STIMULATION OF YIELD IN HEVEA BRASILIENSIS
II. EFFECT OF SYNTHETIC GROWTH SUBSTANCES ON YIELD AND ON BARK RENEWAL

By

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Application to lightly scraped bark below the tapping cut of a number of synthetic growth substances in an oil vehicle has resulted in increases in yield and in the thickness of renewed bark above the cut.

Repeated applications of the treatments at six-monthly intervals over a period of three years have not resulted in an increased incidence of 'dry' trees but the yield response is found to decrease with each successive treatment.

Monthly treatment with yield stimulants of renewing bark just above the tapping cut has also resulted in greatly increased yields and in an increase in bark thickness; the latter is confined to the non latex bearing tissues of the outer bark.

The work of the Botanical Division of the Rubber Research Institute of Malaya during the immediate postwar period was concerned largely with the rehabilitation of the field experiments on the Rubber Research Institute Experiment Station and on estates and it was not until early in 1951 that, with the increases in staff, the work on yield stimulation was resumed.

The results obtained in prewar experiments with the use of vegetable oils applied to scraped bark below the cut (BAPTIST 1955) had been ascribed to the presence of natural hormones contained in these oils. It was therefore planned to test the effect on yield of a number of synthetic growth substances, which were available commercially, applied to the bark in an inert carrier.

EXPERIMENTAL

The growth substances used in the first experiment of the new series were:

a 3 - indolyl butyric acid
b 1 - naphthalene acetic acid
c p - chlorophenoxy acetic acid
d 1 - naphthoxy acetic acid
e 2 - naphthoxy acetic acid
f α (2 - naphthoxy) propionic acid

The concentration used was 0.1 per cent in liquid paraffin and, as the chemicals do not dissolve in the oil they were applied as a water in oil emulsion. The emulsions were applied to a three-inch wide strip of bark immediately below a normal half spiral tapping cut on 22 years old seedling trees on both lightly scraped and unscraped bark. A further treatment consisted of light scraping only with no application of growth substances.

The large number of treatments and the limited material available for this experiment necessitated a single 'tree plot' design in which each tree constitutes a treatment plot and the individual tree yields are recorded. The trees were subjected to a period of yield recording before the treatments were applied and the pre-treatment yields were used as a basis for covariance analysis and adjustment of the post-treatment yields.

The results over a period of six months showed that the growth substances *a*, *b*, *c* and *d* at concentrations of 0.1 per cent have a small positive effect on yield, especially *d* (1-naphthoxy acetic acid) which caused an increase of 20 per cent and that treatment *e* (2-naphthoxy acetic acid) has no effect at all. When the mixtures were used at a 1.0 per cent concentration treatment *b* (1-naphthalene acetic acid), treatment *c* (p-chlorophenoxy acetic acid) and treatment *d* (1-naphthoxy acetic acid) gave increases of 27%, 53% and 25% respectively in the first month following the application of the treatment.

In February 1951 Dr G.W. Chapman, Director of the Chemara Central Research Station, Malaya, read at a conference held at the Rubber Research Institute of Malaya an important paper (CHAPMAN 1951) in which he showed the outstanding yield stimulating effect on rubber trees of 2,4-dichlorophenoxy acetic acid (2,4-D) applied in palm oil to scraped bark below the tapping cut. The proprietary yield stimulant 'Stimulex' was developed as a result of this work.

Further experiments carried out at the Rubber Research Institute of Malaya made use of 2,4-dichlorophenoxy acid, at first as the sodium salt of 80 per cent acid equivalent which, as it is insoluble in oil, was used in the form of a water in palm oil emulsion, and later as the normal butyl ester of 80 per cent acid equivalent which is oil soluble. The effects of three concentrations of 2,4-D namely 0.1, 1 and 2 per cent, and of two proprietary yield stimulants have been compared and the results are summarised in TABLE I and graphically presented in *Figure 1*.

The following treatments were applied to a three inch strip of lightly scraped virgin bark immediately below the tapping cut of 22 years old unselected seedling trees which had been tapped for only one and a half years, on the half spiral alternate daily system:

A - 0.1% 2,4-D (Na-salt) in water/liquid paraffin emulsion, increased to 2% from second application onwards.

B - 0.1% 2,4-D (Na-salt) in water/palm oil emulsion, increased to 2% at second application, changed to

2% n-butyl ester of 2,4-D in palm oil from third application onwards.

C - 1% 2,4-D (Na-salt) in water/palm oil emulsion changed to 1% n-butyl ester of 2,4-D in palm oil from third application onwards.

D - 'Stimulex'.

E - 'Eureka'.

F - Scraping a three inch band below the tapping cut only.

O - Control—no treatment.

The principal results of this experiment are discussed below.

The sodium salt of 2,4-D at a concentration of 0.1 per cent either in palm oil or in liquid paraffin has a small, but not statistically significant, effect on yield. A one per cent concentration of the salt gave a significant yield increase and a further increase of concentration to two per cent resulted in higher peak yields but not in a significantly higher mean yield over a period of six months after application. In both treatments *A* and *B* the yield level in the third and fourth six-monthly periods following treatment with two per cent 2,4-D fell to below that of the control after the initial increase in the first two months. The highest response to the yield stimulant was obtained in the first month after treatment after which the yield decreased in the second and third months to about the level of that of the control trees, followed by a slight increase.

The response to the proprietary stimulants 'Stimulex' and 'Eureka' is not significantly better than that to 2,4-D used either as a two per cent or as a one per cent concentration in palm oil.

The bark scraping treatment alone (in this case virgin bark lightly scraped for three inches below the cut) has had a small but not statistically significant effect on yield.

Some bark damage was caused by the downward flow and accumulation of the mixtures containing 2,4-D on to the virgin bark below the treated strip. The bark affection took the form of swelling, followed by splitting and, in extreme cases as observed on estates, by actual drying up of the bark. This type of bark damage is now largely avoided by thickening the consistency of the palm oil by addition of an inert petrolatum grease such as the Standard Vacuum Product 2295C.

