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Chapter 12

Tapping

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1. INTRODUCTION

Tapping is the process of controlled wounding of the bark to extract latex. Aim of tapping is to cut open the latex vessels in the case of trees tapped for the first time, or to remove a thin shaving of bark with the coagula which block the latex vessels in trees under regular tapping. An ideal tapping system is one which would give the highest yield at the lowest tapping cost along with satisfactory tree growth, bark renewal and lowest incidence of brown bast or tapping panel dryness (TPD).

2. HISTORY OF TAPPING

Native method of crop harvest from wild rubber trees in the Amazon basin involved slashing a series of cuts on the tree with an axe or hatchet 'machadinho'. In the long-run this caused severe injury, irregular secondary growth and poor yield and resulted in very early abandonment of trees (Cook, 1928).

The first attempt to evolve a method of tapping which would allow a sustained working of the rubber tree was carried out by Ridley at the Singapore Botanical Garden. The early reports on the scientific method of excision tapping were published in the annual reports of the Royal Botanic Gardens for 1890 and 1891. A detailed description of the excision method was first published in 1897 (Ridley, 1897) which later came to be known as Ridley's method. Employing this method, trees could be continuously exploited by removing a thin shaving of bark along a sloping groove at regular intervals. The method facilitated free flow of latex from vessels through this sloping cut and allowed bark regeneration above the cut. Trees could be exploited on the renewed bark also.

When a tree is tapped for the first time, only a very small quantity of thick latex exudes. Each successive tapping produces more and more latex with lower rubber content until an equilibrium between quantity of latex and rubber content is established. This was reported as early as 1898 (Willis, 1898; Parkin, 1899) as wound response or wound effect.

Demand for raw rubber increased in the beginning of the 20th century. This made the planters to increase the length of the tapping cut and to practise intensive tapping. Till then, trees were continuously tapped for about 25 times and were then given a long period of rest. Tapping cuts such as full spiral and herringbone originated at this time. It was, however, seen that yield was not proportional to the amount of bark consumed. Moreover the yield, good at the beginning, decreased later and bark regeneration was also poor. This led to the development of less intensive tapping systems (Dijkman, 1951).

Many tapping experiments and studies on anatomy and physiology of *H. brasiliensis* by Dutch scientists (de Jonge, 1916; Bobilioff, 1923) helped to formulate tapping systems on a scientific and rational basis. With passage of time, the early tapping systems evolved into modern systems, largely by modifying number and/or length of cuts and frequency of tapping.

3. TAPPING NOTATIONS

Tapping notations are sets of symbols and numbers describing mode of tapping and its frequency. Local names were given for each modified system which, however, led to confusion and difficulties. Hence, an internationally acceptable exploitation notation was needed. A description of notations for tapping systems was first introduced by Guest (1939). Since then many modifications in exploitation techniques have been developed particularly in association with stimulation. These developments led to revised systems of international notation for tapping (Lukman, 1983). The notation consists of three parts to indicate (1) tapping method, (2) panel position and type and (3) stimulation followed for cut tapping and puncture tapping.

3.1 Tapping method

The notations for tapping method include notations for length of the tapping cut, direction, frequency, *etc.*

3.1.1 Symbol of cut

The symbol for type of cut is a capital letter.

Examples

S : Spiral cut

V : V-cut

C : Circumference (symbol C is used for two or more unspecified cuts on a tree tapped on the same tapping day)

Mc : Minicut (5 cm or less in length)

3.1.2 Length of cut

Length of cut is the relative proportion of the trunk circumference that is embraced by the tapping cut. It is represented by a fraction preceding the symbol of cut, except in the case of minicut in which actual length is denoted in cm.

Examples

S : One full spiral cut

V : One full V-cut

C : One full circumference (unspecified cut)

1/2S : One half spiral cut

1/4S : One-fourth spiral cut

1/3V : One-third V-cut

3/4S : Three-fourth spiral cut

1/2C : One half circumference cut

Mc2 : Minicut, the length of cut being 2 cm

3.1.3 Number of cuts

The number of cuts is denoted by a numeral before the notation for length of cut and a multiplication sign in between.

Examples

2 x 1/4S : Two one-fourth spiral cuts on the same tree

4 x Mc2 : Four minicuts of 2 cm length

3.1.4 Direction

No symbol for direction is used when tapping is downward only. For upward tapping, the symbol is an upward arrow (↑) written immediately after the cut notation. Bidirectional tapping on the same tree is denoted by both upward and downward arrows (↑↓), after the concerned cut notation. Downward arrow need not be indicated in combination tapping.

Examples

1/2S	: One half spiral cut tapped downward
1/2S↑	: One half spiral cut tapped upward
2 x 1/2S↑↓	: Two half spiral cuts, one tapped upward and the other tapped downward
1/4S↑+1/2S	: One one-fourth spiral cut tapped upward and one half spiral cut tapped downward

3.1.5 Frequency

The notation for frequency of tapping describes the interval between tappings and is expressed as one fraction or a series of fractions.

3.1.5.1 Actual frequency

The notation of actual frequency is a fraction, the unit being day (d). The numerator of the fraction is d and it denotes the tapping period (day) while the denominator denotes the actual interval between tappings in days or in fraction of day.

Examples

d/1	: Daily tapping
d/2	: Alternate daily (one day in two)
d/3	: Third daily (one day in three)
d/4	: Fourth daily (one day in four)
d/0.5	: Twice a day tapping

3.1.5.2 Practical frequency

When continuous tapping is broken by a regular day or days of rest, a fraction is written after the actual frequency. In the fraction, numerator denotes number of days tapped in a period and denominator denotes the given period.

Examples

d/2 6d/7	: Alternate daily, six days in tapping followed by one day rest (For a task three tappings in six days)
d/3 6d/7	: Third daily, six days in tapping followed by one day rest (For a task two tappings in six days)

3.1.6 Periodicity

Notation for periodicity consists of one or more fractions in time units of week (w), months (m) and years (y). The numerator of each fraction denotes tapping period while the denominator indicates length of the cycle (tapping period + rest).

Example

d/2 6d/7 3w/4 8m/12	: Alternate daily tapping in six days, followed by one day rest, for three weeks followed by one week rest, during eight months followed by four months rest.

3.1.7 Change of tapping cut

When the tapping cut is shortened or lengthened or its direction is changed, the old and new notations are separated with a horizontal arrow(→).

