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The Effect of Direction of Tapping and Position of Cut on Yield Responses to Stimulation

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Tapping systems tapped upwards from the union with no restrictions in drainage area generally gave higher yields and better responses to stimulation than corresponding systems tapped in a downward direction. Similarly, the novel tapping system of two quarter-cuts opened at height of 76.2 cm from union and tapped upwards and downwards with exploitation of different drainage areas gave better yields and responses than the conventional ½S d/2 system. There were no marked differences in d.r.c. values between upward and downward tapped systems. With some exceptions the extent to which stimulation depressed d.r.c. relative to respective unstimulated trees was comparable for both directions of tapping. The incidence of dryness was markedly higher on downward tapped cuts than upward tapped cuts on trees with and without stimulation. The decline in yields and marked increase in incidence of dryness observed when downward tapped cuts were close to the union was not evident on upward tapped cuts.

The results suggest that the positive effects of upward tapping is mainly due to unlimited drainage area. This is most apparent when an intensive exploitation system with heavy drainage of latex is used. There is a tendency towards depressed yields and reduced responses to stimulation despite exploitation of different drainage areas when the bark adjacent to the bark on which the cut is located is not of the same age. The yield advantage of upward tapping might have been more favourable than that reflected by data given in this paper if it were not for a number of practical constraints associated with this mode of tapping. It is evident from the data that available drainage area is a critical factor determining performance of various exploitation systems and consequently productivity of the Hevea *tree.*

The increased yield obtained from stimulation is largely a consequence of prolonged flow as reflected in late drip. It has been demonstrated that the longer flowtime is sustained by an increase in drainage area induced by yield stimulants[1]. It is now believed that available drainage area as defined by the position of the tapping cut in relation to the stock/scion union has an influence on the magnitude of

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responses obtained from stimulation. This is evident from poor responses obtained when the cut approaches the union, which is generally attributed to limitations in drainage area[2]. Further, it seems likely that an excessive rate of extraction from the same drainage area could contribute to poor yields and negative responses to stimulation[3].

In view of the above knowledge it was considered useful to investigate yield responses to stimulation on tapping systems which do not have the drainage area confined to that bordered by the cut and the stock/scion union and which avoid continuous exploitation of the same area. Several of these tapping systems which were derived by varying the position of cut on the panel and the direction of tapping were evaluated in comparison with conventional tapping systems. The pattern of yield responses to stimulation, dry rubber content (d.r.c.) and incidence of dryness as influenced by variations in drainage areas are assessed and discussed in this paper.

MATERIALS AND METHODS

The experiments were carried out on clone RRIM 600 located at *Field 22*, Permatang Division, RRIM Station, Kota Tinggi, Johore and on clone GT 1 located at Pinang Tunggal Estate, Kedah. In the trial on clone RRIM 600 several tapping systems, with ¼S and ½S cuts tapped on d/2 frequency were evaluated together with ethephon stimulation. The cuts positioned on the same or opposite panels were either opened at a height of 150 cm from union and tapped downwards or opened just above the union and tapped upwards. The exception was one system where two quarter-cuts were opened on opposite panels at a height of 75 cm from union and with one tapped upwards and the other downwards. In the trial on clone GT 1, the system with two quarter-cuts opened at 75 cm from union and tapped either upwards or downwards on the same or opposite panels was evaluated in comparison with conventional systems.

The experiments were laid out in a randomised block design with two replications per treatment for RRIM 600 and five replications for GT 1. For RRIM 600 there were thirty-six trees per treatment per replicate, while for GT 1 there were fifteen trees per treatment per replicate. The trees for each treatment were selected on the basis of pre-treatment girth recorded at a height of 150 cm from union. In the trial on RRIM 600, ethephon formulated in palm oil at 5.0% concentration was applied to 4.0 cm scraped bark below cut three monthly, with four applications a year, for the first three years. From the fourth year ethephon in ready-to-use commercial formulation at 5.0% concentration was applied to groove monthly, eight times a year with no application during the wintering months. Similarly, for the trial on clone GT 1, commercial formulation at 2.5% concentration was applied to groove monthly for eight months with no application during the wintering months.

The yield was collected per treatment per replicate at each tapping and recorded as bulk wet weight of latex. The crop obtained from late drip after 11.30 a.m. was recorded as bulk wet weight of cuplumps. The d.r.c. of latex from each treatment per replication was also determined once every three to four tappings. The d.r.c. of cuplumps was calculated assuming a water content of 40% – 50%.

Observation for dry trees was made at two- or three-monthly intervals. The percentage of dryness (expressed as percentage incidence of dryness) was derived by expressing the total length of cut dry for the respective treatments as a percentage of the total length of cut of that treatment. Yield recordings and other measurements were carried out separately for each cut for systems with two quarter-cuts.

The data presented in this paper have been arranged and analysed as outlined below:

- Comparison of yields and responses as influenced by direction of tapping for ¼S d/2 (t, t) and ½S d/2 systems.
- Yields and responses of novel tapping system (2 x ↑ ↓ ¼S d/2) compared with ½S d/2 and ½S d/3 systems for clones RRIM 600 and GT 1 respectively.
- A comparison of depression in d.r.c. values of stimulated trees in relation to the various tapping systems.
- A comparison of dryness incidence in trees with and without stimulation in relation to the various tapping systems.

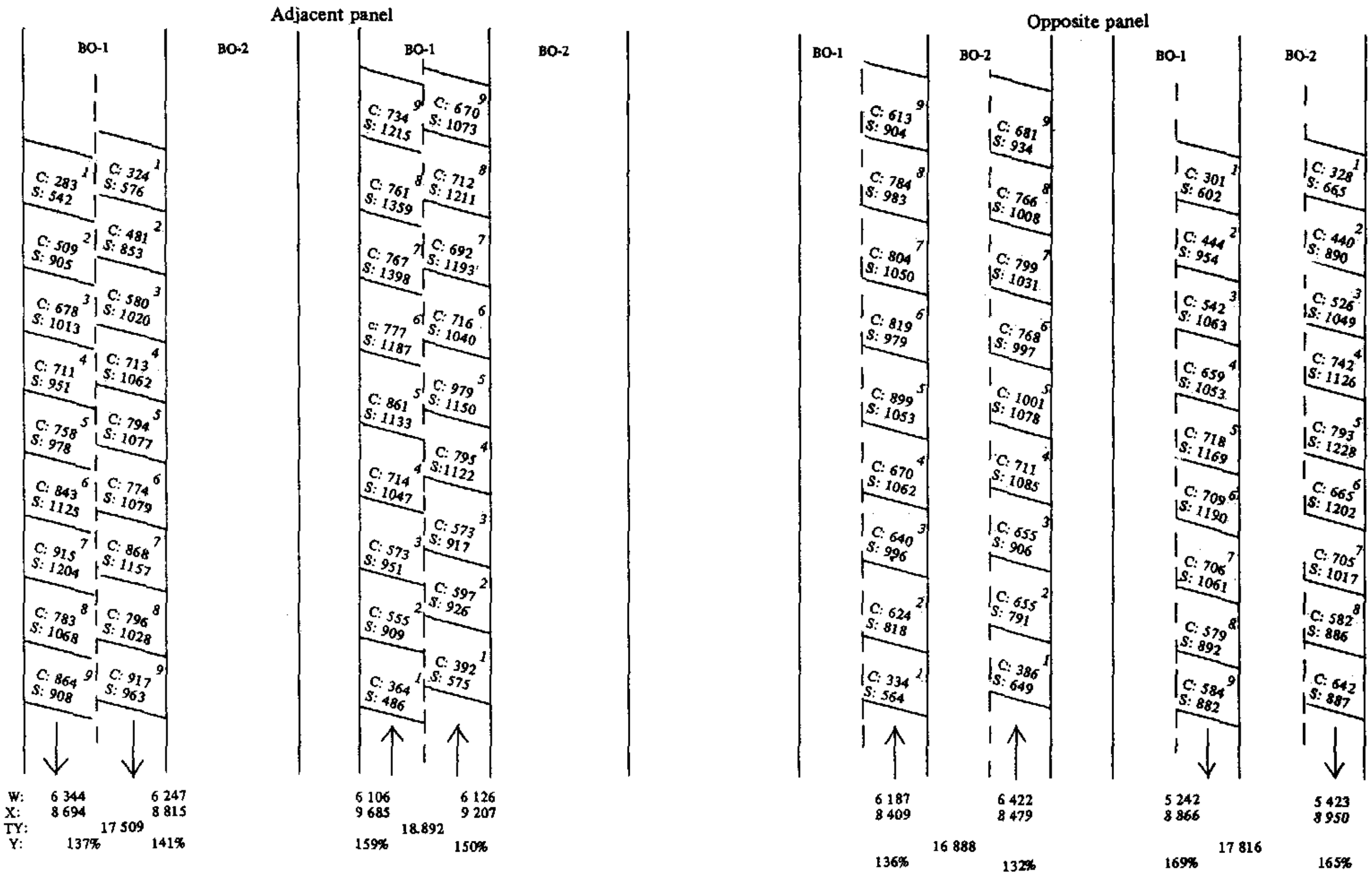
RESULTS

Influence of Direction of Tapping on Yields and Yield Response of Different Tapping Systems – RRIM 600

The yields obtained from tapping cuts opened at the conventional height of 150 cm from union and tapped downwards were compared with cuts opened just above the union and tapped upwards.

