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Novel Stimulants and Procedures in the Exploitation of Hevea: II. Pilot Trial Using (2-chloroethyl)-Phosphonic Acid (Ethephon) and Acetylene with Various Tapping Systems

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This paper describes an experiment on the stimulant action of (2-chloroethyl)-phosphonic acid (ethephon) and acetylene on yield of Hevea brasiliensis. *The two novel stimulants were compared with the conventional stimulant 2,4,5-T, and tested with a variety of tapping systems. Ethephon, used in the form of 'Ethrel', gave very promising results, notably with systems of reduced tapping intensity. The results with acetylene were similar though not as good. Both stimulants were superior to 2,4,5-T but the response of the trees declined markedly when they were repeatedly applied to the same site on the bark.*

The techniques used in the experiment are not considered suitable for practical application but they provided a basis for the subsequent development of practical procedures.

Large yields of latex were obtained from very small cuts under some conditions of treatment with ethephon and acetylene, consistent with earlier predictions.

The experiment also included some treatments with ethylene oxide and bromoethane. The former compound was destructive under the conditions used; the latter, which gave inconclusive results, requires further study.

The trial described in this paper is designated 'Experiment LF.1'. In planning this experiment, the authors made use of the concepts reviewed by ABRAHAM *et al.* (1971) and attempted to devise treatments which might effectively stimulate yield and be adaptable to plantation practice. They also intended to select promising treatments for larger trials. Of the newer stimulants described earlier (ABRAHAM *et al.*, 1971), ethephon and acetylene were chosen as being potentially practicable. Treatments with the conventional stimulant 2,4,5-T were included for comparison. Ethylene gas was not included as no convenient supply was then available. One treatment was made with bromoethane which had been noted as a stimulant by ABRAHAM, WYCHERLEY AND PAKIANATHAN (1968); several treatments with ethylene oxide (TAYSUM, 1961) were also included.

Two different tapping frequencies (d/2 and d/4) and various lengths of cuts were compared, with particular emphasis on shorter-than-normal cuts. This was for the reasons given earlier and because systems of reduced intensity offer the possibility of conservation of bark and, at least in principle, more efficient use of labour.

Ethephon was used in the form of Ethrel (AMCHEM PRODUCTS INCORPORATED, 1969). The dose sizes and methods of application of this material and of acetylene were selected arbitrarily on the basis of the limited knowledge available at the time. Ethrel was known to act as a stimulant when applied in palm oil to scraped bark below the cut (ABRAHAM *et al.*, 1968) but this procedure was thought to be inefficient because of possible loss of ethylene from the site of application to the atmosphere. Accordingly, the closed

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applicators described below were used. The experience gained showed disadvantages in the use of the applicators while further experiments, to be described later, demonstrated that application of Ethrel-in-palm oil was actually a very effective procedure, provided the dose was large enough. With acetylene generated from calcium carbide, some form of closed applicator still seems unavoidable, but the design of applicator used in the first year of Experiment LF.1 was modified subsequently. Although some of the techniques soon became obsolete, the experiment gave valuable information.

MATERIALS AND METHODS

Trees and Design

The trees were of miscellaneous clones planted in a small-scale clone trial in Field 49B of the R.R.I.M. Experiment Station. They were used because they were available and would also give results independent of the characteristics of any particular clone. The trees had been budded in 1951–2 and tapped S/2.d/2 on Panel C, *i.e.*, on the first panel of bark of first renewal, since January 1968. The experiment employed a randomised single-tree-plot design similar to that described by BAPTIST AND DE JONGE (1955). Individual tree yields were pre-recorded for three months from July 1968 while S/2.d/2 tapping continued. Treatments were allocated at random among trees of similar yield. Only ten trees were taken for each treatment since the experiment was conceived as a pilot trial to obtain indications of promising treatments.

The field was divided into two tapping tasks. Each half of the field, *i.e.*, each task, contained five of the ten trees from each treatment. The post-treatment yields were recorded separately from each task, *i.e.*, from groups of five trees each. There were thus two replications of each treatment.

Yield Recording

Latex was collected in polythene bags (SOUTHORN, 1969a) and coagulated in the bags by addition of formic acid. One bag was used for each cut on a tree. Bags containing coagulated latex were collected and the coagula were creped, dried and weighed. Collection was made once every four days when necessary (*e.g.*, during periods of peak yield after stimulation), otherwise once every eight days.

Analysis of Data

The mean yields for each treatment were corrected by covariance analysis for yield differences before treatment. Mean yields were calculated in terms of grams of dry rubber per tree per tapping and pounds per acre per month.

In calculating yields per acre, the number of actual tappings was used and a stand of one hundred trees per acre was assumed, this being close to the actual density in Field 49B.

Stimulants

2,4,5-T. This was used in the form of the I.C.I. product Flomore, which contains the n-butyl ester of 2,4,5-trichloro-phenoxy-acetic acid at 1% (w/w) acid equivalent in palm oil/petrolatum (5:3 w/w). The formulation was originally developed at the R.R.I.M. (DE JONGE 1955).

Ethrel. The formulations of Ethrel, as described by AMCHEM PRODUCTS INCORPORATED (1969) were useful. Although Ethrel is the trademark for Amchem's (2-chloroethyl)-phosphonic acid (ethephon), the name has been applied both to the free acid and to a three-way mixture of the free acid, its monochloroethyl ester and its anhydride. The Ethrel in the earlier formulations produced (*viz.*, Amchem 68–64) consisted of a mixture of free acid (45–48%), the monochloroethyl ester (34–38%) and the anhydride (11–14%). Concentrations of Ethrel in such formulations are expressed as the sum of the free acid equivalents of the three constituents. In the case of Amchem 68–64, the concentration is 4 lb of Ethrel per U.S. gallon (*i.e.*, 480 g per litre), the solvent being propylene glycol.

The Ethrel in more recently produced formulations (*viz.*, Amchem 68-250) is essentially all free (2-chloroethyl)-phosphonic acid (ethephon) without significant amounts of the ester or anhydride. In the case of Amchem 68–250, the concentration is again 4 lb of Ethrel per U.S. gallon, also in propylene glycol as solvent.

Amchem 68–64, diluted further as described below, was used at the beginning of the experiment but was replaced with Amchem 68-250, similarly diluted, as the experiment proceeded, because the latter was the form in which new stocks were supplied and because it seemed likely to become the commercially available form. It was thought also that there would be no difference in potency between Amchem 68-64 and 68-250.

Carbide. The calcium carbide used for generating acetylene was the ordinary grade sold locally for use in carbide lamps.

Ethylene oxide. This was obtained from Etoxin Ltd. of London.

Bromoethane. This substance (laboratory reagent grade) was obtained from BDH Chemicals Ltd, Overseas Division, of Poole, England.

Applicators

The applicator used for Ethrel consisted of an expanded polystyrene frame with a rectangular hole. The frame was attached to an area of very lightly scraped bark using ammoniated latex concentrate as adhesive. The rectangular hole was filled with a pad of paper pulp or paper tissue kept in contact with the scraped bark; the hole was covered with polythene sheet glued to the frame with ammoniated latex concentrate (*Figure 1*).

For acetylene from carbide, the same basic applicator was used but the paper filling was omitted and a polythene bag replaced the simple polythene cover (Southorn, 1970). The gas space in the bag communicated with the area of scraped bark inside the applicator-frame, but was sealed from the atmosphere by folding the top of the bag several times and clipping it *(Figure 2)*.

Rainguards

All trees were fitted with rainguards. These were made from strips of expanded polystyrene

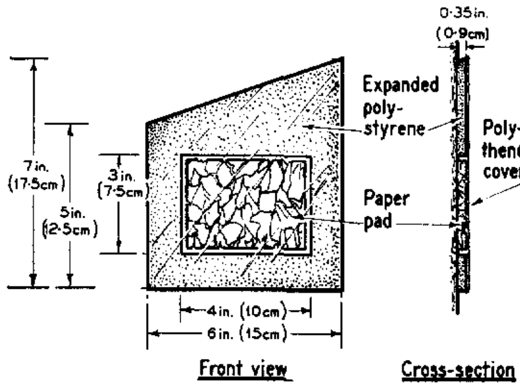

Figure 1. Applicator for Ethrel.

coated on one side with ammoniated latex concentrate (which was allowed to dry) and fixed to the bark after painting it with the same adhesive (Southorn, 1969a). The guards were initially made from a single strip but the one shown in *Figure 3* (a double strip) was later found to be more effective.

Treatments and Methods of Application

(a) *General.* The experiment was originally intended to include fifty treatments, hence

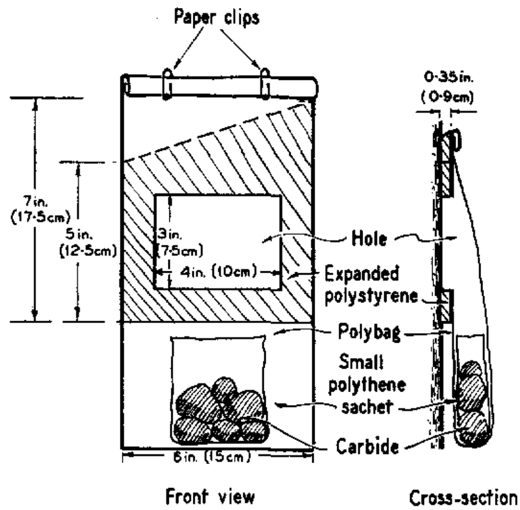

Figure 2. Applicator for acetylene.

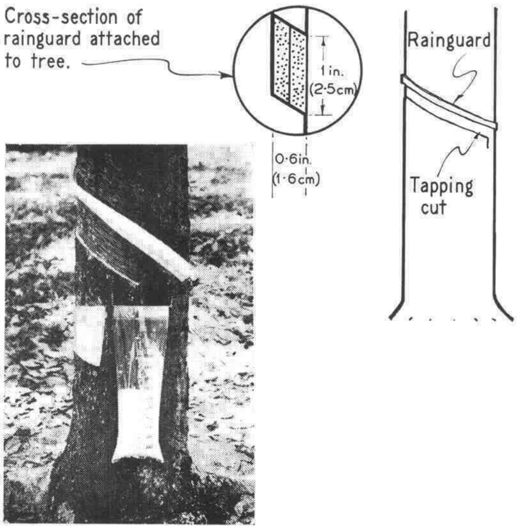

Figure 3. Rainguard, Ethrel applicator and collection bag.