Example

1/4S→ 1/2S : One-fourth spiral cut tapped downward changed to half spiral cut tapped downward

3.1.8 Intensity

Tapping intensity values provide parameters for comparison and evaluation of tapping systems.

3.1.8.1 Relative intensity

Relative intensity is expressed as percentage of the standard system 1/2S d/2 or 1/4S d/1 = 100%. It is calculated by multiplying the fractions in the notation and then multiplying the product so obtained by 400.

Examples

1/2S d/2 = 1/2 x 1/2 x 400 = 100%

1/4S d/1 = 1/4 x 1 x 400 = 100%

3.1.8.2 Actual intensity

Actual intensity is the percentage of tapping actually realized and is calculated by multiplying the length of cut by four and average number of tappings (number of tapping days per year of given tasks) and dividing by total number of days in the given year.

Example

$$1/2S\ d/2 = \frac{1/2 \times 4 \times 167}{365} \times 100 = 92\%,$$

where actual tapping days per year under d/2 = 167.

3.2 *Panel notation*

Panel is the area of bark in which tapping cut is located. Panel notation indicates the panel position and renewal succession of the panel. Though it is not normally included in a tapping notation it should be included in the tapping description. Common panel notations are given in Table 1.

Table 1. Panel notations

Old notation	New notation	Description
A	BO-1	First basal panel of virgin bark
B	BO-2	Second basal panel of virgin bark
C	BI-1	First renewed bark of BO-1
D	BI-2	First renewed bark of BO-2
E	BII-1	Second renewed bark of BO-1
F	BII-2	Second renewed bark of BO-2

First, second, third and fourth high panels of the virgin bark above the standard height of opening are indicated by HO-1, HO-2, HO-3 and HO-4, respectively. Renewed bark is usually not tapped in high panels.

Example

HO-3 : Third high panel of the virgin bark

3.3 Stimulation notation

The complete stimulation notation consists of three parts. The first part denotes stimulant and its concentration; the second, the place of application, quantity of stimulant and method of application; and the third, the number of applications and periodicity. Full stops must be inserted between these units to differentiate them clearly.

Example

ET2.5%.Pa2(1).16/y(2w) : Stimulated with ethephon (ET) at 2.5 per cent concentration applied on panel (Pa) with 2 g of stimulant per application on 1 cm band in 16 applications per year at fortnightly intervals.

3.3.1 Method of application

The method of stimulant application is denoted by a symbol, consisting of two letters, describing the place of application.

Examples

Pa	: Panel application	Ba	: Bark application
La	: Lace application	Ga	: Groove application
Sa	: Soil application	Ta	: Tape or band application

3.4 Complete notations for exploitation system

Tapping and stimulation notations are presented together as a complete notation, with a full stop inserted between them.

Example

1/3S d/3 6d/7.ET5%.Pa2(1).16/y(2w) : One-third spiral cut tapped third daily, six days in tapping followed by one day rest. Stimulated with ethephon (ET) at five per cent concentration applied on panel (Pa) with 2 g of stimulant per application on 1 cm band in 16 applications per year at fortnightly intervals.

3.5 Notation for puncture tapping

Puncture tapping is denoted by the capital letter P and various methods are:

PI : Punctures on vertical band
Pg : Punctures on vertical groove
PS : Punctures on spiral band
PG : Punctures on groove of tapping cut
PC : Punctures on a channel
PB : Punctures on a scraped bark

In complete puncture tapping notation, the number of punctures on a band is denoted by a number before P followed by length of band in cm written in brackets while width of the band in cm is shown after the bracket.

Example

3PI(45)2 d/2 6d/7.ET2.5%.Ta2(2).12/y(m) on BO-1 panel

Three punctures on a vertical band of 45 cm length and 2 cm width, tapped alternate daily, six days in tapping followed by one day rest, stimulated with ethephon (ET) at 2.5 per cent concentration applied on tape or band (Ta) of scraped bark with 2 g of stimulant per application on 2 cm band in 12 applications per year at monthly interval.

3.6 Combination of tapping systems

In many practical situations different tapping systems are practised in combination with different cuts tapped on the same day or alternate days.

Examples

1/3S↑+1/2S	:	One-third spiral cut tapped upward, with one half spiral cut tapped downward on the same tapping day.
1/3S↑, 1/2S	:	One-third spiral cut tapped upward, and one half spiral cut tapped downward on alternate tapping days.

3.7 Notation for change over system

Tapping of a tree done on several panels, each tapped on alternate tapping days or alternate tapping periods is called a change over system. It is indicated by the cycle of changes of each tapping panel given in brackets. Cycle of change of tapping is denoted by t (tapping), w (week) and y (year).

Example

1/2S d/2(t,t)	:	Two half spiral cuts, alternate daily tapping, each tapped alternatively on every tapping day.

Lukman (1983) had given all other relevant details on the revised international tapping notations.

4. TAPPING IMPLEMENTS

The main implements used for exploitation of rubber trees are knives, spouts, cup hangers, latex collection cups, collection buckets and scrap baskets (Plate 29. a). In the beginning of the 20th century, more than 22 types of tapping knives were in use (Wright, 1912). In India, two types of tapping knives are commonly used (Plate 29. b). One of them, the 'Michie-Golledge' is popular. The other one is the 'Jebong' knife, more suitable for speedy and easier tapping but with a slightly higher bark consumption. A third knife called modified gouge knife is also in use, mainly for controlled upward tapping (CUT).

Spout is a metal piece made of galvanized iron (GI) or tin sheet (5 x 3 cm size) bent into a V-shape. It is driven into the bark, to guide the latex into the collection cup after tapping. While fixing the spout, it must be ensured that the cambium is not injured.

Cup hangers are used to place latex collection cups. They are made of GI wire and tied on the trees with the help of coir or plastic thread. There are also self-supporting cup hangers which can be directly placed on the tree at the desired heights. In order to avoid frequent replacement of spout and cup hangers and to increase the efficiency of rainguards, it is advisable to fix them at the half mark of annual bark consumption.

Coconut shells were widely used as collection cups. However, with the large-scale cultivation of high yielding clones during the 1980s, coconut shells were replaced by plastic cups of varying capacity (400 - 900 ml). These cups also help in reduction of cup scrap. Scrap baskets are used for collection of lace, cup scrap, etc. GI buckets are commonly used for collection of latex.

