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Studies on Tree Dryness. I. A Simple and Rapid Method of Inducing Dryness in Hevea *Trees*

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This method of inducing dryness in Hevea *trees involves puncture of the bark at four or five points along vertical strips on the panel before and after conventional tapping and sealing the punctures with drawing pins. This procedure is repeated at weekly or fortnightly intervals with fresh punctures made below the preceding ones. This technique has been shown to be effective for inducing dryness in a wide range of* Hevea *cultivars. However there are differences in the rate at which dryness is induced on virgin and renewed bark of a given cultivar. This technique of inducing dryness in trees under normal intensities of tapping may be a more promising method of studying changes in physiological parameters that may be associated with onset and development of dryness in* Hevea *trees than that based on very intensive methods of tapping.*

This paper also discusses changes in other related parameters such as yield, initial flow rate and dry rubber content in trees subjected to this technique. Further studies are in progress to establish if any of these could be developed as an early warning signal of impending dryness in Hevea *trees.*

The sudden development of dryness with part or the entire length of the tapping cut drying up in otherwise normally yielding rubber trees, has been a common phenomenon in rubber plantations for a long time. In attempts to study the physiological factors related to the development of dryness in rubber trees, researchers resorted to employing very intensive tapping systems to induce dryness in trees, which eventually caused trees to dry up because of the excessive drainage of latex[1,2,3]. The physiological changes that occur in the tree as a result of intensive tapping may not be a reflection of the changes that may be occurring in trees that dry up naturally when tapped at normal tapping intensities[4,5].

It was therefore considered useful for purposes of physiological investigations to develop a technique that could artificially induce dryness in trees tapped at normal tapping intensities. The accidental observation in the field of increased incidence of dryness in trees repeatedly used for turgor pressure measurements led to the development of a technique which was found to be very effective in inducing dryness in trees tapped at normal tapping intensities. This paper discusses this technique and its effectiveness in inducing dryness in various *Hevea* cultivars tapped either on virgin or renewed bark.

MATERIALS AND METHODS

Choice of Trees

Trees of various cultivars which had no incidence of dryness or history of dryness were selected for the experiments. The trees for the various treatments in each

COMMUNICATION 718

experiment were selected on the basis of 10–12 pre-treatment yield recordings. The experimental details together with details of clones and panels are summarised in *Table 1.*

Tapping

In all experiments, trees were tapped on $\frac{1}{2}$S d/2 system both during the pre-treatment and post-treatment periods.

Panel Preparation

Strips in a vertical direction were made on the panel originating from the tapping cut and running down the panel. The strips which were lightly scraped were of 2 cm width and the length varied from 30 cm to 90 cm. There were generally three to four strips per panel and these were made equidistant from each other

TABLE 1. EXPERIMENTAL DETAILS

Experiment No.	Clone	Panel	No. of trees per treatment
1	GT 1	A	2 trees Control – 4 trees
2	RRIM 701	A	5 trees Control – 5 trees
3	RRIM 701	A	5 trees Control – 5 trees
4	RRIM 600	A	2 trees Control – 5 trees
5	GT 1	A	2 trees Control – 2 trees
6	GT 1	A	3 trees Control – 3 trees
7	RRIM 701	C	5 trees Control – 5 trees
8	RRIM 600	C	5 trees Control – 5 trees
9	GT 1	C	5 trees Control – 5 trees
10	RRIM 623	C	5 trees Control – 5 trees
11	RRIM 628	D	4 trees Control – 4 trees
12	Unselected seedlings	B	3 trees Control – 6 trees
13	RRIM 701	A	5 trees Control – 5 trees

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below the half-spiral length of tapping cut.

Puncture Tools

The punctures in the bark were made with a piece of steel wire mounted on a wooden holder. The steel wire had a diameter of 0.7-0.8 mm and length of 2 cm. Drawing pins (nickel plated) of 0.7-0.8 mm diameter and 2 cm length were used to seal the punctures made in the bark.

Recordings/Observations

The yield consisting of No. 1 crop (latex) was recorded as the volume of latex while late drip was recorded as wet weight of cup lumps at each tapping. Recordings of initial flow rates (first 5 min flow) after tapping, dry rubber content (d.r.c.) determinations and dryness observations were generally carried out once in two weeks. The d.r.c. of representative samples of latex collected from the field were determined in the laboratory according to the method of Chin and Singh[6]. Incidence of dryness was expressed as the total length of dry cut as a percentage of the total length of tapping cut for the treatment. The values of all parameters given in this paper refer to the mean values of the respective treatments.

