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Control of black thread (Phytophthora palmivora) in Hevea brasiliensis with Difolatan

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Abstract

Further investigations have shown that Difolatan applications initially slow down bark renewal; however, the thickness of the living bark becomes about normal after 2 years. The previous finding that Difolatan has no direct effect on latex yield was confirmed. Evidence was obtained that the renewing bark is of normal yield capacity.

A suitable colouring agent to check the application of Difolatan is yellow iron oxide; Sterox NJ – a synthetic detergent – should be added to obtain stable suspensions.

Promising yield increase was obtained when 0.25–1 % 2,4-D was added to the Difolatan suspension in water. The percentage yield increase depends not only on the 2,4-D concentration but also on the use of admixtures, which give more bulk to the 2,4-D coating on the bark. The mixtures which gave the highest yield increase caused the greatest proliferation of the renewing bark and were less effective in controlling the disease. When relatively low concentrations of 2,4-D (up to 0.25 %) are mixed with the Difolatan suspension, important yield increases can be obtained without much bark proliferation or loss of fungitoxicity; such applications open up possibilities for mild stimulation of younger trees.

Introduction

It was previously reported that the fungus *Phytophthora palmivora* – the causal agent of black thread – had been successfully controlled in field experiments with a suspension of 1 % Difolatan + 0.1 % Ortho spray sticker in water (Schreurs, 1969). In Liberia, satisfactory disease control is generally obtained with weekly applications. The suspension is applied by paint brush to the recently tapped portion of the panel. In Malaya, Difolatan is currently recommended for black thread control in a concentration of 2 % for application after each tapping (Chee, 1969). The frequency of the applications and the Difolatan concentration depend, however, on several factors: climatic conditions, susceptibility of the *Hevea* tree, damage done in previous years in the planting, and on the degree of disease control required.

Since Difolatan residues are hardly visible on the bark, the checking upon the quality of the applications is almost impossible. Accordingly, colouring agents were added to the Difolatan suspension for laboratory and field experiments. In contrast to the first observations, further tests have shown that Difolatan applications do slow down bark renewal initially. This side effect of the application was therefore more deeply investigated.

Various concentrations of 2,4-dichlorophenoxyacetic acid (2,4-D) were added to the Difolatan suspension in water and these mixtures were tested in the field to investigate their effect on bark renewal, black thread control and rubber production. 2,4-D is widely used to stimulate the yield of *Hevea*, but is usually applied in palm oil or petrolatum; therefore, 2,4-D in Treseal was incorporated in some trials as a treated control.

Literature on renewal of treated bark

The effect of palm oil, petrolatum and, in particular, mixtures of 2,4-D in such carriers on tapped *Hevea* trees has been extensively tested. Generally, above-cut stimulation with 2,4-D in an oil-base carrier or in a petrolatum, is applied only to older trees on panels which are not to be tapped again; therefore, the use of these stimulants is normally restricted to the last 8 to 10 years of a planting. At the Firestone Plantations in Liberia 0.25–0.5% 2,4-D butyl ester in the petrolatum Treseal is applied weekly. Such applications produce a very thick renewal of the bark. Anliker and Scanlon (1965) mentioned that 1-year-old renewing bark on above-cut stimulated panels was 11.7 mm thick in a planting of the *Hevea* clone BD 5, compared with 6.3 mm for the untreated panels.

The stimulated panels often show excessive surface cracking and exudation of latex through cracks in the bark. However, the proliferated tissue sloughs off in less than 8 years, even in the most extreme cases of thick bark regeneration (Anliker and Scanlon, 1965).

The stimulated bark has an abnormally thick hard bast and cork; the soft bast is of a normal thickness (de Jonge, 1957). The carriers for 2,4-D (petrolatum, palm oil) also stimulate bark renewal, but not to the same extent as 2,4-D. It is de Jonge's conclusion that 'The increased thickness of renewed bark as a result of the treatments appeared to be due solely to activation of the cork cambium. No increase of lactiferous tissue was noted'.

Anliker and Scanlon (1965) observed that size and number of laticifers as well as other types of cells in the soft bast were normal. It is remarkable that so little is still known of the latex production capacity of stimulated bark after eight to ten years. Puddy and Warriar (1960) reported that the yield of 3½-year-old renewed and stimulated bark was of the same order as from 10-year-old untreated bark. Levandowsky (1960) obtained the same promising results with renewed bark of only 21 and 27 months of age, although continued tapping resulted in exhaustion.

It is still uncertain whether the renewed bark of stimulated trees above the cut will produce a normal yield for another whole tapping cycle. This will greatly depend on such factors as fertility of the soil, the intensity of the tapping system, clonal reaction of the *Hevea* tree and whether or not the bark can be easily tapped (depending on disease and tapping history).

Materials and methods

The 7 field experiments which are reported were carried out on the *Hevea* clone BD 5, and application of the products was above the tapping cut at regular intervals with a 1-inch-wide paint brush for the liquid treatments. The trees were 20–24 years old when the treatments were applied. Tapping was on half spiral, alternate daily (S/2, d/2, 100%), except for Exp. 3 which was tapped monthly periodic (S/2, 30d/60, 100%).

