Poisoning Experiments with Hevea brasiliensis II. Results of a Further Tree Poisoning Experiment with 2, 4, 5-T

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An experiment is described in which three different grades of gas oil confounded with two concentrations of 2, 4, 5-trichlorophenoxy acetic acid have been compared as poisons of old Hevea brasiliensis trees.

The effect of these mixtures on rate of death of trunks, branches and roots is discussed together with the effect on the yield.

THE PRACTICAL VALUE OF 2, 4, 5-T as a tree poison suggested in Part I has been subjected to further investigation in an experiment carried out on the R.R.I. Experiment Station. Two concentrations of the normal butyl ester of 2, 4, 5-T have been compared in three different oil carriers on twentyfive-year-old well grown unselected seedling trees. The following oils were used containing 0, 2½% or 5% acid-equivalent of 2, 4, 5-T.

1 Shell Diesoline (low viscosity)

2 Shell Diesel Fuel (medium viscosity)

3 Shell Fuel Oil (high viscosity)

Furthermore, a comparison was made between normal S/2.d/2.100% tapping in renewed bark and V/2.d/2.100% tapping in an upward direction in virgin bark on both poisoned and control trees. Tapping of poisoned trees was continued until the cuts dried out.

The experimental formulations were applied to a full circumference band at the base of the trees from ground level to a height of fifteen inches. The downward tapped cuts, therefore, moved toward the treated strip of bark, whereas the upward tapped cuts moved away from it.

The average quantity applied per tree was 220 ml for all formulations. This high dose was necessitated by the large girth of the trees (66.2 inches) at the place of application, and works out at approximately 0.22 ml per square inch of bark.

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The following thirteen treatments have been compared:

A	Diesoline	Normal S/2.d/2.100% tapping in renewed bark
B	Diesel fuel	
C	Fuel oil	
D	Diesoline + 2½% 2, 4, 5-T	
E	Diesel fuel + 2½% 2, 4, 5-T	
F	Fuel oil + 2½% 2, 4, 5-T	
G	Diesoline + 5% 2, 4, 5-T	
H	Diesel fuel + 5% 2, 4, 5-T	
J	Fuel oil + 5% 2, 4, 5-T	
K	Diesoline + 2½% 2, 4, 5-T	Upward V/2.d/2.100% tapping in renewed bark
L	Diesoline + 5% 2, 4, 5-T	
M	Control	
O	Control	Normal S/2.d/2.100% tapping in renewed bark

Design of experiment

A suitable design to compare such a large number of treatments with a reasonable degree of accuracy without using an unduly large acreage is the 'tree-plot-design', in which each tree is considered as a treatment plot. Earlier experiments on yield stimulation had shown that 30 trees per treatment gives a satisfactory basis for judgement of yield performance. The area available allowed for 35 trees per treatment. Some planning was given to 'randomisation', by the introduction of 35 theoretical blocks of 13 trees each. Trees within each block were, on the average, of nearly similar yield capacity, as judged by two months' yield recording of individual trees; and, by further arrangements, each treatment contained approximately the same number of vigorous, moderate and poorly grown trees. Randomisation of treatments was done within blocks.

Recording

The yield was recorded by coagulation of the latex in the cup on all tapping days. Individual tree yields had been recorded over a period of two months before the treatments were applied and the yield recording was continued until the trees ceased to yield.

The girth of each tree was measured around the centre of the bark strip to be treated, i.e. at approximately 7½ inches from ground level. (See Table I).