Development of the Technique

The technique was basically evolved by modification of certain procedures used for routine measurements of turgor pressures in *Hevea* trees[7]. The strips were punctured upto the wood commencing just below the tapping cut at three or four points equidistant from each other. The punctured points were then sealed immediately with drawing pins pushed into the bark upto the wood, minimising the amount of exudation of latex at each punctured point. The trees were then tapped normally. After tapping fresh punctures were made adjacent to the previous punctures and the punctured points were similarly sealed with drawing pins. The process was repeated either weekly or fortnightly as described in the experiments. The new round of punctures were made immediately below the previous punctured points at all positions as carried out previously. The punctures were sealed with the same drawing pins used in the earlier round except when the pins were broken or rusty.

RESULTS

The technique was evaluated and perfected in two initial experiments, *Experiments 1* and *2* on cultivars GT 1 (tapped on *Panel A*) and RRIM 701 (tapped on *Panel B*). In these experiments three lengths of strips and two frequencies of puncture were compared to establish the most effective combination for maximum induction of dryness. The results for three months of dryness incidence, yield, initial flow rates and d.r.c. are summarised in *Tables 2* and *3*.

The technique was very effective in inducing dryness in both cultivars irrespective of length of strip or frequency of puncture, as evident from the data. The incidence of dryness within the first month for GT 1 was as high as 77% in one treatment, while for RRIM 701, the highest was 48%. In clone GT 1 there was further increase in incidence of dryness in the second month for most treatments and no increase thereafter in the third month. However in RRIM 701, a different pattern of increase in incidence of dryness was recorded. In the second month there was generally no increase but in the third month there was a two-fold increase in most treatments to levels of 70%-80% dryness. The most effective combination for rapid and maximum induction of dryness in the first month

TABLE 2. SUMMARY OF DATA ON PERCENTAGE INCIDENCE OF DRYNESS, YIELD AND DRY RUBBER CONTENT
Experiment 1 – GT 1 (Panel A)

Treatment				Incidence of dryness (%)			Mean yield (g/tree/tapping)			D.r.c. (%)		
No. of strips	Length of strip (cm)	No. of points/ strip	Frequency of pricking	1st month	2nd month	3rd month	1st month	2nd month	3rd month	1st month	2nd month	3rd month
3	30	4	Weekly	57	78	68	27.5	21.8	23.3	41.2	41.2	44.2
3	60	4	Weekly	74	84	75	21.4	11.5	12.3	31.5	34.8	36.8
3	90	4	Weekly	77	76	71	26.3	12.6	10.6	36.3	36.1	38.0
3	30	4	Fortnightly	61	58	58	28.1	21.7	21.3	38.0	35.1	36.5
3	60	4	Fortnightly	49	47	64	28.9	24.2	19.4	34.0	32.2	34.5
3	90	4	Fortnightly	74	81	84	34.1	19.0	9.9	32.9	36.1	36.8
Control	-	–	–	2	4	Nil	29.4	28.7	20.4	31.3	34.2	31.0

TABLE 3. SUMMARY OF DATA ON PERCENTAGE INCIDENCE OF DRYNESS, YIELD, INITIAL FLOW RATE AND DRY RUBBER CONTENT
Experiment 2 – RRIM 701 (Panel A)

Treatment				Incidence of dryness (%)			Mean yield (g/tree/tapping)			Flow rate for 1st 5 min (ml/min)			D.r.c. (%)		
No. of strips	Length of strip (cm)	No. of points/ strip	Frequency of pricking	1st month	2nd month	3rd month	1st month	2nd month	3rd month	1st month	2nd month	3rd month	1st month	2nd month	3rd month
3	30	4	Weekly	35.6	41.1	81.5	40.8	42.8	11.3	2.6	1.2	1.7	45.0	35.7	41.5
3	30	4	Fortnightly	31.5	40.6	70.1	38.7	30.1	11.9	2.7	1.6	2.1	40.4	34.2	40.6
3	60	4	Weekly	47.9	35.8	69.2	56.3	58.4	23.4	3.7	2.4	2.7	38.2	37.1	40.9
3	60	4	Fortnightly	38.6	28.8	70.8	55.3	57.3	15.3	3.3	1.9	2.8	41.9	40.3	40.1
3	90	4	Weekly	29.7	31.6	70.9	52.6	51.7	9.7	3.2	1.6	2.2	38.1	36.7	38.8
3	90	4	Fortnightly	42.6	38.4	63.2	46.6	51.2	13.4	2.6	2.0	1.8	39.7	38.9	34.8
Control	–	–	–	Nil	Nil	Nil	69.7	77.1	34.3	4.1	3.9	4.0	34.1	36.2	34.3

in both cultivars was weekly puncture on a 60 cm strip.

A drop in yield of treated trees was recorded during the first month with clone RRIM 701 showing a greater decline than clone GT 1. However, a marked reduction in yield of treated trees (50%–70% below control yield) was recorded in the second and third months for both cultivars. The relationship between levels of dryness and yield was evident in the third month, when the greatest depression in yield was seen in treatments with the highest levels of dryness. In both cultivars, a marked decline in yield of treated trees was generally recorded when incidence of dryness exceeded 70%.