In Exp. 4 and 7, tapping was on second renewed bark and in the other experiments on first renewal. In Exp. 4 however, tapping was on virgin bark above the old panel on a number of trees. Exp. 1 and 7 were of randomized block design, replicated 4 times, and the others of randomized tree plot design. Generally, the treatments were applied from June/July and continued throughout the rainy season (until November/December). In Exp. 1, the liquid treatments were applied after every tapping and the petrolatum Treseal after two tappings. In the other experiments, application was once a week for all treatments. 2.5–3.5 ml of the liquid products per application per tree was used and 1.5–2.5 g Treseal. Some further information on these experiments is given in Table 1.

Test for disease control

Care was taken that the mean black thread damage on trees in the previous rainy season(s) was of the same level for all the treatments, as there is a positive correlation between the occurrence of old wounds and new infections. The results of the treatments were evaluated at the end of that rainy season (or later) and the degree of damage was estimated, using a standard of evaluation from 0 (healthy panel) to 6 (maximum damage possible) (Schreurs, 1969).

Tests for effect on rubber yield

The yields of each tree were recorded; the cup coagulum weighed and the dry rubber content determined. The figures in the tables show the average yield of dry rubber in g per tree per tapping (g.t.t.). Generally the yield was recorded for at least 2 months before the experiments were laid out after which the trees were randomized in such a way that low, average and high producers were equally distributed over the treatments. The trees were also leveled on old black thread damage.

Observations on bark renewal

These observations were confined to measurements of the thickness of the renewing bark and were made in Exp. 1–4.

Table 1. Pre-treatment yields and black thread damage of experimental material.

Exp.	Year of treatments	Number of trees per treatment	Variation in pre-treatment	
			black thread damage among treatments	rubber yield (g.t.t.) among treatments
1	1965	± 60	1.9–2.4	–
2	1966	± 80	2.0	36.9–37.6
3	1967	26	0.8	22.9–24.1
4	1968	62	0.7–0.8	29.0–29.4
5	1968	31	2.0–2.5	31.3–32.1
6	1969	27	1.5–1.6	27.4–28.7
7	1969	± 52	1.0–1.1	–

Tabel 1. Vooropbrengsten en oude streepjeskankerschade in het proefmateriaal.

A Schlieper bark gauge was used for the measurements made in 1968 in Exp. 2 and 3 and readings were estimated to the nearest 0.25 mm. Afterwards a Lindeteves-Stokvis 'Barkometer' (Sharp, 1937) was used and readings were made to the nearest 0.1 mm.

Girth of the trees and the thickness of virgin and renewing bark in a clonal *Hevea* planting are positively correlated. Accordingly, groups of trees were selected for measurement which had about the same average girth or bark thickness (a minimum of 10 trees and a maximum of 33 trees per treatment).

The treatments were applied when tapping was on first (Exp. 1–3) or second renewed bark (Exp. 4); in other words, the bark of second and third renewal was measured. The positions where the measurements were made are shown in Fig. 2. After first measuring the thickness of the entire bark, the cork layers were scraped off and the thickness of the living bark was determined. This consists of two distinct layers, the soft bast which contains the latex vessels and, on the outside, the hard bast. In 2 experiments the thickness of both of these layers was determined by scraping off the hard bast.

The number of applications covering each measured spot is shown in Fig. 2. The number of coatings depends on the tapping system, the frequency of the applications and on the width of the treated strip. During each tapping 1.6–1.7 mm of bark is used. Therefore in periodic tapping, the cut goes down by approximately 12.5 mm per week during the tapping period. In weekly application a 1-inch-wide brush reaches not only the tapped off portion in the same week, but also the 12.5 mm above it, which had already been treated the week before (2 coatings). In alternate daily tapping, the cut goes down only by approximately 6 mm per week; accordingly, overlapping occurs 4 times in weekly application with the same brush.

Products used and their sources

Fungicides: Antimucin (organic mercury compound): Sandoz Ltd, Basel, Switzerland; Difolatan 80 WP (N-(1,1,2,2-tetrachloroethylsulfenyl)-cis △ 4-cyclohexene-1,2-dicarboximide): Chevron Chemical Co., San Francisco, U.S.A.; Waxrex Treseal (petrolatum, a fatty semisolid mixture of paraffin hydrocarbons): Mobil Oil Co., London, England.

Stickers, wetting agents and detergents: Agral wetting agent: Plant Protection Ltd., Fernhurst, England; Mobilcer Q (wax emulsion) and XRD-24 (emulsifiable Treseal): Mobil Oil Co.; Ortho spray sticker: Chevron Chemical Co.; Plyac spreader/sticker: General Chemical Division, Allied Chemical and Dye Corporation, Morristown, USA; Sterox NJ (synthetic detergent): Monsanto Co., St Louis, USA.

Colouring agents: Panelred (red additive, recommended by producer to improve visibility of Antimucin treatments): Sandoz Ltd; Yellow iron oxide (YO-2087): Pfizer Overseas Inc., New York, USA.

