High Panel Exploitation of *Hevea* Trees:
A Comparative Study of Five Tapping Systems

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ABSTRAK

Penorehan Hevea *di tapak torehan atas, menggunakan lima sistem torehan telah dikaji. Torehan hala ke atas pada suku lilitan selama lapan bulan diikuti dengan torehan di tapak torehan bawah selama empat bulan memberikan hasil yang sama dengan torehan ke bawah separuh lilitan menggunakan tangga (kawalan). Walau bagaimanapun, kandungan getah kering lateks lebih tinggi; masa penorehan bagi tiap-tiap sepokok kurang; kos penyapuan ubat penggalak lebih murah dan kurang penggunaan kulit. Pisau jebong atau pisau CUT yang digunakan bagi torehan hala ke atas tidak memberikan apa-apa perbezaan pada hasil lateks, tetapi apabila alur torehan mencapai paras tinggi pisau jebong mengambil lebih masa untuk penorehan setiap pokok. Pada torehan hala ke atas, hasil daripada torehan separuh lilitan melebihi suku lilitan tetapi kandungan getah kering lateks lebih rendah. Juga torehan separuh lilitan memerlukan lebih masa untuk menoreh bagi setiap pokok, penggunaan kulit yang lebih, dan kos penyapuan ubat penggalak lebih tinggi dibandingkan dengan torehan suku lilitan. Terdapat sedikit sahaja perbezaan dalam penghasilan di antara torehan mikro-x dan torehan menggunakan tangga. Torehan mikro-x memberikan kandungan getah kering lateks yang tinggi dan penggunaan kulit sangat kurang tetapi kos penyapuan ubat penggalak lebih tinggi, dan masa penorehan bagi setiap pokok lebih lama.*

ABSTRACT

High panel exploitation of Hevea *using five different tapping systems was studied. Upward tapping on a quarter-spiral cut for eight months, followed by base panel tapping for four months gave the same yield as downward ladder tapping on a half-spiral cut (control). However, the dry rubber content of the latex was higher; the time taken to tap per tree was less; stimulation cost was lower and so was bark consumption. The jebong and CUT knife were compared for upward tapping on a quarter-spiral cut and showed no differences on the yield of latex, but it took more time to tap a tree with the jebong knife when the tapping cut reached higher levels. In upward tapping, the yield obtained with the half-spiral cut, was higher than the quarter-spiral cut, but the dry rubber content of the latex was lower. Also, it took a longer time to tap the tree; it had a higher bark consumption and the cost of stimulation was higher compared to the quarter-spiral cut. There was little difference in yield between reverse micro-x and ladder tapping. Reverse micro-tapping gave a higher dry rubber content of the latex and consumed much less bark, but the stimulation cost was higher, and it took a longer time to tap a tree.*

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INTRODUCTION

Hevea trees are often tapped on the high panels when the bark at the base panels is no longer economical to exploit. This stage is reached when the first renewed bark of the base panels has been completely tapped. The high panel cut is usually on virgin bark above the base panel and extends upto a height of 250 to 300cm from ground level. This is commonly referred to as tapping the rubber tree on high panels or high panel exploitation.

Two basic tapping systems have generally been used to exploit the rubber tree on high panels. One is to tap downwards with the aid of a ladder as in ladder tapping (Rubber Res. Inst. M'ysia, 1954b, 1959a, Selby, 1970; Wright, 1912), and the other is to tap upwards as in controlled upward tapping (P'ng, *et al.* 1976; Ng, 1965; Rubber Res. Inst. M'ysia, 1970; Sharp, 1945). Ladder tapping is reported to increase tapping cost due to a reduction in the number of trees tapped by a tapper (task size) (Rubber Res. Inst. M'ysia, 1954b). Other problems encountered are heavy bark consumption, flattening the angle of slope of cut, spillage of latex, and the danger of falling off from the ladder. Additionally, the yield of latex begins to decline as the tapping cut approaches the renewed bark of the low panel due to the 'bark island' effect (Djikman, 1951). Upward tapping, on the other hand, has been shown to give higher yields than ladder tapping (Rubber Res. Inst. M'ysia, 1970). However, it is inconvenient and difficult for workers to maintain a high standard of tapping. Also, bark consumption and latex spillage are excessive.

