Recent Advances in Yield Stimulation of Rubber

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Despite competition with synthetic rubber, the natural rubber industry is still an expanding industry. Each year it increases its production, and it is consistently selling its entire producton. The sharp fall in rubber prices over the past few years (Figure 1) *however, has made it essential for the industry to develop cheaper methods to remain viable. While the rubber industry has not yet fully evaluated the use of the new stimulant Ethrel, it is a major hope that this product will make natural rubber more economically competitive with synthetic rubber.*

Following this article there is a report of trials on Ethrel carried out by DASF staff at the Bisianumu Rubber Centre on the Sogeri Plateau, Central District.

Remarkable advances in rubber production have been achieved over the years, through selection of high-yielding clones, improved nursery and field selection methods, use of fertilizers and so on. High-yielding clones have been developed which have produced up to 6,000 lb/acre/year. Many established stands, however, consist of much lower-yielding trees and it is on these older stands that the newly developed stimulants are expected to be of greatest value.

THE CONCEPT OF PLUGGING

Little is known of how and why latex is produced in a rubber tree. It is manufactured when the tree is wounded—the tree is then exploited by tapping which is only a sophisticated form of wounding.

Immediately after tapping, latex flow is quite rapid; it then slows down progressively and finally stops. If a tree is re-cut ten minutes later the flow increases sharply and this procedure can be repeated several times with the same result. (*Figure* 2).

This means that very soon after tapping some sort of barrier develops in the latex vessels close to the cut, and this is removed by further tapping. Thin sections of bark have been studied using an electron microscope and photographs have been obtained showing the

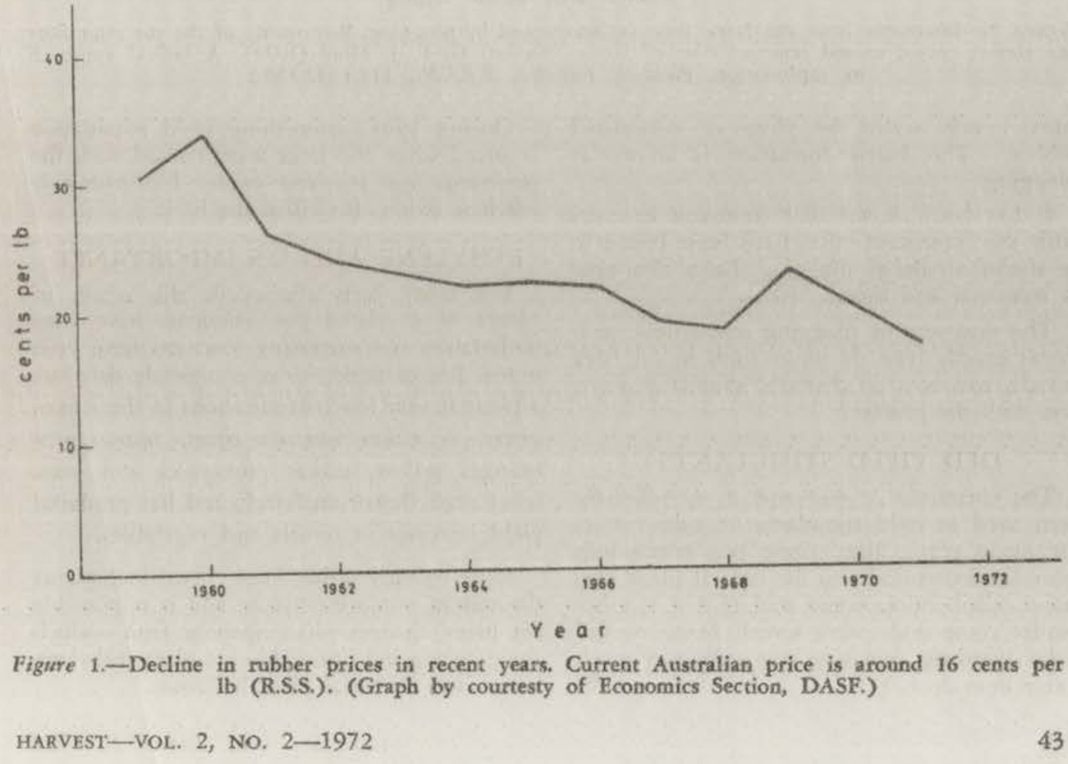

Figure 1.—Decline in rubber prices in recent years. Current Australian price is around 16 cents per lb (R.S.S.). (Graph by courtesty of Economics Section, DASF.)