50 × 10 trees. Ten trees were discarded during pre-recording because of root disease, wind damage, etc. Eleven treatments involving application of ethylene oxide, described below, were terminated early in the experiment. *Table 1* shows the remaining thirty-eight treatments. (The treatment numbers originally used are retained in *Table 1.*)

(b) *Tapping systems.* Because of the division of the field into two tasks, one group of five trees in each treatment was always tapped on a different day from the other five trees in the treatment. Many of the tapping systems listed in *Table 1* will be recognisable since, as far as possible, the terminology follows the usual rules (Guest, 1939 and 1940). However, some annotations are necessary and these follow.

S/2.d/2 (2 × 2d/4) — There were two half-spiral cuts on opposite sides of the tree; one was the original cut on Panel C; the other was newly opened at the same height on Panel D, *i.e.,* on the second panel of bark of first renewal; the cuts were tapped in alternation, each being tapped once in four days.

S/4.d/2 (2 × 2d/4) — The two quarter-spirals were respectively the lower half of the original half-spiral cut on Panel C and a newly opened quarter-spiral at the same height and directly opposite, on Panel D; the cuts were tapped in alternation, each tapped once in four days.

S/8.d/2 and S/8.d/4 — The lowest quarter of the original half-spiral cut on Panel C was tapped.

5 mm. d/2 and 5 mm d/4 — The cut was opened on Panel C directly below the centre of the existing S/2 cut and roughly 15 in. (38 cm) from it [*Figure 4(a)*]. The cut was made using a small gouge like a miniature tapping knife with a 5 mm curved blade (a standard wood-carving tool). The gouge was inserted into the bark at right angles to the axis of the tree, instead of tangentially. The cut was made to the wood at first opening

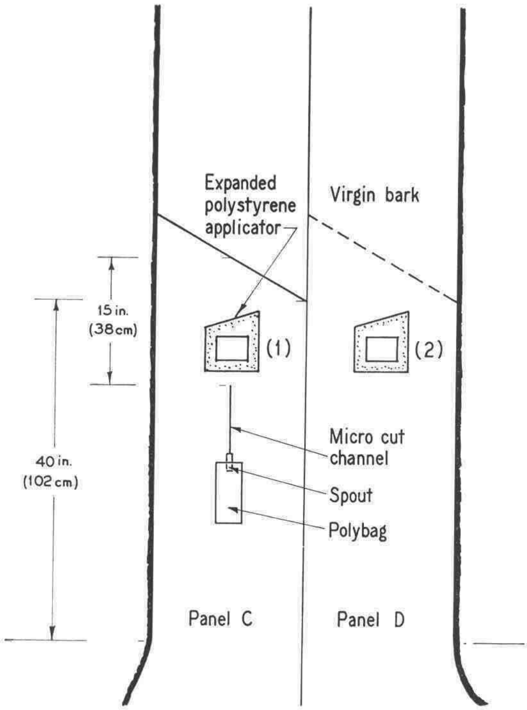

Figure 4(a). Placement of single 5 mm micro-cut and applicators.

and at each tapping, when a shaving was removed so that the cut progressed vertically down the tree, rather as in conventional tapping. However, in practice, the bark shaving removed at each tapping was much thicker than in conventional systems, so that the narrow cut moved rather rapidly down the tree. When it was inconveniently near the base, a new cut was opened at the same level as the beginning of the preceding one and beside it.

4 × 5 mm d/2 (2 × 2d/4) — There were two groups of four micro-cuts, each micro-cut being as just described; one group was placed on Panel C [two cuts at 15 in. (40 cm) and two at 35 in. (90 cm) from the graft union]; the other group was placed on the opposite side of the tree with two cuts at 55 in. (140 cm) and two at 75 in. (190 cm) [*Figure 4(b)*]; the two groups of cuts were tapped in alternation, each group being tapped once in four days.

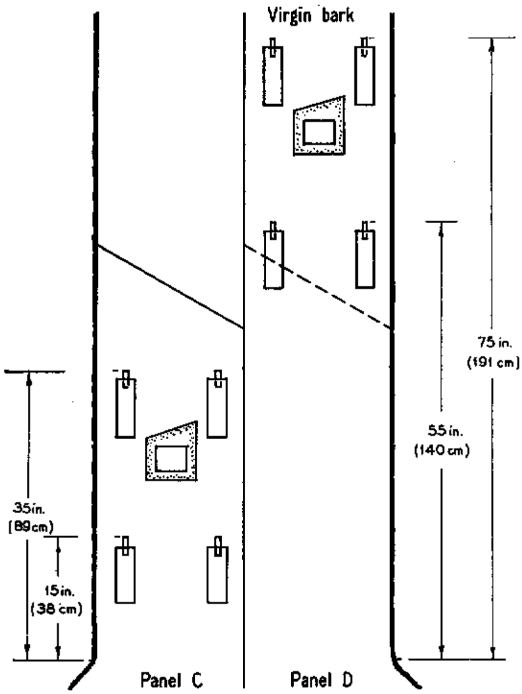

Figure 4(b). Placement of multiple 5 mm micro-cuts and applicators.

(c) *Initial application of stimulants.* The first application of stimulants was made on 28 November 1968 by the following methods:

2,4,5-T. Flomore was applied to bands of scraped bark 1½ in. (4 cm) wide. For Treatment No. 43 *(Table 1)*, this band was in the commonly-used position immediately below the cut. Since Treatment No. 43 was tapped on S/2.d/2, the treated bark was gradually removed in the usual manner.

With systems involving cuts shorter than the half-spiral, the placement of 2,4,5-T presents a problem. If the standard formulation is applied immediately below the cut to a 1½ in. (3.8 cm) band, then the dose per tree is less than that applied to trees tapped on S/2. If the concentration of 2,4,5-T in the carrier is increased or the band widened to counteract this, other complications arise (*e.g.*, the local effect of increased concentration of 2,4,5-T or the impossibility of tapping off the wider band in the right time). Similar difficulties occur with tapping systems of reduced frequency (*e.g.*, d/4 in this experiment). The problem was solved by applying the Flomore to a 1½ in. band of scraped bark over half the circumference of the tree on the lowest area of renewed bark above the graft union. For treatments with a single cut (No. 2, 11, 15, 19, 23, 27, 31 and 35), the band was single and continuous, placed vertically below and parallel with the orginal half-spiral cut. For treatments with cuts on each side of the tree (No. 7, 39 and 44), two bands of standard width were used, each of S/4 length: one was placed vertically below the lower half of the original S/2 cut and the other directly opposite on the other side of the tree. All trees treated with 2,4,5-T thus received approximately the same dose (on average, 3 g of Flomore or 30 mg of acid equivalent of 2,4,5-T per tree).

It was realised at the outset that trees treated near the base with 2,4,5-T would show bark damage, since the treated bark could not be tapped off. The method was convenient for the purposes of the experiment but has no practical value.