2,4-dichlorophenoxyacetic acid compounds (2,4-D): butyl ester (containing 79% acid equiv.): Dow Chemical Co., Midland, USA; diethanolamine salt (Super D Weedone weedkiller, containing 13.7% acid equiv.): Amchem, Fort Washington, USA; dimethylamine salt (containing 72.5% acid equiv.): Uniroyal Chemical Division, Naugatuck, USA; isooctyl ester (containing 48% acid equiv.): Chevron Chemical Co.

The concentrations in text and tables refer to the active ingredient for Difolatan, the acid equivalent for 2,4-D compounds and the commercial formulation for all other products.

Experiments and results

Colouring agents

The liquid Panelred was added to the Difolatan suspensions in some field experiments and was also used in practice. However, in a concentration of 0.1% – which gives the panels a distinct red colour – the Difolatan suspension becomes unstable. This undesirable effect of Panelred was less distinct with Difolatan batches produced before the end of 1967. The changes in inert materials in the newer batches made the suspension less compatible with Panelred. Another disadvantage of Panelred is that the colour fades too quickly. With water soluble dyes it is never certain that a proportional amount of the suspended Difolatan powder is applied to the panel, especially when the suspension is not very stable. Therefore insoluble colouring agents of about the same particle size as Difolatan are to be preferred. Yellow iron oxide meets these requirements. In a concentration of 1%, the panels are coloured distinctly yellow; the product is not washed off by rain, nor does the colour fade. The Difolatan powder does not contain enough detergents to keep the yellow powder in suspension; however, when some Sterox NJ is added, stable suspensions are obtained. The mixture most extensively tested in the more recent field experiments contained 1% Difolatan (= 1.25% of the 80% wettable powder), 1% yellow iron oxide, 0.1% Ortho spray sticker and 0.01% Sterox NJ.

The producer of Difolatan indicated that there was no noticeable degradation of Difolatan in 20 times concentrated suspensions after storage at 25–30 °C for 14 days; after 40 days 88% of the Difolatan was recovered. This means that the above mixture is also chemically quite stable.

Black thread control with Difolatan + yellow iron oxide in comparison with some other treatments

The results of some treatments of Exp. 6 and 7 are compared in Table 2. The black thread damage was evaluated twice in Exp. 6 to check whether the system of evaluation criteria is accurate enough and also to check if the degree of damage, seen shortly after the rainy season, might change later on in the various treatments.

The difference between the two Difolatan treatments was insignificant at the 5% level in the 2 experiments. This means that the yellow iron oxide does not change the fungitoxic properties of Difolatan. In Exp. 6, disease control was significantly better with Difolatan than with Treseal or Antimucin, and Treseal was significantly better then Antimucin, confirming previous findings. In Exp. 7, however, Treseal was about as effective as Difolatan. Probably, Difolatan had lost some of its fungitoxic properties because of decomposition, as the suspensions were prepared at the beginning of this trial and used throughout the rainy season.

The December and June evaluations differed very little in Exp. 6, which shows that such figures give a reliable record of the damage.

Table 2. Black thread control with different fungicide treatments.

Treatments	Exp. 6		Exp. 7
	Dec. '69	June '70	June '70
1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide + 0.01% Sterox NJ	1.9[1]	2.1[1]	1.4[1]
1% Difolaton + 0.1% Ortho sticker	2.0[1]	2.1[1]	2.2[1]
Treseal	2.9	3.1	1.9[1]
1% Antimucin + 5% Mobilcer Q + 0.05% Panelred	4.1	3.9	3.7

[1] These results are not significantly different at the 5% level in the Duncan test. Standard of evaluation: 0 = healthy panel, 6 = maximum damage possible.

Tabel 2. Ziektebestrijding in verschillende fungicide-behandelingen.

Rubber production of Difolatan and Treseal treated panels

In Table 3, the average rubber production is given for trees at varying intervals after the commencement of the trials. There were no significant differences in rubber yield between treatments in any of the 4 experiments. Observations over a year in these experiments indicate that the treatments had no effect on the incidence of dry trees.

The mixture of Difolatan, Ortho spray sticker, yellow iron oxide and Sterox NJ was also tested in Exp. 6, giving a rubber production of 33.5 g.t.t., practically the same as for Treseal and Difolatan + Ortho spray sticker.

Recently, an experiment was set up to determine whether such applications affect the rubber producing capacity of the renewed bark. Therefore, tapping of 4-year-old renewed bark was begun in 1970 on trees of old Exp. 2 at the portion of the panel where the first fungicide applications had been made in 1966. Over the first $4\frac{1}{2}$ months tapping, the production of the trees was very much the same in the treated treatments as in the untreated control.

Yield stimulation, bark proliferation and disease control with mixtures of 2,4-D and Difolatan in water

The results of 3 experiments are given in Table 4 and the treatments are arranged in sequence of highest to lowest yields.

Table 3. Mean rubber production as g.t.t. of treated and untreated panels.

