. Severity of infection mainly ranged from slight to moderate for montly inspection but moderate to very severe for trimonthly inspection. Severity of infection for bimonthly inspection was intermediate between monthly and trimonthly inspections.

Incidence and severity of disease infection detected from foliar inspection

TABLE 3.
EFFECTIVENESS OF TREATMENTS IN FIRST SERIES TRIALS

Trial no.	Age of trees (mths)	Pre-treatment symptoms		Fungicide/treatment rate per tree		Total trees		Length of observation (mth)
		Collar infection	Colour of foliage			Treated	Survived	
RPD89/1	18	Slight and mod	Green	Bayfidan	10 ml	2	2	18
		Slight and mod	Green	Bayfidan	20 ml	2	2	
		Slight and mod	Green	Bayleton	10 g	1	1	
		Slight and mod	Green	Bayleton	20 g	2	2	
		Slight and mod	Green	Control (water)		2	0	
		Severe	Green	Bayfidan	10 ml	3	0	
		Severe	Green	Bayfidan	20 ml	3	2	
		Severe	Green	Bayleton	10 g	3	1	
		Severe	Green	Bayleton	20 g	2	2	
		Severe	Green	Standard estate Control (water)		1	0	
RPD89/2	29	Slight and mod	Green	Bayfidan	20 ml	8	8	16
		Slight and mod	Green	Bayleton	20 g	8	8	
		Severe	Green	Bayfidan	20 ml	7	7	
		Severe	Green	Bayleton	20 g	7	5	
		Very severe	20% yellow	Bayfidan	20 ml	1	0	
RPD89/3	18	Slight and mod	Green	Bayleton	10 g	10	10	16
		Slight and mod	Green	Bayleton	20 g	8	8	
		Slight and mod	Green	Tilt	10 ml	6	6	
		Slight and mod	Green	Tilt	20 ml	8	8	
		Severe	Green	Bayleton	10 g	9	5	
		Severe	Green	Bayleton	20 g	11	9	
		Severe	Green	Tilt	10 ml	7	7	
		Severe	Green	Tilt	20 ml	11	11	
		Very severe	20% yellow	Bayleton	20 g	1	0	
		Very severe	50% yellow	Tilt	20 ml	1	0	

TABLE 4.
EFFECT OF FREQUENCY OF COLLAR INSPECTION ON INCIDENCE AND SEVERITY OF INFECTION – TRIAL RPD90/1

Inspection interval	*Total trees inspected*	*Disease symptoms*		*No. of infected trees*					
		Collar infection	*Colour of foliage*	*Month* 1st	2nd	3rd	4th	5th	*Total*
Monthly	± 2002	Slight	Green	7	11	12	14	–	44
		Moderate	Green	14	5	9	8	–	36
		Severe	Green	7	5	4	2	–	18
		Very severe	20% yellow	2	0	0	0	–	2
			Total	30	21	25	24	–	100
Bimonthly	± 1997	Slight	Green	6	–	8	–	18	32
		Moderate	Green	12	–	11	–	8	31
		Severe	Green	21	–	4	–	6	31
		Very severe	20% yellow	2	–	1	–	0	3
			Total	41	–	24	–	32	97
Trimonthly	± 1989	Slight	Green	6	–	–	6	–	12
		Moderate	Green	8	–	–	15	–	23
		Severe	Green	18	–	–	16	–	34
		Very severe	20–50% yellow	1	–	–	7	–	8
			Total	33	–	–	44	–	77

at three frequencies of inspection – trial RPD90/2. Results of trial RPD90/2 are given in *Table 5.*

Incidence of root disease declined markedly with each progressive round for monthly and bimonthly inspections but only slightly for trimonthly inspections.

In the final inspection round, incidence of disease was considerably lower for monthly and bimonthly compared to trimonthly inspection.

Third series trials

As treatment trees in the third series trials were derived from infected trees detected in the second series trials, treatment success obtained thereof would be reflective of the method and frequency of inspection employed in the second series trials.

Effect of frequency of collar inspection on treatment success – trial RPD90/3. Results are shown in *Table 6.*

All trees inspected at monthly and bimonthly intervals recovered from application of fungicides while seven out of thirty-one trees in the section inspected at trimonthly interval did not survive. The mortality in the trimonthly inspection resulted from trees showing very severe symptoms of infection. Such trees could not be 'saved'.