P'ng *et al.* (1976) introduced a new technique of tapping called 'controlled upward tapping' (CUT) by the use of a nodified gouge tapping knife. They demonstrated that controlled upward tapping (CUT) especially on a quarter-spiral cut (¼S) together with yield stimulation resulted in several advantages compared to the earlier systems. The task size for CUT on a ¼S is about the same as for base panel tapping; it gives a better long term sustained yield; and lower bark consumption. Cho and others (1981) carried out a survey on the adoption of the CUT system by rubber growers. They reported that considerable areas in Peninsular Malaysia have adopted the CUT System but with numerous modifications. In South Johore it is observed that ladder tapping is still being practised commonly by estates. In areas where the CUT system is adopted, jebong tapping knives are used instead of the modified gouge.

In view of the problems associated with high panel exploitation, a study was initiated to compare five tapping systems on high panels with the objective of improving existing methods in relation to latex spillage, bark consumption, and other practical problems. Also, the effects of the two types of tapping knives (jebong and modified gouged) were observed.

MATERIALS AND METHODS

This study was carried out at Tebrau Estate, Johor Bahru. The area selected is rather flat, and the soil type is of the Rengam series. The trees are clone RRIM 612 planted in 1958 at a distance of 6.1 by 2.0 metre.

The trees had been tapped using the one-third spiral third daily (1/3S d/3) system since coming into maturity. The first renewed bark had already been completely consumed at the commencement of the experiment. The study was carried out over a period of two years.

The high panel tapping cut was on virgin bark opened at a height of 240cm from ground level for ladder tapping. In the case of upward tapping the cut was opened just above the junction of the virgin and renewed bark. The angle of slope of cut was 35° and 45° from the horizontal for ladder and upward tapping respectively. The frequency of tapping was third daily, a normal practice of the estate. Only one tapper, who had no previous experience in high level tapping, was employed to tap the trees throughout the entire period of the study.

The tapping systems selected for the study are shown in Table 1.

Ladder tapping is the most common method of tapping the high panel practised by both estates and smallholdings in the area of experimentation. Thus, system 1 was made the control in this study. Systems 2 and 3 have been tested by P'ng *et al.* (1976) and Ismail *et al.* (1981). They found that the two systems gave encouraging yields, but the yield for the half-spiral (½S) cut declined at a faster rate with

TABLE 1
Tapping systems employed in high panel exploitation of *Hevea* trees

No.	Tapping System	Remarks
1.	½S (240cm) d/3 ET.5.0% La 1. 6/y (2m) — CONTROL	Ladder tapped on one half-spiral cut opened at 240cm from ground level, tapped third-daily. Ethephon (5% concn) applied bimonthly on lace at 1g/tree. Tapping done with a jebong knife.
2.	½S ↑d/3. ET.5.0% La 1. 8/y (m), ½S d/3 (8m, 4m) — CUT KNIFE	Upward tapping on one half-spiral cut, tapped third-daily. Ethephon (5% concn) applied monthly on lace at 1g/tree (8 applications/year). Trees tapped on this system for 8 months using the CUT knife; then followed by base panel tapping on one half-spiral cut, tapped third-daily for 4 months with the jebong knife.
3.	¼S ↑d/3 ET.5.0% La 0.5. 8/y (m), ¼S d/3 (8m, 4m) — CUT knife	Same as (2) above except that the upward tapping cut was reduced from half to a quarter-spiral cut.
4.	¼S ↑d/3. ET.5.0% La 0.5. 8/y (m), ½S d/3 (8m, 4m) — jebong knife	Same as method (3) except that upward tapping was done with the jebong instead of the CUT knife.
5.	6 PG (½S) d/3, ¼S d/3 (8t, t) ET. 5.0% La 1. 12/y (m) — reverse micro-x	Micro-x tapping with 6 punctures on one-half spiral upward cut, tapped third-daily for eight consecutive tappings; followed by one excision tapping using the CUT knife in the cycle; Ethephon (5% concn) applied monthly on lace at 1g/tree (12 applications/year).