Treatments	Exp.			
	1	2	4	6
1% Difolatan + 0.1% Ortho sticker	62.4[1]	42.4[1]	47.6[1]	34.8[1]
Treseal	56.6[1]	46.5[1]	42.9[1]	32.8[1]
Untreated control	58.1[1]	42.5[1]	—	—

[1] These results are not significantly different at the 5% level in the Duncan test. In addition, 0.05% Panelred was added to the Difolatan suspension in Exp. 4.

Tabel 3. Gemiddelde rubberproduktie in gram droge rubber per boom per tapping van behandelde en onbehandelde tapvlakken.

Table 4. Rubber yield after 2,4-D treatment in Exp. 4, 5 and 6.

Treatments	Rubber yields			
	as g.t.t.	as % yield increase over treatment(s) without 2,4-D	% bark proliferation	black thread damage
Exp. 4 (yields over 7 months)				
0.25% 2,4-D in Treseal	69.0	53	99	1.7
0.5% 2,4-D + 1% Difolatan + 10% XRD-24 + 0.05% Panelred	68.8	52	82	2.0
0.5% 2,4-D + 1% Difolatan + 0.5% Ortho sticker + 0.05% Panelred	63.7	41	20	1.1
0.5% 2,4-D + 1% Difolatan + 0.1% Ortho sticker + 0.05% Panelred	63.3	40	29	1.2
0.5% 2,4-D + 1% Difolatan + 0.05% Panelred	63.2	40	27	1.1
0.25% 2,4-D + 1% Difolatan + 0.5% Ortho sticker + 0.05% Panelred	59.2	31	5	1.1
1% Difolatan + 0.1% Ortho sticker + 0.05% Panelred	47.6	–	0	0.6
Treseal	42.9	–	0	1.5
Exp. 5 (yields over 12 months)				
1% 2,4-D + 1% Difolatan + 0.1% Ortho sticker	63.4	44	13	1.7
1% 2,4-D + 1% Difolatan + 0.5% Ortho sticker	62.5	42	13	2.6
0.5% 2,4-D + 1% Difolatan + 0.1% Ortho sticker	60.1	37	2	1.5
0.5% 2,4-D + 1% Difolatan + 0.5% Ortho sticker	59.6	36	3	1.6
0.25% 2,4-D + 1% Difolatan + 0.1% Ortho sticker	56.3	28	0	1.3
0.25% 2,4-D + 1% Difolatan + 0.5% Ortho sticker	55.4	26	1	1.1
Untreated control	43.9	–	0	3.9
Exp. 6 (yields over 6 months)				
0.25% 2,4-D in Treseal	53.7	59	99	4.5
1% 2,4-D + 1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide	42.9	27	39	2.7
0.5% 2,4-D + 1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide	38.6	15	16	2.6
0.25% 2,4-D + 1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide + 0.005% Sterox NJ	37.8	12	2	2.6
0.1% 2,4-D + 1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide + 0.01% Sterox NJ	35.7	6	0	2.3
1% Difolatan + 0.1% Ortho sticker	34.8	–	0	2.0
1% Difolatan + 0.1% Ortho sticker + 1% yellow iron oxide + 0.01% Sterox NJ	33.5	–	0	1.9
Treseal	32.8	–	0	2.9

The butyl ester of 2,4-D was used in Treseal, the dimethylamine salt in the aqueous mixtures with Difolatan in Exp. 4 and 5, and the isooctyl ester in Exp. 6.

Tabel 4. Rubberopbrengsten, bastwoekering en streepjeskanker-schade in de Veldproeven 4, 5 en 6.

a. *Yield stimulation.* 2,4-D in Treseal gave higher yield increases than in water with Difolatan in comparable concentrations. However, high yield increases were also obtained with 2,4-D in aqueous mixtures, especially when 10% XRD-24 was added. Ortho spray sticker had no noticeable effect in this respect in concentrations of 0.1% and 0.5%.

The percentage yield increases obtained in Exp. 4 and 5 were fairly similar for the aqueous treatments in comparable concentrations. However, in Exp. 6 the yield increases were much lower, although 2,4-D in Treseal was at least as effective as in Exp. 4. A salt of 2,4-D was used in Exp. 4 and 5 and an ester in Exp. 6. Whether the differences in yield response can be attributed to this difference is still unknown.

b. *Bark proliferation.* The result of above-cut stimulation with 2,4-D in Treseal – also occurred in the aqueous 2,4-D treatments. In Table 4, the area of the abnormal bark is expressed as a percentage of the total treated area. Fig. 1 shows panels of 4 treatments in Exp. 4. The proliferation was greatest when stimulation was most successful (Exp. 4: compare 0.5% 2,4-D + 10% XRD-24 with the other 0.5% 2,4-D treatments). The degree of proliferation (and the yield increase) depends not only on the 2,4-D concentration, but also – as is shown in Table 4 – on the use of products like XRD-24, which give more bulk to the coating on the bark. The better the 2,4-D adheres to the panel, the higher is the yield increase and the greater the proliferation.