The results given in *Figure 1* compare yields obtained from ¼S d/2 (t, t) system tapped in upward and downward direction with the quarter-cuts adjacent to each other on the same panel and on opposite sides. The cumulative yields for nine years from unstimulated trees were not very different between adjacent quarter-cuts tapped downwards from the height of 150 cm and similarly placed quarter-cuts tapped upwards from the union. However, the cumulative yields from stimulated trees for nine years for quarter-cuts tapped upwards from the union were more than those of quarter-cuts tapped downwards. The excess in total yields was 1383 kg per nine years. The percentage response obtained over nine years was better for both quarter-cuts tapped upwards from union than that of quarter-cuts tapped downwards.

The percentage responses to stimulation during the ninth year for both quarter-cuts tapped downwards were marginal, with responses being markedly lower than those of preceding years. In contrast, cuts tapped upwards recorded good responses during the eighth and ninth years on both cuts, with responses comparable to preceding years. With exception of the first two years and the fifth year the responses to stimulation on upward tapped cuts were higher than those of the downward tapped cuts throughout the nine years' stimulation *(Figure 2)*. The responses on upward tapped cuts after the fifth year were markedly higher than those of the downward tapped cuts. However, on stimulated trees with cuts



W = Total yield for unstimulated panel
X = Total yield for stimulated panel
TY = Total yield obtained from nine years of stimulation
Y = Total yield of stimulated panel as percentage of total yield of unstimulated panel
C = Control
S = Stimulated

Figure 1. Comparison of upward and downward tapping with ¼S d/2(t, t) system – RRIM 600 (Panel BO-1/BO-2).

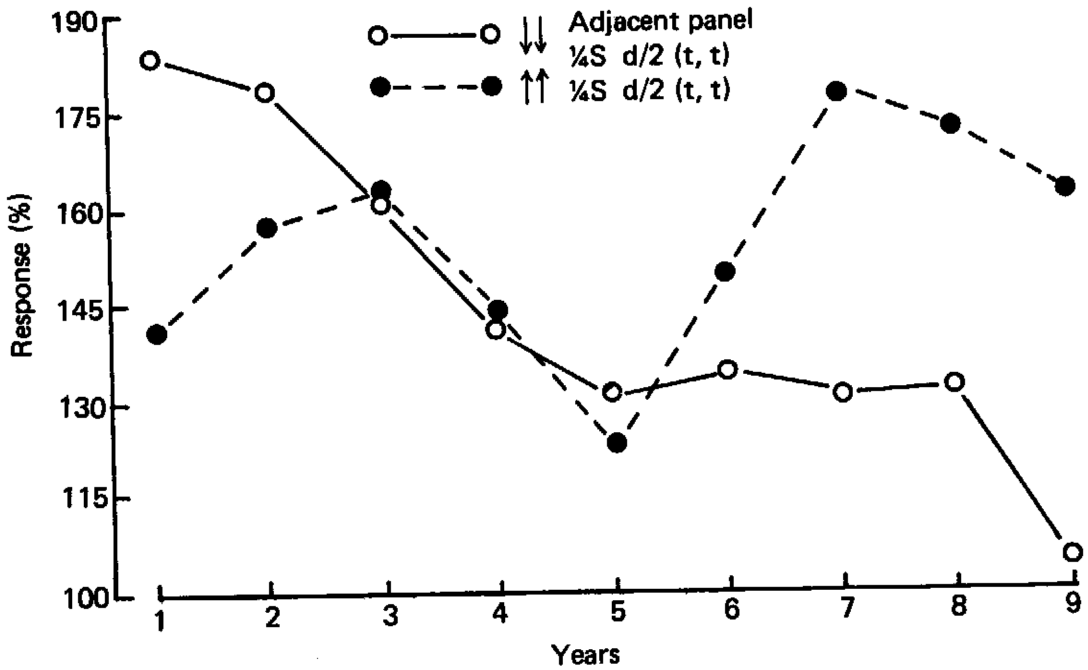


Figure 2. Comparison of response to stimulation between upward and downward tapping ¼S d/2 (t, t) systems.

tapped downwards there was decline in response after the third year with diminishing response after the eighth year due to the limitation in drainage areas as the cut approached the stock/scion union.

Yields obtained from ¼S d/2 (t,t) system with the quarter-cuts positioned on opposite panels showed that the cumulative yields for nine years from both quarter-cuts of unstimulated trees tapped upwards were in excess of those obtained from trees tapped downwards *(Figure 1)*. With stimulation, the cumulative yields for both quarter-cuts tapped upwards were about 400 – 500 kg lower than those of cuts tapped downwards.

As observed before in trees tapped downwards there was a decline in yields of both unstimulated and stimulated trees during the eighth and ninth years when the cuts were close to the union. In contrast, for trees tapped upwards, the yields of stimulated and unstimulated trees during the eighth and ninth years were comparable or only marginally lower than those of the preceding years.

Comparison between Quarter-cuts in Relation to Position on Panel

Downward tapping. In unstimulated trees, quarter-cuts positioned adjacent to each other on the same panel gave 800 – 1000 kg more yield than the quarter-cuts on opposite panels, at the end of nine years' tapping *(Figure 1)*. However, in contrast, stimulated trees with quarter-cuts on opposite panels gave marginally higher yields. In view of the lower control yields the responses to stimulation were better on quarter-cuts positioned on opposite panels for most of the nine years of stimulation. During the last year when cuts were close to the union, the responses of quarter-cuts adjacent to each other on the same panel declined sharply, while in contrast there was no marked decline on quarter-cuts positioned on opposite panels *(Figure 3)*.

Upward tapping. The quarter-cuts positioned on opposite panels gave 377 kg more yield than quarter-cuts positioned adjacent to each other on the same panel at the end of nine years' tapping in unstimulated trees *(Figure 1)*. However, the cumulative yields of stimulated trees with quarter-cuts on the same panel was 2000 kg more than those of trees tapped with quarter-cuts on opposite panels. The responses to stimulation with the exception of the first and fourth years were better on quarter-cuts on the same panel with levels of response obtained during the last three years (seventh to ninth years) being much higher (25% – 40% more) *(Figure 4)*. However, a decline in response was evident in these trees, with a fall in response of 14% between the seventh and ninth years. In contrast trees with quarter-cuts on opposite panels showed rising yield trend from the sixth year *(Figure 4)*. The erratic yield responses may be due to loss of crop with upward tapping caused by spillage.

