Decay of Rubber Wood in a Replanting and its Effect on Root Disease

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A field experiment, of 2^5 factorial design, was undertaken to study factors affecting the rate of decay of poisoned trees or stumps of Hevea brasiliensis, *half of which were artificially inoculated with* Fomes lignosus, *and the resulting root disease on the replanted stand. Poisoning with 2,4,5-T caused faster decay than with sodium arsenite and the presence of* F. lignosus *accelerated the decay of the roots. Despite an extremely high rate of infection of the young trees consequent on the artificial infection of the old stand, routine treatment and supplying gave a substantially disease-free planting, without eradicating sources of infection except as required for sampling. A legume cover greatly reduced the incidence of infection and losses.*

As a cheaper alternative to mechanical clearing, a stand of old rubber ready for replanting can be poisoned to hasten colonisation by wood-rotting fungi which exclude, or at least partly suppress, root disease fungi. Such biological eradication of actual or potential sources of infection, by enabling saprophytes to compete with the root parasites, has proved most valuable in the control of root disease in rubber replantings (Fox, 1965).

NEWSAM *et al.* (1961) had reported the results of a small-scale experiment on poisoning rubber, recording the progress of rotting over a period of 36 months and the relative importance of fungi and insects in bringing about decay. The experiment, concluded with a further year of observations, showed that the decay was primarily brought about by fungi and that it was almost complete in four years after poisoning; 2,4,5-T gave rather faster decay than sodium arsenite, and stump poisoning was better in this respect than poisoning standing trees.

A similar larger experiment, started at the Experiment Station in 1960, studied in addition, the effect of root disease introduced into the old stand.

EXPERIMENTAL DESIGN

The eight acres of land had first been planted from jungle in 1931, at a spacing 20′×20′, after felling, burning and clean clearing. It was divided into four blocks of eight plots; each plot had four rows of six trees in the original planting, the rows forming sub-plots.

The experiment was arranged in a 2^5 factorial design. Three pairs of treatments were replicated four times on whole plots. They were: tree poisoning vs. stump poisoning; insecticidal treatment of the base of the tree or the stump vs. nil; clean weeding vs. presence of creeping legume covers. The remaining two pairs of treatments—sodium arsenite vs. 2,4,5-T as the poison, and inoculation of the roots of the old stand with *Fomes lignosus* vs. nil—were applied to the single-row sub-plots.

METHODS

Standing trees were poisoned by spraying 2,4,5-T (5%) in diesel oil on the basal portion of the trunk or by applying sodium arsenite in a paste of tapioca flour at the rate of 2 oz per tree on an 8-inch ring-barked portion at the base. Similar applications were made to the stumps of trees (cut at about 18 in. above ground). Insecticidal treatment consisted of wetting the soil around the bole with one gallon of 0.05 per cent dieldrin and spraying 0.1 per cent gamma BHC on the above-ground portion (up to five feet on the trees) at fortnightly intervals for six weeks, thereafter monthly for a year. *F. lignosus* was inoculated by burying

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sections of roots penetrated and killed by the fungus under and in contact with a prominent lateral root, about 15 inches away from the collar. The 'non-cover' plots were kept clean weeded. In the 'cover' plots a mixture of *Pueraria phaseoloides*, *Centrosema pubescens* and *Calopogonium mucunoides* was planted a month after poisoning. At about the same time *Hevea* seedlings raised in baskets were planted at a spacing 20′×12′. A year later the poisoned trees were felled, five feet above ground, because of the danger from falling branches.

METHODS OF ASSESSMENT

At six months and at eighteen months after poisoning, the trees or stumps were individually examined to record the extent of death, the presence of fruit bodies and the intensity of insect attack.

Rate of decay was assessed from observations at 18, 24, 30 and 36 months after poisoning, on four representative stumps or trees from the four replications of each treatment combination, so chosen that the mean of their girths came the closest possible to the mean girth of all the stumps or trees that had received that treatment combination. Uniform drawing of each sample from the four replicates of each treatment combination at the rate of one stump per sub-plot receiving that treatment combination was not always possible, casualties in the old stand having resulted in the survival of less than the four reasonably-sized stumps needed in some sub-plots for so doing.