It is interesting to note that there was very little abnormal bark renewal with 0.25% 2,4-D in aqueous mixtures, although these treatments gave important yield increases in Exp. 4 and 5.

Much less bark proliferation occurred in Exp. 5 than in Exp. 4, probably because of differences in girth of the trees as there is a very distinct negative correlation between girth and proliferation. The cycle of bark renewal probably also has an influence on the proliferation.

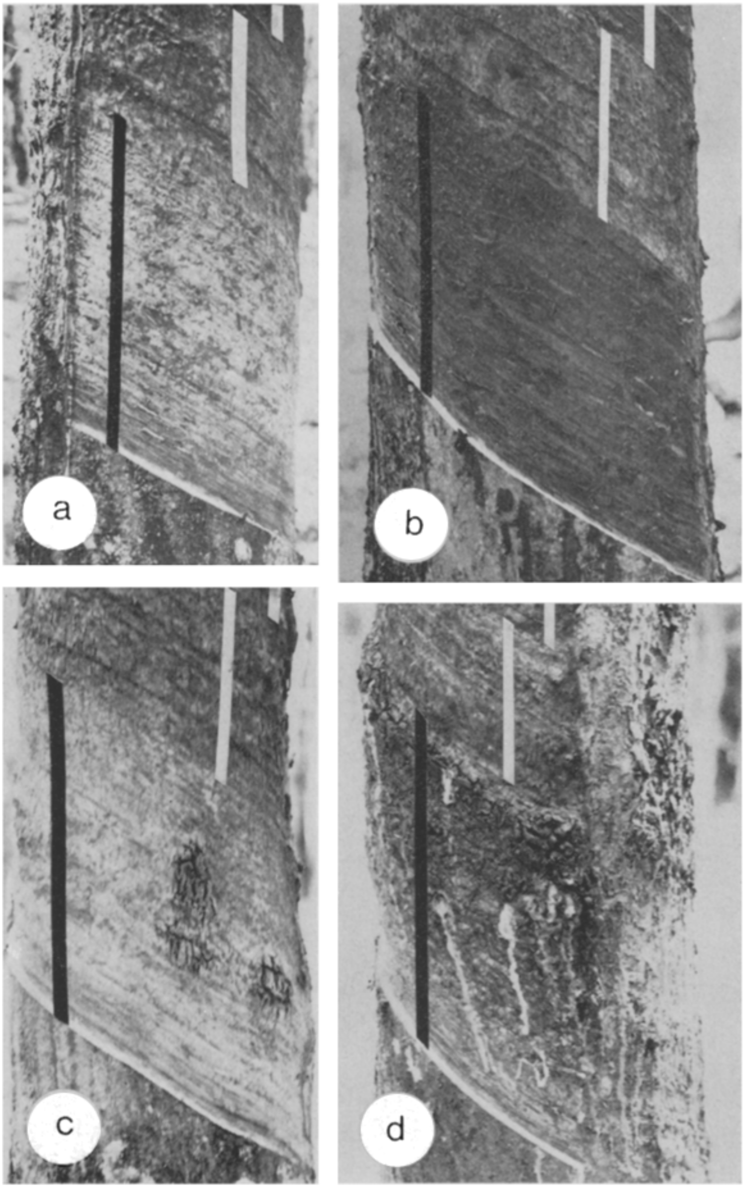
Two years after the applications the proliferated dead cork layers began to slough off (Exp. 4). The mean maximum thickness of the dead cork was 9 mm for a sample of ten trees; the thickest sample of dead cork measured 15 mm. The bark under the proliferated cork was more knobby than on unstimulated panels.

c. *Black thread control.* Addition of 2,4-D to the Difolatan suspension distinctly lowered the effectiveness of Difolatan in the three experiments. Such differences may disappear with time, but the initial damage is greater. Difolatan is unstable in an alkaline environment. The salt of 2,4-D, used in Exp. 4 and 5, may have caused decomposition of Difolatan. However, when an ester of 2,4-D was used Difolatan was also less effective than on its own (Exp. 6).

Effect of Difolatan, Treseal and 2,4-D on the thickness of renewing bark

The shaded area (see Fig. 2) of each panel was treated during the course of the experiments. The dotted lines indicate the place where the first applications were made and the dots the place where the thickness of the bark was measured. Because of the 1-inch-wide brush used, 1 inch of bark was treated above the dotted lines in Exp. 2 to 4. In Exp. 1, Treseal had been applied to all panels till shortly before the beginning of the trial. In all other cases no products were applied several months before beginning or after ending the experiments.