Initial flow rate measurements were only recorded for clone RRIM 701. A reduction in initial flow rates of treated trees relative to control was recorded for all treatments during the first month. A further sharp decline in initial flow rate of treated trees was recorded in the second month, with no further drop in the third month. The initial flow rates of most treatments were depressed to 40%–50% of those of control trees.

Generally for both cultivars higher d.r.c. values than control were recorded for treated trees of most treatments. The d.r.c. of treated trees were generally about 2–10 units above those of control trees. With the exception of a few treatments there were no marked changes in d.r.c. values of treated trees with progressive treatment from the first to the third month.

Effect of Age of Bark on Induction of Dryness

The induction of dryness on virgin and renewed bark of a similar clone was compared using the most effective combination of strip length and frequency of puncture, determined from the initial experiments. This comparison was carried out on three clones *viz.* RRIM 600, GT 1 and RRIM 701 and the results for dryness, yield and initial flow rates are given in *Figures 1–3.*

In all three clones dryness was more rapidly induced in virgin bark than in renewed bark. The incidence of dryness in trees tapped on virgin bark was markedly higher than that of trees tapped on renewed bark. Thus, in clones GT 1, RRIM 701 and RRIM 600 tapped on virgin bark, the incidence of dryness at the end of the first month was 70%, 48% and 60% respectively, while in trees tapped on renewed bark, the incidence

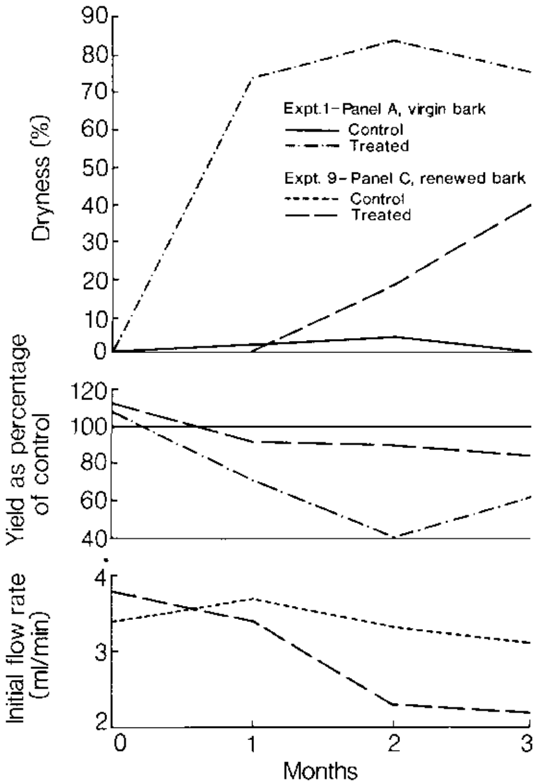

Figure 1. Percentage incidence of dryness, yield and initial flow rates for control and treated trees (four points, three strips, 60 cm length, weekly) of clone GT 1.

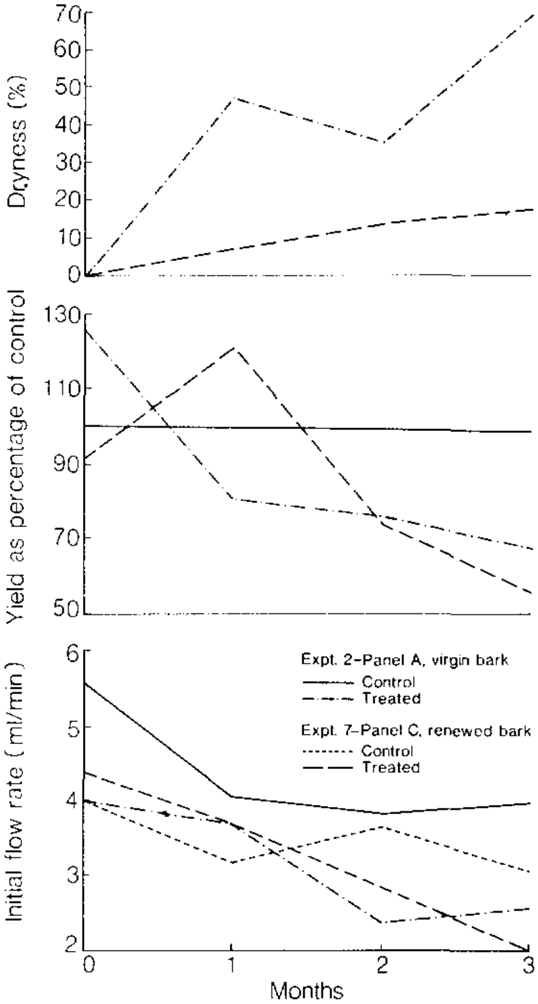

Figure 2. Percentage incidence of dryness, yield and initial flow rate for control and treated trees (four points, three strips, 60 cm length, weekly) of clone RRIM 701.