The results given in *Figure 5* compare yields obtained on ½S d/2 (t,t) system. The cumulative yields obtained for eight years were markedly better for both cuts of unstimulated and stimulated trees tapped upwards. The total yield obtained from stimulated trees tapped upwards was 3000 kg more than that of stimulated trees tapped downwards. The responses of both the downward and upward

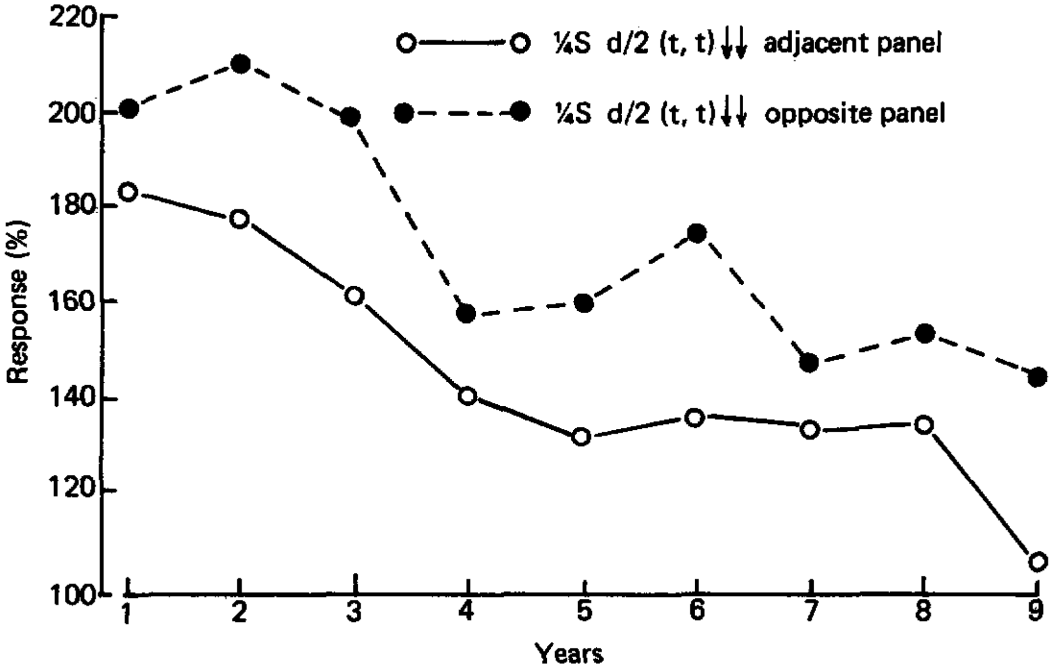


Figure 3. Comparison of response to stimulation between adjacent and opposite panels on ¼S d/2 (t, t) ↘↘ system.

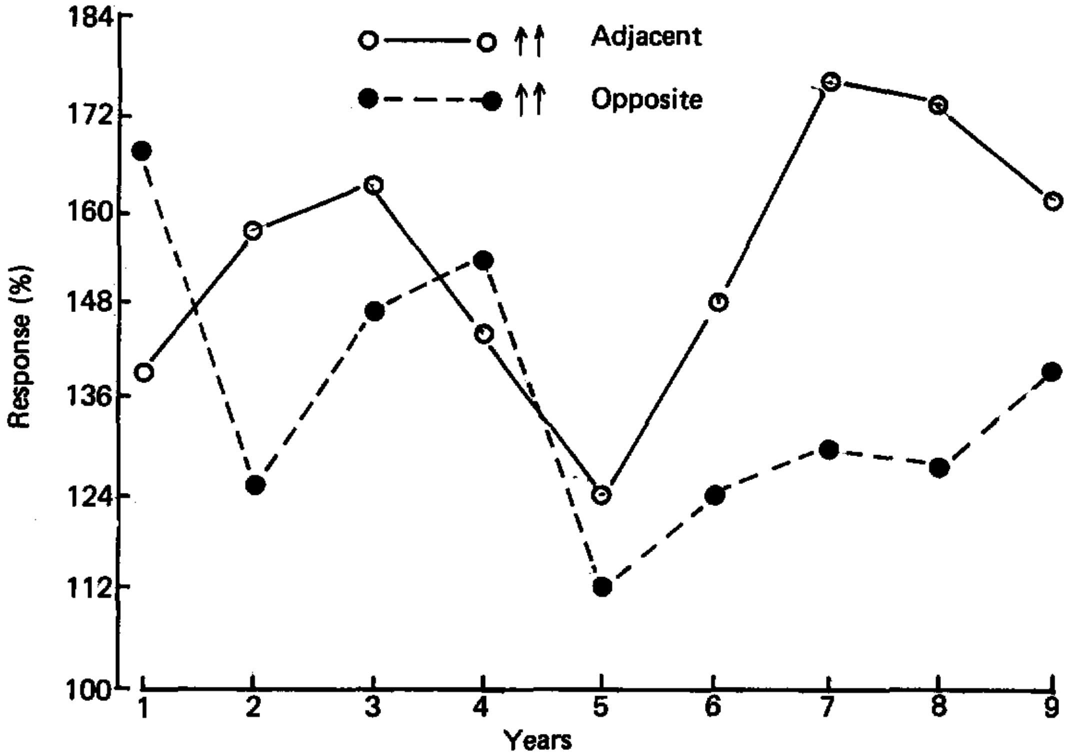
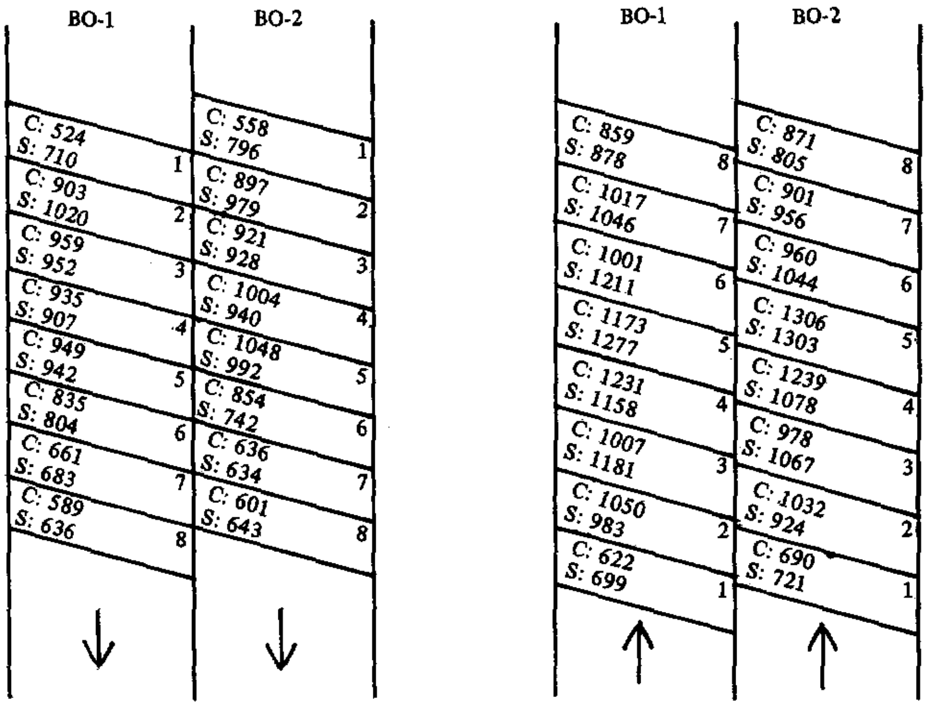


Figure 4. Comparison of responses to stimulation between adjacent and opposite panels on ¼S d/2 (t, t) ↖↖ system.



W :	6 355		6 519	7 960		7 977
X :	6 654		6 654	8 433		7 89
TY :		13 308			16 331	
Y :	105%		102%	106%		99%

W = Total yield for unstimulated panel
X = Total yield for stimulated panel
TY = Total yield obtained from nine years of stimulation
Y = Total yield of stimulated panel as percentage of total yield of unstimulated panel
C = Control
S = Stimulated

Figure 5. Comparison of upward and downward tapping with ½S d/2 (t, t) system – RRIM 600 (Panel BO-1/BO-2)

tapped cuts to stimulation on this system were poor or marginal for most of the eight years of tapping. Thus, the yields from stimulated trees at the end of eight years' tapping were only 2%–6% higher than those of the respective controls.

A marked difference in yields was evident between upward and downward tapped cuts for both unstimulated and stimulated trees during the seventh and eighth years of tapping. Thus, the yields obtained from upward tapped cuts on both unstimulated and stimulated trees were 676 – 540 kg higher than the downward tapped cuts during the seventh and eighth years respectively when the latter cuts were close to the union.

