Chapter 3

INCIDENCE OF TPD
3.1 INTRODUCTION

Tapping panel dryness (TPD) of rubber trees (*Hevea brasiliensis* Muell. Arg.), also known as brown bast is a serious disorder occurring in all rubber growing countries resulting in severe loss of yield. In the early decades of the commercial cultivation of natural rubber TPD was relatively a minor issue assumed to be due to predominance of relatively low yielding clonal and bud-graft populations (Rands, 1921a). According to Bryce (1921), the incidence of TPD was very small in Ceylon where mild tapping has been the practice unlike in several other countries where the incidence was high and the tapping was severe. It is assumed that when more high yielding clones were evolved and practices including stimulation commenced, TPD became a much serious problem. Today, TPD is a major factor affecting productivity and a key stumbling block in realizing the full yield potential in plantations of newly developed high yielding clones. Although yield of affected trees can be fully lost, loss of the trees due to TPD has never been reported. Obviously, a tree getting affected during its early years of tapping will cause much more net loss to the grower than if it is affected later in its economic cycle.

Rands (1921) observed 52-85% incidence of brown bast in seedling trees in Java. Observations from China (Shaoqiong, 1989), Malaysia (Sivakumaran and Haridas, 1989) and Sri Lanka (Samaranayake and Yapa, 1989) revealed clonal differences in susceptibility (Chua, 1967; Bealing and Chua, 1972). In India, TPD has been known to affect rubber plantations since the beginning of commercial rubber cultivation. However, it became more serious with the introduction of the high yielding clones. The high yielding clone RRII 105 planted in more than 85% of rubber growing area in India is highly susceptible to TPD.

The incidence of TPD in smallholdings can be in the range of 0-5% in the first few years of tapping which can eventually go up to as much as 5-10% or even higher (Sethuraj, 1992; Sivakumaran *et al.*, 1994; Nair, 2004). There are holdings, especially in the final stages of tapping in which more than 20% trees are fully lost due to TPD. According to Chan (1996), up to 10% of the trees affected by TPD in the A panel and up to 15% in the B panel. The literature is rather confusing with respect to the extent of prevalence of TPD. Some studies have reported as much as 50% or even more TPD incidence (Lukman, 1992; Soepena, 1992).

There are reports of variations in the incidence of TPD with regard to clone, age of the plant, stages of tapping and system of tapping (Chan, 1996; Eschbach *et al.*,...
TPD trees in clusters of two or more have been observed in plantations (Mydin et al., 1999; Taysum, 1960; de Soya et al., 1983). In many cases the immediate next trees to the affected tree also was affected. Even though the occurrence is at random in the initial years, immediate next trees to the affected ones in the direction of tapping are reported to be affected subsequently.

The most commonly recommended practice to manage TPD is taping rest (leaving the trees untapped) (de Silva, 1961). Tapped trees are regularly watched for incipient symptoms of early TPD. Low frequency tapping, shallow tapping, discrete use of stimulants and adopting controlled upward tapping are other management strategies (Anthony et al., 1981). Application of a compound containing microelements (Xiaodi et al., 1997), use of petrolactum (Sethuraj, 1992) and tar has been reported (Bobilioff, 1921) for controlling TPD. Changing tapping from an affected A panel to a fresh B panel led to the syndrome spreading into the B panel within a matter of less than one year (Krishnakumar and Jacob, 2002). Eschbach et al., (1994) reported the increase in the intensity of bark necrosis with panel change. Management of TPD by adopting upward system of tapping has been attempted by some workers. Earlier reports on management of TPD trees by adopting upward system of tapping showed that TPD trees tapped under CUT system are initially free from dryness and can be exploited although in some trees, dryness developed on upward cuts after six months of tapping (Sivakumaran et al., 1986). However, results of upward tapping with stimulation were not always encouraging (Lukman, 1989; 1992; 1996). Tapping any part of the tree that is not affected was suggested as the only practical management solution for TPD trees which were impossible to recover (Commere et al., 1989).

In order to assess the actual extent of TPD in clone RRII 105 from the estate sector and from small holdings in different years of tapping, a study was made by making observations from the field. The spread of TPD from the affected to the nearby trees along the direction of tapping was also investigated for getting any evidence on the biotic etiology of TPD. An attempt was also made to study various management practices adopted by the growers and its feasibility and success.
3.2 MATERIALS AND METHODS

Since, the field management practices differ between small holdings and large estates, observations were made from both. Different rubber plantations both from the estate and small holdings sectors with trees of clone RRII 105 at different years of tapping were closely observed to quantify the incidence of TPD. The experimental blocks were selected from the first year to the final year of tapping from different small holdings in Kerala and estates in Kanyakumari district of Tamil Nadu.

3.2.1 Design of experiment

3.2.1.1 Location

Observations in small holdings were carried out at six locations under different Regional Offices of Rubber Board spread all over the Kerala State namely Nedumangadu, Adoor, Kanjirappally, Pala, Mannarkadu and Thaliparamba. These locations were selected to represent different types of rubber growers ranging from those with highest productivity and traditionally considered to be adopting very good management practices (Pala and Kanjirappally) to those with lesser productivity and inferior management practices (Nedumangadu and Adoor). Field management practices differ slightly in each location.