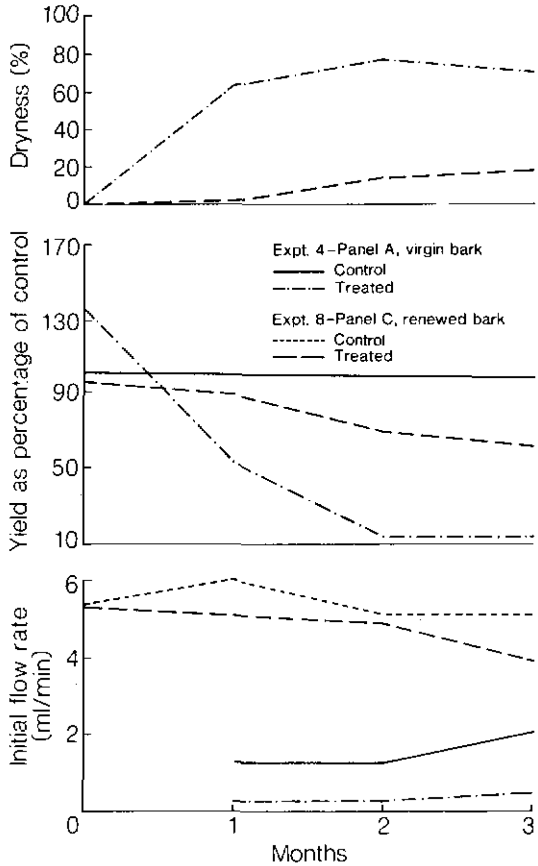

Figure 3. Percentage incidence of dryness, yield and initial flow rates for control and treated trees (four points, three strips, 60 cm length, weekly) of clone RRIM 600.

was less than 5% in RRIM 600 and RRIM 701, with no dryness in GT 1. An appreciable increase in incidence of dryness in trees of all three clones tapped on renewed bark was only noted after two months of treatment. However the levels of dryness induced after three months of treatment in trees tapped on renewed bark were still much lower than that in virgin panels at the end of the first month of treatment.

The differences in incidence of dryness between virgin and renewed bark were also reflected in the yield patterns. A marked depression in yield was evident from the first month of treatment for trees tapped on virgin bark, with trees of clones GT 1, RRIM 701 and RRIM 600 showing yield decline of 30%, 20% and 50% respectively. In trees tapped on renewed bark the decline at the end of the first month in clones GT 1 and

RRIM 600 was less than 10%, with no decline recorded for clone RRIM 701.

The initial flow rates of both trees tapped on virgin and renewed bark were depressed below those of control trees. However, in clones RRIM 701 and RRIM 600, a greater and faster rate of decline in initial flow rates was recorded for trees tapped on virgin bark.

The slower rate of induction of dryness by this technique of trees tapped on renewed bark was also observed for two other clones, RRIM 623 and RRIM 628, tapped on *Panels C* and *D* respectively. The results summarised in *Table 4* show that in RRIM 623 there was no incidence of dryness during the three months of treatment while in RRIM 628, low levels of dryness was only recorded after two months of treatment.

Induction of Dryness in Seedlings

The effectiveness of this technique in inducing dryness in seedling trees was tested in a trial on unselected seedling trees tapped on virgin panels. The results of this trial given in *Figure 4* show that the percentage incidence of dryness was 60% at the end of the first month of treatment. There was no further increase with continued treatment. The yield levels declined markedly after the first month of treatment, with a 70% depression at the end of two months of treatment. The initial flow rates of treated trees recorded marked decline from the first month of treatment, in comparison with control trees. The d.r.c. of treated trees remained higher than that of control trees throughout the three months of treatment.

Comparison of Sealing with No Sealing after Puncture

Studies on the effects of sealing after puncture on induction of dryness were carried out in two experiments on clones GT 1 and RRIM 701 tapped on virgin bark. The punctures made in the bark for the non-sealing treatment were not sealed

TABLE 4. SUMMARY OF DATA ON PERCENTAGE INCIDENCE OF DRYNESS, YIELD AND INITIAL FLOW RATE
Experiment 10 – RRIM 623; *Experiment 11* – RRIM 628

Clone		Incidence of dryness (%)			Mean yield (g/tree/tapping)			Flow rate for 1st 5 min (ml/min)		
		1st month	2nd month	3rd month	1st month	2nd month	3rd month	1st month	2nd month	3rd month
RRIM 623	Control	Nil	Nil	Nil	80.2	82.2	77.2	–	–	6.2
	Treated	Nil	Nil	Nil	81.3 (101)	83.9 (102)	71.6 (93)	–	–	5.2
RRIM 628	Control	Nil	1.5	Nil	53.8	46.0	22.2	–	2.4	5.3
	Treated	Nil	7.1	18.0	40.9 (76)	27.0 (59)	16.7 (75)	–	1.8	1.9

Treatment – six punctures on three strips of 60 cm length at weekly intervals

Figures in brackets refer to percentage values of control.