A day to day picture of the peak yield period after the second application of the treatments depicted in *Figure 1* shows the rapidity of the response of *Hevea* trees to yield stimulants applied to a three inch strip of lightly scraped bark below the tapping cut, the maximum increase occurring on the fifth day following the application of the bark treatments (*Figure 2*).

This yield trend has been confirmed in all subsequent experiments.

An experiment to test the effect of successive applications of yield stimulant applied at six-monthly intervals was set up in

TABLE I: YIELDS ADJUSTED ON PRETREATMENT YIELDS AND EXPRESSED AS A PERCENTAGE OF THE CONTROL

Treatments	*A*	*B*	*C*	*D*	*E*	*F*
Mean pretreatment yield in gm/tree/tapping	40.8	43.5	41.3	41.6	39.3	39.5
1st application						
1st month after	114	121	132	140	142	112
2nd month after	105	107	113	114	122	106
3rd month after	109	109	117	117	128	109
Mean 3 months	110	112	120	123	130	109
2nd application						
1st month after	141	176	153	200	167	119
2nd month after	153	161	146	145	158	120
3rd month after	122	115	116	119	123	109
4th month after	112	110	108	119	125	106
5th month after	114	112	119	117	116	110
6th month after	110	112	114	111	109	110
Mean 6 months	128	131	126	132	135	112

Changeover of tapping panels

Mean pretreatment yield in gm/tree/tapping	34.3	32.7	29.5	29.6	32.9	31.8
3rd application						
1st month after	148	171	157	153	147	122
2nd month after	121	121	125	133	120	115
3rd month after	102	98	109	107	109	108
4th month after	94	94	104	108	113	108
5th month after	97	113	124	119	119	101
6th month after	92	110	120	117	107	93
Mean 6 months	108	117	122	122	119	108
4th application						
1st month after	123	161	145	170	150	109
2nd month after	96	119	120	125	112	101
3rd month after	83	94	105	99	94	95
4th month after	84	88	104	108	87	96
5th month after	80	96	115	116	94	99
Mean 5 months	92	111	117	123	106	100

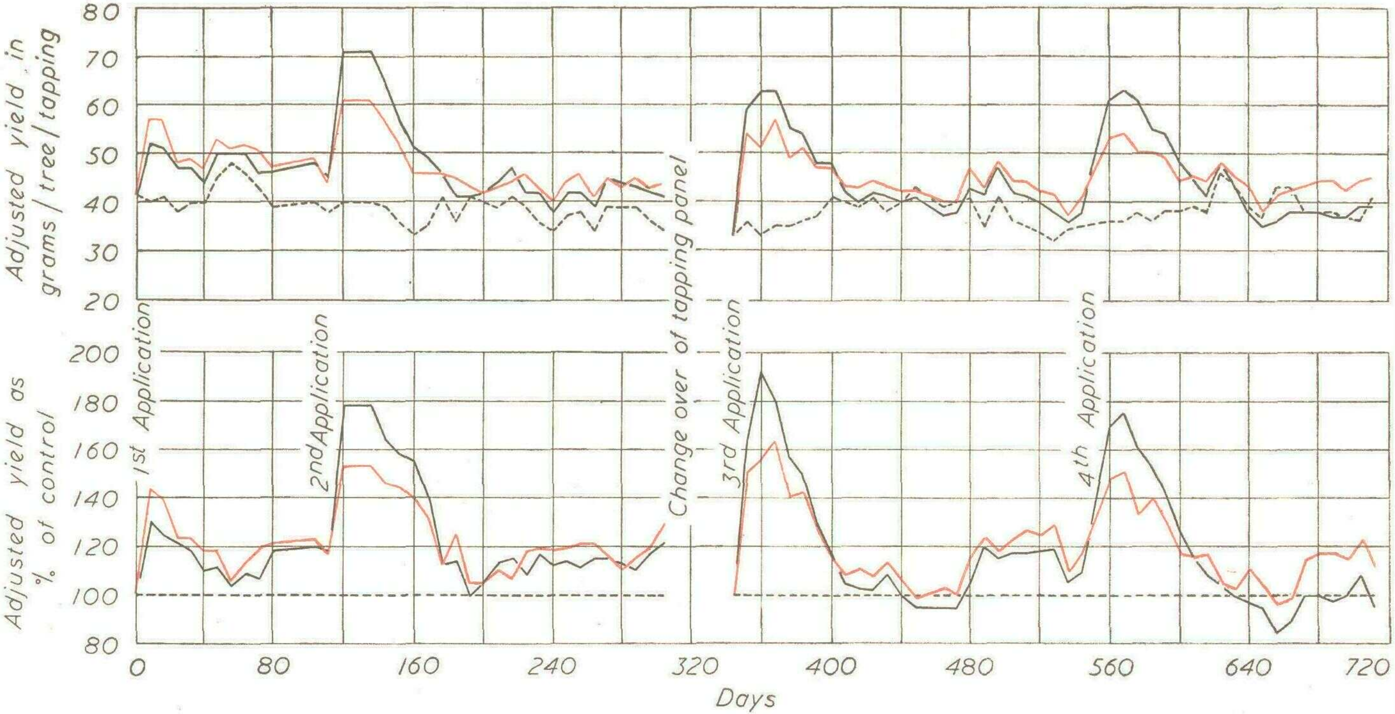


Figure 1. Comparison of the effects on yield of 2,4-D in different concentrations.

0.1% 2, 4-D in palm oil changed to 2% concentration from 2 application onwards

1% 2, 4-D in palm oil . . . . *Control*

N.B. The Na salt of 2,4-D of 80% acid equivalent was used at 1st and 2nd application. The n-butyl ester of 2,4-D of 80% acid equivalent was used at 3rd and 4th application.