time. System 4 has been studied in smallholdings as reported by Anthony and Abraham (1981). This system was found to give satisfactory yields, and bark consumption was very much reduced. However, they used the bidirectional knife, and the frequency of tapping was alternate daily. System 5 was chosen to be included in this study because it has been shown to give encouraging yields, and consumes very little bark (Ismail, Yoon and P'ng, 1981). The differences are that the reported experiment was on clone PR 107 and the trees were tapped alternate daily, while in this study clone RRIM 612 was used and the tapping frequency was third daily.

Ethephon was applied to the tapping groove without removing the tree lace by means of an artist's brush (Othman *et al.*, 1980). The amount of stimulant used per tree per application was 1g for the standard half-spiral cut, and was reduced to half (0.5g) for the quarter-spiral cut. The interval between each stimulant application was not exactly a month, but followed the tapping cycle of the reverse micro-x system. This means that if the reverse micro-x tapping was

delayed in completing the cycle of 8 puncture tappings followed by 1 excision tapping due to rain or other circumstances, the cycle was extended beyond one month. The stimulant was applied at the end of each cycle.

The jebong knife used for tapping systems 1 and 4 is popularly used for upward tapping by the local tappers. The knife is similar to the bidirectional knife as described by Abraham and Anthony (1980), except that it is heavier by about 130g and the angle between the blades is 80° instead of 45°. The angle between the blades for the CUT knife used in systems 2, 3 and 5 is 80° instead of 60° as is the case for the normal CUT knife (P'ng *et al.*, 1976). The modification was made, as tappers found difficulties in negotiating corners when the 60° knife was used due to the very thick virgin bark of the tree. The base panel of systems 2, 3 and 4 were tapped during the wintering period using the jebong knife. The puncture tool used for micro-x tapping system is as described by P'ng *et al.* (1979). The ladder used is the X-form type (Rubber Research Inst. M'ysia, 1956b) which is suited to

any girth size of the trees.

A latex guide (latex collecting tape) was used in conjunction with the reverse micro-x tapping system. This is to allow for the collection of latex spilled on to the side of the groove and guide the latex flow to the spout situated about 20cm below the tapping cut.

Yield of latex collected from each replication after every tapping was bulked and its fresh (wet) weight recorded. The crop obtained from late drip after the first collection was recorded as bulk weight of cup lump. The dry rubber content. (d.r.c.) of the latex for each treatment was determined using the Rapid Method C (Rubber Res. Inst. M'ysia, 1973). The d.r.c. for the cup lump was calculated based on the assumption that its water content was 50% (Paardekooper, 1969). The dry rubber yield of latex and cup lump (gm/tree/tapping) is expressed as the product of the wet weight and the d.r.c. over the number of trees tapped per tapping.

The time of operation for tapping and stimulation was recorded from the time when the first tree was tapped or stimulated until the work was completed on the last tree in each plot. The

timing includes the time for walking from one tree to another.

Bark consumption was measured at the end of the study period (two years). The measurement was taken vertically at three points along the tapped panel. The mean value of the three points was taken as the total bark consumed for each particular tree.

The treatments were arranged in a randomized complete block design with four replications per treatment. Each replicate consisted of forty tappable trees. As the tapper could not finish tapping the entire experimental block in one day, the area was divided into two tapping tasks. Each task consisted of two replicates of each treatment and was tapped in two consecutive days. Tapping was started on a rotational basis from a different plot at every tapping to reduce the effects of time of tapping on latex yield (Lee and Tan, 1979; Pardekooper et al., 1969).