The importance of taking bark thickness measurements at a point on the site of applications of the poison before the treatments were applied was realised too late. Measurements were taken one month later at 5 inches above the treated strip of bark at the North, East, West and South positions on each tree. They showed an increase of bark thickness when 2, 4, 5-T was applied in Diesoline and diesel fuel, but not when it was applied in the highly viscous fuel oil (see Table I). However, the

TABLE 1. GIRTH, BARK THICKNESS AND NUMBER OF DEAD TREES IN EACH TREATMENT (35 TREES)

Treatment	Mean girth in inches	*Mean bark thickness in mm	Trees dead after one year	
			number	percentage
A Diesoline	67.0	7.9	Nil	—
B Diesel fuel	69.7	8.4	Nil	—
C Fuel oil	67.9	7.7	Nil	—
D Diesoline + 2½% 2, 4, 5-T	66.3	9.8	28	80
E Diesel fuel + 2½% 2, 4, 5-T	63.7	9.9	20	57
F Fuel oil + 2½% 2, 4, 5-T	64.9	8.5	Nil	—
G Diesoline + 5% 2, 4, 5-T	64.4	10.1	33	94
H Diesel fuel + 5% 2, 4, 5-T	60.6	9.7	29	83
J Fuel oil + 5% 2, 4, 5-T	67.4	8.7	Nil	—
K Diesoline + 2% 2, 4, 5-T + u/t	68.2	9.2	17	49
L Diesoline + 5% 2, 4, 5-T	66.1	9.9.	30	86
M Control u/t	64.2	8.6	Nil	—
O Control d/t	69.8	8.2	Nil	—

u/t = upward tapping
d/t = downward tapping
* = measurements taken one month after application of treatments

data for the control trees show that the thickness of the renewed bark was well above average for bark of second renewal of unselected seedling trees.

Observations on the effect of the poison on the foliage and the bark of the trees were commenced immediately after the application of the treatments on 18 July 1955. At first they were made weekly, later at fortnightly intervals up to April 1956, noting for each tree: when leaf discolouration commenced; leaf shedding started; all leaves had been shed; refoliation was observed; new leaves had been shed; treated bark was dead; latex flow had ceased; borers invaded the stem. A final round of inspection was made one year after the start of the experiment in July, 1958. As criterion for 'death' of the trunk, the following observations were combined: all leaves were shed; treated bark was dead; untreated bark would yield no latex; borers were in the trunk. When these conditions were met the trees were possibly not completely dead, but were at any rate dying without chance of recovery. The crowns were usually disintegrating before the bark completely ceased to yield latex, but when the bark was removed the cambium was found to be discoloured and black streaks were seen in the sapwood.

RESULTS

Kill of Trees

Table I lists the mean girth and bark thickness of the 35 trees allocated to each treatment, together with the number of trees killed one year after treatments were applied. The slight variation in girth between treatments is caused by the fact that the trees were allocated to the various treatments primarily on a basis of yield performance, girth being a secondary consideration.

Measurements of bark thickness were taken one month after the treatments were applied. The effect of 2, 4, 5-T on bark thickness can be seen on trees of treatments *D, E, G, H, K* and *L*. The fuel oil treatments with 2, 4, 5-T (treatments *F* and *J*) had no effect on bark thickness.

The following treatments have proved ineffective as tree poisons:

A Diesoline alone

B Diesel fuel alone

C Fuel oil alone

F Fuel oil + 2½% 2, 4, 5-T

J Fuel oil + 5% 2, 4, 5-T

From these observations it appears that diesel oils are not effective tree poisons when applied over a 15-inch full circumference band to the bark at the base of rubber trees. Furthermore it is shown that fuel oil is an unsuitable carrier for 2, 4, 5-T, because of its high viscosity and poor penetration.

Six treatments, effective in varying degrees, remain to be considered—those containing 2½% or 5% of 2, 4, 5-T in either Diesoline or diesel fuel. The results obtained with these materials have been summarised in Tables 2 and 3, Table 2 giving the effects of formulations containing 2½% 2, 4, 5-T and Table 3 those of formulations containing 5% 2, 4, 5-T.

TABLE 2. EFFECT OF 2½% 2, 4, 5-T FORMULATIONS

Month after treatment	No. of trees dead	Mean girth
1	14	44.9
2	9	56.0
3	20	62.7
4	6	73.9
5	10	70.1
6–11	14	67.6
Number of survivors	31	77.2
Total number of trees treated	104	66.1

TABLE 3. EFFECT OF 5% 2, 4, 5-T FORMULATIONS

Month after treatment	No. of trees dead	Mean girth
1	14	46.9
2	18	66.4
3	15	60.0
4	13	72.9
5	13	65.4
6–11	19	75.7
Number of survivors	13	81.2
Total number of trees treated	105	67.1

A breakdown of the figures by individual treatments, indicating the number of killed trees and survivors, is given in Table 4.