The stumps were dug out and cut open to score the extent of decay on the scale 0=alive, 1=hard rot, 2=fairly hard rot, 3=fairly soft rot, 4=soft rot, 5=advanced rot and 6=humus. Scoring was done separately for the above-ground parts, the collar and tap root, and the main lateral roots. The remains of the sampled stumps were removed from the site and burnt. Because the extent of decay was for the most part far from uniform throughout each of the three parts of the stump, a mean score was arrived at by roughly estimating proportion of each part to which a particular rot score would apply.

The effects of the various treatments of the old stand, on root disease incidence and losses in the replanted stand, was assessed as part of routine two-monthly rounds of inspection for foliar symptoms and treatment starting a year after planting and continuing for four years.

FUNGUS AND INSECT COLONISATION

Six months after poisoning the old stand, and five months after planting, the covers were spreading but had not filled the inter-rows. Death of the above-ground parts of poisoned stumps was 90 to 100 per cent complete; of the poisoned trees, 75 to 80 per cent complete. The common saprophytic fungi *Schizophyllum commune*, *Lenzites rependa*, *Polyporus occidentalis*, *Daldinia concentrica* and *Xylaria* sp. had already established themselves, as evidenced by their fructifications. The activity of ambrosia beetles (Scolytidae and Platypodidae) was already on the decline, the stumps and trees having already largely dried out, but there were numerous shot-hole borers (Bostrychidae and Lymexylidae) tunnelling the trunk, especially of the poisoned trees. Erotylid and Endomychid beetles were commonly present, feeding on the fungal fructifications. Termite activity was less than expected, perhaps because the dieldrin treatment in half the number of plots had largely driven them from the site.

Eighteen months after poisoning, the stumps were completely dead and had started to decay. The cover was complete in the inter-rows, in many places growing over the stumps and around the trees. Fructifications of more saprophytes (*Trametes corrugata*, *Polyporus rugulosus*, *Polyporus scopulosus*, *Ganoderma applanatum*, *Ganoderma lucidum*, *Kretzschmaria cetrarioides* and *Lentinus* sp.) were seen, and were especially numerous in the cover plots. Eighty-eight per cent of the stumps and trees inoculated with *F. lignosus* in the 'cover' plots had fructifications of this fungus, as against 56 per cent in the 'no-cover' plots.

Eighteen months after poisoning there was also a marked change in the insect fauna. Borers had given place to beetles of the families Cerambycidae, Tenebrionidae, Elateridae, Lamiidae, Passalidae, Buprestidae and Brenthidae, tunnelling and breeding in the wood in various stages of decay; while Lucanidae,

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Cetoniidae, Melolonthidae and Rutelidae were breeding in wood already decayed. A cockroach, *Panesthia angustipennis*, was the predominant insect, colonies living in cavities inside the rotting wood.

Insect activity at both these stages—scored on the scale 1=very light, 2=light, 3=moderate, 4=heavy, 5=very heavy—is represented in *Figure 1.* The insecticidal treatments did not completely exclude insects, but reduced their populations; they were more numerous in trees than in stumps, and following 2,4,5-T rather than sodium arsenite poisoning.

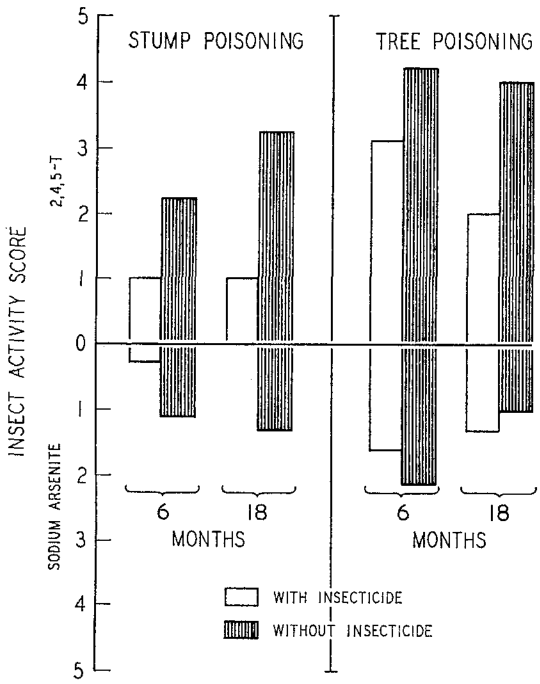

Figure 1. Mean scores of insect activity.