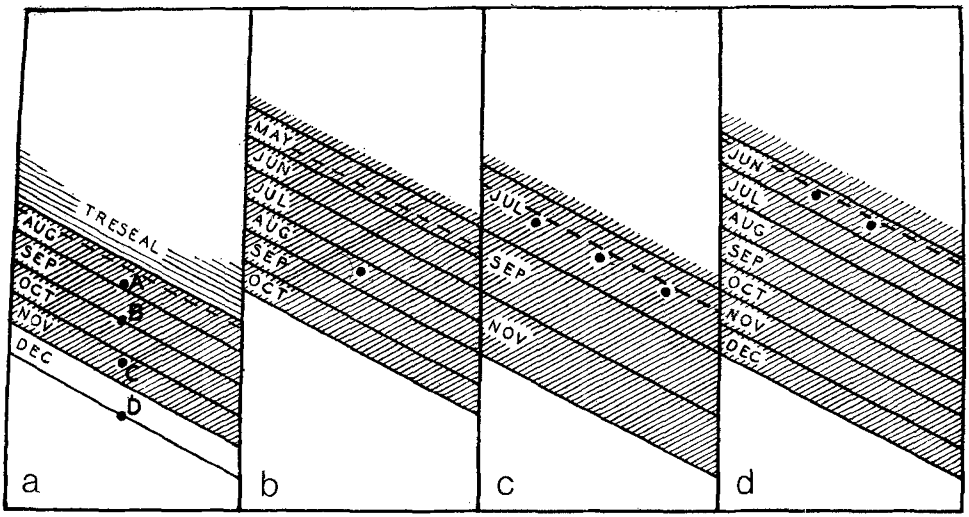
Fig. 1. Appearance of panels in different treatments.



The treated portion of each panel is marked with a black line, and the untreated portion above with a white line. In the year before, Treseal had been applied to all panels and a small portion of this bark is visible in the right top corners (short white lines). The scale is one fifth of the natural size. Bark renewal was normal and smooth with 1% Difolatan + 0.1% Ortho sticker + 0.05% Panelred in water (a) and with Treseal (b). Patchy deformation occurred when 0.5% 2,4-D was added to the above Difolatan suspension (c). The renewing bark was entirely and greatly proliferated with 0.25% 2,4-D in Treseal (d); note latex exudation through surface cracks and abnormal thick bark renewal.

Fig. 1. Bastherstel van tapvlakken behandeld met een Difolatansuspensie (a), Treseal (b), Difolatan + 0.5% 2,4-D (c) en Treseal + 0.25% 2,4-D (d).

Fig. 2. Location of bark measurements on panels of Exp. 1–4. a: Exp. 1 (Tables 5 and 6); b: Exp. 2 (Table 5); c: Exp. 3 (Table 5) and d: Exp. 4 (Table 7).



	a	b	c	d
Bark thickness measured at age:	3 years	2 and 4 years	6 months	2 years
Tapping system:	Alternate daily	Alternate daily	Monthly periodic	Alternate daily
Frequency of applications:	After each tapping	Once a week	Once a week	Once a week
Number of applications covering each measured spot:	10–15 (A, B, C)	4	2	4

Fig. 2. Plaatsen op de tapvlakken waar bastdiktemetingen werden verricht in Veldproeven 1–4.

The measurements made on the thickness of the living bark and the cork are given in Table 5.

The thickness of 6-month-old living bark differed significantly at the 5% level among treatments, except between Treseal and Difolatan + 2,4-D. Treseal promoted the growth of the bark and Difolatan reduced the growth during the first 6 months of renewal. 2,4-D in water stimulated the bark renewal more than Treseal, even on the portions of the panel, which were not visibly proliferated. In combination with Difolatan, 2,4-D stimulated bark renewal to the same extent as Treseal. The living bark renewal and the cork formation was slowed down by Difolatan in the first 6 months; the cork in the Difolatan treatments was significantly thinner than in the other treatments. Four years later the cork was still very thin. After 2 years, the Difolatan treated panels had the same living bark thickness as the untreated control in Exp. 2; in the Treseal treatment the living bark was still thicker, even after 4 years.

It can be expected that the initial differences in bark thickness between Difolatan and untreated panels will have vanished when the bark has fully matured and is to be tapped again at the age of 8 to 10 years.

Table 5. Thickness (mm) of renewing bark at different ages in some treatments of Exp. 1, 2 and 3.

Treatments	Age of living bark				Age of cork			
	6 months (Exp. 1)	2 years (Exp. 2)	3 years (Exp. 1)	4 years (Exp. 2)	6 months (Exp. 3)	2 years (Exp. 2)	3 years (Exp. 1)	4 years (Exp. 2)
1% Difolatan	3.5	5.5	5.7	6.0	1.0	1.0	1.1	1.0
Untreated control	3.8	5.5	–	5.9	1.4	1.4	–	1.4
Treseal	4.1	6.0	6.2	6.6	1.3	2.2	1.7	2.2
0.25% 2,4-D + 1% Difolatan	4.2	–	–	–	1.0	–	–	–
0.25% 2.4-D	4.7	–	–	–	1.3	–	–	–

The figures are means of 21–25 trees with 3 measurements each for 6-month-old bark; 30–33 trees with 1 measurement each for 2 and 4-year-old bark; 20 trees with 1 measurement each for 3-year-old bark. In Exp. 1, 0.03% Plyac spreader/sticker and 0.02% Agral wetting agent were added to the Difolatan suspension; in Exp. 2 and 3, 0.1% Ortho sticker which was also added to the 2,4-D treatments in Exp. 3. The diethanolamine salt of 2,4-D was used.