(–) No recording

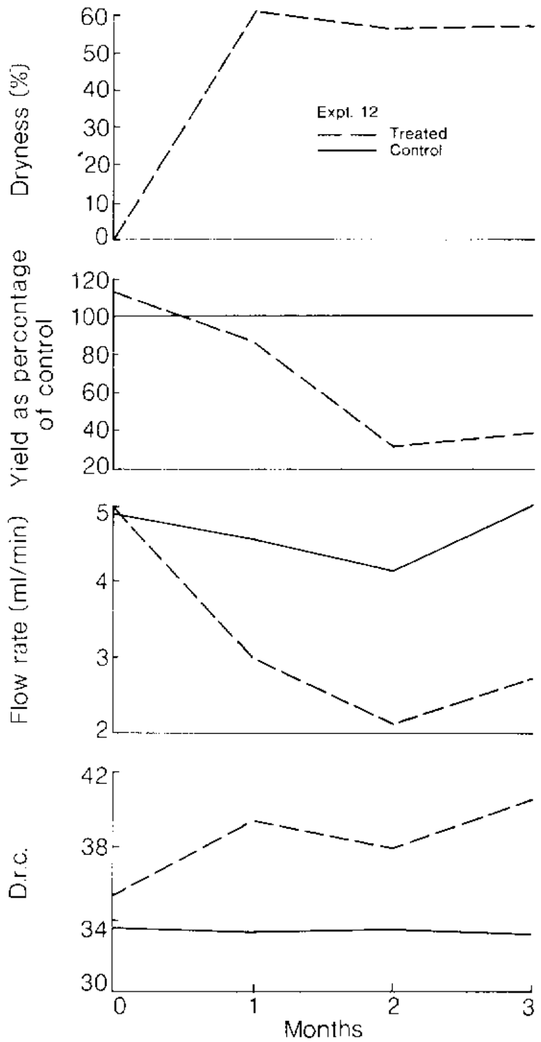

Figure 4. Percentage incidence of dryness, yield, initial flow rates and dry rubber content for control and treated trees (four points, three strips, 60 cm length, weekly) of unselected seedlings.

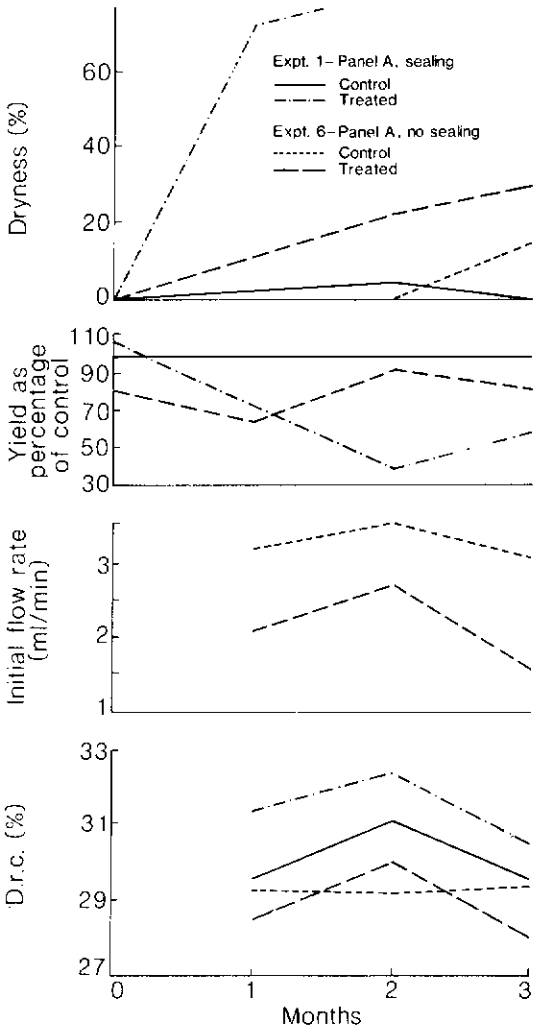

Figure 5. Percentage incidence of dryness, yield, initial flow rates and dry rubber content of clone GT 1, comparing treatments with sealing and non-sealing after puncture.

thus allowing free exudation of latex from punctured points. The treatment used was four points on three strips of 60 cm length punctured weekly. The results of percentage incidence of dryness, yield, initial flow rates and d.r.c. are given in *Figures 5* and *6*.