DECAY OF STUMPS AND TREES

Mean rot scores for the above-ground parts, the collar and tap root and the lateral roots, on each sampling occasion, were analysed (*Table 1*).

Poisoning with 2,4,5-T gave much faster decay of the exposed parts than with sodium arsenite. Poisoning the stumps gave faster rotting than poisoning the standing trees, but by 30 months this effect had started to disappear.

Below ground, the collar and tap root decayed faster with 2,4,5-T than with sodium arsenite, and also on plots with cover-crop than on those without. Rate of rotting below ground was not influenced by tree poisoning vs. stump poisoning, or by applications of insecticide. The effect of inoculation with *F. lignosus* was apparent in lateral roots by 18 months, and a year later it was increasing the rate of decay of collar and tap roots.

ROOT DISEASE IN THE NEW STAND

Artificial infection of half the old stand resulted in exceptionally heavy root disease incidence amongst the young trees. Five infections with *Ganoderma pseudoferreum* were seen, the rest were *F. lignosus*. There was a peak incidence at 14 months, with a smaller one at 24 months.

Incidence and loss figures for the whole-plot treatments are given in *Table 2,* expressed as the percentage of the total number of planting points attacked and of the total number at which a tree (or more than one) was killed; this gives a more realistic picture of the result than would be given by presenting the numbers of trees (including supplies) attacked or lost, for in many plots these numbers exceeded the total planted stand.

The large and significant reduction in root disease incidence in the presence of a creeping leguminous cover is illustrated in *Figure 2.* The distribution of infected trees of the new stand in relation to inoculated trees or stumps of the old stand can be seen in *Figure 3.*

DISCUSSION AND CONCLUSIONS

The first part of the experiment confirms the provisional conclusions reached by NEWSAM *et al.* (1961) that 2,4,5-T is better than sodium arsenite in bringing about a rapid decay of a poisoned old stand; also, that decay is primarily brought about by fungi, encouraged by the damp conditions created by cover plants. The presence of *F. lignosus* tended to hasten the decay of the roots. The part played by insects that colonise wood in various stages of decay was not clearly revealed because the

TABLE 1. MEAN ROT SCORES OF FIVE PAIRS OF TREATMENTS SHOWING SIGNIFICANCE LEVELS FOR COMPARISONS

Plot/sub-plot treatments	Above-ground parts				Collar and taproot				Lateral roots			
	18 months	24 months	30 months	36 months	18 months	24 months	30 months	36 months	18 months	24 months	30 months	36 months
Tree poisoning	1.81	3.07	4.35	4.84	1.62	2.95	4.11	4.98	3.23	4.33	5.57	5.82
Stump poisoning	2.52 ***	3.63 **	4.57	4.99	1.58	2.90	4.00	4.85	3.14	4.16	5.34	5.69
Treated with insecticides	2.00	3.34	4.39	4.83	1.59	3.06	3.98	4.90	3.40	4.42	5.43	5.67
No insecticidal treatment	2.33 *	3.36	4.53	4.99	1.60	2.79	4.13	4.93	2.98 *	4.07	5.49	5.84
Creeping legume cover	2.10	3.43	4.54	4.93	1.53	3.22	4.49	5.20	3.17	4.50	5.57	5.81
No cover	2.23	3.28	4.38	4.89	1.66	2.63 **	3.63 ***	4.63 **	3.20	3.99 *	5.35	5.71
Sodium arsenite poisoning	1.46	2.64	4.01	4.49	1.49	2.72	4.00	4.64	3.05	3.79	5.50	5.65
2,4,5-T poisoning	2.87 ***	4.06 ***	4.91 ***	5.35 ***	1.71 *	3.14 **	4.12	5.19 **	3.32	4.70 ***	5.42	5.86 **
Stumps inoculated	2.14	3.31	4.47	4.86	1.60	3.07	4.34	4.95	3.46	4.76	5.63	5.85
Stumps not inoculated	2.19	3.39	4.45	4.96	1.60	2.78	3.78 **	4.88	2.91 **	3.73 ***	5.29 **	5.66 *

Significance levels at 5,1 and 0.1 percentages are denoted by *, ** and *** respectively.