5. OPENING FOR TAPPING

5.1 Standard for tappability

Rubber trees are tapped only after they attain a standard girth. It is well known that tapping reduces growth of rubber trees. Therefore, to obtain sustained yield for a number of years, it is necessary to maintain a satisfactory rate of growth of trees under tapping. If trees are tapped before attaining the specified girth, the yield obtained will not be economical in the long-run. Hence, a standard for tappability has been fixed after considering all these aspects. The standard is different for seedlings and buddings owing to the difference in the anatomy of bark and shape of trunk.

Seedling trees are opened for tapping at a height of 50 cm, when the girth at that level is 55 cm. If opening at a higher level is preferred, it can be at a height of 90 cm when the girth at that level is 50 cm. However, the height specified for opening subsequent panels on a seedling tree is 100 cm.

When the third panel (BI-1) is opened above the first panel (BO-1), a small portion of virgin bark, 15 to 20 cm wide in between the new tapping cut and the previous one yields substantially less on tapping. This portion of the bark is known as bark island. The decrease in yield can be minimized using yield stimulants.

Budded trees are considered tappable when they attain a girth of 50 cm at a height of 125 cm from the bud union. Subsequent panels are also opened at the same height. This height has been fixed after considering the average height of tappers and the convenience in tapping. Although opening for tapping at 175 cm did not show much variation in yield (Abraham and Hashim, 1983), it resulted in excessive wounding and spillage.

Tappability of trees is assessed using suitable girth wires. Girth wires are made by fixing a piece of wire of 55 or 50 cm length respectively on a straight stick 50 cm long for seedling trees and 125 cm long for budded trees. For assessing tappability, the stick is held against the tree with one end on the ground (for seedling trees), or on the bud union (in the case of budded plants) and the wire on the other end is wound around the tree. If the free ends of the wire just meet or leave a gap (Plate 29. c), it indicates that the tree has attained standard tappable girth and is marked for tapping. Alternatively measuring tapes can be used.

5.2 Marking

It is economic to begin tapping when 70 per cent of the trees in a selected area attain the standard tappable girth. Generally it takes six to seven years to reach this stage. However, by planting advanced planting materials like polybag plants, the immaturity period can be reduced. Panels are marked on the trees selected for tapping, using a template and marking knife (Plate 29. d), parallel to the contour terrace or planting line to facilitate efficient tapping operation. The template is made of a strip of flexible metal, preferably GI sheet (of low carbon content) 16 to 18 cm wide for seedlings and 20 to 23 cm for buddings. Separate templates are required for seedlings and buddings and should be made in such a way that when used to mark, the slope of the cut should be 25° for seedlings and 30° for buddings.

After deciding the position of the panel, a vertical line, called front channel line, is drawn. On this line, the opening height is marked. Since half spiral tapping is the standard, the half circumference of the tree at the opening height is determined using a measuring tape or string and marked on the back. Another vertical line, called back channel line, is marked on the half spiral point above the opening height. With the aid of the template placed between these two lines, at the opening height, ensuring a high left to low right, the line for tapping cut and a few guide lines (Plate 29. e) are marked through the grooves. The vertical front end of the template should be kept on the front channel of the tree, parallel to it and the free end of the template is wound on the trunk towards the left side. After marking the guide lines, spout and cup hanger are fixed (Plate 29. f,g). Subsequent guide lines are marked every year before commencing of tapping (Plate 29. h).

5.3 Tapping

Tapping is a process of controlled wounding of bark and rubber trees are exploited by regularly removing a thin shaving of bark from the surface of the tapping cut at specified intervals (Plate 30. a-d).

In India, the best period for opening new fields for tapping is March to April. The trees that are left behind for want of standard girth may be considered for opening in September. The tapping cut is opened along the uppermost template marking. The markings below serve as guide lines for subsequent tappings to maintain the slope of the cut and to control bark consumption.

5.3.1 Slope and direction of cut

Latex vessels in the bark are oriented at an angle of 2 to 7° from the vertical, low left to high right. Therefore, a cut from the high left to the low right of the stem severes maximum number of latex vessels.

Tapping cut on a budded tree should have a slope of 30° to the horizontal. Since the bark of seedling trees is fairly thick, the cut should have a slope of 25°. A very steep cut leads to wastage of bark when tapping reaches the base of the tree and too flat a cut leads to overflow (spillage) of latex. The slope should be marked annually with appropriate templates. Slopes, other than the recommended, have not resulted in any increase in yield (de Jonge, 1919). The tapping cut should have an inward slope towards cambium. Absence of such slope can also lead to spillage.

5.4 Depth of tapping and bark consumption

Tapping is a highly-skilled operation. The tapping cut should be sufficiently deep but should not injure the cambium. A good tapper acquires this skill through practice and will tap to the optimum depth of within 0.5 mm of the cambium to obtain optimum yield without injuring the cambium. Shallow tapping results in considerable loss of crop. To remove the plugs of coagulated latex at the cut ends of latex vessels, it is enough to cut off only a thin layer of bark at each tapping. Yield is not enhanced further with increase in thickness of the bark shaving (de Jonge and Warriar, 1965). However, under low frequency tapping systems, a slightly thicker bark shaving per tapping is to be removed. Even removal of bark along the whole length of the tapping cut up to the correct depth, is important. Average annual bark consumption on half spiral cut of different frequencies is as follows :

Alternate daily	:	20 - 23 cm
Third daily	:	16 - 18 cm
Fourth daily	:	14 - 16 cm

Bark regeneration (formation of the renewed panel) is brought about by the activity of the cambium. The rate and extent of renewal are dependent on the inherent genetic characters of the planting material, fertility of the soil, climatic conditions, tapping system, intensity and quality of tapping, planting density, disease incidence, *etc.* In the renewed panel, slightly higher bark consumption is allowable in view of its lower thickness.

5.5 Time of tapping

It is necessary to commence tapping early in the morning as late tapping will reduce latex yield due to increased transpiration leading to lower turgor pressure. Such reduction is more marked in the summer months. For pre-dawn tapping, head lights can be used. In practice, the beginning and end points of the task are changed periodically to allow comparable period of latex flow from all the trees in a block.

5.6 Tapping task

Number of trees allotted to a tapper for a day's tapping is known as tapping task. Task size is fixed on the basis of stand per ha and topography of land. Normal tapping task in India, varies from 300 to 400 trees. Task size is often reduced when double cut or other intensive systems are practised.