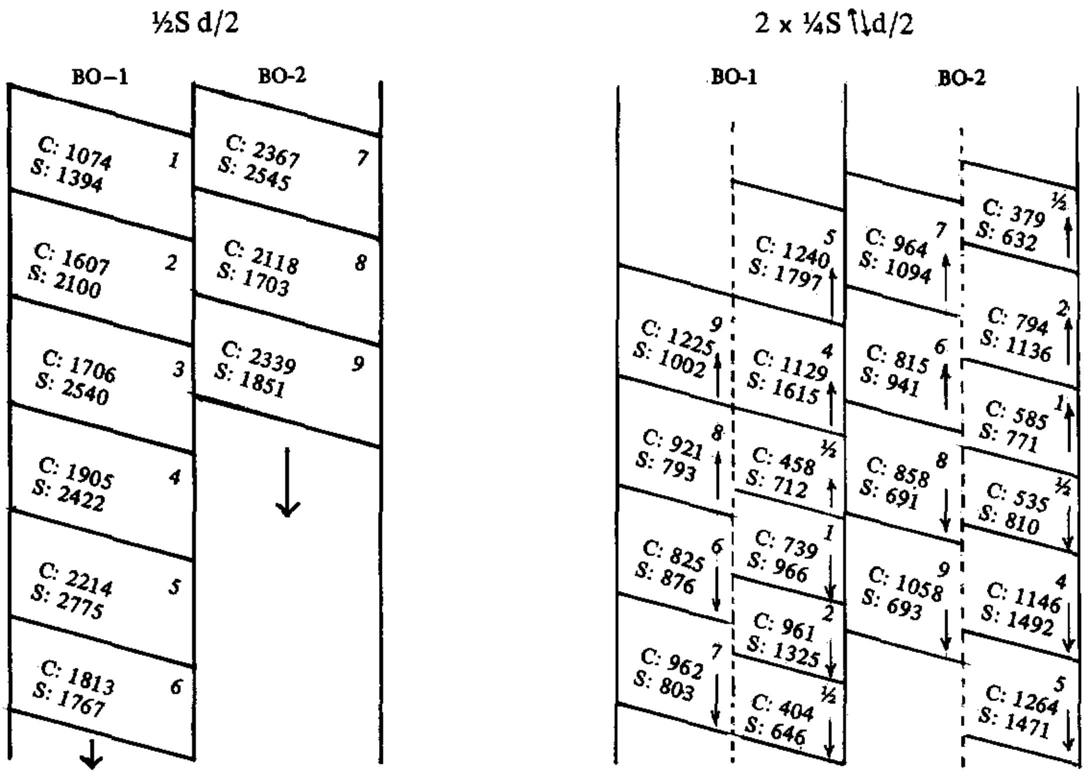
Comparison of Novel Tapping System with Combination of Upward and Downward Tapping with Conventional ½S d/2 Systems

The novel tapping system of 2 x $\uparrow\downarrow$ ¼S d/2, with two quarter-cuts opened at a height of 75 cm from union and positioned on opposite panels was tapped in both downward and upward directions. This system with position of cuts changed at intervals of two-and-a-half and two years was compared with the conventional ½S d/2 system opened at a height of 150 cm and tapped downwards.

The results of this comparison for clone RRIM 600 *(Figure 6)* show that the yields from unstimulated trees tapped on 2 x $\uparrow\downarrow$ ¼S d/2 system were higher (9% – 23% more) than those obtained from unstimulated ½S d/2 tapped trees during the first five years of tapping. Similarly, the responses to stimulation on 2 x ¼S d/2 system were better than those obtained on ½S d/2 system during the first five years. The responses to stimulation on ½S d/2 system declined after the third year, while for the 2 x ¼S d/2 system, good responses were maintained till the fifth year of tapping. The highest response to stimulation was recorded on 2 x ¼S d/2 system, which was 15% more than the best response obtained on ½S d/2 system.

During the first two-and-a-half years of tapping, there were no marked differences in yields between the quarter-cut tapped upwards and that tapped downwards for both unstimulated and stimulated trees. However, during the second two-and-a-half years, the yields obtained during the fourth and fifth years from stimulated quarter-cuts tapped upwards were better than those obtained from stimulated quarter-cuts tapped downwards. Similarly, the responses relative to respective controls were higher on the upward tapped cuts.

After the fifth year the responses to stimulation were generally negative on the conventional ½S d/2 system. The tapping cut of the conventional ½S d/2 system despite changeover to a new *Panel BO-2* after the sixth year, recorded only a marginal response in the first year (seventh year) with negative responses thereafter in the eighth and ninth years. Similarly, the yields of both unstimulated and stimulated trees tapped on 2 x ¼S d/2 system showed a decline and were lower than those of unstimulated ½S d/2 system after the fifth and sixth years respectively. The stimulated trees of this system showed a greater depression in yields than the stimulated ½S d/2 system after the sixth year. How-



		½S d/2	2 x ¼S ⇅d/2
W:	(Year 1–5)	8 506	9 634
	(Year 6–9)	8 637	7 628
X:	(Year 1–5)	11 231	13 373
	(Year 6–9)	7 866	6 893
TY:		19 097	20 266
Y:	(Year 1–5)	132%	139% (157)
	(Year 6–9)	91%	90%

W = Total unstimulated yield
X = Total stimulated yield
TY = Total yield obtained from nine years of stimulation
Y = Total yield of stimulated panel as percentage of total yield of unstimulated panel

Figure within brackets is response expressed as percentage of ½S d/2 control.

Figure 6. Comparison of novel tapping system (2x¼S ⇅ d/2) with conventional ½S d/2 system – RRIM 600 (Panel BO-1/BO-2).

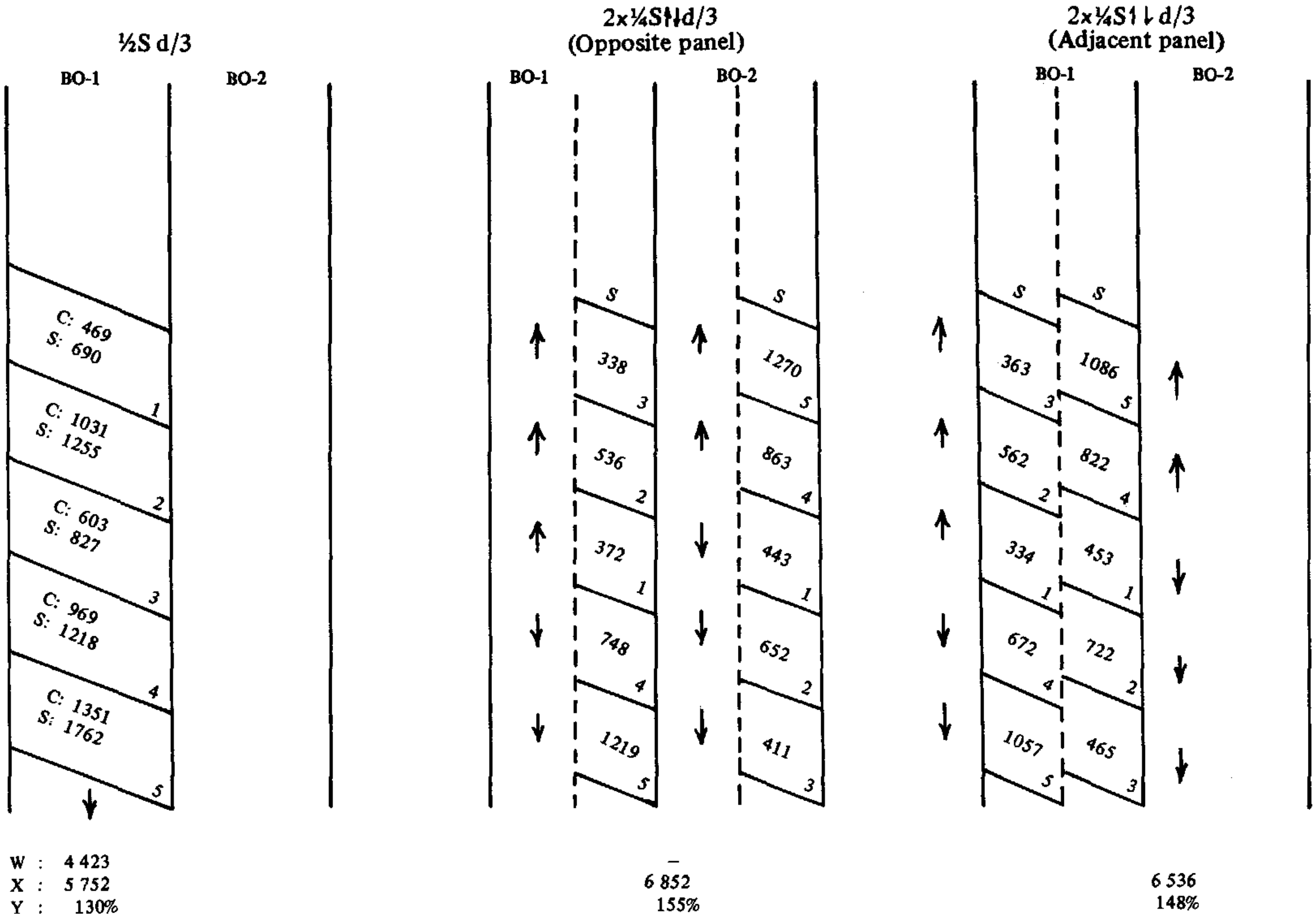
ever, there were differences in responses to stimulation between the quarter-cuts tapped upwards and downwards. Thus, in the sixth and seventh years, the quarter-cut tapped upwards showed a positive response to stimulation relative to its control, while for the quarter-cut tapped downwards the response to stimulation in the seventh year was negative relative to its control. In the eighth and ninth years both the quarter-cuts recorded negative responses though the yields of both unstimulated and stimulated quarter-cuts tapped upwards were markedly higher than those of corresponding quarter-cuts tapped downwards.