The following conclusions are drawn from the data presented in Tables 2, 3 and 4:

a None of the treatments has resulted in a 100% kill one year after poisoning. However, most of the 'survivors' show advanced symptoms of poisoning and are already partially dead. On such trees it is often observed that a narrow strip of bark winding spirally up the stem remains alive, and the branch it connects up with also remains alive, whereas other branches are already disintegrating.

b The most rapid and effective tree poison used in this experiment is the 5% concentration of 2, 4, 5-T in the thin fluid Shell Diesoline.

c Upward tapping appears to delay the effect of the poison.

Table 4. Number of Dead Trees per Month (Cumulative)

Months after poisoning	Diesoline +5% 2, 4, 5-T	Diesel fuel +5% 2, 4, 5-T	Diesoline +5% 2, 4, 5-T	Diesoline +2½% 2, 4, 5-T	Diesel fuel +2½% 2, 4, 5-T	Diesoline +2½% 2, 4, 5-T
	d/t	d/t	u/t	d/t	d/t	u/t
1	—	—	—	—	—	—
2	10	3	1	6	8	—
3	18	9	5	11	11	1
4	20	13	14	19	20	4
5	25	18	17	21	22	6
6	27	21	25	28	24	7
7	29	25	27	28	25	10
8	30	25	28	28	25	10
12	32	29	30	28	28	17
Number of survivors	2 (both dying)	6 (five dying)	5 (four dying)	7 (five dying)	7 (five dying)	17 (twelve dying)
% survivors	6%	17%	14%	20%	20%	50%

Before the treatments were applied, all trees were being tapped on a half spiral cut in renewed bark. After application of the treatments on trees which were to be tapped in an upward direction, new V/2 cuts were opened in virgin bark just above the renewed bark on the opposite side. This has, no doubt, caused a partial ringing effect which may have interfered with the translocation of the 2, 4, 5-T. The discolouration of the leaves after the application of the treatments was observed earlier on the downward tapped than on the upward tapped, trees of comparable treatments (Table 5).

TABLE 5. ONSET OF LEAF DISCOLOURATION FOLLOWING POISONING (CUMULATIVE NUMBER OF TREES)

Months	Diesoline -2½% 2, 4, 5-T	Diesoline -5% 2, 4, 5-T	Diesoline -2½% 2, 4, 5-T	Diesoline +5% 2, 4, 5-T
1955	d/t	d/t	u/t	u/t
July	5	6	1	2
August	17	17	5	12
September	22	23	8	19
October	29	29	9	20
November	30	34	23	33
December	34	35	24	33
1956				
January	34	35	24	34
February	35	35	24	34
Number of trees showing no discolouration	Nil	Nil	10	1

Observations made elsewhere also support the view that trees tapped on several cuts on both sides of the stem react less rapidly to the 2, 4, 5-T tree poison. However, it would appear from the figures in Table 4 that if the concentration of 2, 4, 5-T is at the 5% level the effect of upward tapping is only a delaying one, the ultimate kill being nearly similar to that of the trees treated in the same way but tapped downwards. With the 2½% 2, 4, 5-T concentration a definite reduction in the number of trees killed was caused by upward tapping.

The time of leaf discolouration appears to depend more on the tapping system than on the concentration of 2, 4, 5-T in the Diesoline.

Leaf discolouration and subsequent shedding are, however, also governed by environmental conditions. On one estate a solid block of 120 acres of old seedling trees was poisoned with 5% 2, 4, 5-T in diesel fuel. Practically all trees were completely defoliated within a fortnight and a record seemed to have been established. Poisoning was done in a severe dry spell of weather which continued for three weeks after application of the poison. With the advent of the rains, however, a very high proportion of the trees refoliated and the subsequent kill was slow and unsatisfactory.