TABLE 1. EXPERIMENT LF. 1 — COMPARATIVE ADJUSTED MEAN YIELD IN GRAMS PER TREE PER TAPPING

Treatment	No.	Yield (monthly) 1	2	3	4	5	6	7	8	9	10	11	12	Annual yield
S/2.d/2. Scraped + Carrier	1	73.4	77.9	78.1	46.3	50.9	49.7	56.8	65.1	75.8	59.9	62.3	50.4	64.5
" + 2, 4, 5-T	2	99.1	85.1	88.2	55.2	67.9	67.5	75.4	74.0	97.9	77.7	87.5	74.5	81.1
" + Ethrel	4	121.5	89.6	86.4	51.4	62.5	53.3	55.4	45.4	71.3	49.5	64.7	49.2	73.2
" + Acetylene	5	109.3	74.8	93.1	45.8	56.9	60.4	66.8	65.6	105.3	60.5	67.3	62.1	76.0
" + 2, 4, 5-T (below cut)	43	105.3	91.2	78.9	53.6	71.3	57.9	76.7	61.7	96.6	68.4	74.5	62.5	78.1
" + Bromoethane	50	101.4	78.9	73.0	41.0	45.8	41.9	65.8	67.2	80.1	68.9	75.6	61.1	69.8
S/4.d/2. + 2,4, 5-T	15	38.7	52.9	55.0	29.4	66.2	56.0	61.2	54.5	70.3	35.8	37.5	42.4	49.5
" + Ethrel	17	96.9	70.6	84.0	48.5	54.8	44.2	49.8	38.6	50.3	35.0	36.8	34.3	59.9
" + Acetylene	18	104.1	56.2	76.5	33.0	38.8	28.9	38.0	39.6	50.8	39.6	54.1	42.3	56.0
S/8.d/2. + 2, 4, 5-T	23	26.2	30.2	33.7	22.8	51.8	36.1	63.9	48.4	69.4	60.1	74.9	45.1	43.6
" + Ethrel	25	78.3	74.3	54.6	23.5	28.3	15.3	19.4	9.5	24.1	15.3	22.5	16.6	39.1
" + Acetylene	26	70.0	36.3	58.7	18.9	29.3	15.0	18.5	16.0	42.4	28.6	43.7	27.6	38.3
5mm.d/2. + 2, 4, 5-T	31	2.3	0.8	2.4	1.34	10.7	7.2	11.2	7.0	10.1	9.1	14.0	12.8	5.7
" + Ethrel	33	32.8	29.8	22.4	6.9	22.5	4.8	17.6	13.9	10.2	2.3	2.4	1.1	16.7
" + Acetylene	34	33.0	16.8	23.8	12.0	15.2	8.0	14.2	11.8	21.2	17.4	23.8	16.6	19.3
S/2.d/4. + 2, 4, 5-T	11	78.7	121.2	117.6	57.5	84.8	89.1	137.9	150.2	167.2	130.7	164.9	167.0	117.3
" + Ethrel	13	212.9	207.1	187.4	97.8	131.3	88.3	119.0	119.8	166.2	104.5	126.0	86.3	149.7
" + Acetylene	14	167.0	113.7	137.4	57.3	96.3	64.2	99.0	68.4	140.9	90.6	138.0	110.4	113.8
" + Ethrel (initial high dose)	49	235.4	190.6	172.2	94.8	131.5	157.5	176.4	145.7	172.5	123.1	140.6	114.9	161.8
S/4.d/4. + 2, 4, 5-T	19	49.2	56.0	70.2	32.3	60.9	62.4	84.1	74.0	95.2	84.2	112.7	96.2	69.7
" + Ethrel	21	142.4	147.8	133.4	67.8	87.8	67.2	79.7	80.1	86.8	61.8	84.1	63.7	101.1
" + Acetylene	22	102.5	72.7	101.3	41.0	52.9	40.2	56.8	62.6	92.1	69.0	75.8	68.7	74.0
S/8.d/4. + 2, 4, 5-T	27	26.8	32.2	34.8	18.3	40.3	23.4	45.8	41.2	64.4	46.3	79.8	59.0	40.4
" + Ethrel	29	95.0	117.3	80.6	39.8	58.7	41.2	47.7	36.4	73.9	55.7	64.4	60.7	70.5
" + Acetylene	30	113.3	40.9	68.7	22.3	40.8	22.4	35.1	37.6	53.5	43.7	72.9	45.7	54.9
5mm.d/4. + 2, 4, 5-T	35	21.3	14.2	19.9	10.4	20.1	10.3	14.3	11.8	19.4	20.0	25.9	16.3	17.5
" + Ethrel	37	63.4	44.0	52.2	24.8	32.1	23.0	22.0	15.9	23.8	17.7	28.3	16.0	35.0
" + Acetylene	38	24.7	11.5	23.8	8.0	14.7	3.6	7.6	3.8	6.2	4.6	7.4	6.3	12.4
S/2.d/2. (2×2d/4) + Scraped + Carrier	6	92.0	105.6	105.6	61.9	42.5	42.5	49.3	66.1	79.0	56.6	63.8	54.9	74.3
" " + 2, 4, 5-T	7	108.1	92.8	80.2	54.1	61.6	68.2	74.8	68.9	70.5	60.5	64.1	62.1	75.8
" " + Ethrel	9	150.3	123.3	106.9	60.4	54.5	51.4	65.5	60.1	59.3	58.8	62.0	46.9	84.8
" " + Acetylene	10	139.9	85.4	96.9	50.7	54.9	44.3	53.8	55.9	69.6	62.9	71.4	60.0	76.9
S/4.d/2. (2×2d/4) + 2, 4, 5-T	44	55.0	59.6	65.5	35.7	51.7	38.1	50.9	57.4	68.9	58.2	83.7	65.4	57.9
" " + Ethrel	46	99.8	93.0	90.9	37.1	50.3	41.3	65.6	40.4	76.7	47.4	48.2	41.1	67.4
" " + Acetylene	47	117.4	64.2	88.5	34.1	46.2	39.2	48.2	46.8	83.7	59.9	75.0	59.3	68.8
4×5mm.d/2. (2×2d/4) + 2,4, 5-T	39	41.7	38.5	42.1	17.8	29.3	19.3	17.2	11.1	27.0	22.4	29.4	22.6	29.5
" " + Ethrel	41	97.1	72.4	91.9	36.5	47.1	19.2	19.7	12.4	23.5	15.6	31.5	18.5	50.3
" " + Acetylene	42	68.0	48.2	67.0	27.5	24.9	19.4	18.0	12.8	24.8	20.0	23.5	17.0	37.1
S.E.		17.24	11.40	14.97	8.57	12.20	9.90	12.56	12.57	11.18	10.89	13.86	10.56	10.29
Min. sig. diff. ($P < 0.05$)		49.5	32.7	43.0	24.6	35.0	28.4	36.0	36.1	32.1	31.3	39.8	30.3	29.5
Mean over all treatments		89.3	74.1	77.5	39.2	52.3	42.7	54.7	49.9	69.0	51.1	63.6	51.5	63.5

TABLE 2. EXPERIMENT LF. 1 — COMPARATIVE ADJUSTED MEAN YIELD IN POUNDS PER ACRE

Treatment		No.	Yield (monthly)												Annual yield
			1	2	3	4	5	6	7	8	9	10	11	12	
S/2.d/2.	Scraped + Carrier	1	254	239	273	134	154	119	199	171	233	209	190	176	2350
”	+ 2, 4, 5-T	2	334	258	303	153	201	161	261	191	297	267	259	256	2941
”	+ Ethrel	4	430	277	306	150	197	130	196	121	224	175	204	174	2583
”	+ Acetylene	5	401	236	336	138	187	149	240	178	343	221	221	225	2876
”	+ 2, 4, 5-T (below cut)	43	354	276	270	148	214	137	266	158	290	233	217	213	2775
”	+ Bromoethane	50	348	241	253	116	134	99	229	175	239	238	228	211	2514
S/4.d/2.	+ 2, 4, 5-T	15	162	171	207	94	213	138	223	152	234	139	138	161	2032
”	+ Ethrel	17	355	222	303	143	177	108	180	106	162	130	127	127	2140
”	+ Acetylene	18	349	168	260	90	113	68	129	99	147	130	152	141	1846
S/8.d/2.	+ 2, 4, 5-T	23	92	93	119	68	149	86	225	128	215	212	239	159	1786
”	+ Ethrel	25	297	236	203	70	99	41	74	31	86	64	88	68	1356
”	+ Acetylene	26	240	110	203	52	88	37	63	40	129	97	129	94	1281
5mm.d/2.	+ 2, 4, 5-T	31	1	5	13	6	32	19	42	21	36	36	52	49	312
”	+ Ethrel	33	121	93	82	21	69	13	63	38	35	10	12	6	564
”	+ Acetylene	34	96	46	74	29	36	17	44	25	52	51	57	50	577
S/2.d/4.	+ 2, 4, 5-T	11	123	177	193	75	131	114	232	192	252	219	246	283	2237
”	+ Ethrel	13	383	324	337	145	212	119	215	162	265	189	199	158	2707
”	+ Acetylene	14	295	176	242	83	157	85	175	90	221	160	210	195	2088
”	+ Ethrel (initial high dose)	49	407	289	294	133	219	206	305	189	265	211	211	196	2928
S/4.d/4.	+ 2, 4, 5-T	19	94	91	130	52	102	84	153	101	154	154	178	175	1468
”	+ Ethrel	21	253	229	273	97	144	89	142	107	133	110	130	114	1785
”	+ Acetylene	22	182	113	180	60	83	53	101	83	142	122	116	122	1357
S/8.d/4.	+ 2, 4, 5-T	27	43	47	57	25	56	30	78	52	100	78	120	100	786
”	+ Ethrel	29	178	187	152	60	104	57	91	53	121	106	105	115	1330
”	+ Acetylene	30	209	69	130	37	69	32	68	54	87	84	121	88	1050
5mm.d/4.	+ 2, 4, 5-T	35	49	29	46	20	36	17	33	20	36	44	48	37	413
”	+ Ethrel	37	129	78	108	43	62	35	50	28	45	44	55	41	718
”	+ Acetylene	38	46	20	45	13	21	5	15	6	11	10	13	13	219
S/2.d/2. (2×2d/4)	+ Scraped + Carrier	6	324	326	373	170	132	103	174	175	249	199	198	194	2616
” ”	+ 2, 4, 5-T	7	399	292	292	160	192	166	269	188	232	222	215	227	2853
” ”	+ Ethrel	9	530	381	377	170	174	126	231	159	184	207	195	166	2900
” ”	+ Acetylene	10	462	262	338	141	165	107	188	146	211	219	217	209	2664
S/4.d/2. (2×2d/4)	+ 2, 4, 5-T	44	202	187	235	102	159	94	182	154	214	209	270	234	2243
” ”	+ Ethrel	46	385	297	337	110	176	105	241	117	256	183	177	159	2545
” ”	+ Acetylene	47	425	202	318	101	153	97	173	127	274	217	248	214	2551
4×5mm.d/2. (2×2d/4)	+ 2, 4, 5-T	39	145	118	148	49	83	48	60	29	82	78	89	79	1009
” ”	+ Ethrel	41	344	224	325	99	140	48	70	33	71	56	99	66	1573
” ”	+ Acetylene	42	230	146	231	76	72	47	61	31	69	66	65	56	1150
S.E.			40.6	28.3	37.6	18.7	28.5	20.3	37.2	28.1	24.5	31.0	32.5	30.7	284.4
Min. sig. diff. ($P < 0.05$)			117	81	108	54	82	58	107	81	70	89	93	88	816
Mean over all treatments			255	183	220	91	129	84	151	103	168	142	154	141	1819