Observations on trees in estates were recorded from Kulasekharam area of Kanyakumari district in Tamil Nadu. The estates included were New Ambady Estate, Maruthi Estate, Kottukulam Gardens, Vrindavan Estate, Nataraja Estate, Vaikundam Agrotech, Vaikundam Plantations, Bethany Estate, Babu Gardens, Ranipuram Estate, Kamadhenu Estate and Sivalokam Estate. Field management practices are slightly different in each estate.

3.2.1.2 Age of the plants

Trees of clone RRII 105 were selected from the first year of tapping in BO 1 panel to the last year of tapping in BI 2 panel (Fig. 3.1, 3.2 & Table 3.1). Usually each of the four panels is tapped for six years under ½ S d/2 system of tapping and hence a total 24 years of tapping was studied. In small holdings 1000 trees each from all four panels (BO 1, BO 2, BI 1 and BI 2) were studied from each location. From the large estates, a block of 100 trees in each tapping year was selected and observed every month continuously for 16 months to study the variations in the intensity of dryness in each tree, development of TPD in new trees and spread of TPD if any from one tree to the next tree (forward spread).
Chapter 3

Development of dryness symptoms in TPD trees when tapped in upward direction was also studied using the same method of evaluation on the upward panel for a period of four months.

Fig. 3.1 Rubber trees at different stages of tapping in BO 1 panel

Fig. 3.2 (a) Tapping on BO 2 panel (7\textsuperscript{th} year) (b) Tapping on renewed bark in BI 1 (13\textsuperscript{th} year)
### Table 3.1 Experiment details

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Small holding</th>
<th>Estates</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of panels</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Years of tapping in each panel</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>No. of blocks in each year of tapping</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>No. of trees in each block</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total no of trees studied</td>
<td>144000</td>
<td>1800</td>
</tr>
<tr>
<td>Frequency of observation</td>
<td>Single observation</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

### 3.2.1.3 Recording of observations

Detailed study on the incidence of TPD in trees in all stages of tapping in clone RR11 105 was performed to quantity the actual extent of TPD. The pattern of latex flow was observed at the time of tapping. The dry area affected by TPD was marked with a chalk piece and the length of the dry area and the total panel length were measured.

The per cent of tapping panel dryness in each tree was calculated using the following formula.

\[
\text{Per cent of TPD} = \frac{\text{Length of cut affected by TPD (dry area)}}{\text{Total panel length}} \times 100
\]

Based on the intensity of TPD, trees were grouped into five categories i.e., no incidence (0%), low TPD (0-25%), medium TPD (25-50%), high TPD (50-75%), and very high TPD (>75%). TPD incidence in a particular panel was calculated by taking the average of TPD incidence in each year of tapping on that panel (total six years). The occurrence of TPD trees one after another along the direction of tapping (clustering) was also recorded.
3.3 RESULTS

3.3.1 Incidence of TPD in small holdings

Among the Nedumangad, Adoor, Kanjirappally, Pala, Mannarkadu and Thaliparampa regions in which observation were recorded from small holdings, Adoor and Nedumangad region showed the highest number of TPD trees and Kanjirappally the lowest (Table 3.2). Out of the 18900 trees observed at Adoor region 3508 trees (18.56%) showed more than 50% TPD, while it was 2425 out of 13700 (17.70%), 2153 out of 12700 (16.95%), 2821 out of 17300 (16.30%), 3106 out of 20200 (15.37%) and 2273 out of 15100 (15.05%) at Nedumangad, Taliparampa, Mannarkad, Pala and Kanjirappally respectively.

Table 3.2 Number of trees with more than 50% TPD at different locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Total trees observed</th>
<th>TPD trees</th>
<th>% of TPD trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoor</td>
<td>18900</td>
<td>3508</td>
<td>18.56&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Nedumangad</td>
<td>13700</td>
<td>2425</td>
<td>17.70&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Taliparampa</td>
<td>12700</td>
<td>2153</td>
<td>16.95&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mannarkad</td>
<td>17300</td>
<td>2821</td>
<td>16.30&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pala</td>
<td>20200</td>
<td>3106</td>
<td>15.37&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kanjirappally</td>
<td>15100</td>
<td>2273</td>
<td>15.05&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Means followed by the same letter are not significantly different statistically

3.3.1.1 Incidence of TPD in different years of tapping

Percentage of TPD trees varied with the year of tapping and in general this increased as the year of tapping progress in all the locations (Fig. 3.3 to 3.8). When the linear trend line of per cent of healthy trees was plotted against year of tapping it showed a definite trend of decrease from the first year to the last year of tapping (Fig. 3.3 to 3.8). The percentage of trees in the category of very high TPD intensity showed a clear trend of increase from the first year to the last year of tapping at all the locations (Fig. 3.3 to 3.8).