The percentage incidence of dryness for both clones GT 1 and RRIM 701 in treated trees with the punctures sealed was markedly higher than that of treated trees with the punctures not sealed. Thus, in both clones GT 1 and RRIM 701 at the end of the first month, trees with the

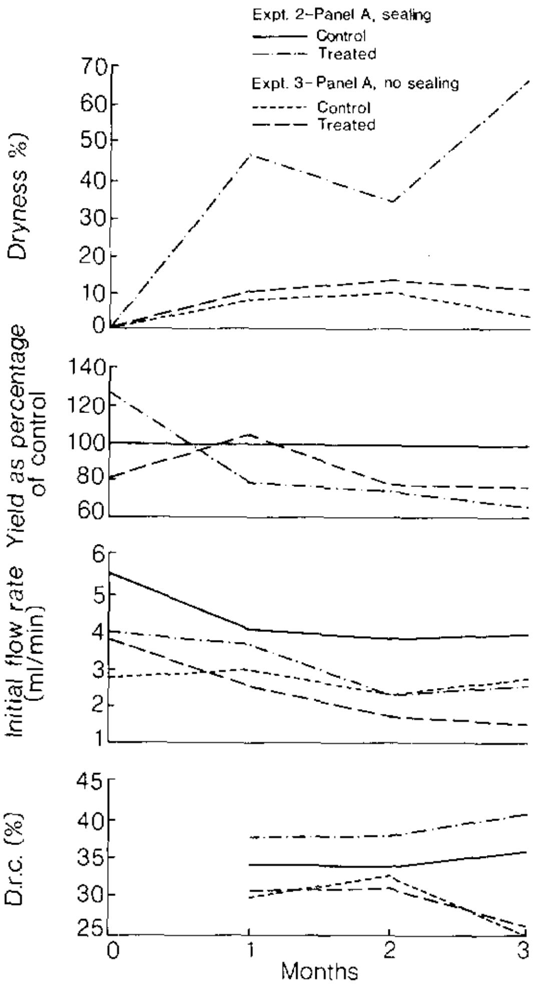

Figure 6. Percentage incidence of dryness, yield, initial flow rates and dry rubber content of clone RRIM 701 comparing treatments with sealing and non-sealing after puncture.

punctures sealed had 80% and 50% incidence of dryness while trees with the punctures unsealed had only 10% dryness. At the end of three months, treated trees of both clones with the punctures sealed had 70%–80% dryness while in contrast trees of clone GT 1 and RRIM 701 with the punctures unsealed had 25% and 10% dryness respectively.

The differences in percentage incidence of dryness between sealed and unsealed treated trees were also reflected in the yield pattern obtained. In both clones the yields of treated trees with the punctures sealed were depressed to a greater extent than those of treated trees with the punctures unsealed. Thus, in clones GT 1 and RRIM 701 the yields of treated trees with the punctures sealed declined rapidly to 60% and 25% below control yields respectively at the end of two months' treatment. In contrast trees of clones GT 1 and RRIM 701 with the punctures unsealed had only 10% and 20% depression in yields respectively at the end of three months.

The initial flow rates of both treated trees with the punctures sealed and unsealed were depressed below those of their respective control trees in both clones GT 1 and RRIM 701 throughout the duration of the treatment. A sharp decline in initial flow rates for both treatments was evident after the first month of treatment.

The d.r.c. of treated trees with the punctures sealed in both clones, GT 1 and RRIM 701 were higher than those of control trees, throughout the three months' duration. However, for trees with the punctures unsealed there were differences between the two clones. In clone GT 1, with the exception of the second month, the d.r.c. was lower than that of control, while in RRIM 701 there were no marked differences between the d.r.c. values of control and treated trees.

Comparison of Puncture and Sealing to Tapping Depth with that upto the Wood

In another experiment on clone GT 1, a variation of the technique to induce dryness was investigated. The first method was as described in the preceding experiments, while in the modified method, puncture and sealing were effected only upto the tapping depth. There were four points of puncture weekly on three strips of 60 cm length. The results of percentage incidence of dryness, yield, initial flow rates and d.r.c. are given in *Figure 7.*

Dryness was induced by both methods of puncture and sealing to tapping depth and wood. However, dryness was more rapidly induced in trees punctured and sealed to the wood with very high levels of dryness being recorded at the end of the first month of treatment. In trees punctured and sealed to the tapping depth, dryness developed more gradually with progressive increase to high levels in the third month of treatment.

The yield pattern however showed a similar decline for both methods. Thus the yields in treated trees were depressed by 25% below that of control trees at the end of the first month of treatment. The yields of treated trees continued to decline with progressive treatment and were 40%–70% below control yields at the end of three months' treatment.

The initial flow rates of trees punctured and sealed to tapping depth were depressed below that of control, throughout the duration of the treatment. A marked fall in initial flow rates of treated trees was recorded after the second month of treatment.

The d.r.c. of trees treated by both methods were higher than that of their respective controls throughout the duration of treatment. A similar margin of difference in d.r.c. values between control and treated trees was maintained irrespective of duration of treatment.