6. FACTORS INFLUENCING TAPPING EFFICIENCY

Efficiency of tapping varies from person to person and is influenced by a number of factors. As a normal estate practice, young trees are given to experienced tappers with the objective of minimizing cambium injury. Proper supervision ensures tapping of all the trees at proper slope and depth and flow of latex through the tapping cut into the cup.

Tapping efficiency is influenced by sharpness of tapping knife, obstacles in inter-rows and topography of the field. Tapping time (excluding collection) comprises 25 per cent actual knife work, 35 per cent walking and 40 per cent cleaning and replacing cups (Paardekooper, 1989). Cleaning time can be reduced considerably by using plastic cups and walking time by proper field maintenance. Besides, age of trees also determines tapping efficiency. Normally, less time is taken for tapping on BO-1 panel as against BO-2 panel because of lower girth. In renewed panel, the time taken for tapping may still be higher due to increased length of tapping cut and condition of the bark.

For a given clone and exploitation system, latex yield from a tapping depends on initial flow rate and duration of latex flow (Rao *et al.*, 1990). Latex vessel pressure existing at the time of tapping has a profound effect on yield and normally tapping is carried out in the early morning hours, when latex contained in the vessels is at a higher hydrostatic pressure (in the range of 1.0 - 1.5 MPa). After sunrise, it normally falls and reaches a minimum at 1300 to 1400 IST. No differences in yield are observed between 2000 to 0700 IST, after which it gradually decreases, and ultimately reaches a minimum of around 70 per cent by 1300 IST, compared to that of the night yield (Paardekooper and Sookmark, 1969; Raghavendra *et al.*, 1984). The diurnal variation in yield closely follows vapour pressure deficit (VPD) of air. This in turn implies the role of transpiration on turgor pressure and its influence on latex flow (Ninane, 1967). The dry rubber content (DRC) of latex at midday increases by four points over that obtained during the night (Paardekooper, 1989). However, a high initial flow rate during night and early morning hours results in higher volume of latex which more or less compensates the slightly lower DRC.

For a given system of tapping, girth of a tree determines the length of the cut. Clonal differences for yield exist with different lengths of cut (Frey-Wyssling, 1933). Drainage area (the area of bark which contributes latex at a single tapping), extending upward, downward and laterally from the cut, also influences yield. It can be measured by bark contraction, turgor pressure, use of radio active chemicals and microtapping (Lustinec *et al.*, 1968). There is clonal variation for drainage area also. High yielding trees have larger drainage areas, which in turn will result in a lower response to increase in length of tapping cut. Variation in yield due to different lengths of tapping cut also varies with season. Besides the length of tapping cut, number of tapping cuts in a tree is another factor affecting tapping efficiency and yield. By operating more than one cut on the same tree, yield can be enhanced. However, double cut systems might affect growth and hence such systems are considered unsuitable for young trees (de Jonge, 1965). There are reports indicating that double cut systems would be profitable after BI-2 panel (Ng *et al.*, 1965). When two cuts are in operation, if the drainage areas do not merge or are independent in a physiological sense, there may not be any serious adverse effect for a reasonable time.

Frequency of tapping has profound effect on the physiology and yield response of trees. Higher frequency will affect the physiological balance between latex extraction and its regeneration, whereas lower frequency would affect yield response. Generally, low frequency systems result in high yield per tapping. An inverse relationship between frequency of tapping and yield per tap was observed for a given length of tapping cut

(Ng *et al.*, 1969). In a comprehensive study on 30 combinations of tapping cut and frequencies with intensities ranging from 17 to 400 per cent, Paardekooper *et al.* (1975) reported overriding influence of tapping intensity on yield.

7. INTENSIVE TAPPING

After less intensive tapping on virgin bark and first renewed bark, intensive tapping systems can be adopted. This can be done either by increasing the number (Plate 31. a) and length of tapping cut or by increasing the frequency. Method of intensive tapping depends on the status of tree, previous tapping systems, availability of bark and the period available for exploitation. If double cut systems are adopted, the cuts should be sufficiently apart (at least 45 cm) to avoid overlapping of drainage areas (Plate 31. b).

Slaughter tapping is the last stage in the tapping cycle implemented two to three years before replanting. Since the objective of slaughter tapping is to extract as much latex as possible from the available bark, very little consideration is given to bark consumption, intensity, frequency and quality of tapping as well as intensity and frequency of stimulation (Plate 31. c).

When tapping of renewed bark on basal panels becomes uneconomic, new cuts are opened in the high panel. The tapper uses a small ladder to reach the 1/2 V-cut (Plate 31. d). Since ladder tapping is more strenuous and time consuming tapping tasks are usually reduced.

8. PUNCTURE TAPPING

The exploitation through methods which do not require high skill was considered in many rubber growing countries. Puncture tapping to extract latex through punctures made on the bark, was one of the alternatives. This method became commercially feasible only with the introduction of good yield stimulants. Research workers in various countries made serious efforts to develop it further (Leong and Tan, 1978; Samosorn *et al.*, 1978; Subronto, 1982).

In puncture tapping, an ethephon-based stimulant is applied to a strip of scraped bark, usually vertical, 1.5 to 2.0 cm wide and 50 to 100 cm long (Plate 32. a, b). On each tapping day, four to ten punctures are made, at equal spacing in the stimulated bark and latex is collected. At monthly intervals a new strip, adjacent to the old strip is prepared, stimulated and puncture-tapped. The practical advantages of puncture tapping over conventional tapping are low requirement of skilled labour, substantially larger task size, better girth increment, chances of less or no panel dryness and possible introduction of exploitation at an early age. This method has a few drawbacks as well. These include spillage of latex (if not properly guided along the strip), late dripping, need for frequent stimulation, and adverse bark reactions like external flaking, bark burst and uneven swellings on the panel. It may be prudent to avoid puncture tapping in sensitive clones like PR 107, PR 251, PR 255 and RRIM 600 (Sivakumaran and Gomez, 1980; Paardekooper, 1989).