The 2 x ¼S d/3 system with cuts opened at a height of 75 cm from union and tapped upwards and downwards was also evaluated in another trial on clone GT 1 and the results are given in *Figure 7*. The quarter-cuts positioned either on opposite panels or adjacent to each other on the same panel were compared with the conventional ½S d/3 system. The cumulative yields for five years from both the 2 x ¼S d/3 system with stimulation exceeded those obtained from stimulated ½S d/3 tapped trees. The yields with quarter-cuts positioned on opposite panels were better than those obtained from adjacent quarter-cuts on the same panel. The response to stimulation at the end of five years was 18% – 25% more than that obtained on the ½S d/3 conventional system. The responses to stimulation throughout the five years' stimulation on 2 x ¼S d/3 system on opposite or adjacent panels were better than those obtained on ½S d/3 system.

During the first three years, the yields on both 2 x ¼S d/3 systems were generally higher on the downward tapped quarter-cuts than the upward tapped quarter-cuts. The yields from both the upward and downward tapped quarter-cuts were better on adjacent quarter-cuts on the same panel than those on opposite panels. However, this pattern was reversed during the fourth and fifth years after change in cuts at the end of three years. Thus, for both 2 x ¼S d/3 systems during the fourth and fifth years the yields from upward tapped quarter-cuts were better than those from the downward tapped quarter-cuts. Further, for both upward and downward tapped quarter-cuts, the yields were markedly higher on cuts positioned on opposite panels than on adjacent cuts on the same panel.

Dry Rubber Content in Relation to Position of Cut and Direction of Tapping: Comparison between Upward and Downward Tapping with ¼S d/2 (t, t) System

Adjacent panels. There were no marked differences in d.r.c. values between unstimulated trees tapped upwards or downwards *(Figure 8)*. A similar pattern with the exception of marginal differences was evident for both groups, with increasing d.r.c. values from the first year to the ninth year irrespective of direction of tapping. Thus, trees tapped downwards showed a progressive increase from a low value of 35 – 36 in the first year to a high value of 40.4 in the eighth year. Trees tapped upwards showed a progressive increase from a low value of 35 – 36 in the first year to a high value of 41 – 42 in the sixth year. D.r.c. values of stimulated trees in both groups were depressed to a similar extent below those of cor-



W = Total yield for unstimulated panel

X = Total yield for stimulated panel

Y = Total yield of stimulated panel as percentage of total yield of unstimulated panel

Figure 7. Comparison of novel tapping system (2x¼S ↑↓ d/3) with conventional ½S d/3 system – GT 1 (Panel BO-1/BO-2).

responding control trees throughout the nine years of stimulation. There was no further marked drop in d.r.c. values for both groups after the initial depression, though trees tapped upwards recorded marginally higher depression towards the later years.

Opposite panels. A similar pattern as described above for adjacent panel was evident for quarter-cuts positioned on opposite panels *(Figure 8).* There were no marked differences between d.r.c. values of quarter-cuts tapped upwards and downwards for unstimulated trees. The d.r.c. of stimulated trees for both directions of tapping was depressed below that of corresponding unstimulated trees. There was no further depression after the initial drop in d.r.c. values for trees tapped downwards. However, for trees tapped upwards a further drop relative to control occurred after the third year. The depression thereafter was uniform with the exception of the seventh year.

Comparison between Upward and Downward Tapping with ½S d/2 System

D.r.c. values of unstimulated trees were similar for both upward and downward tapped cuts during the initial three years.

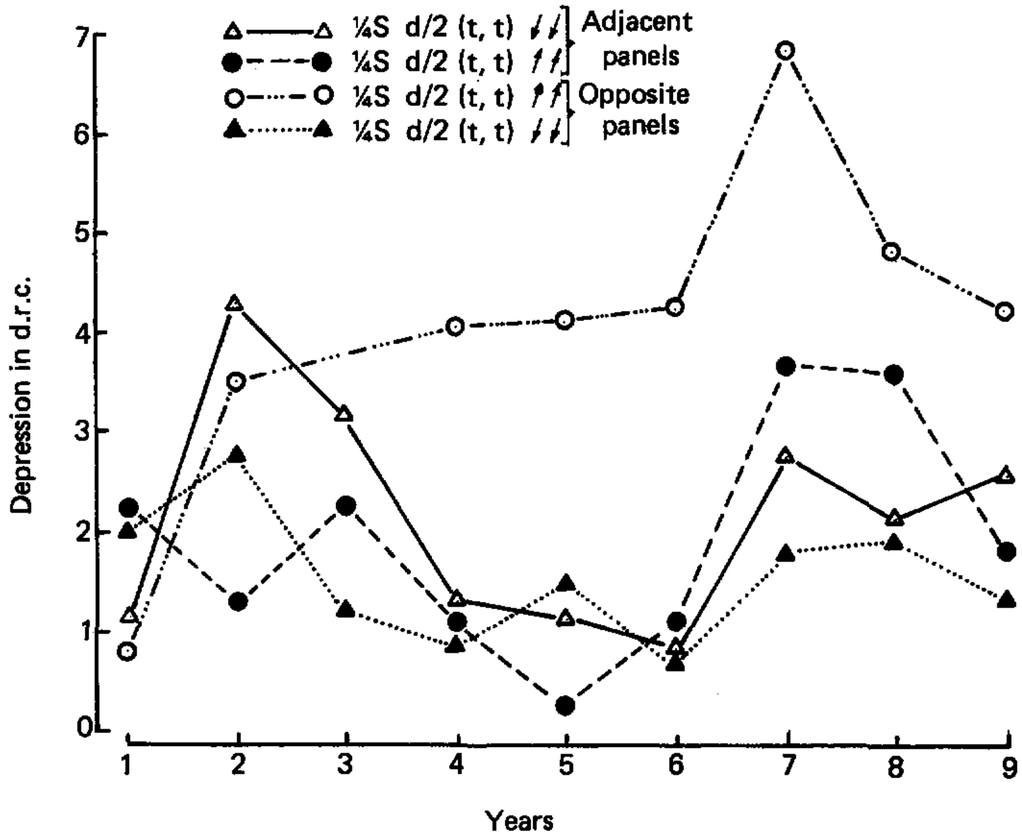


Figure 8. Depression in d.r.c. values of stimulated ¼S d/2 (t, t) system tapped upwards and downwards – RRIM 600 (Panel BO-1/BO-2).

However the d.r.c. values of upward tapped trees showed a progressive increase, with values during the later years being much higher than those of downward tapped trees. The depression in d.r.c. values of stimulated trees tapped downwards was marginal throughout the eight years of stimulation *(Figure 9)*. The depression in d.r.c. values of stimulated trees tapped upwards which was greater than that of downward tapped cuts, was only evident during the later years when the d.r.c. values of control trees showed an increase in values. However, the absolute d.r.c. values for stimulated trees were similar for both directions of tapping.