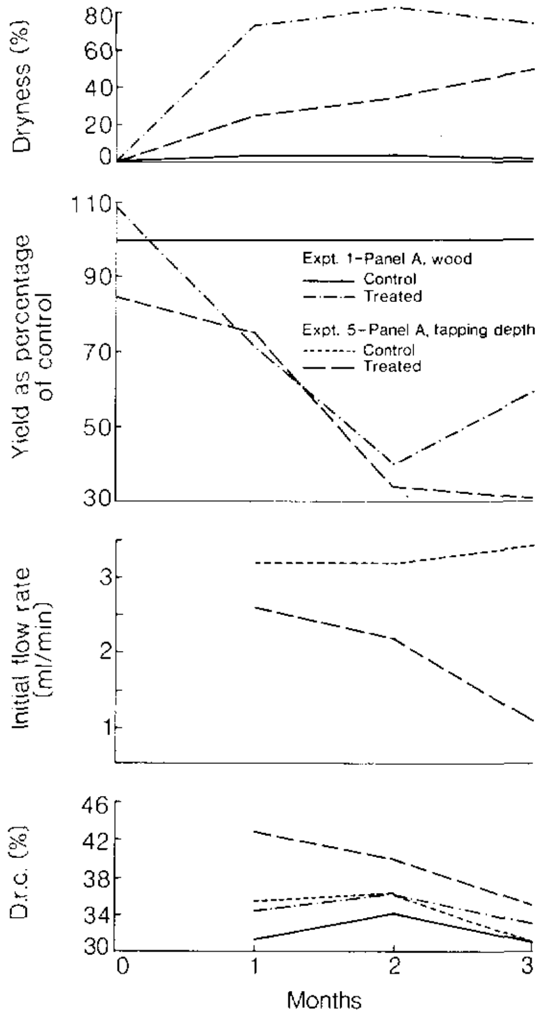

Figure 7. Percentage incidence of dryness, yield, initial flow rates and dry rubber content of GT 1 comparing two methods of puncture and sealing.

Induction of Dryness on Trees Stimulated with Ethephon

The above technique of induction of dryness was also evaluated on ethephon stimulated trees in comparison with non-stimulated trees. This experiment on RRIM 701 trees tapped on virgin bark had similar treatments to those described in the preceding experiments, namely four points of puncture weekly on three strips of 60 cm length. Stimulated trees were treated with 0.5 g of 5% ethephon (amchem formulation) applied to the groove monthly. The results of percentage incidence of dryness, yield, initial flow rates and d.r.c. are given in *Figure 8.*

The same levels of dryness were induced in both stimulated and unstimulated trees. Thus at the end of the first month the dryness in both groups of trees was 44%-45%. The subsequent increase in dryness in stimulated trees was greater than that of unstimulated trees. The incidence of dryness in unstimulated trees at the end of three months was 58% while in stimulated trees it was 74%.

However the yield pattern obtained was different in both stimulated and unstimulated trees. In trees with no stimulation there was marked decline in yield from the first month with a drop of 80% by the end of three months. In stimulated trees, there was an increase in yield above control yield (20% higher) *upto the second month of treatment* (positive response). A decline of 35% was only recorded at the end of three months.

The initial flow rates of both stimulated and unstimulated trees were equally depressed below those of control trees. After the initial depression recorded in the first month there was no further decline with progressive treatment for both groups of trees.

The d.r.c. of unstimulated trees as in the earlier experiments was higher than that of control. The margin of difference did not change with progressive treatment. However in stimulated trees the d.r.c. during the first two months was generally comparable to that of control, but declined after the second month to values lower than that of control at the end of three months of treatment.