TABLE 5.
EFFECT OF FREQUENCY OF FOLIAR INSPECTION ON INCIDENCE AND SEVERITY OF INFECTION – TRIAL RPD90/2

Inspection interval	Total trees inspected	Disease symptoms: Collar infection	Disease symptoms: Colour of foliage	No. of infected trees: Month 1st	2nd	3rd	4th	5th	Total
Monthly	± 1705	Severe	Green	2	1	0	0	–	3
		Very severe	20% yellow	< 8	7	1	2	–	18
		Very severe	20–50% yellow	5	2	4	3	–	14
			Total	15	10	5	5	–	35
Bimonthly	± 1716	Severe	Green	1	–	0	–	0	1
		Very severe	20% yellow	< 6	–	3	–	9	13
		Very severe	20–50% yellow	7	–	3	–	0	10
			Total	14	–	6	–	9	23
Trimonthly	± 1722	Severe	Green	3	–	–	4	–	7
		Very severe	20% yellow	< 9	–	–	2	–	11
		Very severe	20–50% yellow	11	–	–	8	–	19
		Very severe	> 50% yellow	0	–	–	4	–	4
			Total	23	–	–	18	–	41

TABLE 6.
EFFECT OF FREQUENCY OF COLLAR INSPECTION ON TREATMENT SUCCESS – TRIAL RPD90/3

Frequency of collar inspection	Pre-treatment symptoms: Collar infection	Pre-treatment symptoms: Colour of foliage	Fungicide/rate per tree		Total trees: Treated	Survived
Monthly	Slight and mod	Green	Bayleton	15 g	22	22
	Severe	Green	Bayleton	15 g	2	2
Bimonthly	Slight and mod	Green	Bayleton	15 g	22	22
	Severe	Green	Bayleton	15 g	6	6
	Slight and mod	Green	Control (water)		4	0
Trimonthly	Slight and mod	Green	Tilt	15 ml	5	5
	Severe	Green	Tilt	15 ml	4	4
	Very severe	20–50% yellow	Tilt	15 ml	7	0
	Slight and mod	Green	Tilt	7.5 ml	12	12
	Severe	Green	Tilt	7.5 ml	3	3

Trees showing severe infection at the collar successsfully recovered when Bayleton and Tilt were applied at 15 g and 7½ ml respectively. These rates were lower than the effective rates of 20 g and 10 ml respectively indicated in the first series trials.

Effect of frequency of foliar inspection on treatment success – trial RPD90/4. Results are shown in *Table 7.*

There were no survivors for monthly and bimonthly inspections. Survivors for trimonthly inspection were trees whose degree of infection did not exceed the severe stage. Despite the existence of survivors for trimonthly inspection total trees which died was higher than for monthly and bimonthly inspection.

Other observations

Reinfection of disease. Incidence of reinfection on previously treated trees and their treatment success after reapplication of fungicides in trials RPD 89/2, RPD89/3 and RPD90/1 are shown in *Table 8.* Reinfection ranged from nil to 26 per cent on surviving trees with a mean of 12.2 per cent over all trials.

Reinfection generally appeared about six to eight months after treatment with Bayleton or Bayfidan and about eight to ten months with Tilt.

Degree of collar infection was generally slight in most of the reinfected trees. All reinfected trees survived after reapplication of fungicides at the previous rate of treatment.

Comparison of growth of treated trees with normal (border) trees. Results are shown in *Table 9.*

Treated trees were about 13 and 15 per cent poorer in growth compared with their respective border trees in trials RPD89/1 and RPD89/2 in the first nine months after treatment, but

TABLE 7.
EFFECT OF FREQUENCY OF FOLIAR INSPECTION ON TREATMENT SUCCESS – TRIAL RPD90/4

Frequency of collar inspection	*Pre-treatment symptoms*		*Fungicide/rate per tree*		*Total trees*	
	Collar infection	*Colour of foliage*			*Treated*	*Survived*
Monthly	Very severe	20% < yellow	Bayleton	20 g	2	0
	Very severe	20–50% yellow	Bayleton	20 g	3	0
Bimonthly	Very severe	20% < yellow	Bayleton	20 g	3	0
Trimonthly	Severe	Green	Bayleton	20 g	4	4
	Very severe	20% < yellow	Bayleton	20 g	2	0
	Very severe	20–50% yellow	Bayleton	20 g	8	0
	Very severe	> 50% yellow	Bayleton	20 g	4	0

TABLE 8.
REINFECTION OF DISEASE ON SURVIVING TREES

Trial no.	*Treatment*		*% of surviving trees reinfected*	*Appearance of reinfection months after treatment*	*% success after reapplication of fungicides 4-8 months*
RPD89/2	Bayleton	20 g	23	6	100
	Bayfidan	20 ml	20	6-8	100
RPD89/3	Bayleton	10 g	26	6	100
	Bayleton	20 g	6	8	100
	Tilt	10 ml	15	8-10	100
	Tilt	20 ml	5	8	100
RPD90/1	Bayleton	15 g	8	8-10	100
	Tilt	15 ml	0	–	–
	Tilt	7.5 ml	7	8	100

recovered well in growth rate in the subsequent six months.