A vertical strip of 50 to 60 cm length with six punctures per tapping (Plate 32. c,d), stimulation with 2.5 per cent ethephon and a third daily or lower frequency tapping appear suitable for most clones. This method may have potential where there is serious shortage of skilled tappers and for one or two years of exploitation before opening for conventional tapping. In India, puncture tapping is recommended for exploiting immature trees. Trees can be puncture-tapped when they attain girth of 40 to 45 cm, one year before normal opening, with the following precautions :

- Puncture should avoid the cambium, but should be deep enough
- Punctures should be distributed uniformly along the stimulated portion (60.0 x 1.5 cm vertical bands below tapping height) and should not be concentrated on the same point
- Needle (Plate 32. c inset) should have a diameter of 1 mm with blunt tip.
- Ethephon 2.5 per cent active ingredient, 10 applications per year will be required.

9. COMMON TAPPING SYSTEMS IN INDIA

Response to different tapping systems varies from clone to clone. In general, budded trees are to be tapped on half spiral alternate daily (1/2S d/2) system and seedlings on half spiral third daily (1/2S d/3) system. There are, however, certain clones like RRII 105, PB 235, PB 260 and PB 28/59, which are prone to TPD under alternate daily system. To ward off the incidence of panel dryness in such clones, it is recommended to adopt d/3 tapping frequency. It is preferable to resort to d/3 frequency if high incidence of panel dryness is encountered. Daily tapping of trees will lead to more incidence of panel dryness and should be avoided.

For high yielding cultivars d/3 frequency can be adopted from opening of the virgin bark. Although the yield per ha may be marginally lower during the initial period, the difference between d/2 and d/3 system will be narrowed in course of time and there will be an ultimate saving in the cost under d/3 system with increase in net profit.

Yield varies with the clone, age of the tree, fertility of the soil, climatic conditions, tapping system followed and skill of the tapper.

10. CONTROLLED UPWARD TAPPING

History of upward tapping dates back to the early 20th century (Wright, 1912) and the practice of tapping a half spiral or full spiral cut on high panel has since then been followed. This method became widely popular during the second world war period because of the immediate large increase in yield from bidirectional tapping (Ashplant, 1942). However, the high yield was not sustained through the whole panel. In this method, the tapping knives used were the same as those used for basal panel tapping. The absence of a proper knife was one of the major reasons for the poor standard of tapping resulting in severe wounding, profuse spillage, high rate of bark consumption, variable angles of slope and lengths of cut among trees within a task. These defects led to high incidence of TPD, rapid yield decline and too early exhausting to high panels. The lack of proper technique and wrong posture of tapper caused body ache and muscle fatigue, ultimately leading to the tappers' resistance to this method. Because of the above reasons, this method was abandoned.

Subsequently, for long-term exploitation of high panel, downward tapping of 1/2 V-cut from 1 m or more, above the opening height of basal panel was introduced. Since wooden or metallic ladders are used to reach the cut, this method came to be known as ladder tapping. The tapping knife used is the ordinary 'Michie-Golledge' type and there is better control in tapping. However, in this method, yield declines as the cut approaches the renewed bark. Since ladder tapping is more strenuous and time consuming, reduced tapping tasks are usually given resulting in increased tapping cost. Moreover, accidents like falling from ladders are also common.

The drawbacks of the earlier high panel exploitation methods were solved to a large extent by the introduction of controlled upward tapping (CUT) of stimulated short cuts using a long-handled modified gouge knife. This system was introduced in Malaysia in the mid-1970s (p'Ng *et al.*, 1976) and later in India with modifications to suit the local agro-climatic conditions (Vijayakumar, 1991; Vijayakumar and Thomas, 1993). The use of the modified gouge knife for upward tapping minimizes spillage, bark consumption and cambial injury and maintains the angle of the cut. Tapper can tap the cuts from ground without using a ladder. Physical strain on body caused by raising of hands above shoulder while tapping with ordinary knife is not there with the gouge knife as the left hand is not raised above the shoulder and the right hand not above its elbow. Normal tasks can be tapped when CUT is practised. High panel can be exploited for more than eight years sustaining high yield.

CUT can be practised for longer exploitation of the virgin bark, above the basal panel and can be adopted under the following situations :

- Low yield from renewed bark
- Renewed bark is unsuitable for tapping (Plate 33. a) because of outgrowths, diseases or panel dryness
- Too early completion of tapping on virgin bark
- For prolonged exploitation of high panels or for prolonging the economic life after completion of BI-2 panel.

The modified gouge knife (Plate 33. b), specially made for controlled upward tapping, can be used from the ground. The V-shaped knife produces an inverted groove, with an acute angle, which helps in better adhesion of the latex along the groove, whereby spillage is minimized. The knife is fixed on the handle at an angle of 30°. This allows the tapper to stand near the tree while tapping, without having to raise his hands above the shoulder level. This ensures less strain on the arms and body during tapping. Thus, better control of tapping, uniform rate of bark consumption without injury to cambium and proper maintenance of the slope can be achieved with comparable task to that of basal panel. Since the end of the blade is made at a 60° inclination to the keel of the gouge, consistent length of tapping cut is ensured *i.e.* there will be no panel encroachment. A well-sharpened knife ensures easier and faster tapping. The modified gouge knife can be sharpened either from the inner face out or from the outer face. The knife can be fitted on a 1.2 m long metallic or wooden handle. When the tapping cut reaches higher levels, the length of the handle may be increased further. The knife can be light weight

(750 g) or heavy (900 g). When light knives are used, more force is required for tapping, but generally less bark is consumed. It is suitable for beginners in upward tapping. A heavy knife is suitable for experienced tappers as it requires less effort. Bark consumption is also slightly high and hence these knives are suitable for older trees with thicker bark.

For CUT, tapping should commence on the virgin bark of the high panel, just above the renewed bark of the basal panel, preferably on the opposite side of the basal panel under tapping. From the front end of the previous base panel half spiral cut, a vertical line is drawn on the trunk upwards (front guide line). Another vertical line (back guide line) is drawn on the left side of the front guide line, passing through the quarter circumference point of the tree. Between these two lines, a tapping cut with a slope of 45° from the horizontal is made (Plate 33. c). The first few tappings should be done downwards with a regular knife to make available a space equivalent to the width of the modified gouge knife blade (1.5 cm). This will serve as a supporting cut as well. Subsequent to this, upward tapping is practised, in which, the direction of cut is from the front end of the tapping cut towards the back (low right to high left). The quarter spiral cut at 45° slope ensures better control, minimum injury of cambium, lower bark consumption and minimum spillage of latex along the panel.