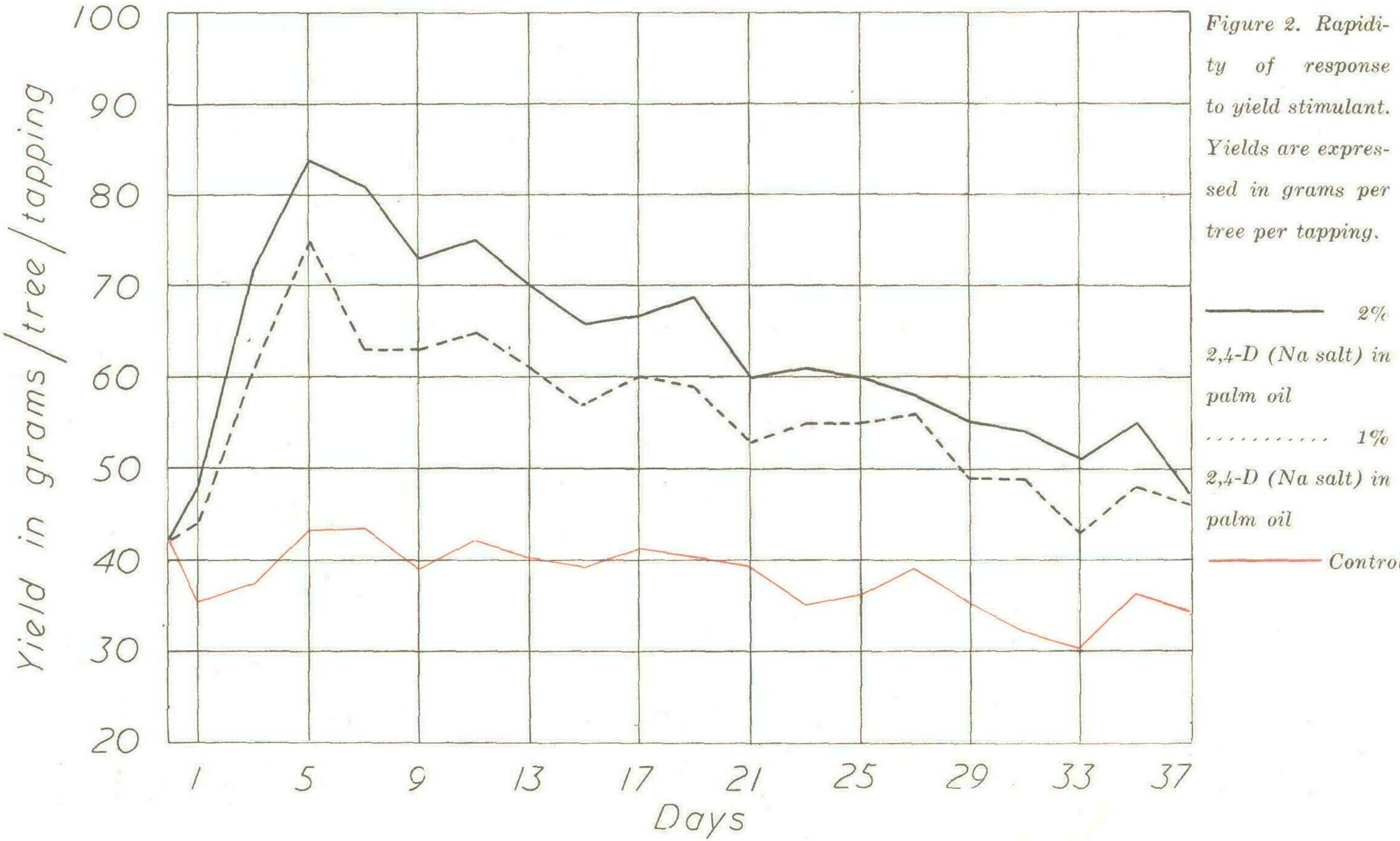


Figure 2. Rapidity of response to yield stimulant. Yields are expressed in grams per tree per tapping.

January 1952 in a field of 20 years old clonal seedling trees (Field 14E Rubber Research Institute Experiment Station) tapped on the half spiral alternate daily system. The area was arranged in 30 blocks each containing 12 trees and the following twelve treatments were allocated randomly within each block. Observed treatment yields have been adjusted by covariance analysis on pre-treatment yields.

- *A* - 'Stimulex'
- *B* - 'Eureka'
- *C* - Palm oil only
- *D* - 1% 2.4-D in palm oil
- *E* - 1% 2.4-D in palm oil plus 1% sulphur (changed to mixture of 2,4-D and2,4,5-T as from third application
- *F* - 1% 2,4,5-T in palm oil
- *G* - Copper sulphate injection
- *H* - Light scraping only (changed to 2,4-D as from second application)
- *O* - Control—no treatment

All treatments were applied to a three inch strip of lightly scraped bark below the tapping cut. The sodium salts of 2,4-D and 2,4,5-T of 80 per cent acid equivalent were used for the first and second applications in the form of water in oil emulsions after which they were replaced by the oil soluble normal butyl esters of the same acid equivalent. The palm oil used as a carrier for the synthetic growth substances was for the third and subsequent applications mixed with an equal quantity of a petrolatum (Standard Vacuum Product 2295C).

The following changes were made to treatments *E* and *H* during the course of the experiment.

	Treatment E	Treatment H
1st application	1% 2,4-D and 1% sulphur	Scraping only
2nd application	1% 2,4-D and 2% sulphur	1% 2,4-D (n-butyl ester)
3rd application	1% 2,4-D and 1% 2,4,5-T	2% 2,4-D (n-butyl ester)

2,4,5-trichlorophenoxy acetic acid (2,4,5-T) in the form of its sodium salt and normal butyl ester of 80 per cent acid equivalent (treatment *F*) was selected because of its relationship to p-chlorophenoxy acetic acid and 2,4-dichlorophenoxy acetic acid which gave good results in previous experiments. The addition of sulphur to the 2,4-D preparation in palm oil (treatment *E*) was to test the claim made by Chapman (1951) that 'elementary sulphur was highly beneficial under certain conditions, when clearly (as judged by the smell) some sulphur compound was formed'. In treatment *G* copper sulphate, shown by COMPAGNON and TIXIER (1950) to be highly effective as a yield stimulant, was injected into trees in two small auger holes two and a half to three inches deep and half inch in diameter bored