TABLE 3. EXPERIMENT LF. 1 — COMPARATIVE ADJUSTED MEAN YIELD OF TREATMENT IN POUNDS PER ACRE AS PERCENTAGE OF CONTROL

Treatment		No.	Yield (monthly)												Annual yield
			1	2	3	4	5	6	7	8	9	10	11	12	
S/2.d/2.	Scraped + Carrier	1	100	100	100	100	100	100	100	100	100	100	100	100	100
,,	+ 2, 4, 5-T	2	132	108	111	114	131	135	131	112	127	128	136	146	125
,,	+ Ethrel	4	169	116	112	112	128	109	98	71	96	84	107	99	110
,,	+ Acetylene	5	158	99	123	103	122	125	121	104	147	106	116	128	122
,,	+ 2, 4, 5-T (below cut)	43	140	116	99	110	139	115	134	92	125	111	114	121	118
,,	+ Bromoethane	50	137	101	93	87	88	83	115	102	102	114	120	120	107
S/4.d/2.	+ 2, 4, 5-T	15	64	72	76	70	138	115	112	89	101	66	73	91	86
,,	+ Ethrel	17	140	93	111	107	115	91	90	62	70	62	67	72	91
,,	+ Acetylene	18	137	70	95	67	74	57	65	58	63	62	80	80	79
S/8.d/2.	+ 2, 4, 5-T	23	36	39	44	50	97	72	113	75	92	101	126	91	76
,,	+ Ethrel	25	117	99	74	52	64	34	37	18	37	31	46	38	58
,,	+ Acetylene	26	94	46	74	39	57	31	32	24	55	46	68	54	55
5mm.d/2.	+ 2, 4, 5-T	31	0	2	5	5	21	16	21	12	15	17	27	28	13
,,	+ Ethrel	33	48	39	30	15	45	11	32	22	15	5	7	3	24
,,	+ Acetylene	34	38	19	27	22	23	14	22	15	22	25	30	28	25
S/2.d/4.	+ 2, 4, 5-T	11	49	72	71	56	85	95	117	112	108	105	129	161	95
,,	+ Ethrel	13	151	136	123	108	138	100	108	95	113	91	105	80	115
,,	+ Acetylene	14	116	73	89	62	102	71	88	53	95	76	110	111	89
,,	+ Ethrel (*initial high dose*)	49	*160*	*121*	*108*	99	*142*	*173*	*154*	*111*	*114*	*101*	*111*	112	125
S/4.d/4.	+ 2, 4, 5-T	19	37	38	48	39	66	71	77	59	66	74	94	100	62
,,	+ Ethrel	21	100	96	87	72	93	75	71	63	57	53	68	65	76
,,	+ Acetylene	22	72	47	66	45	54	45	51	49	61	59	61	69	58
S/8.d/4.	+ 2, 4, 5-T	27	17	20	21	19	37	25	39	31	43	37	63	57	33
,,	+ Ethrel	29	70	79	56	45	67	48	46	31	52	51	55	66	57
,,	+ Acetylene	30	82	29	48	28	45	27	34	32	37	40	64	50	45
5mm.d/4.	+ 2, 4, 5-T	35	19	12	17	15	24	14	17	12	15	21	25	21	18
,,	+ Ethrel	37	51	33	39	32	40	29	25	17	19	21	29	23	31
,,	+ Acetylene	38	18	8	16	9	14	5	8	4	5	5	7	8	9
S/2.d/2. (2×2d/4)	+ Scraped + Carrier	6	128	137	136	127	86	86	87	102	107	95	104	110	111
,, ,,	+ 2, 4, 5-T	7	157	122	107	120	124	139	135	110	100	106	113	129	121
,, ,,	+ Ethrel	9	209	159	138	127	113	105	116	93	79	99	103	94	123
,, ,,	+ Acetylene	10	182	110	124	106	107	89	94	85	90	105	114	119	113
S/4.d/2. (2×2d/4)	+ 2, 4, 5-T	44	80	78	86	77	104	79	91	90	92	100	142	133	95
,, ,,	+ Ethrel	46	152	125	124	83	115	88	121	68	110	88	93	91	108
,, ,,	+ Acetylene	47	*167*	85	117	76	99	*81*	87	75	*118*	*104*	131	122	109
4×5mm.d/2. (2×2d/4)	+ 2, 4, 5-T	39	57	50	54	37	54	40	30	17	35	37	47	45	43
,, ,,	+ Ethrel	41	135	94	119	74	91	40	35	19	30	27	52	37	67
,, ,,	+ *Acetylene*	42	91	*61*	85	57	47	*40*	*30*	*18*	30	32	34	32	49

In Treatment No. 2, 2,4,5-T was applied in this manner to trees tapped on S/2.d/2, giving a direct comparison with application under the cut with the same tapping system (Treatment No. 43).

Ethrel. Two applicators were used on each tree; except in the case of Treatment No. 41, one applicator was placed about 12 in. (30 cm) vertically below the original half-spiral cut and the other directly opposite on the other side of the tree [*Figure 4(a)*]. For Treatment No. 41, with the 4 × 5mm d/2 (2 × 2d/4) tapping system, each applicator was placed within a group of four micro-cuts. One of the applicators was thus on virgin bark above Panel D [*Figure 4(b)*].

Ethrel as supplied by the manufacturers (3 ml) was diluted further with propylene glycol (21 ml). Half this mixture (12 ml) was injected through the polythene cover into the paper pad in each applicator with a hypoder-syringe, and the hole then sealed with ammoniated latex concentrate. The total dose of Ethrel per tree, in Treatments No. 4, 9, 13, 17, 21, 25, 29, 33, 37, 41, and 46 was thus 3 ml of the commercial formulation or 1.44 g of the active ingredient. Treatment No. 49 was given an initial high dose of Ethrel (*viz.*, 3 ml of commercial formulation) plus 21 ml of propylene glycol in each applicator, applied by the same technique. The total dose per tree was thus 6 ml or 2.88 g of the active ingredient.

Acetylene. Two applicators of the type described earlier and shown in *Figure 2* were placed on each tree, the positions being the same as in the corresponding Ethrel treatments. The dose-size was the same for all treatments (No. 5, 10, 14, 18, 22, 26, 30, 34, 38, 42 and 47) and was determined by the amount of calcium carbide used; this was 30 g per applicator or 60 g per tree. The carbide was placed in an open polythene sachet in the bag of each applicator, out of contact with the bark, and allowed to react with moisture, presumably arising from the bark, thus generating acetylene which came in contact with the area of scraped bark inside the applicator frame. The amount of acetylene theoretically available from the hydrolysis of 60 g of pure calcium carbide would be 21 litre, measured at standard temperature and pressure. The commercial calcium carbide used was rated by the suppliers to yield acetylene at the rate of 15 litre from 60 grams.

Bromoethane. This was applied to only ten trees (Treatment No. 50). Two applicators of the same design and placed in the same positions as in the corresponding treatment (No. 5) with acetylene, were used. Bromoethane (10 g) in an open glass tube was placed in each applicator and allowed to evaporate into the space in contact with the scraped bark (b.p. of bromoethane is 38°C).

Ethylene oxide. This was applied to the trees in eleven treatments using the same range of tapping systems as with Ethrel and acetylene. Acetylene-type applicators were used, two being placed on each tree in the same positions as in the corresponding treatments with acetylene. The technique was essentially the same as that used with bromoethane, but the dosage was only 5 ml per applicator or 10 ml per tree. Because of its extreme volatility (b.p. of ethylene oxide is 11°C), the ethylene oxide was chilled in a mixture of alcohol and solid carbon dioxide for transport to the field and placement in the applicators.

(d) *Controls.* The basic control was Treatment No. 1, tapped S/2.d/2 without stimulant. These trees were however scraped below the cut and palm oil/petrolatum (5 : 3 w/w) was applied to the 1½in. band of scraped bark.

Treatment No. 6 [S/2.d/2 (2 × 2d/4)] provided an additional unstimulated control. In this case, two bands of standard width and S/4 length were scraped on opposite sides of the trees near the base and treated with palm oil/petrolatum. This control was thought necessary because the tapping system is of 100% intensity and hitherto little information has been published about its effects on yield. No unstimulated controls with tapping systems below 100% intensity were used, because these could be expected to yield well below S/2.d/2 and the practical interest of these systems was in their performance when stimulated. Yields from all systems were therefore related to those from the unstimulated S/2.d/2 control *(Table 3)*.

As already indicated, the 2,4,5-T treatments were included as a standard of comparison ('positive control') for the newer stimulants. There was thus a 2,4,5-T treatment for each tapping system *(Table 1)*.

(e) *Reapplication of stimulants.* After the first application of stimulants, yield trends were observed and it was decided to apply the stimulants again when the effects had subsided, *i.e.*, when the yields were returning to pre-treatment levels. On this basis *(Figure 5)*, the second application was made after two months, *i.e.*, on 28 January 1969. Further applications were made at two-monthly intervals thereafter, with the exceptions noted below.

(i) In the case of trees treated with 2,4,5-T near the base, the expected bark damage occurred and it was not possible to reapply the stimulant on the same site. The second application was therefore made to a fresh band of scraped bark immediately above the first and each subsequent application was made just above the preceding one.

(ii) Where application of 2,4,5-T was made below the cut (Treatment No. 43), subsequent applications were also made below the cut, but at intervals of four instead of two months, approximating to commercial practice.

(iii) Reapplications of Ethrel were made by the same technique as the original applications and to the same sites. The only exception was Treatment No. 49 which had received an initial high dose of Ethrel: this was given only the same dosage as in the other Ethrel treatments at the second application. Bark damage was observed inside the applicators in this case and, before the third application (on 28 March 1969), a new applicator was placed at the left of the original site. The standard dose of Ethrel, not the initial high dose, was then given and repeated at the fourth, fifth and sixth applications without again moving the applicators.

Reapplications of acetylene from carbide were made without changes of technique, site or dose level. The residue of hydrolysed carbide and its containing sachet were removed from each applicator bag before the re-application. Reapplication of bromoethane were also made without changes.

(iv) The trees treated with ethylene oxide gave very high yields of latex initially but the bark cracked inside the applicators and large quantities of latex 'bled' from the cracks. Within the first month, necrosis of bark began and dryness occurred at the tapping cuts. No reapplications of ethylene oxide were made and these treatments were deleted from the experiment.

Modifications after One Year

After the experiment had run for twelve months, many changes were made in the treatments; in effect, the trial was converted into a preliminary study of different application techniques for Ethrel and acetylene. The present paper is concerned mainly with the results of the first year which are presented in detail. The changes at the beginning of the second year, and their consequences, are then discussed briefly.

RESULTS AND DISCUSSION

The mean yields in grams per tree per tapping for the first year are given in *Table 1*. The mean yields in lb per acre are given in *Table 2*, expressed relative to control (= 100) in *Table 3* and plotted in *Figure 5 (a – l)*. Owing to the heterogeneous nature of the planting material and the small number of trees in each treatment, the standard errors and minimum significant differences shown in *Tables 1* and *2* are large and most of the differences between individual treatments are not significant. Moreover, there were progressively declining responses in yield to successive applications of the novel stimulants (*Table 3* and *Figure 5*), so that differences due to them were not evident in

Figure 5 (a – l) Yield trends of different treatments over twelve months. (Dates of reapplications of stimulants are indicated by arrows.)