RESULTS AND DISCUSSION

The mean annual yield, inclusive of late drip, are summarised in Table 2. Upward tapping on

TABLE 2
Mean annual yield and percent late drip of five tapping systems on high panel

No.	Tapping system	[Z]Yield gm/tree/tapping		[Z]Percent late drip Kg/ha			
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
1.	½S d/3.ET5.0% (Ladder) Jebong knife (Control)	55.08 [b]	55.03 [b]	1679 [b](100)	1303 [b](100)	16 [a]	18 [a]
2.	½S ↑d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	83.08 [a]	96.80 [a]	2533 [a](151)	2292 [a](1776)	15 [a]	14 [a]
3.	¼S ↑d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	56.80 [b]	62.78 [b]	1732 [b](103)	1486 [b](114)	17 [a]	17 [a]
4.	¼S ↑d/3.ET5.0%, ½S d/3. (8m, 4m) — Jebong knife	64.95 [b]	69.00 [b]	1980 [b](118)	1634 [b](125)	15 [a]	16 [a]
5.	6PG (½S) d/3, ½S d/3. (8t,t).ET5.0% — reverse micro-x	51.30 [b]	62.43 [b]	1564 [b]	1478 [b](113)	18 [a]	18 [a]

No. of tappings in year 1 = 103; year 2 = 80
Assumed tappable stand per hectare was 296 trees
Figures within brackets are percentage values of control (½S Ladder)

[Z] Mean values having the same letter within columns are not significantly different at P = 0.05 according to DMRT.

a half-spiral cut with stimulation for 8 months followed by base panel tapping for 4 months [½S d/3 ET. 5%, ½S d/3 (8m, 4m] produced the highest yield/tree/tapping or yield/ha amongst the tapping systems studied. The yield was 51% and 76% more than that of control (½S ladder) in year 1 and 2 respectively. Similarly, Ng (1965) in his study showed that more yield was obtained with upward than downward ladder tapping in the first 18 months of tapping. The increase in yield/tree in year 2 was due to the lesser number of tapping days due to rain and other circumstances. Ng *et al.* (1969) also reported that reducing the frequency of tapping has the effect of increasing the yield/tapper. The results suggests that for the first panel, clone RRIM 612 responds better to upward than ladder tapping.

Quarter-spiral upward (¼S) and the reverse micro-x tapping systems produced no significant differences in yield from control. Thus, controlled upward tapping (¼S) or reverse micro-x tapping can be a good alternative tapping system for high exploitation of *Hevea*. The same suggestions were put forward by P'ng *et al.* (1976) and Ismail, Yoon and P'ng (1981) in their studies. The reverse micro-x system requires fewer skilled tappers and offers

flexibility in tappers' movement as compared to conventional tapping. Therefore, the reverse micro-x tapping system can be adopted in areas where skilled tappers are in short supply as experienced in some areas today.

The use of the jebong or CUT knife has no effect on the yield obtained which means that either one could be used for upward tapping. The choice of knife to use would, therefore, depend on the tapper's preference. This possibly explains why many tappers in Southern Malaysia, particularly Johore State, use the jebong knife for upward tapping.

There no significant differences in the percentage of late drip obtained for all the tapping systems studied. The amount of late drip ranged from a low of 14% to a high of 18%.

The mean annual dry rubber content (d.r.c.) of latex varied with the tapping system as shown in Table 3. The d.r.c. of latex of reverse micro-x tapping system was highest in both year 1 and year 2. The d.r.c. in year 1 was 40.85% and in year 2 was 41.2%. Ladder tapping showed a significantly lower d.r.c. than reverse micro-x tapping, but higher than the other three systems studied. System ½S ↗ — CUT gave the lowest d.r.c. in both the two years studied. Similar findings have been reported by other

TABLE 3

Annual mean dry rubber content and two years bark consumption of five tapping systems on high panel