TABLE II: COMPARISON OF THE EFFECT OF EIGHT YIELD STIMULATION TREATMENTS

Treatment	*Adjusted mean treatment yields over six months period following each application in grams per tree per tapping and as a percentage of the control*				
	1st period on 1st panel	*After change over to opposite tapping panel*			
		2nd period	*3rd period*	*4th period*	*5th period*
A	62.2 (137%)	45.9 (146%)	39.6 (135%)	41.5 (117%)	43.3 (122%)
B	57.7 (121)	43.1 (136)	39.5 (134)	40.3 (114)	42.2 (119)
C	54.4 (114)	39.0 (124)	34.7 (118)	33.4 (94)	36.7 (104)
D	58.6 (123)	35.9 (114)	31.5 (107)	28.3 (80)	31.0 (88)
E	59.3 (124)	44.2 (140)	45.3 (154)	39.9 (113)	42.0 (119)
F	51.5 (108)	48.5 (154)	45.2 (154)	41.6 (118)	42.5 (120)
G	55.4 (116)	45.7 (145)	38.2 (130)	42.6 (120)	40.1 (113)
H	51.2 (107)	48.1 (152)	45.7 (156)	45.4 (128)	41.6 (118)
O	47.7 (100)	31.6 (100)	29.4 (100)	35.4 (100)	35.4 (100)
Standard error of a mean	± 2.54	± 3.98	± 4.30	± 4.55	± 4.49
Min. 5% sig. difference	7.0	11.1	12.0	12.6	12.4
Min. 1% sig. difference	9.3	14.5	15.7	16.6	16.4

at a downward slope one at each end of the half spiral tapping cut, five grams of the finely powdered salt was introduced into each hole.

The results of this experiment over five periods of six months each are summarised in TABLE II and the yield trends in five selected treatments are shown in *Figure 4*.

It should be noted that for the first and second applications the sodium salts of 2,4-D and 2,4,5-T were applied in the form of a water in palm oil emulsion containing 20 parts of water and 80 parts of oil. The practical difficulty of preparing emulsions of exactly similar physical properties may account for the irregularity obtained in a few cases.

The results over each successive period of six months following the applications of the treatments are discussed in the following pages.

FIRST PERIOD

The first application of the various treatments was made to a three inch strip of lightly scraped bark below a half spiral cut which was then about eight inches from the ground.

The results show a marked increase in yield ($P<0.01$) due to the proprietary stimulants Stimulex (*A*) and Eureka (*B*) and to 1 per cent 2,4-D used as the sodium salt in a water in palm oil emulsion, both with and without the addition of sulphur (*D* and *E*).

The sodium salt of 2,4,5-T as a water in oil emulsion (*F*) did not cause a significant yield increase which, judged by later outstanding response to this material, may have been due to inadequate dispersion of the active chemical in the oil phase of the emulsion.

Light scraping of a three inch wide strip of bark (*H*) had a small effect but addition of palm oil to the scraped bark (*C*) caused a yield increase which is nearly significant at the 5 per cent level ($P<0.05$).

The effect on yield of copper sulphate injection (*G*) was significant at the 5 per cent level.

SECOND PERIOD

The second and subsequent applications of the treatments were made on a new tapping panel opened on the opposite side of the trees at 45 inches from the ground.

The proprietary yield stimulants Stimulex (*A*) and Eureka (*B*) and 1 per cent 2,4-D (sodium salt) with 2 per cent sulphur in a water in palm oil emulsion (*E*) caused yield increases which are significant at the 5 per cent level.

The sodium salt of 2,4-D in palm oil alone (*D*) gave disappointing results which could indicate a beneficial effect of the sulphur which had been thoroughly dispersed into the emulsion of treatment (*E*). The sodium salt of 2,4,5-T (*F*) gave a large yield increase which reached the 1 per cent level of significance.

Palm oil applied to the lightly scraped bark caused a yield increase of 24 per cent which failed to reach the 5 per cent level of significance.

The normal butyl ester of 2,4-D dissolved in palm oil (*H*), used for the first time in our experiments gave a 52 per cent increase in yield which was significant at the 1 per cent level.

Copper sulphate injection gave a yield increase of 45 per cent and was again effective at the 5 per cent level of significance.

THIRD PERIOD

In the third application of treatments the sodium salts of 2,4-D and 2,4,5-T were replaced by the normal butyl esters which had meantime become available commercially. It was now possible to dissolve these salts directly into the palm oil and to improve the consistency of the preparation by addition of the inert petrolatum Standard Vacuum Product 2295C. The mixture used in this experiment consisted of equal parts of palm oil and 2295C but it was found later that one of 5 parts of palm oil and 3 parts of 2295C containing 1 per cent acid equivalent butyl ester of 2,4,5-T could be applied more thinly and evenly to the scraped bark and could be stored for long periods (over two years) free from mould and bacterial growth and with no adverse effect on its yield stimulation properties. The 1 per cent normal butyl ester of 2,4,5-T in palm oil and petrolatum (*F*) used for the first time as a yield stimulant, gave a very high peak yield and an increase in yield of 54 per cent over the period of six months following treatment, significant to the 1 per cent level.

Treatment *E*, now altered to a mixture of 1 per cent normal butyl esters of 2,4-D and 2,4,5-T in palm oil and 2295C, and treatment *H*, now increased to 2 per cent normal butyl ester of 2,4-D in palm oil and 2295C gave increases over the period of six months of 54 per cent and 56 per cent respectively which reached the 1 per cent level of significance. It is noted that these high concentrations are not more effective than the 1 per cent n-butyl ester of 2,4,5-T.

'Stimulex' (*A*), 'Eureka' (*B*), 1 per cent 2,4-D mixture (*D*) and copper sulphate injection (*G*) gave high initial increases but the response over the full period of six months failed to reach the 5 per cent level of significance. The fact that these yield increases are not statistically significant is due mainly to the limited number of trees included in each treatment and does not necessarily imply that the treatments have become ineffective, since during the period under review treatments *A*, *B* and *G* increased the yield by at least 30 per cent over the period of six months. In none of the trees in these three treatments did the yield drop below the pre-treatment level.

A study of the graphical representation of the results in *Figure 4* leaves no doubt of the positive effect of 2,4,5-T and Stimulex after the third application of treatments but the effect of the 1 per cent 2,4-D mixture becomes doubtful since in the last three months of that period the yield level dropped well below that of the pre-treatment yields resulting in an overall yield increase of only 7 per cent over the control (TABLE II).