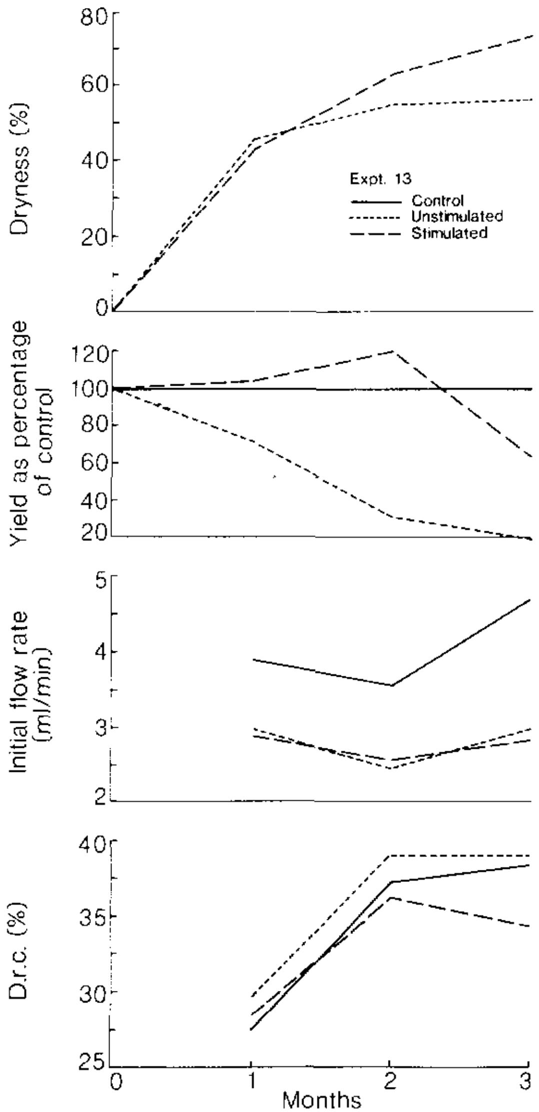

Figure 8. Percentage incidence of dryness, yield, initial flow rates and dry rubber content of RRIM 701 comparing stimulation with no stimulation.

DISCUSSION

Dryness can be readily and rapidly induced in *Hevea* trees under normal intensities of tapping using a simple technique of puncture of the bark and sealing. The external symptoms associated with dryness development induced by this technique were very similar to those seen in trees drying naturally or in trees induced dry by intensive tapping. This technique has been shown to be effective on a wide range of cultivars.

Although not conclusive, data presented in this paper seem to suggest that the age of the panel may have an influence on the rate at which dryness is induced. Thus in three cultivars, GT 1, RRIM 701 and RRIM 600, the induction of dryness in trees tapped on virgin bark was more rapid than in trees tapped on renewed bark. The slow process of inducing dryness with low levels of incidence on renewed bark was also demonstrated in two other cultivars, RRIM 623 and RRIM 628. The reasons for this difference between virgin and renewed bark are not clear but it may be related to observations made in numerous exploitation trials that generally, in most cultivars, the incidence of dryness in virgin panels are higher than that of renewed panels[8].

The experiments comparing sealing with no sealing after puncture seem to suggest that for the technique to be very effective there is a need to minimise exudation of latex at the punctured point, thus allowing for *in situ* coagulation of latex at the respective punctured and sealed points. These experiments also explain the reasons why there is normally only minimal incidence of dryness in puncture tapped trees[9]. This is largely because in puncture tapped trees exudation of latex from the punctured point is not impeded by an obstruction. In addition the outflow is aided by the presence of a yield stimulant on the bark.

Stimulation had no influence on the initial rate of induction of dryness by this technique though with time the levels of dryness in stimulated trees were higher than those of control trees. It is of interest to note that despite similar levels of dryness, the stimulated trees recorded yield increases during the first two months. In contrast the yields of unstimulated trees were markedly depressed below that of control from the first month of treatment. The increased yields must have come from non-dry latex vessels which must have been stimulated to flow longer thus sustaining higher yield levels for a limited period. It is apparent from this experiment that in stimulated trees there may be a time lag before the effects of high levels of dryness are reflected in the yields obtained.

Studies of changes in relevant physiological parameters and other related investigations are currently in progress to ascertain the mechanism or mechanisms by which this technique induces dryness in *Hevea* trees. However an examination of the mechanisms that have been proposed in the past[2,3,4] to explain dryness development in *Hevea* trees suggests that the mechanism associated with exhaustion particularly of specific constituents of latex resulting from excessive drainage of latex, may not be a likely mechanism to account for dryness development induced by the technique described in this paper. The basis for this conclusion is the fact that in these trees there was no excessive drainage of latex but on the contrary the levels of latex extracted were lower than those of control trees which had no incidence of dryness. It is also reasonable to suppose that the mechanism will be one which is not linked with depletion or lack of metabolites at the tapping panel. This is evident from the experiment comparing puncture to tapping depth with that to the wood, which seems to suggest that the interruption of flow of translocates along the trunk of the tree arising from possible damage to the vascular tissues may not be a primary factor contributing to dryness development in these experiments. It will be necessary when formulating a mechanism to explain this method of induction of dryness to take into account the differences between the rates of induction of dryness on virgin bark with that on renewed bark.

It is reasonable to suppose that the mechanism advanced to explain dryness development induced by this technique will be one that may be more closely related to the mechanism causing natural dryness development in *Hevea* trees as opposed to mechanisms deduced from studies carried out on intensively tapped trees.

The results show associated changes in certain related parameters such as initial flow rates, yield and d.r.c., in trees subjected to this technique of induction of dryness. The magnitude of change in these parameters in relation to levels of dryness varied between different cultivars. It is of interest to study in greater detail these changes to determine if one of these parameters can be developed as an early warning signal of impending dryness in *Hevea* trees. In view of this further work is in progress to monitor changes in these parameters, over a longer period so that more data can be obtained to establish effective correlations prior to selection of an appropriate early warning signal.

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