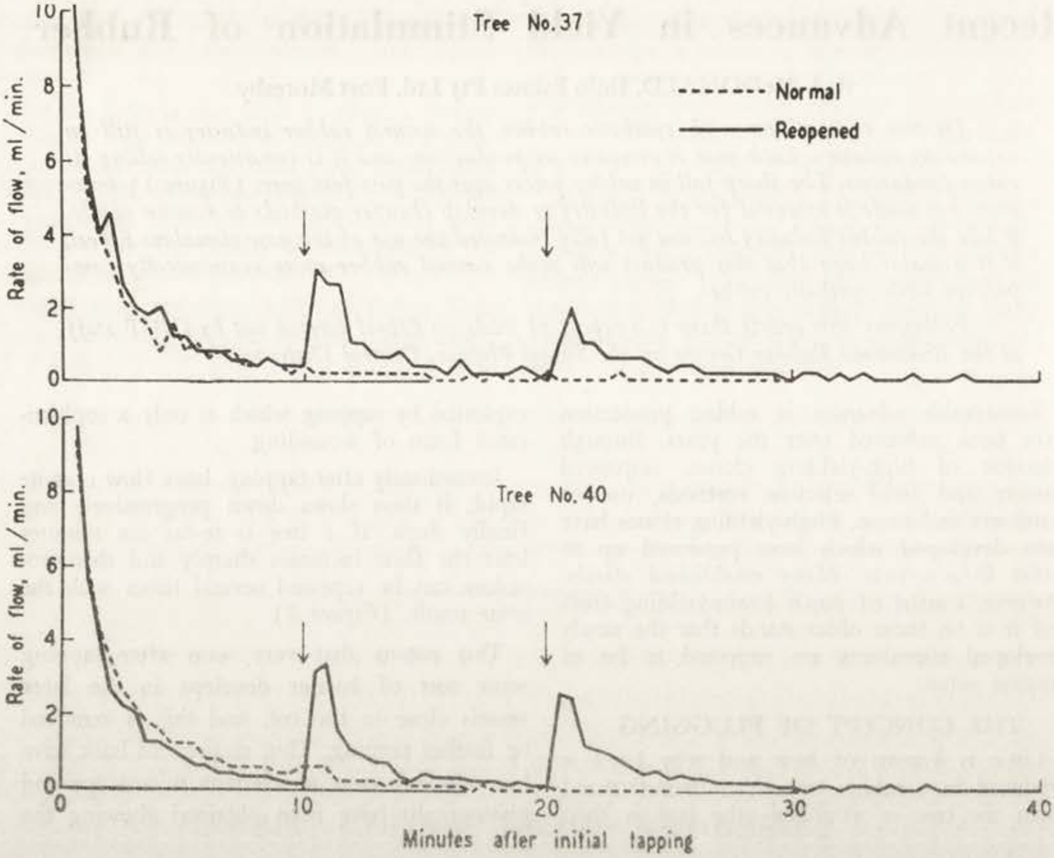

Figure 2.—Illustrates how the latex flow is interrupted by plugging. Re-opening of the cut after flow has almost ceased caused renewed flow of latex. (Source: G. F. J. Moir (1970). A radical approach to exploitation. *Planters' Bulletin, R.R.I.M.*, 111 : 342-350.)

latex vessels sealed by plugs of coagulated rubber. This barrier-formation is known as plugging.

It has been shown that treatment of trees with the compounds that have been found to be stimulants delays plugging. Latex flow-time is increased and thereby yields.

The discovery of plugging raised new questions: exactly how do plugs form in cut latex vessels, and how do chemical stimulants interfere with the process?