In CUT, good tapping standards should be stressed. Wounding the trees, which could also cause spillage of latex, has to be avoided and a depth within the range of 0.5 to 1.0 mm from the cambium may be ensured.

The amount of bark to be consumed for a fixed period has to be marked on every tree. In CUT, the rate of bark consumption varies according to the height of the panel and age of the bark. At the commencement of CUT, since tapping of the high panel is within reach and the tree lace can be removed by hand before tapping, the rate of bark consumption should be maintained at 2.5 cm per month (Vijayakumar, 1991). However, at higher levels, since tapping has to be done without removing the lace, bark consumption up to 3 to 4 cm per month is not unusual.

Increase in the length of tapping cut enhances yield per tap per ha. However, with effective yield stimulants like ethephon, there is no need to resort to longer cut than 1/4S↑. Moreover in the short cut, the time required for tapping is more or less the same as that for conventional downward tapping. There is only small decline in yield but ultimately there is a longer exploitation period. For a quarter cut, effective exploitation is possible only with stimulation. Generally, ethephon at 5 per cent concentration is applied on lace at monthly intervals. Positions of the first and subsequent panels would depend on the positions of the basal panels and the tapping cut in the basal panel.

For successful implementation of CUT, the tapper's body movement is very important. Since the tapping is from the front end of the tapping cut towards the back, the tapper has to stand facing the front channel with legs abducted at about 60 cm apart (Plate 33. d). This helps in equal distribution of body weight. While tapping, due to alternate leg movement, body weight gets shifted from one leg to the other. During tapping, the handle of the knife should be held close to the body and the left arm should never be lifted above the shoulder. The tapping knife should be held in the right hand and the left hand used for guiding the knife along the tapping cut. Even when the tapping cut is at a higher level, for easy tapping, the left and right hands should gradually and progressively glide down over the handle. If all the operations are carried out in a proper and systematic way, CUT will be the easiest exploitation technique for high level tapping. However, special training for about a week is required to use the modified gouge knife and to tap without raising the hands above the shoulder level.

The length of the tapping cut depends on the duration for which CUT is to be followed. Normally with alternate daily tapping, one panel can be tapped for two years. Thus, with one-third spiral cut, tapping can be done for six years. The duration can be increased with one-fourth spiral cut. The best known system for CUT in South India is periodic panel changing, with base panel tapping with rainguarding during rainy season and CUT on high panel during non-rainy seasons. Following this system, CUT on 1/4S can be practised for 12 years, each panel being exploited for 24 months (eight months per year).

Tapping frequency for CUT is the same as that for base panel, *i.e.* d/3 for high yielding clones and d/2 for medium and low yielding clones. Around 50 per cent yield increase over conventional tapping of renewed bark in the basal panel can be achieved by adopting CUT.

11. RAINGUARDING

Any suitable device, fixed above the tapping panel to keep the panel, the tapping cut and the collection cup dry during the rainy season, is termed as rainguard. Rain interference during tapping operations is a serious problem in rubber plantations resulting in crop loss due to no tapping, late tapping or wash out. Interference of rain in tapping can be minimized by the use of rainguards. Rainguards of various forms and shapes and of various materials have been evaluated (Southern, 1969; Wood *et al.*, 1984; Chew *et al.*, 1985). Rainguards like RRIMGUD and Ebor Eaves are very effective in Malaysia (Chan *et al.*, 1990). Skirts of polythene sheet stitched to provide frills are found useful in Sri Lanka and India. Due to the wide variation in the rainfall pattern, the rainguards which are very useful in other countries may not be equally effective in India. A major portion of the rainfall in India occurs during early morning hours. In many countries like Malaysia, only 16 per cent of the total rainfall occurs during the normal tapping time (Daud *et al.*, 1989).

Every year, around 80 tapping days are lost due to rains in India. In a normal year, around 25 to 40 tapping days can be gained in a field by rainguarding, depending on the tapping frequency (d/3 or d/2). In the traditional rubber growing regions of India, the rainfall is bimodal comprising southwest and northeast monsoons. Of these, the diurnal pattern directly affects tapping operations during southwest monsoon period.

Three types of rainguards, *viz.* polythene skirt, modified ready to use skirt-type rainguard and tapping shade are popular in India (Plate 34. a-d). Among the various types of rainguards, polythene skirt is widely accepted because of its efficiency and cost effectiveness. Depending on the prevailing market price of rubber and cost of rainguarding, profitability may vary (Joseph *et al.*, 1989). The materials required to rainguard 300 trees (average girth 72 cm) using polythene skirt are given in Table 2.

Table 2. Quantity of materials for rainguarding 300 trees

Item	Quantity
Polythene (LDPE) 300 gauge thickness, 45 cm width	12.0 kg
Bituminous rainguard compound	30.0 kg
'Kora' cloth	6.0 m
Staple pins (No.10 for virgin bark and 24/6 for renewed bark)	2000

11.1 Method of rainguarding

The different steps involved in polythene skirt rainguarding are(Plate 34. b) given below:

- Frill the polythene at equal distance using a sewing machine, ensuring 40 per cent reduction in length.
- Using a scraper, lightly scrape the dry bark 10 cm above the tapping cut and parallel to it (Plate 35. a). The scraped band should extend a minimum of 15 cm from front and back end of the tapping cut.
- After removing the dust, firmly smear a thin film (roughly 2 mm thick and 4 cm wide) of rainguard compound on the scraped band (Plate 35. b).
- Fix the frilled polythene on this, ensuring that only the lower half (2 cm) of the rainguard compound is covered by the polythene.
- Fix the 'kora' cloth ribbon of around 2 cm width firmly using suitable stapler pins over the cut end of the polythene in such a way that 1 cm width of the cloth will be over the polythene and the remaining portion over the compound (Plate 35. c). It is desirable to use medium-quality cloth, as it ensures infiltration of the rainguard compound and thereby proper binding.
- Then apply the second coat of the compound to completely cover the cloth ribbon (Plate 35. d).

For better rainguarding, the polythene must be frilled up to the maximum possible length before taking to the field. From this, the required quantity has to be cut for each tree. Frilling of the polythene directly on the adhesive without stitching is not a good practice. Only good quality rainguarding compound should be used. If warming is required, the closed containers may be kept in open sunlight during morning hours. Heating of the compound directly on flame or mixing with kerosene must be avoided.