Tabel 5. Dikte (mm) van herstellende bast van verschillende leeftijd in Veldproeven 1, 2 en 3.

The thickness of the soft bast, hard bast and the cork was determined separately in Exp. 1 and 4. In Exp. 1, the measurements were made at 4 heights on the panels as shown in Fig. 2; spot D was taken from untreated bark. The results of these measurements in Exp. 1 are given in Table 6. The figures show clearly that Difolatan and Treseal did not cause differences in soft bast thickness after 3 years renewal. Evidence has been obtained from other observations that the soft bast renewal is about normal from the beginning. The total bark thickness at the untreated portion was practically the same in the 2 treatments; this means that there is no important after-effect of the

Table 6. Thickness (mm) of different bark layers of 3-year-old renewing bark in Exp. 1.

Treatments	Soft bast	Hard bast	Total (living bark)	Cork	Total (whole bark)
1% Difolatan + 0.03% Plyac + 0.02% Agral					
spot a	4.5	1.4	5.9	1.2	7.1
spot b	4.5	1.2	5.7	1.1	6.8
spot c	4.4	1.1	5.5	1.2	6.7
spot d	4.3	0.9	5.2	1.1	6.3
Treseal					
spot a	4.3	1.6	5.9	1.7	7.6
spot b	4.6	1.6	6.2	1.7	7.9
spot c	4.4	1.4	5.8	1.8	7.6
spot d	4.1	1.1	5.2	1.2	6.4

The figures are means of 20 trees with 1 measurement each.

Tabel 6. Dikte (mm) van verschillende bastlagen van drie jaar oude herstellende bast in Veldproef 1.

Table 7. Thickness (mm) of different bark layers of 2-year-old renewing bark in Exp. 4.

Treatments	Soft bast	Hard bast	Total (living bark)	Cork	Total (whole bark)
0.5% 2,4-D + 1% Difolatan + 10% XRD-24 + 0.05% Panelred	3.4	3.1	6.5	1.4	7.9
0.25% 2,4-D in Treseal	3.4	2.4	5.8	1.2	7.0
Treseal	3.1	1.9	5.0	1.8	6.8

The figures are means of 10 trees with 2 measurements each.

Table 7. Dikte (mm) van verschillende bastlagen van twee jaar oude herstellende bast in Veldproef 4.

treatments on the underlying panel. The conclusion can be drawn that Difolatan has a temporarily retarding effect on the activity of the cork cambium.

In some 2,4-D treatments of Exp. 4, two years after the applications the thickness of the different bark layers was also measured (Table 7). Practically all treated bark was greatly proliferated in the 2 stimulated treatments. The dead, proliferated cork was removed first, if still present, and the figures refer to the remaining and more normal looking cork. In the unstimulated Treseal treatment, the whole cork was measured; therefore the figures in the table show a thicker cork in that treatment.

It can be seen that the hard bast was considerably thicker in the 2,4-D treatments, especially in the 0.5% aqueous 2,4-D treatment. Also the soft bast was somewhat thicker, but this can possibly be attributed to inaccuracy of the measurements as it is difficult to determine by scraping where the hard bast ends exactly and the latex-containing soft bast begins.

Mixing of Difolatan

The most promising Difolatan mixture for black thread control is with yellow iron oxide, Ortho spray sticker and Sterox NJ. It is practical to prepare first a concentrate of 20 times the strength applied to the trees and to dilute with water on the day the applications have to be made. The concentrate should be made up no earlier than 1 month in advance because of decomposition of the active ingredient during prolonged storage. Such a concentrate in water contains 25% Difolatan 80 WP (= 20% active ingredient), 20% yellow iron oxide, 2% Ortho spray sticker and 0.2% Sterox NJ. The specific gravity is approximately 1.27. Dilution of one volume concentrate with 19 volumes of water gives the dilution ready for use.

It is recommended that a slurry of the Difolatan powder should first be prepared, but if too much water is added, the aggregated Difolatan particles do not separate and an unstable suspension is immediately obtained. Following this stage, more water should be added whilst stirring, and then the other ingredients added. It is advisable to make a suspension of the yellow powder before it is added to the Difolatan suspension. The whole procedure can be simplified and speeded up with the aid of strong electric agitators. The quantity of water added instantly to the Difolatan powder is then less critical, but the more concentrated the original suspension, the better.

The powders in the concentrate and in the dilution ready for use settle down with time. Therefore, when the suspensions are left to stand for some time, they should be re-suspended prior to dilution, distribution or application.

Discussion

Although in the reported experiments better control of black thread was usually obtained with Difolatan than with other fungicides, notable fungal damage occurred in several instances. In the experiments, the panels were exposed to severe infection as the disease could build up on neighbouring untreated control trees or on trees treated with less effective fungicides. Also, tapping tasks with a rather severe black thread history were chosen, to make sure that the disease incidence would reach a high level so that the relative effectiveness of the treatments could easily be assessed. Therefore, in commercial practice better disease control is obtained with Difolatan, especially because the applications are made more often than once a week when a high black thread incidence is to be expected. The most common causes for unsatisfactory disease control with Difolatan are: a. Difolatan suspension and application technique were of poor quality (tapper influence); b. the applications were begun too late in the black thread season or terminated too soon (in Liberia the disease needs no treatment during the 3 to 4 driest months); c. too long intervals between applications; d. severe black thread history and high susceptibility of the *Hevea* planting.