Palm oil applied to scraped bark (*C*) gave an increase of 18 per cent over the full period of six months.

FOURTH PERIOD

None of the treatments induced a yield increase which was statistically significant and, although there is little doubt of a positive effect of treatments *A*, *B*, *E*, *F*, *G* and *H*, the magnitude of the responses has in general gradually decreased with each successive application. Treatment *D* (1% 2,4-D in palm oil) gave a 54 per cent increase in the first month following treatment but its yield level after the second month dropped well below that of the control and even below that of treatment *C* (light scraping and palm oil), showing an overall decrease of 20 per cent over the six month period.

FIFTH PERIOD

The response to all treatments during this six months period was very much the same as that during the preceding period with the exception of treatment *G* (copper sulphate injection) which gave a smaller increase (45 per cent) in the first month and no increase over the mean yield of the control for the full period of six months following treatment.

SIXTH PERIOD

The results for the first two months of the six monthly period now available show yield increases of the order of 50 per cent during the first month for treatments *A*, *B*, *E*, *F* and *H*. Treatments *C*, *D* and *G* show during the same period yield increases of the order of only 10 per cent.

DISCUSSION

The results for the second and third periods which show the superiority of treatment *F* (1% n-butyl ester of 2,4,5-T) over the other treatments have already been published by R.R.I. MALAYA (1953).

The high value of the standard error caused by the relatively low number of trees allotted to each treatment (30 trees) does not allow for proof of significance, even at the 5 per cent level, from the fourth period onwards when the response to treatments had shown a decline, although there is little doubt of the real effect of a number of treatments. The mean monthly yield data covering a period of two and a half years of this experiment, adjusted by regression on pretreatment yields, (*Figure 4*) show in general a decreasing level of response to treatment with successive half yearly applications.

The superiority of treatment *A* (Stimulex) and treatment *F* (1% n-butyl ester 2,4,5-T) over treatment *D* (1% n-butyl ester 2,4-D) and treatment *G* (copper sulphate injection) is well brought out in this long term experiment, the latter treatments showing after the initial yield increase an appreciable decrease below the yield level of the control. This fall in yield which is shown for the first time during the second treatment period in treatment *D* and during the fourth period in treatment *G* should be taken as a warning for caution in the use of yield stimulants at six monthly intervals in normal commercial tapping. The disappointing performance of 1 per cent 2,4-D (treatment *D*)

Figure 3. Damage to bark caused by injection of copper sulphate.

has not been repeated in other experiments, although a fall in yield level below that of the control occurred after treatment with 2 per cent 2,4-D in a previous experiment (TABLE I).

It is interesting to note that the three synthetic growth substances which in these experiments have induced the greatest yield response, namely p-chlorophenoxy acetic acid, 2,4-dichlorophenoxy acetic acid and 2,4,5-trichlorophenoxy acetic acid, have in common a chlorine substituted phenoxy group and a carboxyl group, the indications being that the efficacy as a yield stimulant increases with the number of chlorine ions substituted in the phenoxy group.

The use of copper sulphate as a yield stimulant whether by injection (Compagnon and Tixier 1950) or by application in paste form to bark below the tapping cut (WIERSUM 1954) cannot be recommended (BOTANICAL DIVISION 1953) because of the danger of accidental contamination of the latex resulting in an increased copper content of the crop beyond the limits specified for R.M.A. grade of rubber (8 parts per million) by the Rubber Manufacturers Association of New York and for latex concentrates (10 parts per million) by the American Society for Testing Materials. Furthermore, serious bark damage to tapping panels of a fairly high proportion of trees has in our experiments been caused by injection of copper sulphate in auger holes bored into the main stem. An example of severe damage is shown in *Figure 3*.

When comparing the performance of Stimulex with that of n-butyl ester of 2,4,5-T it should be borne in mind that the one per cent concentration of 2,4,5-T used in our long term experiment corresponds to one of 0.8 per cent acid equivalent and is therefore weaker than that recommended by the Institute for purposes of yield stimulation. The prescription for a yield stimulant which has been developed as a result of this work and which is manufactured locally by commercial fertiliser firms is the following:

> One and a half fluid ounces of n-butyl ester 2,4,5-T (10 lb per gallon acid equivalent) in a mixture of 5 pints of commercial red palm oil and 3 pints of petrolatum (Standard Vacuum Product 2295C or Shell Otina C).

Full details of the method of preparation of this yield stimulant for use on estates have been issued in leaflet form and patent protection for the use of 2,4,5-T as a yield stimulant has been applied for on behalf of the Industry.

In view of a possible cumulative harmful effect of yield stimulants on the tree we would advise caution in their use on young trees. Provisionally we consider that old trees may be treated once a year, or once in six months if they are due to be cut out within a period of four to five years.

An interesting observation made in the course of this work is that trees treated at six-monthly intervals with a yield stimulating mixture on lightly scraped bark below the tapping cut show a significantly better renewal of bark above the cut. This effect on bark renewal is examined in detail by DE JONGE (1955).

APPLICATION OF YIELD STIMULANTS ABOVE THE TAPPING CUT

Experiments carried out by this Institute before the war had shown that palm oil applied to renewing bark above the tapping cut increased the rate of bark renewal (BEELEY and BAPTIST 1939) but no detectable effect on the yield of latex was demonstrated in those early experiments (BAPTIST 1955). Further experimentation to amplify those findings has been in progress since 1952 on buddings of clone AVROS 50 established in November 1930. The treatments have been applied at monthly intervals to the freshly excised bark of the previous month. Yield recording is done once a week and measurements of bark thickness are made annually. The results are presented separately for each of the first two years of the experiment, the bark thickness measurements in TABLE III and the yield data in TABLE IV.

During the first year the increase in bark thickness with treatments, *3*, *6* and *7* is significantly greater ($P<0.001$) than that of the control but, as shown by anatomical examination of bark sections, it is confined to the outer non latex bearing portion of the bark and has not measurably affected the number of rows of latex vessels. The effects of treatments *2* and *5* are significant at the 5 per cent level but that of treatment *1* (palm oil), although better than that of the control trees, is not established with confidence. In the following year no treatment effects are significant, although again the best responses are shown by treatments *3*, *6* and *7*.