The modified ready to use skirt-type rainguard (Plate 34. d) is also widely used. It is made of high modulus high density polyethylene (HMHDPE) and its width varies according to its position on the tree, *i.e.* 18 cm at the backside and 40 cm at front side of the tapping cut. The frills are made in the factory itself. Method of fixing is almost similar to that of polythene skirt rainguard. This rainguard also ensures full protection of the tapping panel. However, the cost is higher than the polythene skirt-type. Depending on the girth of the trees, three sizes (small, medium and large) are available.

Unlike the other two types, tapping shade is a rigid-type of rainguard (Plate 34. c) made of high density polyethylene (HDPE) and polyvinyl chloride (PVC). It is fixed horizontally on the tree, leaving 15 cm from the back end of the tapping cut, in a circular manner ensuring that the hood region is positioned above the front end of the tapping cut. Being rigid, chances of panel wetness and wash out are more during rains accompanied by winds. In the first two or three years of tapping, there is no hindrance for tapping, whereas in subsequent years visibility and access to the tapping cut are obstructed. Quality of tapping will be affected considerably. Tapping shades are also available in varying sizes (small, medium and large). Among the three types, the tapping shade is the costliest (Joseph *et al.*, 1989), but it can partly be reused.

Irrespective of the type of rainguard, if tapping is carried out during the rainy season, use of an effective panel protectant is required. The major panel disease noticed on trees tapped in the rainy season is bark rot (black stripe). Panel washing with a fungicide like mancozeb at 0.375 per cent a.i. at weekly intervals may be done during the rainy season (Jacob *et al.*, 1995). Due to its hydrophobic nature, application of a good quality wound dressing compounds like rubberkote also ensure less incidence of panel diseases. In India, rainguarding is recommended only in fields where the yield is 675 kg or more per ha per annum and 25 or more tapping days (under d/2 frequency of tapping) are lost annually due to rain (Joseph *et al.*, 1989).

Many small growers remove the entire rainguard after the rainy season along with the rainguard compound, by scraping and apply fungicides on the scraped area. Instead of this, it is advisable to remove the polythene, leaving around 5 cm of it on the tree. This will reduce the intensity of stem flow just above the newly-fixed rainguard by diverting most of the water. Thus the bark immediately above the rainguard will also remain comparatively less wet.

12. MODERN EXPLOITATION TECHNIQUES

Survival of the natural rubber industry is being threatened by low and fluctuating prices, escalating cost of production and scarcity of skilled tappers. Use of the commercial yield stimulant ethephon for conservation of bark and reduction in labour inputs for sustainable yield is attempted in all rubber growing countries. One of the major outcome of these efforts is the practice of low intensity tapping systems consisting of lower frequency of tapping or shorter tapping cuts (Vijayakumar *et al.*, 1990a). In low frequency systems, judicious ethephon stimulation could be employed to enhance productivity and reduce labour input (Sivakumaran and Hashim, 1985; Gohet *et al.*, 1991; Zarin *et al.*, 1991). Many clones respond favourably to low frequency system with mild ethephon stimulation (Gan *et al.*, 1989; Zarin *et al.*, 1991; Thanh *et al.*, 1996; Nugawela *et al.*, 1997). Since these systems invariably involve yield stimulation, refinement by latex diagnosis, wherein levels of physiological parameters are estimated in the latex (Gohet *et al.*, 1991), can be used to optimize yield.

Application of ethephon at the time of resuming tapping as booster dose has been found to improve yield performance (Gan *et al.*, 1989). Of late, gaseous methods of yield stimulation like Hypodermic Latex Extraction (HLE)/RRIMFLOW and REACTORRIM coupled with puncture tapping or minicut systems, have also been developed as a potent and far more effective method than conventional methods of stimulation (Guha *et al.*, 1992; RRIM, 1993) as a labour saving device.

Tapper wages constitute a major component of cost of production of natural rubber. Due to shortage of tappers and the resultant high wages, low frequency tapping systems are favoured in most of the countries. From the d/2 system, the initial shift was towards d/3, with a subsequent shift to d/4 system. Weekly tapping (d/7) has also been attempted. In high yielding clones like RRII 105 and PB 260, higher incidence of TPD is another reason for shifting to lower frequencies. The primary objective is a sustained rate of crop extraction over a long period. Compared to 1/2S d/2 tapping (100% intensity), lower frequency tapping without stimulation will reduce the crop production. Hence, low frequency tapping coupled with yield stimulation is the ideal approach. The intensity of stimulation depends on the frequency of tapping, clone, panel and many other factors. However, long-term experiments with 2.5 per cent ethephon at four to six applications per year on the virgin panel gave a sustainable yield (Thanh *et al.*, 1996). The higher productivity per tapper makes the low frequency tapping more attractive and helps to reduce the requirement of skilled tappers. In countries like Malaysia, lower frequency coupled with higher task size (750 trees) has led to a marked reduction in tapper requirement and thereby decrease in the cost of production. Here, the skilled tapper completes tapping, whereas collection and allied works are done by unskilled workers (RRIM, 1993).

Another approach to low intensity tapping is to reduce the length of the tapping cut to 1/3S, 1/4S, minicut or even to a single puncture, or to combine reduced frequency and reduced cut length (Lee, 1989; Zarin *et al.*, 1991; Lukman, 1995). Usually short cuts are employed for exploiting the high panels. In both the situations, stimulation not only compensates the yield loss due to lower intensity but also conserves bark for a longer period. Short cuts on basal panels are mainly practised for periodic change over with low doses of yield stimulation.

Periodic tapping can also be adopted for increasing land to man ratio. In this, the frequency is maintained at d/3 but the number of blocks allotted to one tapper is increased to four. At any given time only three blocks will be under tapping and the fourth will be under tapping rest for one month (Sivakumaran *et al.*, 1991; Chong and Sivakumaran, 1997).

