Jl. Rubb. Res. Inst. Sri Lanka, (1995) 75(I), 61–70

PENTA CHLORO PHENOL - EFFECTIVE AND ECONOMICAL FUNGICIDE FOR THE MANAGEMENT OF WHITE ROOT DISEASE CAUSED BY *RIGIDOPORUS LIGNOSUS* IN SRI LANKA

C K Jayasinghe, K E Jayasuriya and T H P S Fernando

(20 January 1995)

SUMMARY

White root disease caused by *Rigidoporus lignosus* is still the major root disease in rubber plantations of Sri Lanka. Presently around 5% – 10% of the cultivated lands are affected and under bare patches due to this disease.

Penta chloro nitro benzene (PCNB), recommended chemical for the control of white root disease was suspended during the year 1989 with the discovery of its carcinogenic contaminants. Results of initial *in vitro* experiments conducted with three fungicides namely triadimenol, triadimefon and penta chloro phenol (PCP) to find an alternative for PCNB revealed that all three fungicides can check growth of the fungus very effectively.

Then a series of *in vitro* and *in vivo* experiments was launched with different concentrations of PCP, the most economical fungicide to find a lowest effective dosage in management of white root disease. Observations of the field experiments carried out for 2½ years with PCP, revealed that a concentration of 2% ai. is effective provided that fungicide is applied at early stages of infection. The degree of infection at the collar appeared critical to treatment success. None of the concentrations tested proved to be effective on plants with severe foliar symptoms. The economics of the use of PCP and the necessity of the development of an environmental friendly fungicide are also discussed.

Key words: Penta chloro phenol, white root disease, *Rigidoporus lignosus*, chemical control

INTRODUCTION

White root disease caused by *Rigidoporus lignosus* (Klotzsch) Imazeki, is still the major root disease problem in rubber (*Hevea brasiliensis* Muell. Arg.) plantations of Sri Lanka (Jayasinghe, 1993). It accounts for the largest number of losses during the first three years of growth of the plants, particularly in areas where the pre-planting eradication of the sources of infection has been incomplete. If proper control measures are not adopted in the immature clearings it could lead to the development of large bare patches, resulting in considerable economic loss. It was reported that 5–10% of the cultivated rubber lands are under bare patches in Sri Lanka due to this deadly disease (Liyanage, 1977).

The results of International Rubber Research and Development Board survey conducted in 1993 indicated that white root disease is a severe problem in Cote d'Ivoire and Nigeria too and a significant endemic problem in Gabon, Indonesia, Malaysia and Thailand (Anon, 1994).

Traditional post planting control measures of this disease comprise of exposing the root system of the infected and neighbouring trees followed by surgical removal of the infected areas and application of a collar protectant dressing containing an effective fungicide. In recent past most widely used fungicide in Malaysia and Sri Lanka was the penta chloro nitrobenzene (PCNB) (Fox, 1966; Liyanage, 1984).

As this technique was labour intensive, Pathologists in Cote d'Ivoire (Tran, 1985) and Malaysia (Ng & Yap, 1990; Tan, 1990) initiated the research programmes to develop soil drenching fungicides in the management of white root disease.

As a result seven drenching chemicals namely hexaconazole (Anvil) (Tan, 1990; Lam & Chin, 1993), myclobutanil (Systan) (Tan, 1990), propiconazole (Tilt) (Tan, 1990 & Chan *et al*, 1991), terbuconazole (Folicur) (Tan, 1990), triadimefon (Bayleton) (Ng & Yap, 1990; Tan, 1990; Chan *et al*, 1991) triadimenol (Bayfidan) (Ng & Yap, 1990; Tan, 1990) and tridemorph (Calyxin) (Tran, 1985) were evaluated in Africa and Eastern Hemisphere with various success during the last decade. Unfortunately, high cost involved in purchasing of these chemicals prevented the wide use of them in most of the natural rubber producing countries.

However, in Sri Lanka where the labour is comparatively cheap, use of collar protectant dressing was continued with success till PCNB was banned in 1989 after the discovery of carcinogenic contaminants.

We report here results of experiments carried out for three years to find an economically viable alternative fungicide for PCNB in the management of white root disease in Sri Lanka.

MATERIALS AND METHODS

1. Inoculum

Rigidoporus lignosus isolate AG1 obtained from *Hevea* roots from Agalawatta was used in all *in vitro* experiments.