Treatment of border trees. Results of *ad-hoc* observations on treatment of border trees are given in *Table 10.*

In trial RPD89/1, two out of twenty-two border trees died one year after prophylactic treatment while in trial RPD89/2, all border trees left untreated survived. Treated trees probably became as vulnerable to disease infection as non-treated trees about six to ten months after treatment when the residual effect of the fungicides wore off.

DISCUSSION

Treatment success of young rubber trees infected by white root disease varied with the stage of infection at time of fungicide application, type and rate of fungicide applied and method and frequency of root disease inspection.

The degree of infection at the collar appeared critical to treatment success. When disease infection advanced beyond the severe stage of infection, going into the very severe stage, application of fungicides was unsuccessful in controlling the disease. Conversely when it was not exceeded, most trees could be saved by applying the higher rates of 15–20 g Bayleton and 20 ml Bayfidan when infection was severe and 10 g Bayleton and 10 ml Bayfidan when infection was slight to moderate. Application of Tilt at 7.5 ml was effective against the disease for all stages of infection ranging from slight to severe.

Tan (1990) proposed similar rates of 20 g Bayleton and 20 ml Bayfidan but a higher rate for Tilt at 20 ml for control of disease on infected trees up to four years old. Lower rates of Tilt were however not tested. Ng and Yap's (1990) recommendations for similar ages of trees were 10 g Bayleton and

TABLE 9.
COMPARISON OF GROWTH OF PREVIOUSLY INFECTED TREES WITH NORMAL TREES

Trial no.	*Type of tree*	*No. of trees*	*Pretreatment mean girth (cm)*	*Girth increment after treatment (cm)* Month						
				0-3	*3-6*	*6-9*	*Cumulative (0-9)*	*9-12*	*12-15*	*Total 9-15*
RPD89/1	1. Treated trees	12	15.6	2.6	2.7	3.2	8.5 (100%)	3.2	2.5	5.7 (100%)
	2. Border (normal)	17	15.0	3.0	3.0	3.6	9.6 (113%)	3.1	2.7	5.8 (102%)
RPD89/2	1. Treated trees	28	24.5	1.9	2.3	3.1	7.3 (100%)	3.5	2.8	6.3 (100%)
	2. Border (normal)	22	23.9	2.6	2.2	3.6	8.4 (115%)	3.7	2.8	6.5 (103%)

TABLE 10.
TREATMENT OF BORDER TREES

Trial no.	*No. of border trees*	*Treatment rate/tree*	*No. of trees surviving after 16 months*	*% success at 16 months*
RPD89/1	12	Bayfidan 10 or 20 ml	12	100
	10	Bayleton 10 g or 20 g	8	80
RPD89/2	22	nil (no treatment)	22	100

10 ml Bayfidan which are lower than the effective rates obtained in the above trials and also Tan's effective rates.

Collar inspection resulted in much higher treatment success than foliar inspection as diseased trees could be detected at a much earlier stage of infection. Most diseased trees detected by foliar inspection were beyond 'saving' as infection had advanced to beyond the severe stage.

Collar inspection carried out at monthly and bimonthly intervals resulted in full treatment success compared with a lower success for trimonthly intervals due to the same reasons as above. However with the general shortage of field workers in most estates presently, it would be difficult to achieve even bimonthly intervals of collar inspection especially for estates with a large hectarage of immature rubber. A certain percentage of mortality due to root disease may therefore have to be allowed for where labour is short.

Although reinfection of disease was encountered about six to ten months after application of fungicide, it was successfully controlled by reapplication of fungicides at the previous rates.

It may not be worthwhile to carry out prophylactic treatment on border trees if infected trees have been treated with fungicide as treated trees become vulnerable to disease infection when the residual effect of the fungicide wears off about six to ten months after application.

In summary, the salient points may be enumerated as follows:-

- Drenching with effective fungicides was successful in controlling root disease provided infection at the collar had not advanced beyond the severe stage.
- For slight and moderate cases of collar infection, 10 g Bayleton, 10 ml Bayfidan and 7.5 ml Tilt effectively controlled the disease. When collar infection was severe, effective rates were 15–20 g Bayleton, 20 ml Bayfidan and 7.5 ml Tilt.
- Collar inspection resulted in much higher treatment success than foliar inspection as diseased trees could be detected at a much earlier stage of

infection. Most diseased trees detected by foliar inspection were beyond 'saving' as infection had advanced to beyond the severe stage.

- Collar inspection carried out at monthly and bimonthly intervals resulted in higher treatment success than at trimontly intervals.

- Reinfection of disease was encountered about six to ten months after application of fungicide. However control was easily effected by re-application of fungicide at the previous rate.

- Prophylactic treatment of non-infected border trees may not be worthwhile if infected trees are treated with fungicides.

- Growth rate of treated trees which had recovered returned to normal about nine months after treatment.

CONCLUSION

Immature rubber trees infected with white root disease can be successfully controlled with fungicide drenching provided the disease has not advanced beyond the severe stage of infection.

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