No such climatic extremes have been experienced during the period covered by our experiment, in which 16% of the trees treated with 5% 2, 4, 5-T in either Diesoline or diesel fuel refoliated after complete or partial defoliation. All but three of these died in later months.

d Most of the surviving trees are of above average girth, and the figures show a trend, the less vigorous grown trees being more rapidly killed (Tables 2 and 3).

We know from experience that thinning in a young tappable stand of rubber can be effectively done with a 2½% or 5% concentration of 2, 4, 5-T in Diesoline. In the tree poisoning experiment under review there have, however, been a few poorly grown old seedling trees which were less rapidly killed than other, more vigorously grown, trees.

Irrespective of tapping systems roughly 74% of the trees poisoned with 5% 2, 4, 5-T in Diesoline were killed within six months after poisoning, and 10% survivors were counted after one year. Of the surviving trees belonging to these treatments there was only one which appeared healthy, though even in this case some effects of treatment could be observed on the bark. All other survivors were partially dead.

Yield

The effect of the various treatments on yield is shown in *Figure 1A*, *B* and *C*. The following observations are noted:

a Diesoline and diesel fuel have both induced a significant increase in yield over a period of between two and three weeks after application (*Figure 1A*). This effect is not shown by the viscous fuel oil. It would appear that any action which wounds or partly kills the bark of a rubber tree results in an increased latex flow. Slashing, a mild fire, scraping of the bark, and in this case painting of a large strip of bark with a penetrating mineral oil, all result in a temporary yield increase. Treatment with a yield stimulant may be listed in the same group. All these 'actions' result in the formation of new protective tissues, and it is suggested that the formation of these new wound tissues (a form of growth) is closely related to the increased rubber regeneration.

b Addition of 2½% or 5% 2, 4, 5-T to these oils has resulted in high, though transitory, yield increases (*Figure 1A*). One month after poisoning the yield had come back to control level; it then dropped steeply by subsequent defoliation and kill of the trees.

Fuel oil + 2½% 2, 4, 5-T had a slight effect on leaf colour but did not kill a single tree. The yield was increased over a period of two and a half months after which it dropped below control level. There is only a slight difference between diesel fuel and Diesoline as a carrier for 2½% or 5% 2, 4, 5-T with regard to yield (*Figure 1A* and *B*).

c Upward tapping has clearly resulted in a longer period of increased yield (*Figure 1C*). Profitable tapping can then be done for a period of two and a half to three months after poisoning. This is, of course, linked with the delaying effect of upward tapping (mentioned earlier) on the defoliation and kill of trees.