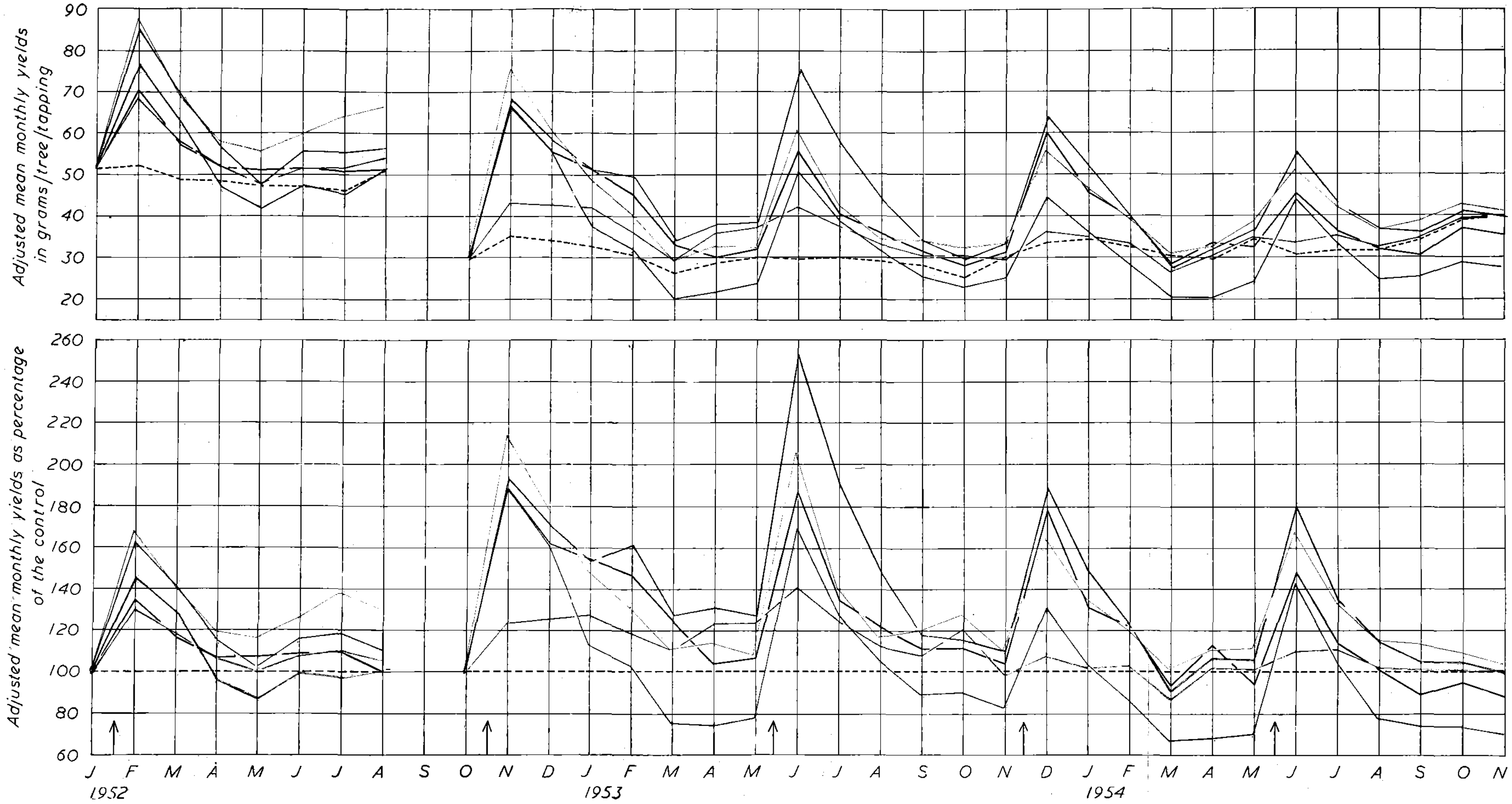


Figure 4. Comparison of five treatments in a long term yield stimulation experiment. Adjusted mean monthly yields are expressed in grams per tree per tapping and as a percentage of the control.

TABLE III: INCREASE IN BARK THICKNESS

Treatment	*Increase in bark thickness in millimetres*	
	First year	*Second year*
1. Palm oil	1.6	0.2
2. Palm oil + 0.1% 2,4-D	1.7	0.3
3. Palm oil + 1.0% 2,4-D	2.9	0.4
4. VP 2295C	1.4	0.2
5. VP 2295C + 0.1% 2,4-D	1.7	0.4
6. VP 2295C + 1.0% 2,4-D	3.7	0.4
7. Stimulex	3.3	0.4
8. Control	1.2	0.2
Standard error of means	± 0.16	± 0.14
Min. 5% sig. difference	0.5	0.4
Min. 1% sig. difference	0.6	0.5
Min. 0.1% sig. difference	0.8	—

The yields of the experimental plots before the application of the treatments were not identical and observed post-treatment yields have therefore been adjusted to correct for these pre-treatment differences. These adjusted yields are presented in TABLE IV.

Treatments *3*, *6* and *7* which gave marked increases of bark thickness in the first year have also resulted in large increases in yield which are significant at the 0.1 per cent level. The yield increases caused by treatments *2* and *5*, containing 0.1 per cent of 2,4-D, are highly significant in the first year while that due to palm oil (treatment *1*) just reaches the 5 per cent level of significance. These observations are believed to be the first to be recorded in which increased yields have been obtained by application of growth promoting substances above the tapping cut. They do not support Chapman's (1951) contention that such a procedure depresses yield.

The responses to treatments are smaller in the second year. The yield increases shown by treatments *3*, *6* and *7* remain significant at the 0.1 per cent level but those due to palm oil (treatment *1*) and palm oil with 0.1 per cent 2,4-D (treatment *2*) are not proven.