2. Fungicides

Effectiveness of penta chloro phenol (PCP), the most economical fungicide was evaluated in large scale experiments, though another two chemicals namely triadimenol and triadimefon were also found to be potential fungicides in preliminary trials (Jayasinghe, 1991). Concentrations ranging from 0.035 to 2.5% ai PCP in a bituminous base was incorporated in screening programme after testing the phytotoxicity on *Hevea* seedlings and polybag plants.

3. Application of PCP collar protectant dressing

The root system of the infected plants were exposed, dead roots were removed, the superficial mycelium was scraped around the tap roots and laterals and they were painted with PCP upto one foot (Liyanage, 1984).

4. Drenching

Drenching was carried out by making a furrow approximately 5 cm deep by 25–30 wide radius around the collar of the tree (Tan, 1990). One litre of triadimenol in two concentrations *viz* 10 ml/l and 20 ml/l was poured into the furrow making sure that collar region in properly drenched.

5. *In vitro* screening

Four concentrations of PCP *viz* 0.035% ai, 1.0% ai, 2.0% ai, and 2.5% ai were screened against *R. lignosus* using the method described by Fox, 1977. PCP in bituminous base was applied on 6 cm long pieces of healthy rubber roots obtained from mature rubber trees, leaving 0.5 cm area free of the chemical. Prior to application, root pieces were washed free of soil and autoclaved at 15 psi for 1 h. The untreated end of the wood piece was then implanted to a 7 day old culture of *R. lignosus* grown on 10 ml of Malt Agar in boiling tubes. Each treatment was replicated six times and root pieces without application of fungicides served as the control. The length of the treated area covered by the fungus was measured after 6 days incubation at room temperature 28 ± 2°C.

6. *In vivo* screening

6.1 Curative trials on inoculated plants

Seventy five plants of the clone RRIC 100 were established in the Rubber Research Institute premises. At the end of the first year each plant was inoculated using three pieces of 30 cm long naturally infected *Hevea* roots. Six months were allowed to establish the infection and PCP (0.6%, 1.0%, 1.5% ai) was applied and drenched with triadimenol (10 ml and 20 ml/l) on infected plants after collar inspection. Inoculum pieces were removed in all treated and untreated plants. Ten plants were left untreated after collar inspection which served as the control.

6.2 Curative trials on naturally infected plants

PCP was tested at two concentrations *viz* 0.6% & 2.0% ai on 85 naturally infected 2 year old plants of the clone RRIC 100 at four localities in Kalutara District. The treated plants showed varying degrees of infection at the time of treatment and severity of infection and number of treated plants in each locality are given in Table 3.

RESULTS AND DISCUSSION

The results of the *in vitro* experiments clearly showed that PCP 1% ai can check the growth of the fungus significantly and PCP 2% ai inhibits the growth of the fungus totally (Table 1).

Treatment means in the same column not followed by the same letter are significantly different at the 0.05 level according to Duncan's Multiple Range Test.

Table 1. *Effect of different concentrations of PCP on the growth of R. lignosus on sterilized root pieces (in vitro)*

Fungicide	Percentage of the treated area covered by the fungus	
	Expt. 1	Expt. 2
PCP 0.035% ai	83.81 b	**
PCP 1.0% ai	2.7 c	**
*PCP 2.0% ai	**	1.87 b
*PCP 2.0% ai	**	0.56 b
PCP 2.5% ai	**	0.08 b
Control	96.79 a	76.22 a

* same formulation from two different companies.
** not performed

All treatments *viz* application of PCP (0.6%, 1.0% and 1.5% ai) and drenching with triadimenol (10 ml and 20 ml) on inoculated plants performed satisfactorily resulting 87.5% and 100% success rate in 0.6% ai and 1.0% ai PCP treatments respectively. Though the success rates obtained with triadimenol were around 90%, statistical analysis on the results indicated that there are no significant differences exist ($\chi^2 = 1.510$; $p = 0.680$) among different treatments (Table 2).

Assessments at 20 months (Site c) and 30 months (site d) after application of 2.0% ai PCP on naturally infected trees with slight collar infection and with or without buckling of leaves showed a 100% recovery rate (Table 3). But treatment success was reduced significantly to 78% and 33% (χ^2 + 7.785; $p = 0.005$) respectively when trees with moderately and severely affected collars were treated at site c. Similarly, treatment successes were 80% & 50% ($\chi^2 = 3.519$; $p = 0.064$) when plants of the same conditions were treated at site d indicating that infection at collar is critical to treatment success. The importance of early disease detection in success of chemical control of white root disease has also been shown by several previous workers in Malaysia (Fox, 1966; Tan, 1990, Ng & Yap, 1990; Chan *et al*, 1991), and Sri Lanka (Peries, 1965).