TABLE 2. ROOT DISEASE INCIDENCE AND LOSSES EXPRESSED AS A PERCENTAGE OF THE TOTAL PLANTING POINTS AFFECTED

Root disease	Old stand		Covers in replanting		Old trees or stumps treated with	
	trees poisoned	stumps poisoned	legumes	none	insecticide	no insecticide
Incidence	52	48	40	60	48	52
Losses	51	49	37	63	50	50

insecticidal treatments did not sufficiently reduce their numbers, but it may be surmised that they help to distribute saprophytes as well as to directly assist the breakdown of wood to humus. Poisoning the standing trees, or the stumps after felling, made little difference on the rate of decay of the below-ground parts.

The infection of the replant showed a 50% higher incidence of *F. lignosus* in clean weeded plots over plots with a legume cover, and a still higher increase in losses. In addition to their effect in hastening the decay of sources of infection, the legumes encourage a heavy vegetative growth of *F. lignosus* in the litter

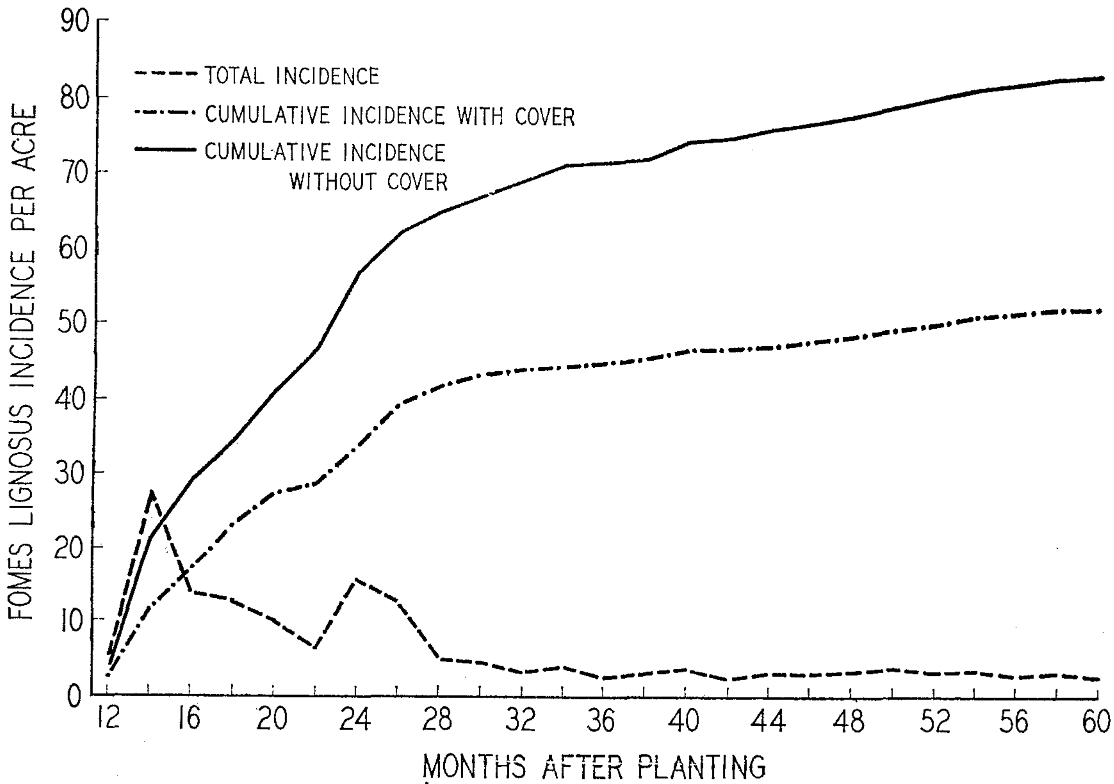

Figure 2. Incidence of Fomes lignosus.

that forms beneath them, and the production of abundant fructifications on infected stumps —depleting the food reserves of the pathogen and so reducing its inoculum potential by the time the roots of the young trees move into the inter-rows. Despite the exceptionally heavy incidence of *F. lignosus* in the second part of the experiment, due to the inoculation of half the old stand, the new stand was brought to an almost disease-free condition after five years, by treating cases that could be saved and supplying losses at frequent intervals. The sources of infection were left to decay *in situ*, except that their numbers became progressively depleted by sampling to record their decay; but the observed rate of decay would otherwise largely have eliminated them as potential sources of infection, even where *F. lignosus* was present, within 36 months.

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