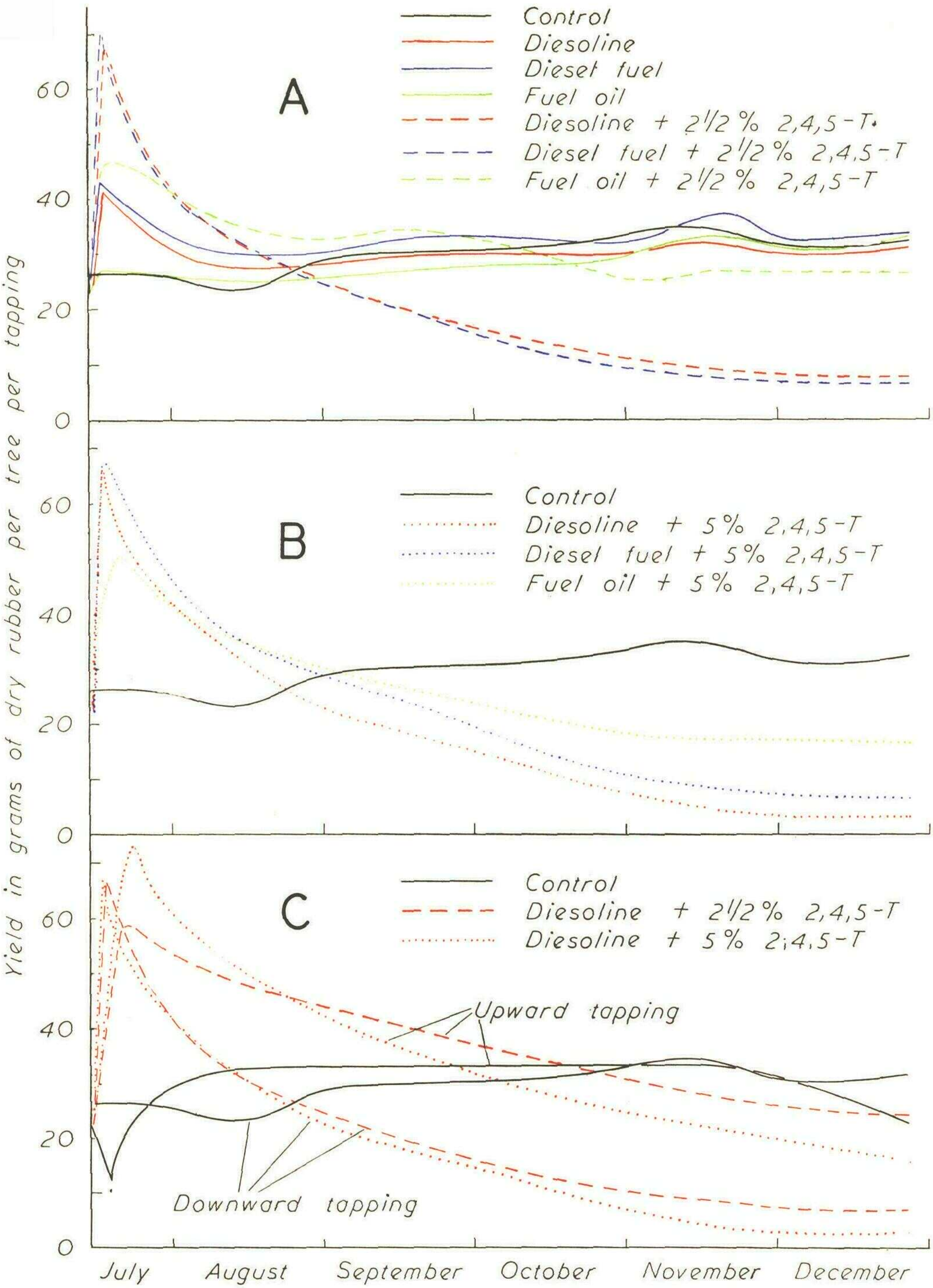

Figure 1. Comparison between treatment

When tapping in an upward direction the longest period of increased yield was noted for treatment Diesoline + 2½% 2, 4, 5-T which also resulted in a high number of survivors.

CONCLUSION

Application of 2, 4, 5-T formulations as tree poisons have resulted in greatly increased yields of rubber trees.

The period of increased yield which lasts approximately one month on downward S/2.d/2.100% tapping can be lengthened to two and a half to three months when tapping V/2.d/2.100% in an upward direction in virgin bark.

No intensive tapping systems have been tried out in conjunction with tree poisoning, but our observations suggest that intensive multiple-cut tapping systems may interfere with the efficacy of the tree poison.

Effect on the Root System

A major object of poisoning old rubber trees is to obtain a rapid kill of the root system, which otherwise might become a serious source of root disease infection to the young replanting. When the root systems of a few poisoned trees in this experiment were exposed it was found that the lateral roots had remained alive for a much longer period than the trunk and branches. It was then decided to expose the root systems of all trees poisoned with a 5% concentration of 2, 4, 5-T in either Diesoline or diesel fuel, and also of the untreated control trees. The main lateral roots were exposed to a distance of four feet from the trunk and the taproot was exposed to a depth of four feet.

The effect of poisoning on the kill of roots one year after application of 2, 4, 5-T is summarised in Table 6.