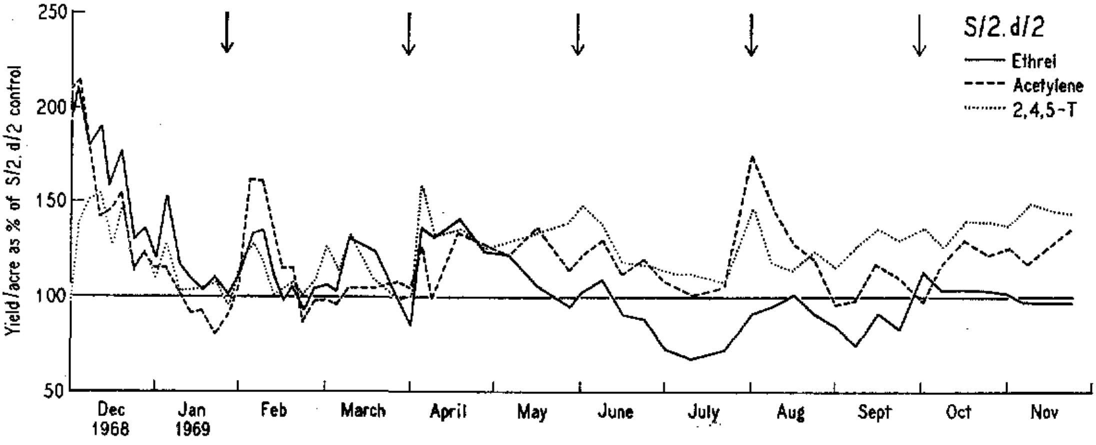

Figure 5 (a). S/2.d/2 system.

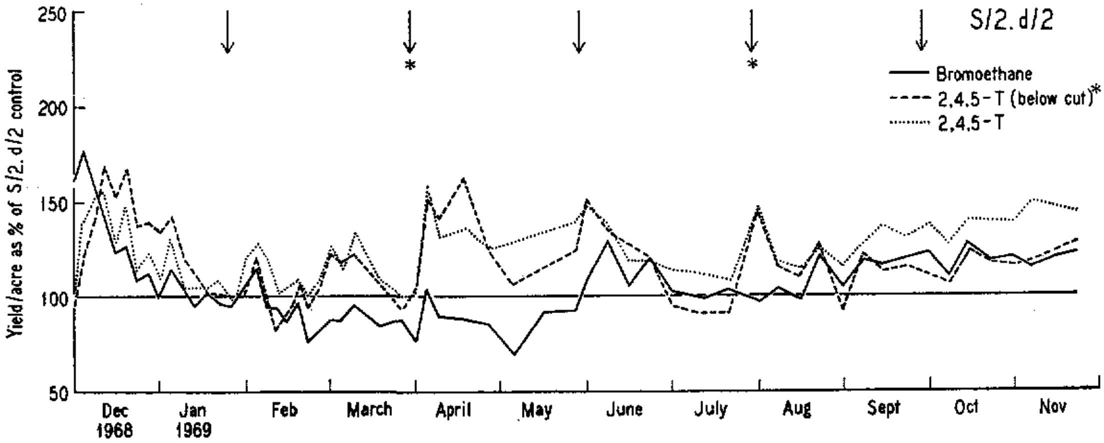

Figure 5 (b). S/2.d/2 system. Reapplications of 2,4,5-T in this Treatment were made only on the dates indicated by asterisk (see text).

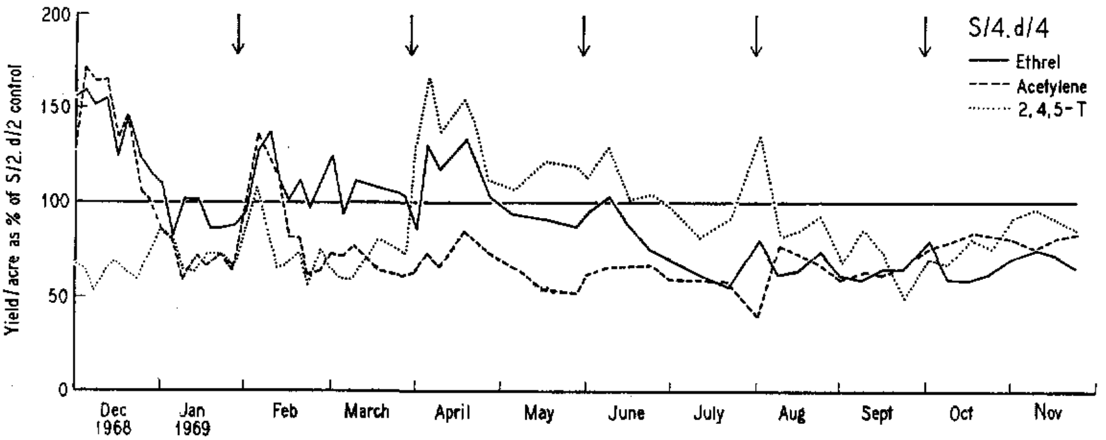

Figure 5 (c). S/4.d/4 system.

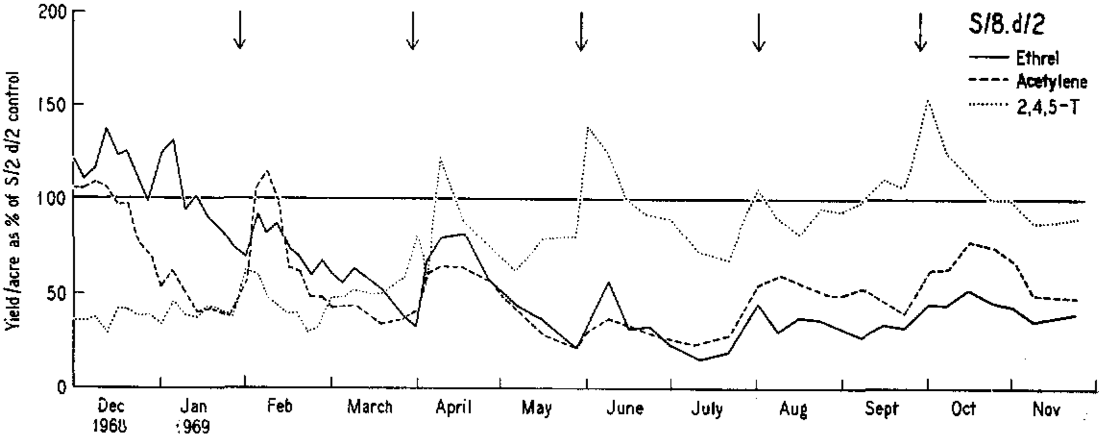

Figure 5 (d). S/8.d/2 system.

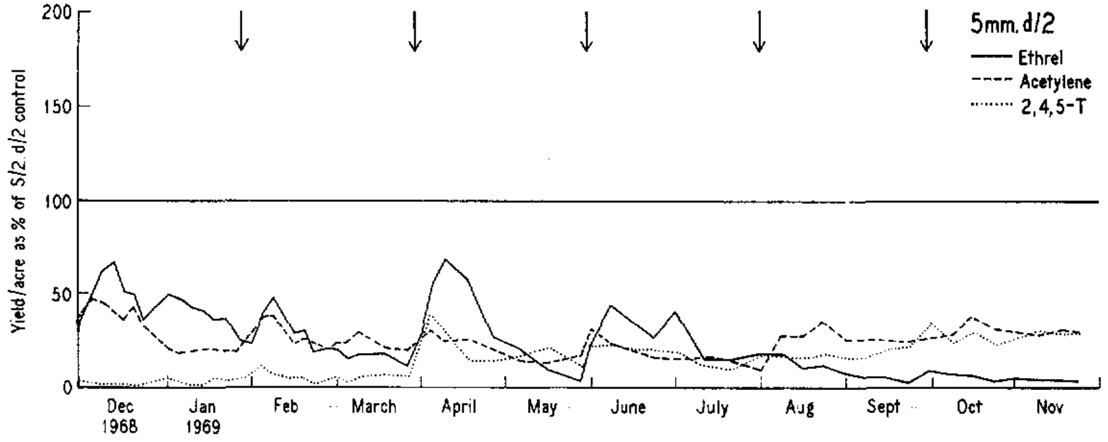

Figure 5 (e). 5 mm.d/2 system.

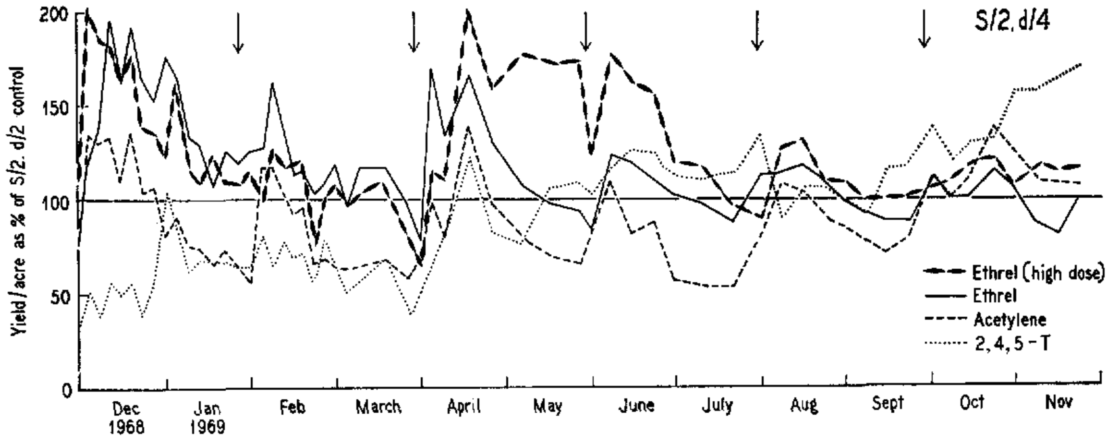

Figure 5 (f). S/2.d/4 system.

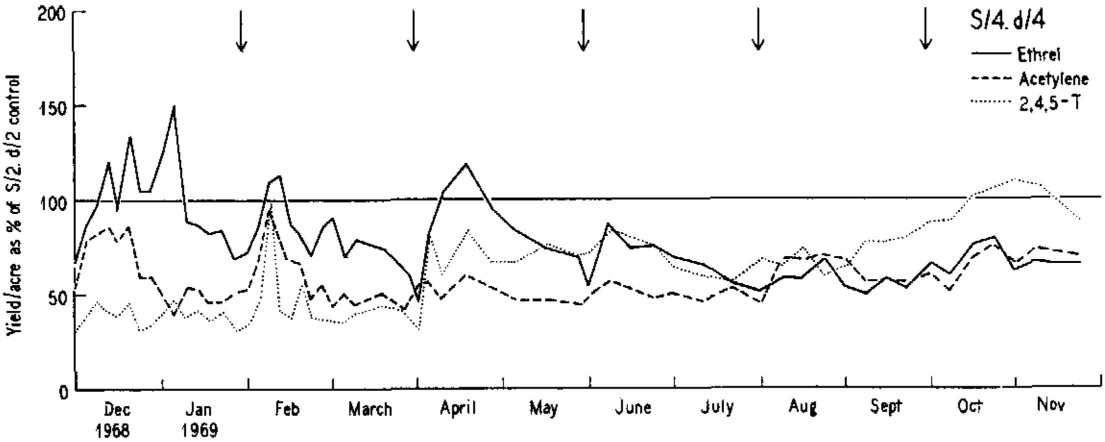

Figure 5 (g). S/4.d/4 system.