No.	Tapping system	[Z]Dry rubber content		[Z]Bark consumption	
		Year 1 %	Year 2 %	2 Years (cm)	Mean (cm/year)
1.	½S d/3.ET.5.0% Ladder Jebong knife (Control)	38.15 [b]	38.90 [b]	76.30 [a]	38.2 [a]
2.	½S ↗d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	33.45 [d]	34.80 [e]	77.95 [a] (24.30)	39.0 [a] (12.2)
3.	¼S ↗d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	36.60 [c]	36.65 [d]	70.73 [b] (24.20)	35.4 [b] (12.1)
4.	¼S ↗d/3.ET5.0%, ½S d/3. (8m, 4m) — Jebong knife	36.60 [c]	37.85 [c]	70.88 [b] (24.50)	35.4 [b] (12.3)
5.	6PG (½S ↗) d/3, ½S d/3. (8t, t).ET5.0% — reverse micro-x	49.85 [a]	41.20 [a]	22.18 [c]	11.1 [c]

[Z] Mean values having the same letter within columns are not significantly different at P = 0.05 according to DMRT.

Figures in brackets are bark consumption for base panel tapping.

workers (Abraham and Tayler, 1967; De. Jonge 1965; Ismail, *et al.*, 1981; Ng *et al.*, 1969; Tan and Menon, 1973; Wycherley, 1974) who showed that the d.r.c. of latex is influenced by the length of cut, frequency of tapping, and stimulation practices. The d.r.c. of latex for the reverse micro-x tapping system was markedly higher in both years among the five systems studied. This is in agreement with the findings of Ismail, Yoon and P'ng (1981) who reported that the d.r.c. for micro-x tapping was higher than the CUT system. The d.r.c. of latex obtained from the ½S cut was significantly lower than the ¼S cuts in upward tapping. This is to be expected as it has been reported earlier that the d.r.c. of latex gets lower as the tapping cut gets longer (Ng *et al.*, 1969). In the ¼S tapping system a lower d.r.c. was obtained with the CUT than the jebong knife in the second year. The difference could be attributed to the higher percentage of dryness exhibited by the trees tapped with the CUT knife.

Reverse micro-x tapping consumed the least amount of bark among the systems studied (Table 3). This is to be expected since the system involved a cycle of eight days of puncture tapping in which no bark is removed, and one day of conventional tapping. The considerable saving on bark consumption offers the opportunity to

extend the period of exploitation of the high panel. The same conclusion has been arrived at by other studies (Ismail *et al.*, 1979, 1980; P'ng *et al.*, 1978).

The bark consumption on the high panel for the ½S ↗ tapping was about the same as that for ½S ladder. This was because upward tapping was done for only 8 months in a year while ladder tapping was carried throughout the whole year. A similar observation has been made by Ismail, Yoon and P'ng (1981) who reported that bark consumption of controlled upward tapping was very much higher than ladder tapping. Therefore, in order to control bark consumption on the high panel system ½S ↗ should be used for 8 months in a year. Tapping should then be done on the base panel for 4 months; especially during the wintering season. This will allow for the same amount of bark consumption as ladder tapping.

The ¼S ↗ systems consumed a significantly less amount of bark than the ½S ↗ system. The mean bark consumption per year for the ¼S ↗ systems was 35.4 cm compared to 39.4 cm for the ½S ↗ system. The results suggests that there is a tendency for the tapper to shave off a thicker layer of bark at each tapping when the length of cut is longer. Also, there was no significant difference in bark consumption when the length of

TABLE 4

Mean time of tapping a tree and possible task size for five tapping systems on high panel

No.	Tapping System	[z]Tapping Time (sec/tree)		[z]Possible Task size	
		Year 1	Year 2	Year 1*	Year 2*
1.	¼S d/3.ET5.0% Ladder Jebong knife (Control)	42 [b]	30 [c]	300 [b]	420 [c]
2.	½S d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	39 [b]	36 [b]	323 [b]	350 [b]
3.	½S d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	28 [c]	26 [d]	450 [c]	485 [d]
4.	¼S d/3.ET.5.0%, ½S d/3. (8m, 4m) — Jebong knife	28 [c]	31 [c]	450 [c]	406 [c]
5.	6PG (½S) d/3. ½S d/3 (8t, t). ET5.0% — Micro-x	46 [a]	61 [a]	274 [a]	207 [a]

*Assumed tapping period of 3½ hours.