Novel Tapping System (2 x ¼S d/2 ↑↓ 76.2 cm)

The d.r.c. values of upward and downward tapped quarter-cuts of unstimulated trees were generally comparable for most of the nine years of tapping *(Figure 10)*. The depression in d.r.c. values of stimulated trees during the first three years was similar for both upward and downward tapped cuts. However, from the fourth year, a greater depression in d.r.c. values was evident on cuts tapped downwards, particularly during the eighth and ninth years of tapping. During the early years, the depression in d.r.c. values of stimu-

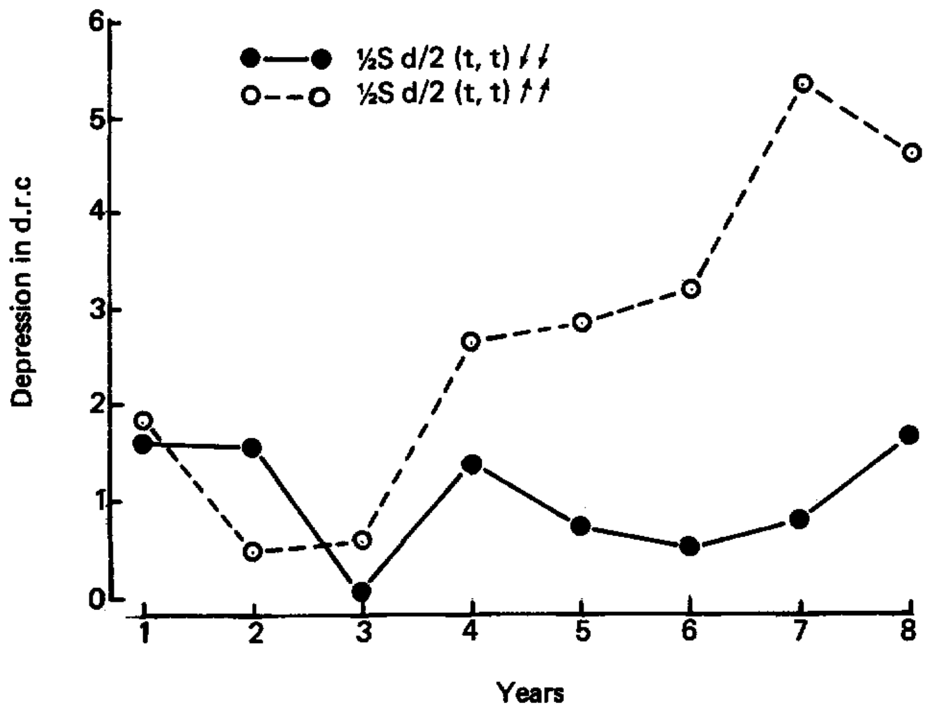


Figure 9. Depression in d.r.c. values of stimulated ½S d/2 system tapped upwards and downwards – RRIM 600 (Panel BO-1/BO-2).

lated trees was similar for both the conventional ½S d/2 system and the novel tapping system. However, during the later years, the depression on the downward tapped cut of the novel tapping system in contrast to the upward tapped cut was much higher than that of the conventional system.

negligible with the exception of the last three years when an increase was recorded *(Figure 11).* A contrasting pattern between upward and downward tapped cuts was evident for stimulated trees. Thus, for upward tapped cuts, with the exception of the first two years, the incidence of dryness was negligible or marginal for

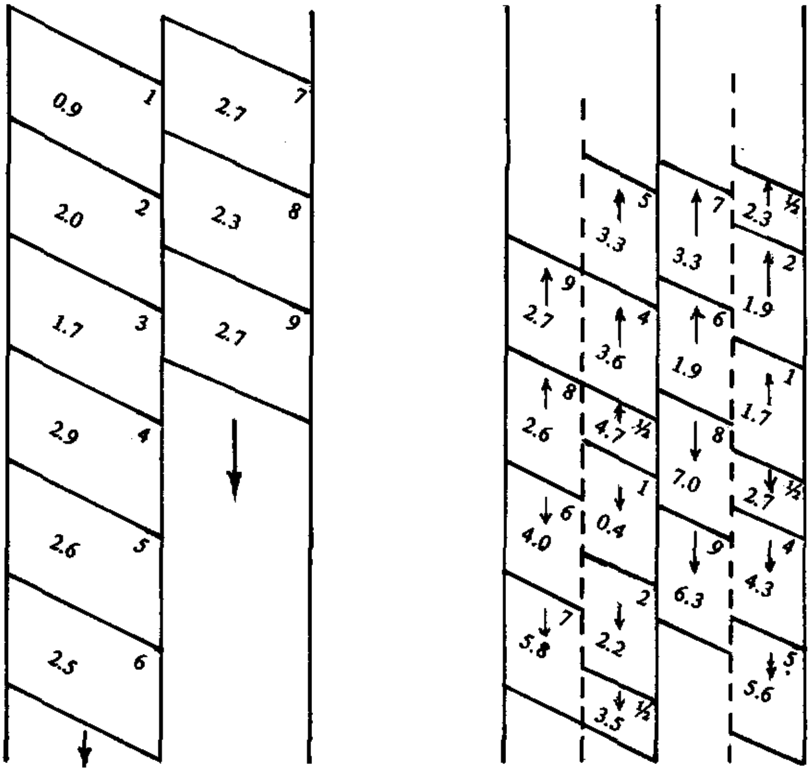


Figure 10. Depression in d.r.c. values of stimulated ½S d/2 and 2x¼S d/2↑↓system – (Panel BO-1/BO-2).

most of the nine years of tapping. However, for downward tapped cuts, there was an increasing incidence of dryness from the seventh to the ninth year. A marked increase in incidence occurred on both quarter-cuts during the ninth year when the cuts were close to the union.

Dryness Incidence in Relation to Position of Cut and Direction of Tapping: Comparison between Upward and Downward Tapping with ¼S d/2 (t, t) System

Adjacent panels. The incidence of dryness in unstimulated trees for both upward and downward tapped cuts was

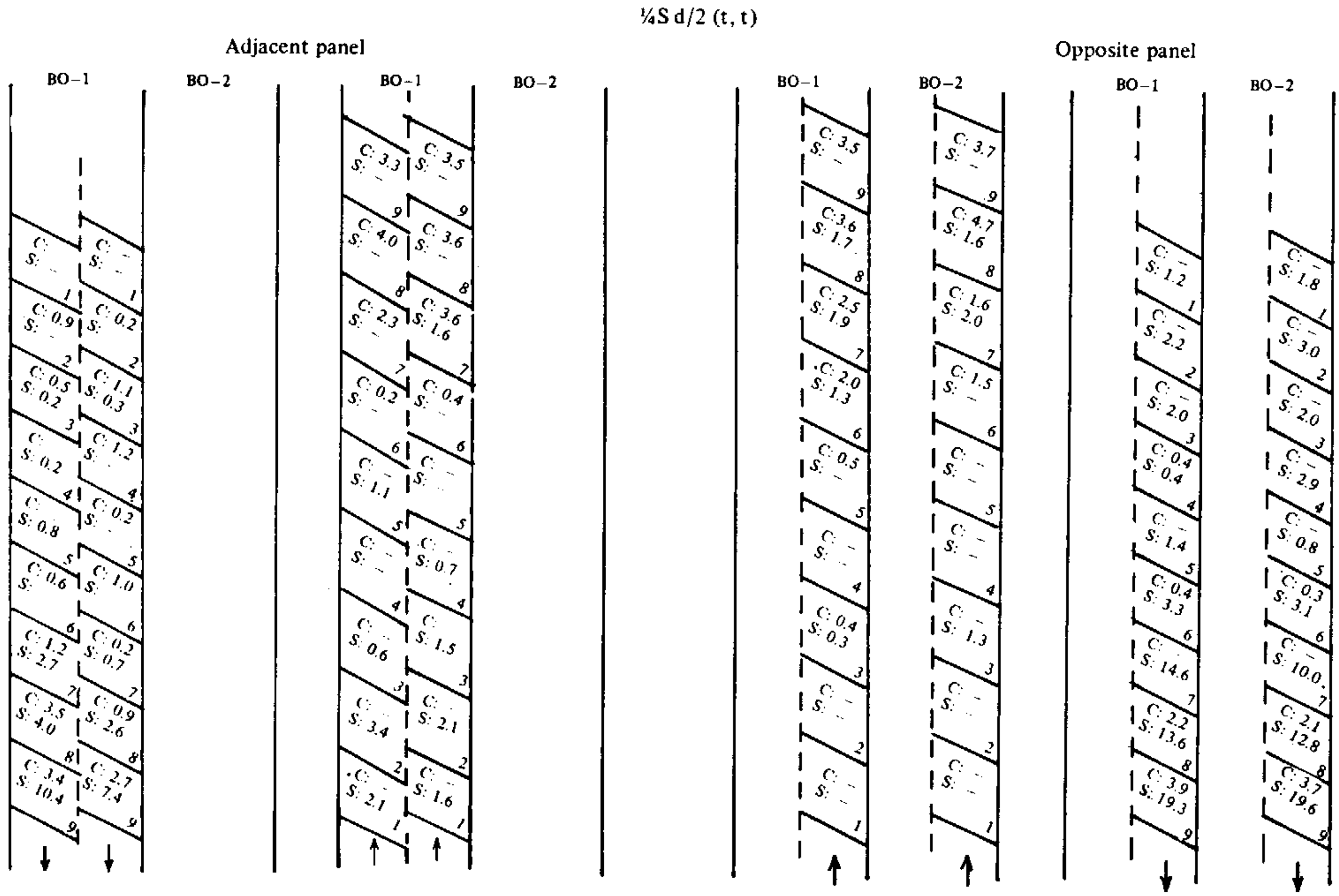


Figure 11. Incidence of dryness on upward and downward tapped ¼S d/2 (t, t) system – RRIM 600 (Panel BO-1/BO-2).