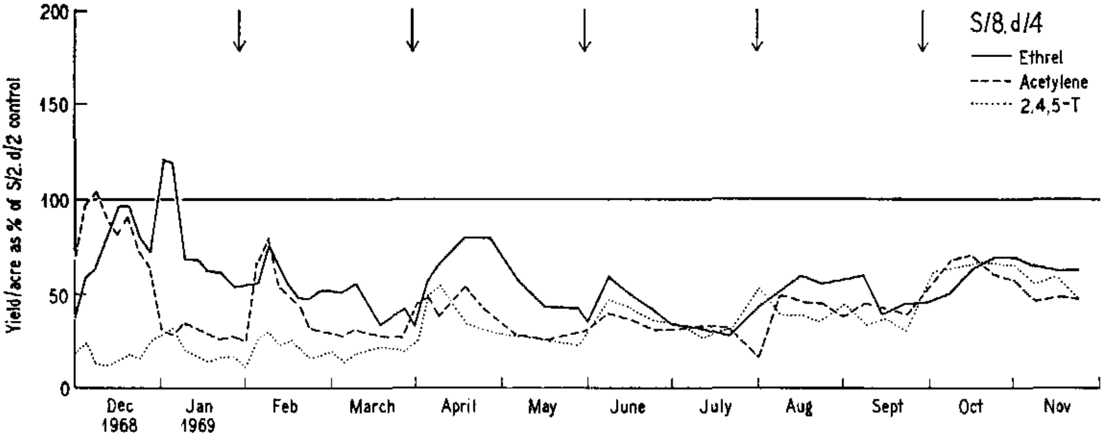

Figure 5 (h). S/8.d/4 system.

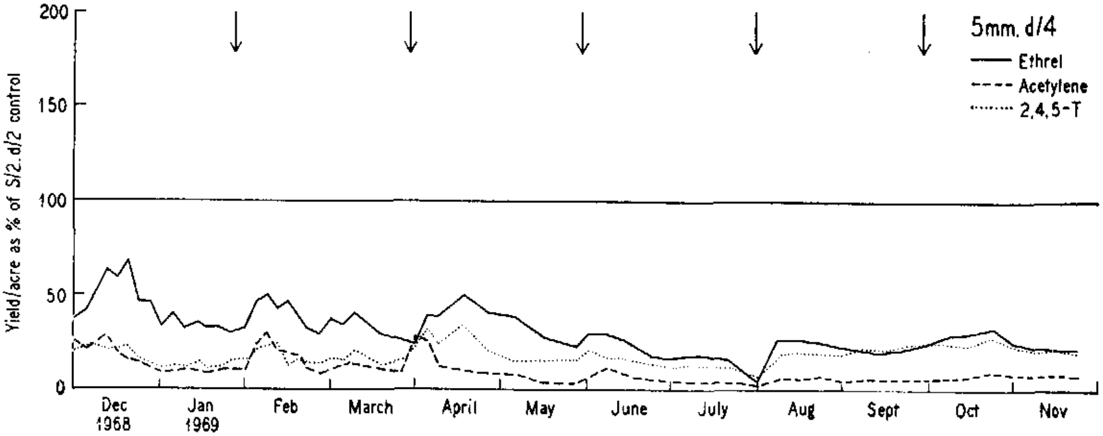

Figure 5 (i). 5 mm.d/4 system.

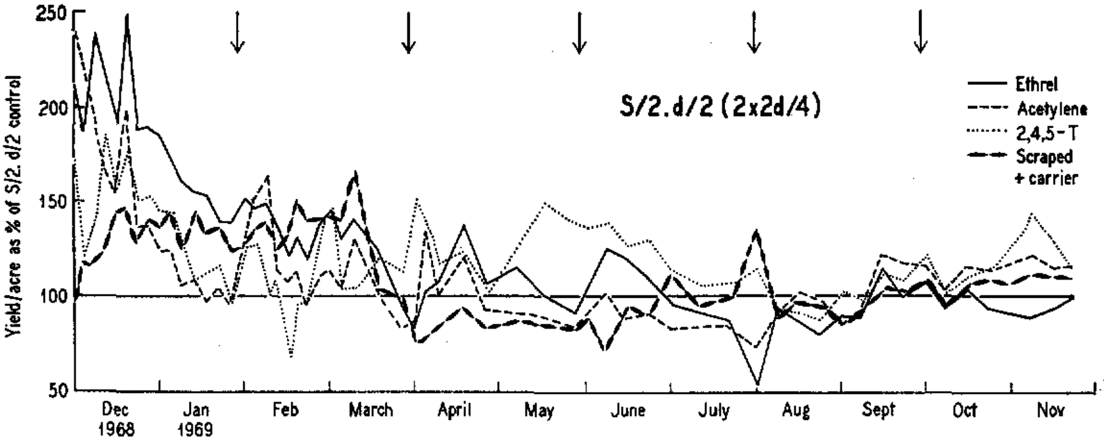

Figure 5 (j). S/2.d/2 (2 × 2d/4) system.

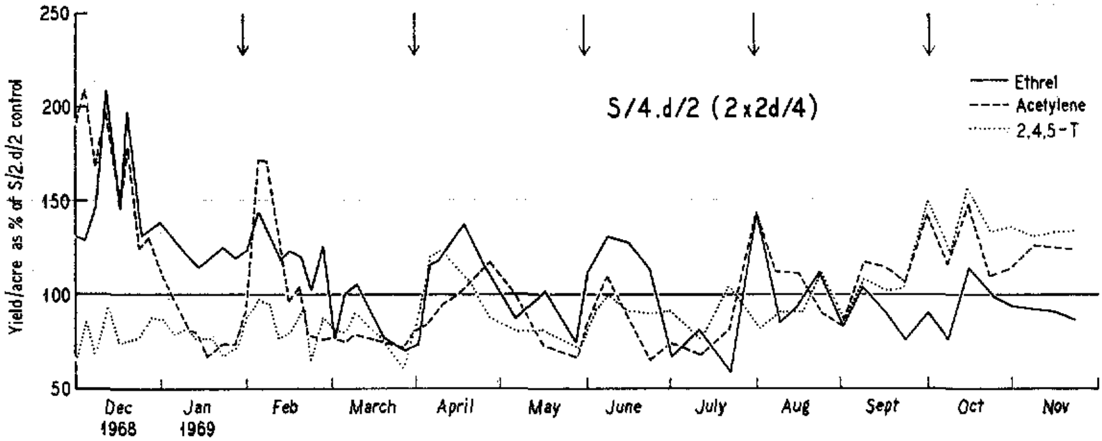

Figure 5 (k). S/4.d/2 (2 × 2d/4) system.

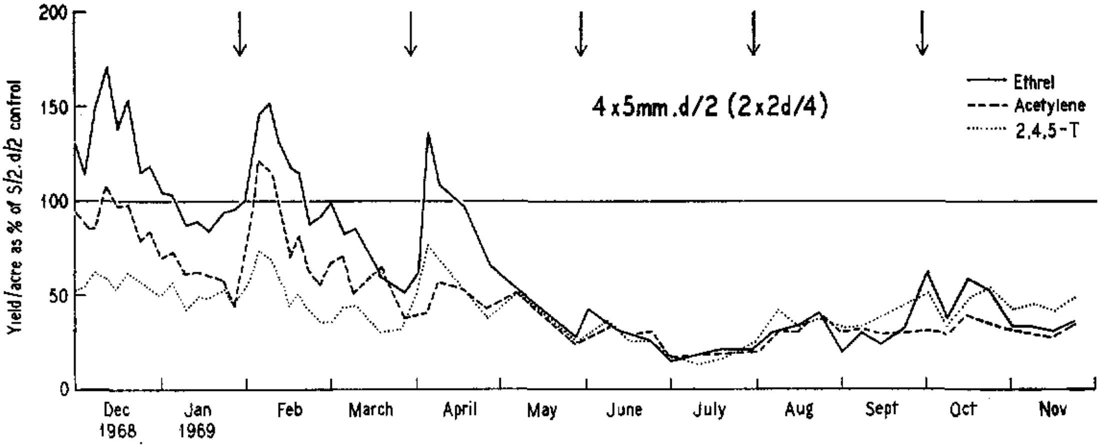

Figure 5 (l). 4 × 5mm.d/2 (2 × 2d/4) system.

the latter periods or in some cases in the annual means.

The improvement in response to successive applications of 2,4,5-T *(Table 3* and *Figure 5)* was possibly due to the progressive reduction in the distance between the site of each new application and the cut. On the other hand, the generally deteriorating responses to successive applications of acetylene and Ethrel can be attributed to these reapplications being made on the same site. This explanation is confirmed by:

(i) the good response to the third application of Ethrel at the usual rate in Treatment No. 49 (S/2.d/4 initial high dose of Ethrel) when the applicator was moved [*Table 3* and *Figure 5(f)*];

(ii) good responses at the beginning of the second year of the experiment when all application sites were changed; and

(iii) further experiments, reported in the next paper in this series, which show that sustained responses to reapplications can be obtained provided the site of application is changed regularly.

Therefore the responses during the first period of two months following the first applications, *i.e.*, before the declining trends became evident, are of most interest. They are treated separately in addition to the annual means in the following analyses.

Twenty-four of the treatments may be analysed as a factorial of 3 stimulants × 2 frequencies of tapping × 4 lengths of cut.

Also, the nine treatments involving multiple cuts may be analysed as a factorial of 3 stimulants × 3 lengths (or types) of cut.