[z] Mean values having the same letter within columns are not significantly different at P = 0.05 according to DMRT.

cut remained the same, irrespective of the type of knife used.

Generally, the ¼S ↑ tapping cuts needed a significantly lesser amount of time to tap each tree than the ½S ↑ cuts (Table 4). Thus, it is possible for a tapper to tap 127 to 135 trees more per task per day. The task size for upward tapping on a ¼S ↑ cut is similar to that as conventional tapping (½S d/2) on base panel. P'ng *et al.* (1976) also showed that tapping on a ¼S ↑ cut could have the same task size as conventional tapping on the base panel.

There was no significant difference in time taken to tap upward when compared with ladder tapping using the ½S cut in the first year. The time taken for upward tapping was 39 sec, and for ladder tapping was 42 sec — a possible task size of around 300 trees for both systems. However, the time taken to tap a tree for ladder tapping decreased from 42 sec in the first year to 30 sec in the second year. The main reason is that the height of cut has been reduced to some extent, and this makes the task of tapping much easier for the tapper. The tapper could, therefore, take a much shorter time to tap a tree which means a greater number of trees can be tapped per task. Thus, the task size increased by 120 trees in the second year for ladder tapping.

In order to take advantage of this, retasking has to be done annually for ladder tapping.

The tapping time increased slightly from 28 sec in the first year to 31 sec in the second year when the jebong knife was used. The reason is that the tapper found it more difficult to control the knife to get the correct position of cut. It means that tapping with the jebong knife would become more difficult as the tapping cut reaches a higher level with time. This could be seen by the reduction in the possible task size of 450 trees in year 1 to 406 trees in year 2. Therefore, using the jebong knife for upward tapping has the disadvantage of a reduction in possible task size with time.

Reverse micro-x system took the longest time to complete the tapping operation and as a result, the task size was the lowest compared to the other systems studied. This is contrary to the recorded task size of 750 trees for base panel tapping by Ismail *et al.* (1979). The marked reduction in task size on high panel tapping using the micro-x system is due to the fact that the tapper has to spend extra time to guide the flow of latex without spillage into the collecting cup placed below the cut. It was further observed that the flow of latex along the groove became more and more difficult as the lace became

TABLE 5

Mean time of operation for stimulation and possible number of trees a worker can stimulate per day

No.	Tapping system	[Z]Stimulation time (sec/tree)		[Z]Number of trees a worker can stimulate	
		Year 1	Year 2	Year 1*	Year 2*
1.	½S d/3.ET5.0% Ladder Jebong knife (Control)	40 [a]	24 [c]	540 [a]	900 [c]
2.	½S d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	32 [b]	33 [b]	675 [b]	655 [b]
3.	¼S d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	24 [c]	22 [d]	900 [c]	982 [d]
4.	¼S d/3.ET5.0%, ½S d/3. (8m, 4m) — Jebong knife	21 [c]	23 [d]	1028 [c]	939 [d]
5.	6PG (½S) d/3, ½S d/3 (8t, t).ET5.0% — reverse micro-x	34 [b]	39 [a]	635 [b]	554 [a]

*Assumed work period of 6 hours per day

[Z] Mean values having the same letter within columns are not significantly different at P = 0.05 according to DMRT.