OLD YIELD STIMULANTS

The chemicals 2, 4-D and 2, 4, 5-T have been used as yield stimulants on rubber trees for many years. Since these two compounds are related chemically to the natural plant hormone called indole acetic acid (I.A.A.), other similar compounds were tested. Many proved to be stimulants, but none was really very much better than 2, 4, 5-T.

During 1961, astonishing yield stimulation occurred when the trees were treated with the poisonous gas ethylene oxide. Unfortunately ethylene oxide also killed the bark.

ETHYLENE AND ITS IMPORTANCE

For many years studies of the action of plants of a related gas, ethylene, have been undertaken and surprising reactions have been noted. For example, it can completely defoliate a plant at very low concentrations in the atmosphere, it makes bananas ripen, turns green oranges yellow, makes pineapples and some other fruit flower uniformly and has produced yield increases in cereals and vegetables.

More recently it has been found that plants themselves produce ethylene and is responsible for many changes—like ripening fruit—which occur during the life cycle of a plant. Ethylene is, in fact, a natural plant hormone.

Moreover, it has been found that plants are stimulated to *make* ethylene by the hormone I.A.A., by 2, 4-D, by 2, 4, 5-T, by copper sulphate, by some poisons and by physical injury such as cutting. Ethylene produced by the plant actually produces naturally the same kind of changes applied to the plant.

So perhaps yield stimulants of rubber might be working by making the tree produce ethylene. To test this, ethylene was tried out on rubber trees to see whether it would act as a stimulant.

It was announced in 1968 that large increases in latex production were obtained by treating trees with ethylene gas, and a similar result with the chemically similar gas acetylene. This discovery led to tests of a mixture of (2-chloroethyl)-phosphonate and palm oil, a mixture which had already been found to be a convenient means of applying ethylene to plants.

(2-choroethyl)-phosphonic acid is commonly called ethephon and is the active ingredient of 'Ethrel'. It has the property of decomposing gradually in the presence of water, releasing ethylene and it will do this within the tissues of plants. It proved to be a very effective stimulant and it is probably a more direct and specific 'unplugging agent' than 2, 4, 5-T and other stimulants, since these appear to work by making the plant produce ethylene.

ETHREL FIELD TRIALS

Comprehensive large and small scale field trials were commenced by the Rubber Research Institute of Malaya to evaluate response to Ethrel. Commonly planted clones of different ages were treated using a variety of tapping systems. Various concentrations of the active ingredient were tried and applied to the tree in a range of methods. 2, 4, 5-T was included in the trials for comparison.

Yield Increase

Applications of 2, 4, 5-T gave an average increase in yield of 35 per cent when tapped on S/2.d/2 system ($\frac{1}{2}$ spiral on alternate days). The response to Ethrel was nearly twice as good on average.

There are large differences between clones in their response to stimulants. This is related to stimulants (since the latex flow will be to the "plugging index" of the clone. Clones with a high plugging index, that is, clones whose latex flow rapidly ceases after tapping, like Tjir 1, should theoretically respond more allowed to continue longer) than clones with a low plugging index such as RRIM 501, whose flow is relatively slow initially but flows for a longer period.

Figure 3 shows the results for the nine clones tested in this trial. Note the striking response of clone PB 86 to Ethrel.

Results of trees tapped on the shorter cuts were interesting. The plugging reaction varies not only with clones but also with cut length. The shorter the cut the more intense and rapid plugging becomes. This suggests that short cuts would respond better to stimulants than long cuts. In these trials S/3.d/2 (1/3 spiral on alternate days) gave approximately the same yield as S/2.d/2 with Ethrel stimulation in both cases. This means that when Ethrel stimulation is used, shorter cuts may be used, with less damage to the tree as a result. Tests currently being carried out are examining the possibility of using tapping cuts as little as $\frac{3}{8}$ inch long, in conjunction with Ethrel stimulation.

Third daily tapping frequency was not included in the earlier large scale field trials. However, results from current trials show that reponse to stimulation from trees tapped S/2.d/3 ($\frac{1}{2}$ spiral every third day) would equal or exceed that of trees tapped S/2.d/2, the benefit being the same yield with 1/3 less tapping force.