Table 2. *Effect of different fungicides on the control of WRD on inoculated Hevea plants.*

Fungicide	Disease severity index (from collar inspection)	Total number of trees treated	Number of trees reinfected/dead	% of treatment success	Duration of the experiment (months)
PCP	A	16	2	87.5	13
(0.6% ai)	B	–	–	–	–
	C	–	–	–	–
PCP	A	4	0	100.0	13
(1.0% ai)	B	–	–	–	–
	C	–	–	–	–
PCP	A	5	0	100.0	13
(1.5% ai)	B	–	–	–	–
	C	–	–	–	–
Triadimenol	A	11	1	91.0	13
(10 ml)	B	–	–	–	–
(Single application)	C	–	–	–	–
Triadimenol	A	13	2	84.0	13
(20 ml)	B	–	–	–	–
(Single application)	C	–	–	–	–

(Disease severity index: A, collar slightly infected; B, collar moderately infected, bark partially dead; C, collar severely affected, mycelium right round the collar, tap root partially or completely dead)

* Chi square test indicated that there are no significant treatment differences exist between fungicides tested $\chi^2 = 1.510$; $P = 0.680$

Table 3. *Effect of different concentrations of PCP on the control of WRD on naturally affected Hevea plants.*

Fungicide	Disease severity index (from collar inspection)	Foliage symptoms of the plants in each category	Total number of trees treated	Number of trees reinfected/dead	% of treatment success	Duration of the experiment (months)
PCP	A	0(1);+(4);++(–);+++(–)	5	2	60	20
(0.6% ai)	B	0(2) ;+(3);++(1);+++(3)	9	5	44	20
(Site a)	C	0(–);+(1);++(1);+++(3)	5	3	40	20
PCP	A	0(2);+(–);++(1);+++(4)	7	4	43	22
(0.6% ai)	B	0(–);+(4);++(2);+++(1)	7	4	43	22
(Site b)	C	0(–);+(1);++(–);+++(2)	3	1	67	22
PCP	A	0(4);+(8);++(1);+++(–)	13	0	100	20
(2.0% ai)	B	0(–);+(6);++(2);+++(1)	9	2	78	20
(Site c)	C	0(–);+(–);++(7);+++(2)	9	6	33	20
PCP	A	0(2);+(7);++(2);+++(–)	11	0	100	30
(2.0% ai)	B	0(2);+(1);++(1);+++(1)	5	1	80	30
(Site d)	C	0(–);+(–);++(1);+++(1)	2	1	50	30

Disease severity index:

I. collar inspection: A, collar slightly infected; B, collar moderately infected; C, collar severely infected, Mycelium right round the collar, tap root partially or completely dead

II. foliage symptoms: + slight buckling; ++ Moderate buckling & yellowing; +++ severe buckling and yellowing

* Significant treatment differences exist in recovery rates when treated with PCP 0.6% ai/PCP 2.0% ai (χ^2 = 9.68; P = 0.002)
* Significant treatment differences exist in recovery rates when the plants of disease index A are treated with PCP 2.0% ai compared to plants of disease index B and C at site C (χ^2 = 7.785; P = 0.005) and site d (χ^2 = 3.519; P = 0.064).

The other important operation in the management of white root disease using collar protectant dressings is the detection and eradication of the food base and this recommendation was originated far back in 1904 (Ridley, 1904; Petch, 1921; Napper, 1932).

Napper in 1932 recommended the first fungicide, 2% solution of copper sulphate in controlling white root disease and later in 1958 organomercurial fungicide tillex was introduced by Riggenbach in place of 2% copper sulphate.

During 1960's the necessity of water immesible chemicals was emphasized and as a result the first collar protectant dressing, 20% penta chloro nitro benzene in a bituminous/greece base was recommended in Malaysia (Fox, 1966) and Sri Lanka (Liyanage, 1984) and it was widely used with success in Sri Lanka till it was suspended in 1989.

The results of our study clearly show that 2% PCP could be used in place of 20% PCNB in management of white root disease in young rubber plants of Sri Lanka.