TABLE 6

Cost of stimulation per hectare for two years for the five different tapping systems

No.	Tapping system	Total number of applications	Stimulant [b] ET.(g)	Cost ($)	Labour Hour [c]	Cost ($) [d]	Total Cost ($)	Difference [e] ($)
1.	½S d/3.ET5.0% Ladder Jebong knife (Control)	11 (6 + 5) [a]	3256	49.81	29.6	37.00	86.81	—
2.	½S ↗d/3.ET5.0%, ½S d/3. (8m, 4m) — CUT knife	14 (8 + 6)	4144	63.40	37.33	46.06	110.06	+ 23.25
3.	¼S ↗d/3.ET5.0%, ½S d/3. (8m, 4m) — Jebong knife	14 (8 + 6)	2072	31.70	26.64	33.30	65.00	− 21.81
4.	¼S ↗ d/3.ET5.0%, ½S d/3. (8m, 4m) — Jebong knife	14 (8 + 6)	2072	31.70	25.16	31.45	63.15	− 23.66
5.	6PG (½S ↗) d/3, ½S d/3. (8t, t).ET5.0% — reverse micro-x	22 (12 + 10)	6512	99.63	65.62	82.03	181.66	+ 94.85

Assumed no. of tappable trees per hectare was 296.

[a] Figures in brackets show the no. of application in Year 1 and Year 2.

[b] price level in 1982.

[c] based on calculated mean time of operation in TABLE 4.

[d] labour wages of $10.00 per day working for 8 hours = $1.25/hour.

[e] the difference compared to ladder tapping

thicker and thicker with each tapping operation. A latex guide (latex collecting tape) has to be installed to collect the resulting spillage of latex from the groove.

The different tapping systems brought about differences in the number of trees a worker can stimulate (Table 5), and the total cost of applying the stimulant (Table 6). The possible number of trees a worker can stimulate for the various tapping systems studied range from a low of 540 to a high of 1028 based on a six-hour working day. Tapping systems with the ¼S cut took a significantly shorter time to apply the stimulant (Table 5). As a result the recorded number of trees stimulated by a worker each day was highest for the ¼ cut systems. A much lesser number of trees was stimulated on the micro-x tapping for the two-year period. Additionally, it needed the largest amount of stimulant, and more labour to stimulate a hectare of trees (Table 6). This is because the reverse micro-x system required the stimulant to be applied at every tapping cycle. Thus reverse micro-x tapping proved to be the most expensive system for stimulation. The total cost (labour + stimulant) per hectare was $181.66, whilst it only cost $63.00 to $65.00 for the ¼S cut, and $86.81 to $110.06 for ½S cut tapping systems. The results obtained in this study are in agreement with the observation made by Shepherd *et al.* (1978) that the cost of stimulant application varies with the tapping systems in use.

CONCLUSION

Upward tapping on high panel is economically feasible for use on trees in which the first renewed bark of the base panel has been completely tapped off as shown in this study with clone RRIM 612. The upward tapping system with one quarter-spiral cut tapped for eight months, followed by base panel tapping on one half-spiral cut for four months (¼S ↗ d/3 .ET5.0%, ½S d/3 (8m, 4m)) could probably be a good substitute for ladder tapping. The yield obtained is similar to that of ladder tapping, but the dry rubber content of latex is lower. Additionally, the time needed to tap a tree is less which means a larger task size per tapper. Bark consumption is lower and the cost of stimulation is cheaper.

No differences in yield was obtained with either the jebong or CUT knife. However, a difference in time taken to tap a tree became evident in the second year between the two types of knives used. When the cut reached a higher level it took a longer time for the tapper to finish tapping using the jebong knife and thereby reducing the possible task size.

Upward tapping on a half-spiral cut resulted in a significantly higher yield than on a quarter-spiral cut, but the dry rubber content of the latex is lower. Bark consumption and stimulation costs are markedly higher. This system seems to be suitable for short term exploitation of old trees just prior to being replanted.

The yield obtained by the reverse micro-x tapping system is similar to that for ladder tapping. The dry rubber content of the latex, however, is significantly higher than that of ladder tapping. The tapping time incurred is longer for the reverse micro-x system since the flow of the latex has to be guided. The time spent in guiding latex flow can be reduced to some extent by the use of a latex guide. Micro-x tapping consumed very little bark, but the cost of stimulation is high. This system is, perhaps, suitable for use in areas where skilled tappers are scarce since it requires little or no skill.

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