Age

The responses obtained have been greater on first renewed bark (panels C and D) than panel B, which is the second panel of virgin bark. The response from panel A—first panel of virgin bark—has been the lowest. Size and age of the trees are probably the important factors and not that the bark is renewed.

Concentrations

Mixtures of Ethrel in palm oil from 0.25 to 22 per cent active ingredient have been tried and 10 per cent was adopted for most of the commercial trials. The mixture is applied to the scraped bark below the tapping cut at 2-monthly intervals. The width of the treated band is equal to the bark consumption over 2 months. Treatment at 2-monthly intervals was found to be more effective than a single application during 6 months. Responses to frequent applications of more dilute mixtures were not as good as the 10 per cent Ethrel applied every 2 months.

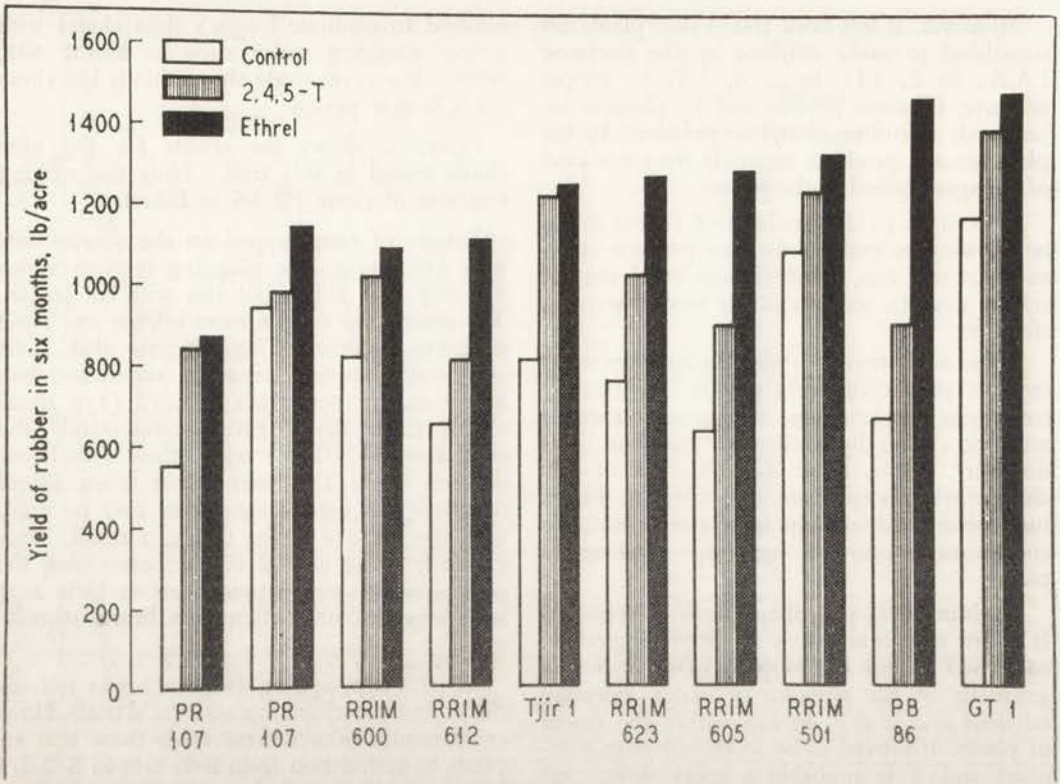

Figure 3.—Results of Ethrel and 2, 4, 5-T trials on a number of clones. (Source: J. W. Blencowe (1970). Recent advances in the yield stimulation of rubber. Paper presented to the Sabah Planters' Association at Tawau, on 20th November, 1970.)

In the range 6.7 to 13 per cent the difference in response is not large; planters may, for reasons of economy, prefer to treat larger numbers of trees with a 6.7 per cent mixture and accept a possibly lower response.

Dosage is inevitably imprecise; applying a greasy mixture to the scraped bark gives a somewhat arbitrary dosage per tree. Although the preparation may be thoroughly mixed and applied to a band of standard width, the girth (and therefore the treated area) of a tree is variable and the thickness of the layer applied cannot be standardized exactly.