TABLE IV: TREATMENT YIELDS

Treatments	First year: Adjusted post-treatment mean yields (gm/tree/tapping)	First year: Adjusted post-treatment yields as % of control	Second year: Adjusted post-treatment mean yields (gm/tree/tapping)	Second year: Adjusted post-treatment yields as % of control
1. *Palm oil*	16.9	113	18.5	107
2. *Palm oil + 0.1% 2,4-D*	18.2	122	16.4	95
3. *Pailm oil + 1.0% 2,4-D*	25.6	172	25.7	148
4. *VP 2295C*	16.3	109	16.1	93
5. *VP 2295C + 0.1% 2,4-D*	17.3	116	19.2	111
6. *VP 2295C + 1.0% 2,4-D*	21.7	145	21.5	124
7. *Stimulex*	24.4	163	22.8	132
8. *Control*	14.9	100	17.3	100
Standard error of adjusted post-treatment mean yields	± 0.64		± 0.64	
Min. 5% sig. difference	1.8		1.8	
Min. 1% sig. difference	2.4		2.4	
Min. 0.1% sig. difference	3.2		3.2	

The yield trend of three selected treatments applied each month above the tapping cut to bark excised during the previous month is shown in *Figure 5*. The best results over the two years have been obtained with 1 per cent 2,4-D in palm oil and with Stimulex in the order given while 0.1 per cent 2,4-D fails to maintain its lead over the control in the second year. A feature of the graph is that the yield curves do not exhibit the marked initial peak responses shown in *Figure 4* where application of the yield stimulants were made at intervals of six months to bark below the tapping cut. The relative yield curves (*Figure 5b*) show two peaks which coincide with the drop in yield of the control trees (*Figure 5a*) during the dry month of February in each of the two years.

The method of application of a yield stimulant above the tapping cut is undergoing comparison with several other methods in an experiment on a mixed stand of mature budded trees of clones AVROS 50 and Pilmoor D 65, budded in October 1931, and tapped on weak renewed bark. The yield stimulant used is the normal butyl ester of 2,4,5-T at a concentration of 1 per cent acid equivalent in a mixture of palm oil and petrolatum.

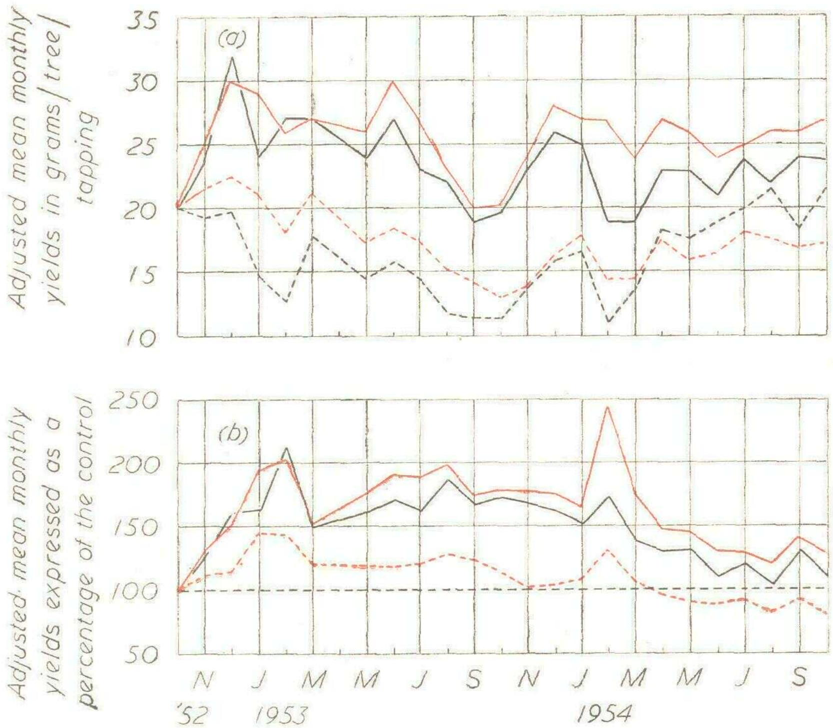
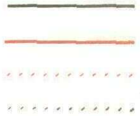


Figure 5. Yield trend after application of stimulant above the tapping cut. Adjusted mean monthly yields are expressed in grams per tree per tapping and as a percentage of the control.



The following treatments have been included:

A Yield stimulant applied at intervals of six months to a three inch strip of lightly scraped bark below the tapping cut.

B Yield stimulant applied at intervals of six months to a three inch strip of unscraped bark below the tapping cut.

C Yield stimulant applied at intervals of six months to a three inch strip of lightly scraped bark on a half circumference of the stem at a height of 5 feet above the tapping panel.

D Yield stimulant applied above the tapping cut at intervals of one month to the width of bark excised during the previous month.

O Control—no treatment.

The available yield data for the first three months of this experiment are summarised in TABLE V.

Examination of the table shows the clear effect on yield of light scraping of the bark (by comparison of treatments *A* and *B*), the small effect of treatment *C* and the most promising effect of treatment *D* which confirms that established in the previous experiment (TABLE IV).

The design of this experiment allows for a comparison of the response to yield stimulants by high yielding and low yielding plots. The yield trends of the highest yielding and of the lowest yielding plots of treatments *A* and *D* are shown in *Figure 6*.

The graphs clearly demonstrate that the higher yielding trees respond much better than the lower yielding trees to yield stimulant applied to a three inch strip of lightly scraped bark below the cut (treatment *A*) and that for lower yielding trees the method of monthly application of yield stimulant to freshly tapped bark of the previous month (treatment *D*) is greatly superior to the more conventional treatment *A*.

The mean yield data show that initially, over the first seven weeks of the experiment, treatment *A* is more effective than treatment *D* but thereafter its effect declines. Over the completed period of three months the mean effect of treatment *D* is slightly superior to that of treatment *A*, as shown by the mean yield increases of 68 per cent and of 56 per cent respectively. For the lower yielding trees the best response by far has been obtained with treatment *D* which caused a total yield increase of 149 per cent compared with an increase of approximately 34 per cent for treatment *A*.

The difference in the shape of the yield curves is presumably due to the frequency of treatment. The yield curve in treatment *A*, in which the yield stimulant is applied below the cut at intervals of six months, shows an initial peak rise followed by a fall while that in treatment *D*, in which applications of the yield stimulant are made above the cut at monthly intervals, shows a more gradual rise to a level which for the present is being sustained.