A practical, preventative measure likely to be successful is to stop tapping the trees with severe black thread damage on the panel of the foregoing year during the most susceptible months.

It is interesting that important yield increases can be obtained with 2,4-D in water, applied as such or in combination with Difolatan. Promising results with 2,4-D in water were also reported by Puddy and Warriar (1960); inert materials such as kaolin were added in their trials, giving more bulk to the coating on the bark.

Generally, the more 2,4-D adheres to the bark, the higher are the yield increases obtained; however, bark proliferation becomes more severe and disease control less effective. There are indications that Difolatan becomes less effective in such mixtures because of greater susceptibility of above – cut stimulated trees (Treseal also gives poorer disease control when mixed with 2,4-D) and because the contact between Difolatan particles and the bark is reduced (the particles are embedded in the XRD-24 in Exp. 4). It is not yet known whether Difolatan is more readily decomposed in combination with 2,4-D in aqueous mixture. Very little bark proliferation occurred in the treatment with 0.25% 2,4-D + 1% Difolatan + 0.1%–0.5% Ortho spray sticker (with and without yellow iron oxide and Sterox NJ). Such a mixture still gave a reasonably effective disease control and a rather important increase in yield. Therefore, mixtures with not more than 0.25% 2,4-D might deserve further testing on younger trees.

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Samenvatting

Bestrijding van 'streepjeskanker' in Hevea brasiliensis met Difolatan

Gebleken is dat het fungicide Difolatan, toegepast bij de bestrijding van *Phytophthora palmivora* – veroorzaker van een tapvlakziekte, bekend als 'black thread' (Ned. naam: 'streepjeskanker') – aanvankelijk een remmende invloed heeft op het herstel van de *Hevea*-bast. Echter, na enkele jaren bereikt de levende bast toch een normale dikte. Waarschijnlijk vermindert Difolatan in het begin de activiteit van het kurkcambium, waardoor minder harde bast en kurk worden gevormd. In verscheidene veldproeven werd aangetoond dat Difolatan geen effect heeft op de latexproduktie; de produktiecapaciteit van de herstellende bast zelf is waarschijnlijk ook normaal. Difolatantoepassingen op de bast worden beter zichtbaar door 1 % geel ijzeroxide toe te voegen aan de waterige suspensie, welke 1 % Difolatan (1.25 % van het 80 % spuitpoeder) en 0.1 % 'Ortho spray sticker' bevat; in dit geval dient nog 0.01 % Sterox NJ (een uitvloeier) te worden toegevoegd om een stabiele suspensie te verkrijgen.

Hogere rubberopbrengsten werden verkregen door 0.25-1 % 2,4-D aan de suspensie toe te voegen. De produktie kan nog verder worden opgevoerd met behulp van hechters, die een dikkere laag residu op de bast achterlaten. De grootste produkties gingen gepaard met sterke woekering van de herstellende bast en een minder bevredigende ziektebestrijding. Evenwel, in betrekkelijk lage 2,4-D concentraties (niet hoger dan 0.25 %) werden toch nog belangrijke meeropbrengsten verkregen zonder noemenswaardige bastwoekering of een sterke teruggang in fungitoxische eigenschappen van het mengsel. Deze formuleringen bieden mogelijkheden voor een milde stimulatie van jongere bomen, terwijl tegelijkertijd de 'streepjeskanker' wordt bestreden.

References

Anliker, W. L. & Scanlon, D. H., 1965. Evaluation of a technique for stimulating yield of *Hevea brasiliensis*. Expl. Agric. 1: 153–160.

Chee, K. H., 1969. Leaf fall due to *Phytophthora botryosa*. Plrs' Bull. Rubb. Res. Inst. Malaya 104: 190–198.

Jonge, P. de, 1957. Stimulation of bark renewal of *Hevea* and its effect on yield of latex. J. Rubb. Res. Inst. Malaya 15: 53–71.

Levandowsky, D. W., 1960. Clonal variations in yield and bark regeneration of *Hevea brasiliensis* after yield stimulation. Proc. nat. Rubb. Res. Conf., Kuala Lumpur: 270–288.

Puddy, C. A. & Warriar, S. M., 1960. Yield stimulation of *Hevea brasiliensis* by 2,4-dichlorophenoxyacetic acid. Proc. nat. Rubb. Res. Conf., Kuala Lumpur: 194–210.

Schreurs, J., 1969. Difolatan, a promising fungicide for control of the tapping panel disease black thread in *Hevea brasiliensis*. Neth. J. Pl. Path. 75: 113–118.

Sharp, C. C. T., 1937. Experiments with economic tapping systems. J. Rubb. Res. Inst. Malaya 8: 24–38.

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