Ethrel can be bought as a readymixed compound containing 10 per cent active ingredient. Papua New Guinea planters are currently using it at the rate of two thirds of a pint per acre (150 to 180 trees). The latest results of trials comparing response to different concentrations of active ingredient are shown in the *Table*. It can be seen that the highest response was at 10 per cent active ingredient.

The response to Ethrel is rapid, over 200 per cent increase within a few tappings, declining sharply within a month and then tapering down to prestimulation levels. Applications to areas should be staggered to allow for the initial surge of latex to be processed within each factory's capacity. Transport in some cases would be required to cope with this crop and either late or twice-daily collections arranged for the extended drip.

Late collections are successfully carried out at Ilolo by supplying the tapper with two churns. If afternoon rain is likely the second collection is brought forward. Latex still dripping after the second collection (considerable for 2 weeks after applying Ethrel) can be recovered as ground scrap and processed as Crepe (see *Plate* 1). In Ethrel-treated areas at Ilolo, at least 5lb dry rubber per tapper per day (450 trees) is recovered as ground scrap.

Plate I.—Ground scrap being processed. The rollers have a tearing action and foreign material is washed out of the rubber.

EFFECTS ON DRY RUBBER CONTENT

The large increases in yield obtained by the application of Ethrel are accompanied in some cases by a fall in the dry rubber content (d.r.c.) of the latex. Reduction in d.r.c. also follows successful stimulation with 2, 4, 5-T. For instance, in experiments in Malaysia involving a number of commonly planted clones tapped S/2.d/2, mean percentage d.r.c. was 35.4 in latex from unstimulated trees, 32.4 from 2, 4, 5-T stimulation and 28.8 from Ethrel-treated trees.

There are several practical steps which may be taken to compensate for this. The tapping frequency or the length of the cut may be reduced, the trees may be rested, or the Ethrel applied less often. If any of these measures are taken the d.r.c. can be expected to improve quite rapidly. Results in Malaysia suggest that resting trees from stimulation will restore the d.r.c. to the level obtained before treatment.

Table **1.—Response to different concentrations of Ethephon[1]**

% active ingredient	mg Ethephon per tree	Yield[2]	Response % of Control
Control	0	49.5	
6.7	134	72.3	146
10.0	200	95.8	194
12.0	240	90.4	183
13.3	260	86.1	174

1. Ethephon is the common name for the active ingredient in the commercial product Ethrel. Ethrel normally contains 10 per cent of ethephon but in this case various concentrations of ethephon were used.
2. Yield is measured as average number of grammes of latex per tree for the first year.

DRY TREES (BROWN BAST)

The incidence of brown bast (or of totally dry trees) has so far been very small and has occurred randomly in the various treatments. Totally dry trees have been treated with Ethrel and have sometimes started to yield once more, but this improvement was short-lived and the observation may have been confounded with the re-opening of trees when experimental treatment began.

One example of the onset of dryness following Ethrel treatment was attributed to the concurrent use of the fungicide Antimucin W.B.R. as a treatment for black stripe disease of the tapping panel. Antimucin has been found to react with Ethrel causing a fairly rapid evolution of ethylene. Whether the damage to the trees is due to the over-rapid release of ethylene or to the toxic effects of the reaction products is not known, but careful watch must be kept for interactions of this sort.

LONG-TERM EFFECTS

A rubber plantation is a very long-term investment and naturally the question has been asked, "What are the long-term effects of Ethrel when used as a latex stimulant?" There is no definite answer to this question; long-term effects can only be determined by long-term trials. Large scale field trials have been in progress now in Malaysia for 3 years without any indications whatsoever of deleterious effects. It is recommended however, that Ethrel should only be used on mature trees and areas destined for replanting.

With rising rural wages to contend with, planters in Papua New Guinea will find old low-yielding areas unprofitable. Stimulation is possibly the only answer to keep these blocks economically viable.

Acknowledgement

The experiments discussed in this article were carried out at the Rubber Research Institute of Malaya. Further details can be found in the Planters' Bulletin of the Rubber Research Institute of Malaya, November, 1970.