However we do not recommend for commercial practice the new method of applying the yield stimulant to recently tapped bark above the tapping cut, we need to know whether future results will reveal no adverse effects on yields, incidence of brown bast and on the anatomical structure of the renewed bark.

SUMMARY

The experiments described follow pre-war work on yield stimulation undertaken at the Rubber Research Institute of Malaya.

It is shown that a number of synthetic growth substances applied in an oil vehicle to a narrow strip of bark below the tapping cut, after light scraping, can induce large increases in yield. A secondary effect appears to be some stimulation of the rate of bark renewal.

TABLE V: YIELDS AS GRAMS OF DRY RUBBER PER PLOT (16 TREES) AND AS A PERCENTAGE OF THE CONTROL

Treatments	*A*	*B*	*C*	*D*	*O*
Mean pre-treatment yields	149 (103%)	138 (95%)	147 (101%)	139 (96%)	145 (100%)
Mean yields after treatment					
first month	269 (164%)	222 (135%)	180 (110%)	231 (141%)	164 (100%)
second month	241 (140%)	214 (124%)	187 (109%)	275 (160%)	172 (100%)
third month	194 (111%)	183 (105%)	164 (94%)	273 (157%)	174 (100%)

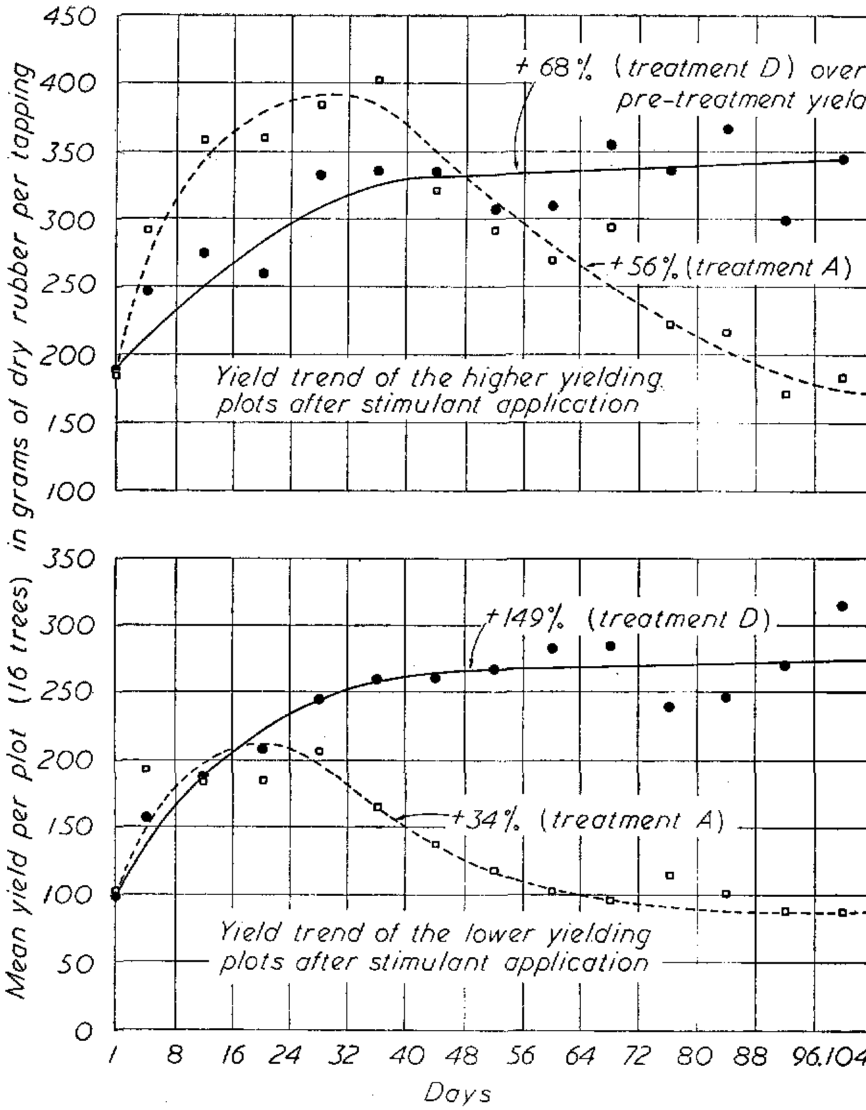


Figure 6. Comparison of two methods of application of yield stimulant. Mean yield per plot (16 trees) expressed in grams of dry rubber per tapping.

· · · · · □ · · · · · *Application of yield stimulant on 3 inch strip of scraped bark below the tapping cut once in 6 months.*

———●——— *Application of yield stimulant on 1 inch strip of freshly tapped bark immediately above the tapping cut once monthly.*

Each dot represents the mean yield of 4 tapping days.

The most marked responses are recorded in the present experiments with salts and esters of chlorine-substituted phenoxy acetic acids. Comparable responses in yield have been obtained with injections of copper sulphate.

Despite very large, though temporary, increases in yield the incidence of 'dry' trees has not been significantly increased after six consecutive treatments with yield stimulating preparations, applied at intervals of six months to lightly scraped bark below the tapping cut on high yielding seedling trees. Injections of copper sulphate have produced similar effects.

The magnitude of the response has shown a steady decrease with each successive treatment.

Yield stimulant mixtures applied at monthly intervals above the tapping cut, application being restricted to the strip of bark excised during the previous month, have resulted in greatly increased yields. The effect on bark renewal also appears to be quite beneficial, though it has been noted that increase in thickness of the renewed bark, at least in the early stages of renewal, is confined to the non latex bearing tissues of the outer bark.

We express our sincere thanks to Mr C.E.T. Mann, Director of the Institute who, as former Head of the Botanical Division, established the wide range of material on which our experiments have been carried out and for his helpful suggestions and interest in this work.

We are indebted to Mr D.R. Westgarth for his guidance in the design of the experiments and for the statistical analysis of the results.

It is a pleasure to place on record our appreciation of the able assistance of Mr O. Karunakaran and Mr T.S. Aiyar in the field work and of Mr Chen Khuan Tai and Mr Fong Fook Lam in the preparation of the data for publication.

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