Opposite panels. In unstimulated trees for both upward and downward tapped cuts the incidence of dryness was negligible with the exception of the last three years when an increase was recorded *(Figure 11)*. For stimulated trees with cuts tapped upwards the incidence of dryness was negligible or marginal for most of the nine years of tapping. However, for quarter-cuts tapped downwards, the incidence of dryness was higher for most of the nine years, with marked increase in incidence from the seventh year. Thus, the incidence was higher than 10% for the last three years with dryness increasing to 19% in the ninth year when the cuts were close to the union.

Comparison between Upward and Downward Tapping with ½S d/2 System

In unstimulated trees, upward tapped cuts had much lower incidence of dryness than downward tapped cuts *(Figure 12)*. The incidence of dryness for upward tapped cuts was generally negligible for most of the seven years with the exception of the eighth year when incidence of dryness increased to 2.0% – 3.8%. However, for downward tapped cuts, the incidence of dryness from the third to the seventh year ranged from 1.3% – 5%, with a marked increase in the eighth year to 9.7% – 10.7%.

Similarly, for stimulated trees, upward tapped cuts had markedly lower incidence of dryness than downward tapped cuts. Thus, for upward tapped cuts, the incidence was low for most of the seven years with levels ranging from 0.7% – 3.3%. In the eighth year, the dryness increased to 5.5%. In trees with downward tapped cuts, there was a marked increase in dryness after the third year to 8.3% – 10.0%. The incidence of dryness remained at this level till the eighth year of tapping.

Novel Tapping System (2 x ↑ ↓ ¼S d/2 76.2 cm)

The incidence of dryness was generally low during the first two-and-a-half years' tapping irrespective of direction of tapping *(Figure 13)*. During the second two-and-a-half years, the dryness incidence on downward tapped cuts for both unstimulated and stimulated trees was higher. Thus, for stimulated trees, the incidence of dryness on downward tapped cuts was 4.8% – 10.9%, which was twice that of upward tapped cuts which had 2.2% – 3.8% dryness. In the sixth and seventh years of tapping, unstimulated trees had similar levels of dryness on both upward and downward tapped cuts. However, in stimulated trees, downward tapped cuts had markedly higher levels of dryness, with incidence being four to eight times more than upward tapped cuts. During the last two years' tapping (eighth and ninth years), the incidence of dryness was comparable for both directions of tapping in both unstimulated and stimulated trees. The incidence of dryness in unstimulated ½S d/2 tapped trees was similar to that of unstimulated trees tapped on the novel system. The exception was the sixth year when the cuts were close to the union. The stimulated conventional ½S d/2 system had markedly higher levels of dryness than the cuts of the novel tapping system from the fourth to the ninth year, despite subsequent change in panels after the sixth year. The highest levels of dryness on stimulated ½S d/2 tapped trees were re-

½S d/2 (t, t)

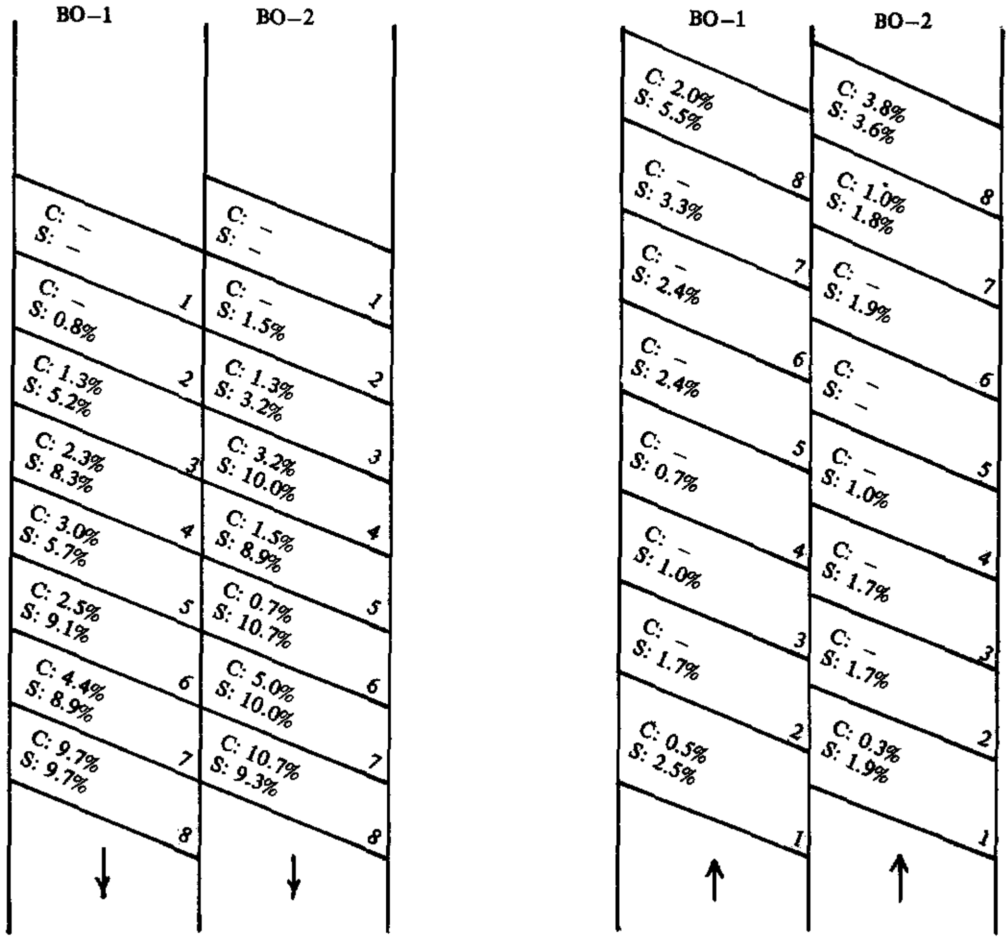


Figure 12. Incidence of dryness on upward and downward tapped ½S d/2 (t, t) system – RRIM 600 (Panel BO-1/BO-2).