The remaining five treatments, including the unstimulated controls, are entered in the following analyses of variance as additional treatments. These analyses enable main effects and interactions to be established with confidence, especially for the first two months after the initial application of stimulants. The analyses of variance are given in *Table 4.*

Mean Yields in Grams per Tree per Tapping

The two-way tables are given in *Table 5*. There are highly significant effects of length of cut and frequency of tapping: the interaction between them is significant for the whole year although only dubiously so for the first two months *(Table 4)*. Ethrel is significantly superior to the other two stimulants; this is very marked during the first two months, when acetylene is also clearly superior to 2,4,5-T. There is a significant interaction between stimulants and frequency of tapping: Ethrel was the markedly superior stimulant with the less frequent tapping system (d/4). The multiple-cut systems differ significantly among themselves; there are significant differences during the first two months between the stimulants applied to them in descending order: Ethrel, acetylene, 2,4,5-T. Most of the variation among the five additional treatments is accounted for by the much greater yields in Treatment No. 49 with the initial high dose of Ethrel and changed site of application.

No marked interaction between stimulants and lengths of cut is apparent in the yield per tree per tapping *(Table 4)* but it becomes obvious if the yield is expressed in milligrams of rubber per millimetre of cut per tapping *(Table 6)*. There is a striking increase in yield per millimetre as the length of cut is reduced, with all stimulants. During the first two months the effect is most marked with Ethrel followed by acetylene and 2, 4, 5-T. The influence of length of cut on the pattern of latex flow and the possible implications for yield stimulation were discussed by SOUTHORN AND GOMEZ (1970). It may also be noted that with two exceptions the yield per millimetre of cut is greater in the d/4 than in the d/2 tapping systems in the annual yields.

Treatments involving double cuts and hence panel changing gave increased yields in all combinations with and without stimulant, during the first two months *(Table 7)* but not consistently over the whole year. An increase in yield due to panel changing may be the result of extension of the drainage area. However, there may be further interactions with length of cut or the use of stimulants or otherwise; the design of

TABLE 4. ANALYSES OF VARIANCE

Source	Degree of freedom	Mean squares: g/tree/tapping, Annual	g/tree/tapping, First two months	lb/acre, Annual	lb/acre, First two months
Lengths of single cuts	3	14 982 ***	20 580 ***	9 373 740 ***	424 611 ***
Stimulants	2	1 041 *	12 644 ***	228 806 N.S.	256 352 ***
Frequencies of tapping	1	7 397 ***	8 640 ***	1 425 541 **	134 196 ***
Cuts × Stimulants	6	36 N.S.	296 N.S.	18 360 N.S.	4 330 N.S.
Cuts × Frequencies	3	1 035 **	989 (P<0.1)	129 769 N.S.	15 043 N.S.
Stimulants × Frequencies	2	870 *	2 314 **	310 787 N.S.	4 820 N.S.
Cuts × Stimulants × Frequencies	6	96 N.S.	505 N.S.	99 146 N.S.	9 485 N.S.
Single-cut treatments	23	2 611 ***	4 698 ***	1 379 143 ***	89 495 ***
Lengths of multiple-cut systems	2	2 487 ***	4 625 ***	4 013 529 ***	210 125 ***
Stimulants	2	256 N.S.	2 471 **	147 509 N.S.	111 649 ***
Multiple cuts × stimulants	4	42 N.S.	121 N.S.	59 019 N.S.	6 294 N.S.
Multiple-cut treatments	8	707 **	1 834 ***	1 069 769 ***	83 590 ***
Between additional treatments	4	3 300 ***	6 291 ***	100 832 N.S.	11 757 N.S.
Between groups of treatments	2	3 988 ***	7 619 ***	6 584 271 ***	536 521 ***
Between all treatments	37	2 348 ***	4 409 ***	1 455 414 ***	103 978 ***
Blocks	1	94 N.S.	26 N.S.	259 283 N.S.	6 173 N.S.
Effective error	36	212	379	161 759	8 432

* P < 0.05 ** P < 0.01 *** P < 0.001 N.S.: Not significant

TABLE 5. TWO-WAY TABLES FOR ANNUAL AND FIRST TWO MONTHS' MEAN YIELDS IN GRAMS PER TREE PER TAPPING

Length of single cut × frequency of tapping

Annual: Frequency \ Single cut	S/2	S/4	S/8	5 mm	Mean	S.E.
d/2	76.8	55.1	40.3	13.9	46.5	± 2.97
d/4	126.9	81.6	55.3	21.6	71.4	(8.5)
S.E.		± 5.94	(17.0)			
Mean	101.9	68.4	47.8	17.8	59.0	
S.E.		± 4.20(12.1)				

First two months: Frequency \ Single cut	S/2	S/4	S/8	5 mm	Mean	S.E.
d/2	97.5	70.6	52.9	19.0	60.0	± 3.98
d/4	150.3	95.3	71.4	30.3	86.8	(11.4)
S.E.		± 7.95	(22.8)			
Mean	123.9	82.9	62.2	24.6	73.4	
S.E.		± 5.62(16.1)				

Stimulant on single cut × frequency of tapping

Annual: Frequency \ Stimulant	2,4,5-T	Acetylene	Ethrel	Mean	S.E.
d/2	45.0	47.4	47.2	46.5	± 2.97
d/4	61.2	63.8	89.1	71.4	(8.5)
S.E.		±5.15 (14.8)			
Mean	53.1	55.6	68.2	59.0	
S.E.		±3.64(10.5)			

First two months: Frequency \ Stimulant	2,4,5-T	Acetylene	Ethrel	Mean	S.E.
d/2	41.5	63.7	74.8	60.0	± 3.98
d/4	49.5	82.2	128.7	86.8	(11.4)
S.E.		±6.89(19.8)			
Mean	45.5	72.9	101.7	73.4	
S.E.		±4.87(14.0)			

Stimulant × multiple-cut system

Annual: Multiple cut \ Stimulant	2,4,5-T	Acetylene	Ethrel	Mean	S.E.
S/2.d/2(2×2d/4)	75.8	76.9	84.8	79.2	± 5.94
S/4.d/2(2×2d/4)	57.9	68.8	67.4	64.7	(17.0)
4/5mm.d/2(2×2d/4)	29.5	37.1	50.3	39.0	
S.E.		±10.29(29.5)			
Mean	54.4	60.9	67.5	60.9	
S.E.		±5.94(17.0)			

First two months: Multiple cut \ Stimulant	2,4,5-T	Acetylene	Ethrel	Mean	S.E.
S/2.d/2(2×2d/4)	100.9	110.8	137.7	116.5	±7.95
S/4.d/2(2×2d/4)	57.2	92.7	96.7	83.1	(22.8)
4/5mm.d/2(2×2d/4)	40.2	58.8	85.6	61.5	
S.E.		±13.77(39.5)			
Mean	66.1	87.4	106.7	86.7	
S.E.		±7.95(22.8)			

Additional treatment

Annual: Treatment	Mean	S.E.
S/2.d/2.(Scraped and carrier only)	64.5	
S/2.d/2. Bromoethane	69.8	±10.29
S/2.d/2. (2×2d/4) (Scraped and carrier)	74.3	(29.5)
S/2.d/2. 2, 4, 5-T (Below cut)	78.1	
S/2.d/4. Ethrel (Initial high dose)	161.8	

First two months: Treatment	Mean	S.E.
S/2.d/2.(Scraped and carrier only)	75.5	
S/2.d/2. Bromoethane	90.9	±13.77
S/2.d/2. (2×2d/4) (Scraped and carrier)	98.4	(39.5)
S/2.d/2. 2, 4, 5-T (Below cut)	98.7	
S/2.d/4. Ethrel (Initial high dose)	214.5	

Note: Figures within brackets denote minimum significant difference ($P < 0.05$).

TABLE 6. ANNUAL AND FIRST TWO MONTHS' MEAN YIELD EXPRESSED AS MILLIGRAMS PER MILLIMETRE OF CUT PER TAPPING

Length of cut	Mean length of cut (mm)	Annual*						First two months†					
		2, 4, 5-T		Acetylene		Ethrel		2, 4, 5-T		Acetylene		Ethrel	
		d/2	d/4	d/2	d/4	d/2	d/4	d/2	d/4	d/2	d/4	d/2	d/4
S/2	495	164	237	154	230	148	302	186	202	186	284	213	424
S/4	235	211	297	238	315	255	430	195	224	341	373	356	617
S/8	115	379	351	333	477	340	613	245	257	462	670	663	923
5 mm	5	1 140	3 500	3 860	2 480	3 340	7 000	310	3 550	4 980	3 620	6 360	10 740

* Unstimulated control S/2.d/2 : 130 mg/mm/tapping
† Unstimulated control S/2.d/2 : 153 mg/mm/tapping

the present experiment does not permit elucidation of these points.

Mean Yields in Pounds per Acre

None of the interactions in the analyses of variance are significant for yield per acre *(Table 4)*. Therefore only the main effects in the orthogonally arranged treatments are given in *Table 8*; all these — lengths of cuts, stimulants and frequencies of tapping — are highly significant during the first two months. Comparisons between the stimulants show Ethrel to be superior to acetylene which in turn is superior to 2,4,5-T. Significant differences due to stimulants are not found in the annual data, which is a consequence of the declining responses already discussed.

There is no significant interaction between stimulants and frequencies of tapping in yield per acre per year (or during the first two months) by contrast with that seen in the analyses of the yields per tree per tapping. This arises because the favourable combinations in yield per tapping (Ethrel with d/4 systems) are tapped less often and contribute less to yield per acre over the whole period. The treatment with initial high dose of Ethrel was also tapped d/4 and not surprisingly does not differ significantly from the other additional treatments.

The response to bromoethane is disappointing even during the first two months. However, this and other halogenoparaffins have been studied separately (PAKIANATHAN, 1970).

Observations on Applicators

Experience with the expanded polystyrene applicators showed that it was very time-consuming to fix them to the trees and achieve a good seal. They often did not adhere well to the lightly scraped bark and therefore had to be resealed. The difficulty was partly due to the relative rigidity of the applicators; in addition, the expanded polystyrene was found to be somewhat permeable to liquids and to lack durability in the field. The design of the applicator was subsequently modified but it was also felt that the use of applicators might not be attractive in practice even if the alternative designs worked better.