The gaseous method of stimulation with ethylene *viz.* HLE / RRIMFLOW is another novel method to overcome the current constraints of exploitation. A small portion of the bark is exposed to ethylene gas, with the help of applicators, made of synthetic rubber, polyethylene, PVC or polystyrene. The applicators are secured over the scraped area of bark with adhesive or appropriate sealers. If leak proof, the same site of application can be used for six to eight months. Ethylene gas is applied at weekly intervals. In HLE, latex is extracted by a hypodermic puncture (1 mm) and collected in an enclosed container containing 8 to 10 per cent ammonia solution (Guha *et al.*, 1992). RRIMFLOW comprises of a minicut (2.5 cm) at d/4 frequency. These methods are advantageous as trees can be exploited using unskilled labour. Reduced frequency of d/4 or d/6 or even less will minimize tapper requirement and the larger task of 900 to 1000 trees will improve labour productivity.

In REACTORRIM, continuous diffusion of gaseous stimulant to the laticiferous system is achieved with the aid of a diffuser secured on the scraped bark. Stimulant gas is slowly and continuously released from a reactor system connected to the diffuser. Latex is extracted by open puncture on a strip (RRIM, 1993).

Low intensity tapping systems also have added long-term advantages like absence of any marked incidence of panel dryness, lower rates of bark consumption and longer economic life span of trees.

13. ECONOMIC LIFE OF TREES

Under regular alternate daily tapping (d/2), each basal panel of budded tress can be tapped for five years. Thus from BO-1 to BI-2 panel, crop harvesting can be continued for at least 20 years. BII panels are usually not suitable for exploitation. If slaughter tapping is resorted to after BI-2, the total productive period will be 22 years. If CUT (1/4 S↑) is adopted, the productive period can be extended up to 28 years. Under d/3 and d/4 frequencies of tapping of the basal panel, the productive period can be extended further by four to eight years. However, the assessment of economic life of the trees will also depend on other factors like price of rubber, wood, availability of new high yielding clones, management practices, policies, *etc.*

14. TAPPING PANEL DRYNESS

Occurrence of TPD, commonly known as brown bast, in tapping trees is a major syndrome encountered in rubber plantations. It is characterized by a gradual, or in rare cases sudden, drying up of the latex vessels below the tapping cut over a part or its entire length, resulting in abnormally low yield or complete stoppage of latex production. This was reported in plantations in Asia since the beginning of the 20th century (Belgrave, 1917; Keuchenius, 1919). Panel dryness is of economic importance as it renders the trees non-productive.

Incipient brown bast trees often show a prolonged flow of watery latex (late dripping) with drastic drop in DRC or in some cases with excessive precoagulation on the tapping cut which precedes development of dryness (de Fay and Jacob, 1989). Subsequently, partial dryness of varying degrees can be noticed. As it advances, latex flow completely stops and typical brownish discolouration as streaks or patches develops. In most of the cases, dryness spreads to the adjacent virgin panel, affecting the entire circumference. The terminal symptoms like bark cracking, flaking and development of burs and nodules can also be observed (Plate 36. a-d).

Tapping panel dryness, could be due to inherent susceptibility of certain cultivars (Sivakumaran *et al.*, 1986) or as a consequence of intensive tapping (Eschbach *et al.*, 1989). Involvement of a pathogen is suspected, but no confirmatory evidence is available so far (Zheng *et al.*, 1988). It is generally considered to be a physiological disorder associated with excessive exploitation (Paranjothy *et al.*, 1975; Chrestin *et al.*, 1985). Climate and growth period are also reported to influence incidence of TPD (Bealing and Chua, 1972). In the case of susceptible clones, the incidence of dryness is higher in agroclimatically dry regions as against wet or moderately dry region (Sivakumaran *et al.*, 1988). Effect of unbalanced nutrition on TPD has been reported (Pushpadas *et al.*, 1975) and nutrient parameters can provide valuable information and help to diagnose onset of TPD (Zainab and Sivakumaran, 1996).

Dryness is primarily a disorder of latex vessels and it originates in the vessels that are exploited. Precoagulation of latex on tapping cut or late dripping is considered to be the expressions of unstable latex. This results in flocculation of rubber particles *in situ* and early latex vessel plugging (Chrestin *et al.*, 1985). The combination of increased peroxidase activity and diminished quantity of scavengers in the latex of affected trees results in destabilization and lysis of lutoids leading to coagulation (Chrestin, 1989). During the development of TPD syndrome, there is an increase in the extent of bark cell wall protein glycosylation with essentially no apparent change in the amino acid composition of the extracted major protein (Prakash *et al.*, 1994).

High intensity exploitation is known to promote incidence of TPD. The proportion of dry trees increases with tapping intensity and particularly so with tapping frequency (Paranjothy *et al.*, 1975; Sulochanamma *et al.*, 1993). Dryness was induced by puncturing the bark and sealing the punctures with drawing pins, at weekly intervals (Sivakumaran and Pakianathan, 1983). It could be due to localized *in situ* coagulation of latex, which triggers further floc formation. Through considerable increase in tapping frequency, brown bast was induced within a short period and clonal variation in the susceptibility could be quantified (Vijayakumar *et al.*, 1990b).

In order to take remedial measures and to control its spread, it is important to detect dryness early. Dryness invariably develops from the tapping cut and spreads along the latex vessels. Generally, dryness seldom spreads from virgin to renewed bark or from one regenerated panel to another. Latex vessels in virgin bark are discontinuous with that of regenerating vessels in adjacent panels and hence dryness that develops in the virgin bark is confined to it.

The common practice in the past was to rest the trees whenever dryness develops on the tapping cut. However, in a majority of such trees, there is recurrence of dryness on resumption of tapping (Chrestin *et al.*, 1985). Similarly, chemical treatment of dry trees is not an effective method though, in partially dry trees, it may boost yield temporarily and cause better bark regeneration in totally dry trees (Sivakumaran *et al.*, 1986).

Physical techniques involving isolation of cuts on the panel can check and prevent spread of dryness along latex vessels (Sivakumaran, 1989). Routine analysis of latex diagnosis parameters can help in early detection of the probability of incidence and hence intensity of exploitation can be reduced sufficiently early to prevent the development of dryness.

Trees with total dryness on the lower panels can be exploited by CUT, preferably with a quarter spiral cut. Incidence of TPD can be reduced by reducing the intensity of exploitation. In rare cases, bark dryness has been observed at the commencement of opening of trees for tapping. As of now, there is no efficient treatment for the control of TPD.

15. TAPPING REST

In South India, the rubber trees shed their leaves during December to February and refoliate soon after (wintering), along with production of flowers. During defoliation and flowering, the yield will be comparatively poor and normally trees are given about four weeks rest, if the soil is very dry and yield is not economic.

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