Since 1990 emphasis were made to recommend soil drenching chemicals based on the results of our preliminary experiments (Jayasinghe, 1991) and intensive research programmes carried out in Malaysia (Tan, 1990; Ng & Yap, 1990; Chan *et al*, 1991) and Ivory coast (Tran, 1985). However, high chemical cost prevented the use of such fungicides in rubber plantations of Sri Lanka. For instance, 40 ml of triadimenol required to treat 2 year old affected rubber plants (two applications) will cost 2 US$ compared to 20 US cents in the case of collar protectant dressing with 2% PCP. Note that cost of labour is not included in the above figures as no paid labour is involved in smallholdings which accounts for about 35% of the total rubber hectarage. In larger estates a labour unit will cost around US$ 1.50 presently. The other limitation is the non availability of recommended soil drenching chemicals in the country as none of these fungicides have been recommended in the disease management of any other agricultural crop in Sri Lanka.

It should be noted that even PCP which is presently used widely in timber industry of Sri Lanka is a highly toxic chemical and it is classified in the group "Highly Hazardous" according to the WHO classification. It is having a LD 50 of 50 mg/kg and 105 mg/kg by oral route and dermal route respectively for rats and is banned in most of the developed countries (Anon, 1989). On the light of this situation presently we are engaged with several research programmes to find a safe and economically viable fungicide to be recommended in future.

ACKNOWLEDGEMENT

The authors are thankful to Mrs W Wijesuriya for statistical analysis and Mrs P Amarasekera for word processing.

REFERENCES

Anon, (1989). Consolidated list of products whose consumption and/or sale have been banned, withdrawn, severely restricted or not approved by the governments. 3rd Issue, United Nations New York, 1989.

Anon, (1994). White root disease. Identification and treatment of diseases of *Hevea brasiliensis*, International Rubber Research and Development Board, Hertford, UK. pp 1–9.

Chan, W H, Wong, C P and Wong, C C (1991). Control of white root disease in immature rubber with three systematic fungicides. *The Planter,* Kuala Lumpur **67**: 251–265.

Fox, R A (1966). White root disease of *Hevea brasiliensis*: collar protectant. *Jl. Rubb. Res. Inst. Malaya*, **19**: 231–241.

Fox, R A (1977). The impact of ecological, cultural and biological factors on the strategy and costs of controlling root diseases in tropical plantation crops as exemplified by *Hevea brasiliensis*. *Jl. Rubb. Res. Inst. Sri Lanka* **54**: 329–362.

Jayasinghe, C K (1991). Review of the Plant Pathology and Microbiology Department. Annual Review of Rubber Research Institute of Sri Lanka, 1991: 29–37.

Jayasinghe, C K (1993). Review of the Plant Pathology Microbiology Department. Annual Review of Rubber Research Institute of Sri Lanka 1993: 43–64.

Lam, C H and Chin, S B (1993). Hexaconazole (Anvil 5sc), a cost-effective fungicide for controlling white root disease in immature rubber. *The Planter*, Kuala Lumpur, **69**: 465–474.

Liyanage, A de S (1977). Review of the Plant Pathology Department. Annual Review of Rubber Research Institute of Sri Lanka 1977: 66–98.

Liyanage, A de S (1984). Root diseases. In Practical Guide to Rubber Planting and Processing (A de S Liyanage and O S Peries Eds.) Rubber Research Institute of Sri Lanka. pp 136–148.

Napper, R P N (1932). A scheme of treatment for the control of *Fomes lignosus* in young rubber areas. *Jl. Rubb. Res. Inst. Malaya*, **4**: 34–38.

Ng, K J and Yap, T H (1990). The effect of triadimefon and triadimenol for controlling white root disease of rubber. *Proc. 3rd Int. Conf. Plant Protection in the tropics,* Malaysia, **2**: 31–35.

Peries, O S (1965). Control of white root disease (*Fomes lignosus*) of *Hevea brasiliensis*. *Jl. Rubb. Res. Inst. Ceylon,* **47**: 81–89.

Petch, T (1921). The diseases and pests of rubber tree. Macmillan & Co. *Ltd*, London.

Ridley, H N (1904). Parasitic fungi on *Hevea brasiliensis*. Agriculture Bulletin, Straits Settlements No. **3**: 173–175.

Riggenbach, A. (1958). A note on the chemical control of white root disease. *Rubb. Res. Inst. Ceylon Quart.* **34**: 8–10.

Tan, A M (1990). The present status of fungicide drenching on the control of white root disease of rubber. *Proc. Int. Rubb. Res. and Deve. Board* Symposium on root diseases of *Hevea*, 1990, China: 47–54.

Tran Van Canh (1985). Use of Calixin and Sandofan F against white root disease and black stripe of *Hevea brasiliensis*. *Proc. Int. Rubb. Conf. Kuala Lumpur* 1985, **3**: 222–237.

(Received 8 January 1994)