Effects of Novel Stimulants on Trees

With any experimental yield stimulant, the possibility of deleterious effects on the trees must obviously be investigated. A progressive fall in the dry rubber content, an increased incidence of dryness at the tapping cut and bark damage are all effects which might occur and would be readily detectable.

TABLE 7. MEAN YIELDS IN GRAMS PER TREE PER TAPPING OF SINGLE AND DOUBLE CUT (PANEL CHANGING) SYSTEMS OF THE SAME INTENSITY FOR THE FIRST TWO MONTHS AND FOR ONE YEAR

Treatments	Annual		First two months	
	Single	Double	Single	Double
S/2.d/2 *versus* S/2.d/2. (2 × 2d/4)				
Control, scraped and carrier only	64.5	74.3	75.5	98.4
2, 4, 5-T	81.1	75.8	92.6	100.9
Acetylene	76.0	76.9	93.2	110.8
Ethrel	73.2	84.8	106.6	137.7
S.E.	±10.29		±13.77	
Min. sig. diff.*	29.5		39.5	
Mean	73.7	78.0	92.0	112.0
S.E.	± 5.15		± 6.89	
Min. sig. diff.	14.8		19.8	
S/4.d/2 *versus* S/4.d/2. (2 × 2d/4)				
2, 4, 5-T	49.5	57.9	45.3	57.2
Acetylene	56.0	68.8	81.8	92.6
Ethrel	59.9	67.4	84.7	96.7
S.E.	±10.29		±13.77	
Min. sig. diff.	29.5		39.5	
Mean	55.1	64.7	70.6	82.2
S.E.	± 5.94		± 7.95	
Min. sig. diff.	17.0		22.8	
Mean over all treatments	65.7	72.3	82.8	99.3
S.E.	± 3.89		± 5.20	
Min. sig. diff.	11.1		14.9	

*$P < 0.05$

Dry Rubber Content

Determinations of the dry rubber content (d.r.c.) were made on latex from the untreated S/2.d/2 control and trees treated with Ethrel, acetylene, bromoethane or 2,4,5-T on the same tapping system (Treatments No. 1, 4, 5, 50 and 43). They were also made on latex from trees tapped S/8.d/2 and treated with Ethrel, acetylene or 2,4,5-T (Treatments No. 25, 26 and 23). These tapping systems were chosen because they represented two widely different tapping intensities and because it was impractical to sample all the treatment in the experiment.

For each of the treatments sampled, a determination of d.r.c. was made twice each month from each of the two groups of five trees in each treatment (see 'Tapping system').

TABLE 8. ANNUAL AND FIRST TWO MONTHS' MEAN YIELD IN POUNDS PER ACRE

Single cut	Annual	First two months	Multiple-cut system	Annual	First two months
S/2	2572	569	S/2.d/2(2 × 2d/4)	2806	775
S/4	1772	398	S/4.d/2(2 × 2d/4)	2446	566
S/8	1265	300	4/5mm.d2(2 × 2d/4)	1244	402
5 mm	467	119			
S.E.	±116.1	±26.5	S.E.	±164.2	±37.5
Min. sig. diff.*	333	76	Min. sig. diff.	471	108
2, 4, 5-T	1497	221	2, 4, 5-T	2035	447
Acetylene	1412	344	Acetylene	2122	576
Ethrel	1648	474	Ethrel	2339	720
S.E.	±100.6	±23.0	S.E.	±164.2	±37.5
Min. sig. diff.	289	66	Min. sig. diff.	471	10.8
d/2	1691	399			
d/4	1347	294			
S.E.	±82.1	±18.8			
Min. sig. diff.	236	54			

*$P < 0.05$

The four values so obtained were averaged to give a 'monthly d.r.c.' for the treatment concerned.

The 'monthly d.r.c.' of latex from trees treated on S/2.d/2 with Ethrel or acetylene was generally below that of the untreated control but the effect did not appear to be serious or progressive. The lowest monthly d.r.c. with S/2.d/2–Ethrel was 28.1 and with S/2.d/2–acetylene 29.7 For the untreated control the lowest value was 36.1. The lowest value was 28.2. with S/2.d/2–2,4,5-T and 36.9 with S/2.d/2–bromoethane, These minima were observed around the middle of the first year.

The general level of d.r.c's from the S/8 treatments was higher than that from the S/2 treatments. Again, there was no profound or progressive drop in d.r.c. under the action of the novel stimulants.

A more detailed account of d.r.c. results seems unjustified while there appeared to be no indication that any of the experimental treatments had to be rejected on the basis of their effect on d.r.c.; it was obvious that further experimentation would be needed to define the effect accurately.

Incidence of Dryness

Tapping cuts were inspected regularly and the incidence of partial or total dryness was recorded. At the end of the first year, eight trees out of the 380 in the experiment were completely dry at the cut. This is quite a small incidence of dryness for trees of this age and the dry trees appeared to be randomly distributed among the treatments. Some trees were observed during the year to go completely dry at the cut and then to recover.

Bark Damage

Bark damage, as already noted, occurred on many of the trees where 2,4,5-T was applied near the base. This took the expected form of proliferation of hard, corky tissue with a cracked and lumpy surface. There was also 'bleeding' of latex from such sites.

The bark inside applicators for Ethrel and acetylene was examined early in the second year when the original applicators were no longer being used. In treatments with the standard dose of Ethrel, there was extensive corky proliferation at the site of application but the thick outer layer was distinctly different from that produced by 2,4,5-T. It was much softer and spongier and could be detached very readily from the latex-bearing tissue beneath. Cracking and 'bleeding' appeared in only a few cases.

In the group of trees (Treatment No. 49) which received an initial high dose of Ethrel (and of propylene glycol), observations were made at a much earlier stage when the site of application was changed. In this case, cracking and 'bleeding' were common; proliferation of cork also developed. It was not clear whether the various effects observed were due to Ethrel alone or whether the propylene glycol contributed to them. A further possibility was an effect of the peculiar (probably unhealthy) environment within the closed applicators.

The bark inside acetylene-applicators showed a corky proliferation rather similar to that seen with Ethrel. No cracking or 'bleeding' was observed.

Bromoethane produced a distinctly different type of damage. There was little proliferation but the bark inside the applicator became extremely hard, cracked and dry; parts of it appeared to be dead.

The observations with Ethrel and acetylene suggested that they were potentially less damaging than 2,4,5-T. RIBAILLER AND D'AUZAC (1970) have concluded that Ethrel does not provoke the disorgansied proliferation of tissue caused by 2,4-D or 2,4,5-T.

Changes in Methods in the Second Year and Preliminary Results

The results from the first year of the experiment showed that when Ethrel was applied to trees in applicators on a fixed site, the response deteriorated with successive reapplications. There was a renewed response to Ethrel in Treatment No. 49 when the site was changed. By the time Experiment LF.1 had been running for a year, other experiments (described in subsequent papers) had confirmed the necessity of changing the site of application of Ethrel to bark and had also shown that Ethrel was effective when 'injected', *i.e.*, placed in a borehole drilled into the wood near the base of the tree.

Therefore, the use of applicators for Ethrel was discontinued at the beginning of the second year; in all but one of the Ethrel treatments application was made by 'injection' into a borehole. In the exception (Treatment No. 49), reapplication of Ethrel was made to scraped bark below the cut in a palm oil carrier.

Such techniques are the subject of later papers in this series and will not be detailed here. The results are of some interest, though they must be regarded with caution because of the short period of time to which they refer. The response to Ethrel at the first application of the second year was, in most treatments, comparable to or greater than that seen a year earlier with Ethrel-in-applicator. In the one treatment where Ethrel was applied in palm oil, the response was approximately equal to that obtained by injection. With every tapping system, the yields (total per month) were greater than those obtained with 2,4,5-T and with one exception the yields from short cuts, micro-cuts and systems of reduced frequency were greater than from the unstimulated S/2.d/2 control, *during the first month.* The exception was Treatment No. 38, 5 mm. d/4. Although the yield in this case did not reach that of the S/2.d/2 control, the increase in yield after treatment was large.

Overall, the results confirmed the expectation that trees which had ceased to respond to Ethrel would do so again if the site of application was changed.

Although results from the first year showed that acetylene was generally less effective than Ethrel, it seemed possible that changes in the method of application might improve its performance. Two different methods of application were tried at the beginning of the second year. In the first, an attempt was made to inject acetylene from a generator containing carbide and water into a borehole near the base of the tree. This was abortive. In the other a modified applicator was used, which was designed to bring acetylene into contact with a much larger area of bark [somewhat as in the experiments of BANCHI (1968), BANCHI AND POLINIERE (1969) and ABRAHAM *et al.* (1968)].

With this second procedure, the initial response to acetylene was very striking. With every tapping system the trees out-yielded, *in the first month*, those treated with 2,4,5-T or Ethrel. The yields from short cuts and micro-cuts were particularly noteworthy since with all but one of these systems the yields were greater than those from the S/2.d/2 control. The performance even of the exception (Treatment No. 38, 5 mm d/4), was rather remarkable since the amount of latex obtained from this minute cut, tapped fourth-daily, approximately equalled that from the S/2.d/2 unstimulated control.

The very high yields obtained from micro-cut systems with acetylene in the modified applicator and with 'injected' Ethrel recall the prediction of SOUTHORN (1969b) and SOUTHORN AND GOMEZ (1970) that, with a sufficiently active anti-plugging agent, flow from a very short cut "should continue at a low rate for a very long period". However, much more experimentation will be needed to determine whether the result can be reproduced on a large scale, with repeated applications and without damage to the trees.

CONCLUSION

This trial showed that Ethrel was a very promising stimulant, superior to 2,4,5-T especially with systems of reduced tapping intensity. It was also evident that when Ethrel is applied to bark, means must be found to change the site of application in order to maintain response.

Acetylene gave results qualitatively similar to those with Ethrel. With the applicator used during the first year, the results were in general quantitatively inferior to those with Ethrel. As with Ethrel, it appeared necessary to change the site of application periodically. Preliminary results with the modified applicator indicated that acetylene was worthy of further investigation: optimum conditions for its use have not yet been defined.

Although they served the purposes of the experiment, none of the treatments used in the first year would appear to have application to plantation practice. The reasons are obvious from the foregoing Discussion; the development of more practicable procedures, especially with Ethrel, is described in the next paper in this series.

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