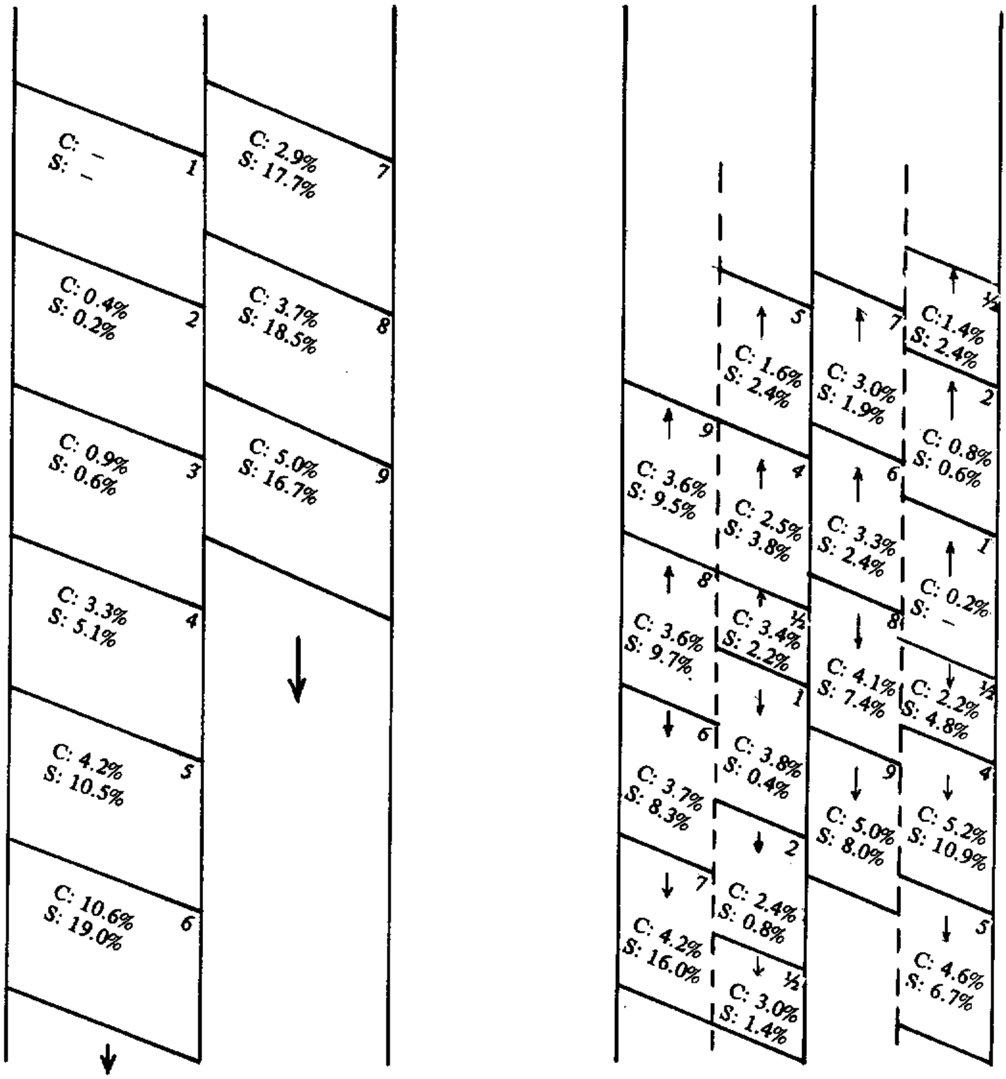


Figure 13. Incidence of dryness on ½S d/2 and 2x¼S d/2↑↓ systems – RRIM 600 (Panel BO-1/BO-2).

corded during the sixth year when the cuts were close to the union.

DISCUSSION

Results suggest that when the design of the tapping systems allows for access to unlimited drainage area, higher yields and better responses to stimulation will be obtained. This was evident on both quarter- and half-spiral cuts tapped upwards from the union in contrast to similar cuts tapped downwards towards the union. However, the tangible effects of unlimited drainage area on yield performance are most apparent when an intensive exploitation system is used or when there are limitations in drainage area arising from proximity of the tapping cut to the stock/scion union. This matter will now be elaborated.

The use of an intensive exploitation system will result in excessive drainage and consequently available drainage area would be a limiting factor. Thus, the results show that on a ½S d/2 (t, t) system with stimulation marked yield differences were obtained between cuts tapped in a upward direction from the union and cuts tapped downwards from a height of 152 cm from the union. However, the effects of upward tapping with a less intensive system such as ¼S d/2 (t, t) with or without stimulation were less apparent though generally better responses to stimulation were obtained on these cuts especially when tapped upwards with no restriction in drainage area. The expected advantage of positioning quarter-cuts on opposite panels with different drainage areas as opposed to quarter-cuts adjacent to each other on the same panel was not seen largely because a low intensity exploitation system was used. This system may have been less demanding in terms of drainage thus avoiding development of stress in the panel. In addition, during the first nine years of tapping, the quarter-cuts irrespective of being on the same or opposite panels were bordered by virgin bark of similar age. The common and contiguous latex vessel rings between the panels may have enabled drainage of latex to occur from bark beyond the panel in tapping.

It is now known from numerous published data[2,4] that with conventional tapping systems tapped downwards towards the union, there is decline in yields as the cut approaches the stock/scion union. This is further accentuated in panels which have been continuously stimulated. This has generally been attributed to limitations in available drainage area although there was no direct confirmation in the absence of comparisons with corresponding cuts tapped in the reverse direction from union upwards. However, data presented in this paper provides evidence in support of the earlier conclusion since in both quarter- and half-spiral cuts tapped upwards, there was generally no decline with time in yields or responses to stimulation. This was particularly evident during the later years from comparisons made between downward tapped cuts which were close to the union and corresponding cuts tapped upwards.

The results suggest that by designing appropriate tapping systems which allow for exploitation of different drainage areas simultaneously, it is possible to maintain an increase in yields and improve responses to stimulation. Thus, the novel tapping system of two quarter-cuts opened at 75 cm from the union, with one cut tapped downwards and the other upwards, out-yielded the conventional ½S d/2 system opened at 150 cm from union and tapped downwards during the first five years of tapping. The responses on this system were sustained for a longer period in contrast to the conventional system which as reported elsewhere[2], recorded decline in responses after the third year with negative responses after five years despite subsequent panel changeover. In contrast, the upward tapped cuts of the novel tapping system maintained positive responses till the seventh year. During the later years, the bark adjacent to the cuts of the novel tapping system was renewing bark in contrast to the first five years when the cuts were bordered by virgin bark of the same age. It is plausible that the presence of bark of different age may have restricted extension in drainage area beyond the cut in tapping because of discontinuous latex vessel rings. This may have precluded obtaining positive responses over an extended period as expected from exploitation of different drainage areas.

The effects of unlimited drainage area on yields and responses would have been more marked than that reflected in the data given in this paper, if not for the peculiar constraints associated with tapping in an upward direction, particularly from the union. These constraints such as tappers' resistance to new mode of exploitation, difficulty in controlling direction and slope of cut, excessive spillage and uneven bark consumption could have caused loss in yield, thus affecting the performance of upward tapped systems. This could also be partly responsible for the absence of very marked differences during the initial years between quarter-cut systems tapped upwards and downwards.

It is now known[2,3,5] that d.r.c. of stimulated latices is generally depressed below that of unstimulated latices during the early years of stimulation. With repeated stimulation over a long term there is no further depression in d.r.c. values and on the contrary there appears to be a recovery in the d.r.c. values of stimulated trees[2,3]. This same pattern was generally evident in trials reported here for both upward and downward tapped systems with certain exceptions. Thus, towards the later years for some upward tapped cuts with stimulation, a greater depression in d.r.c. values occurred because of increases in d.r.c. values of unstimulated trees. The latex obtained from upward and downward tapped cuts had d.r.c. values which were not markedly different in both unstimulated and stimulated trees. These results conform to the belief that the effects of unlimited drainage area on d.r.c., unlike other parameters, will be less apparent because the extension in drainage area will primarily result in increased flow of latex rather than increase in rubber biosynthesis

The incidence of dryness in contrast to d.r.c. values showed marked differences between upward and downward tapped cuts particularly during the later years. Thus, as reported previously[3,4], there was marked increase in incidence of dryness particularly in stimulated trees as the downward tapped cut approached the union. However, comparison with corresponding periods for upward tapped cuts showed no evidence of marked increase in incidence of dryness with minimal differences in incidence between stimulated and unstimulated trees. The sluggish or patchy flow of latex normally observed when cuts are close to the union could be a reflection of partial emptiness of latex vessels resulting from limitations in available drainage area. It could also be symptomatic of an excessively drained panel with circumscribed drainage area. These conditions are absent on an upward tapped cut where there is no limitation in drainage area and consequently as supported by data given in this paper, the incidence of dryness is not marked and generally low by comparison with downward tapped cuts.

It is evident from data examined in this paper that the dimensions of available drainage area have a critical influence on the performance of exploitation systems and consequently the productivity of the *Hevea* tree. Thus, use of systems with access to unlimited drainage area generally resulted in higher yields, better responses to stimulation and very low levels of dryness on the tapping cut. This was most apparent when the bark adjacent to the tapping cut was of similar age to the bark below the cut. It must be appreciated that although there are numerous theoretical possibilities of devising tapping systems with unlimited drainage areas, these are nevertheless limited by constraints of practical implementation in the field.

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