TABLE 6. KILL OF ROOTS ONE YEAR AFTER POISONING

	Treatment	No. of trees	No. of laterals	Laterals % killed	Taproots % killed
G	5% 2, 4, 5-T in Diesoline	35	233	57%	83%
H	5% 2, 4, 5-T in diesel fuel	35	254	54%	86%
L	5% 2, 4, 5-T in Diesoline (upward tapping)	35	248	65%	91%
O	Control	35	255	Nil	Nil

It is shown that under the conditions of this experiment only 55—60% of the lateral roots were completely killed one year after poisoning with a 5% 2, 4, 5-T solution. However, many of the 'living' roots were partially dead and were already invaded with saprophytic fungi.

The observed slow kill of roots is not in accord with a statement in our publication 'Poisoning with 2, 4, 5-T' in *Planters' Bulletin* 17, page 41, the last paragraph of which reads 'Excavation some six months after poisoning has shown that all roots are killed by this time, as for sodium arsenite treatment'. At that time examination of the root system was mainly limited to the taproots and the bases of the laterals. It can be seen from Table 6 that nearly all taproots were dead and the junctions of the laterals with trunk or taproot were also nearly invariably dead. This has, unfortunately, led to an erroneous conclusion. When the root systems of the trees were exposed it was found that a large number of lateral roots were invaded by fungi. At our request an officer of the Pathological Division has made an inspection of all laterals and taproots, the results of which are summarised in Table 7.

TABLE 7. FUNGI IN ROOTS OF POISONED TREES

Treatment	No. of trees	No. of laterals	% of laterals invaded by *Ustulina zonata*	% of laterals invaded by Other fungi	% of dead laterals not invaded
G	35	233	12.7%	50.5%	8.6%
H	35	254	12.6%	42.5%	21.3%
L	35	248	14.5%	54.4%	9.3%
O (control)	35	255	Nil	Nil	Nil

The frequent occurrence of *Ustulina*, which is sometimes parasitic, on lateral roots of the poisoned trees should not be taken as evidence that the roots invaded by it were dead before the poison was applied to the trees. The lateral roots of the control trees did not have any *Ustulina* infection at all, showing that *Ustulina* has invaded the poisoned trees as a saprophyte.

The other identified fungi were *Polyporus rugulosis*, *Ganoderma applanatum*, and species of *Poria* and *Xylaria*. An unidentified brown fungus was also observed. These saprophytic fungi have been grouped together in Table 7 under the heading 'other fungi'. *Ustulina* is listed separately because of its alternate parasitic habit, but the distinction is believed to be without significance.

It was further found that a proportion of the poisoned trees belonging to treatments *G*, *H* and *L* was invaded by termites. Twentynine out of the total of 105 poisoned trees were so affected and of these 16 were invaded by *Coptotermes curvignathus*. Five more trees had carton-like nests similar to that of *Coptotermes curvignathus* and the eight remaining trees were invaded by other species, some which have not been identified. None of the control trees was infested.

These pathological observations are put on record without further comment as experiments are in progress in which the effects of several tree poisoning methods are being compared, and from these more conclusive information is expected.

SUMMARY

The efficacy, as tree poisons, of a 2½% and 5% acid-equivalent concentration of the normal butyl ester of 2, 4, 5-trichlorophenoxy acetic acid in three different grades of diesel oil has been investigated in an experiment carried out on the R.R.I. Experiment Station. Seventy per cent of the trunks and branches of the treated trees were dead within six months, and practically all trees were dead or nearly dead one year after application of 5% 2, 4, 5-T in Shell Diesoline.

The killing effect on the lateral roots was much slower. Sixty per cent of the lateral roots were dead 12 months after poisoning. A record is given of pathological observations.

The yield of trees treated with a 2, 4, 5-T tree poison was greatly increased for a period of one to three months depending on the tapping system employed. It is suggested that full circumference tapping may interfere with the translocation of 2, 4, 5-T and may result in slower kill.

The cooperation of the staff of the Pathological Division in identifying fungi and termites is gratefully acknowledged.

It is a pleasure to put on record the able field work of Mr R. Perumal and the accurate compilation of data by Mr Chen Khyun Thai.

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