The increase in the percentage of trees having more than 50% TPD leads to considerable loss of revenue to the grower and it increased with the age of trees, as evident from the above results.
Fig. 3.3 TPD incidence at Nedumangadu

Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D6 = BI 2

Incidence of TPD

R² = 0.8599

R² = 0.8632
Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D6 = BI 2

Fig. 3.4 TPD incidence at Adoor
Fig. 3.5 TPD incidence at Kanjirappally

Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D6 = BI 2
Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D6 = BI 2

Fig. 3.6 TPD incidence at Pala

- Healthy
- % of TPD trees 0-25
- % of TPD trees 25-50
- % of TPD trees 50-75
- % of TPD trees >75

$R^2 = 0.7976$

$R^2 = 0.7364$
Fig. 3.7 TPD incidence at Mannarkad

Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D4 = BI 2

Inset: $R^2 = 0.8117$

Inset: $R^2 = 0.7764$

-- Linear
-- % of TPD trees > 75
-- % of TPD trees 50-75
-- % of TPD trees < 25
-- Healthy
Fig. 3.8 TPD incidence at Thaliparampa

Panel A1 to A6 = BO 1, B1 to B6 = BO 2, C1 to C6 = BI 1, D1 to D6 = BI 2
3.3.1.2 Incidence of TPD in different panels

Panel wise comparison of TPD incidence in more than 50% of panel length is provided in Table 3.3. $\chi^2$ test of goodness of fit showed that there is significant difference in TPD incidence between the panels in each location and it showed increasing trend from BO 1 panel to BI 2 panel (Table 3.3). Adoor region showed the highest number of TPD trees in the category of >50% in panel BO 1, BO 2 and BI 2 which is 11.4, 17.4 and 30.1 respectively. Nedumangadu region also showed comparatively high incidence of TPD in all panels. Kanjirappally region showed lowest number of TPD trees in the category of >50% in panel BO 2, BI 1 and BI 2 which is 13.9, 19.4 and 26.4 respectively. The number of trees in the category >50% showed an increasing trend from BO 1 to BI 2 panel at all locations.

<table>
<thead>
<tr>
<th>Panel</th>
<th>Nedumangad</th>
<th>Adoor</th>
<th>Kanjirappally</th>
<th>Pala</th>
<th>Mannarkad</th>
<th>Taliparampa</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO 1</td>
<td>8.13</td>
<td>11.4</td>
<td>9.0</td>
<td>6.8</td>
<td>9.5</td>
<td>5.2</td>
</tr>
<tr>
<td>BO 2</td>
<td>15.73</td>
<td>17.1</td>
<td>13.9</td>
<td>14.4</td>
<td>15.4</td>
<td>14.2</td>
</tr>
<tr>
<td>BI 1</td>
<td>24.32</td>
<td>22.7</td>
<td>19.4</td>
<td>25.4</td>
<td>20.1</td>
<td>21.7</td>
</tr>
<tr>
<td>BI 2</td>
<td>29.02</td>
<td>30.1</td>
<td>26.4</td>
<td>27.0</td>
<td>26.5</td>
<td>28.2</td>
</tr>
</tbody>
</table>

3.3.1.3 Forward spread of TPD

Clustered occurrence of TPD trees

In order to study the spread of TPD in the forward direction of tapping in plantations, clustered occurrence of TPD trees corresponding to the direction of tapping was recorded. In some cases there were clusters of 6 to 8 TPD trees in the experimental plots (Fig. 3.9). In one of the holdings two trees planted in the same pit was observed to show TPD symptoms (Fig. 3.10).
Fig. 3.9 A continuous row of TPD trees in the direction of tapping

Fig. 3.10 Trees planted in the same pit, simultaneously (at same tapping stage) showing the TPD symptoms.

It was interesting to note that the number of single occurrence of TPD trees did not show a remarkable increase from the first panel to the last although the total number of TPD trees increased as the year of tapping increased. The number of TPD trees in clusters of two or more showed a remarkable increase compared to the single TPD trees, from the first year of tapping to the last (Table 3.4 & Fig. 3.11 to 3.16) showing that there is a chance of spread of TPD from one tree to the neighbouring tree.

Nedumangadu region showed the maximum number of trees (28.47%) and Kanjirappally showed the minimum number of trees (21.81%) in cluster in BI 2 panel.
Table 3.4 Occurrence of TPD (%) in cluster and at random

<table>
<thead>
<tr>
<th>Location</th>
<th>Panel</th>
<th>BO 1</th>
<th>BO 2</th>
<th>BI 1</th>
<th>BI 2</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nedumangad</td>
<td>Single</td>
<td>6.23</td>
<td>8.41</td>
<td>7.59</td>
<td>7.79</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>Cluster</td>
<td>6.86</td>
<td>16.60</td>
<td>24.63</td>
<td>28.47</td>
<td>14.34**</td>
</tr>
<tr>
<td>Adoor</td>
<td>Single</td>
<td>8.74</td>
<td>10.31</td>
<td>9.94</td>
<td>12.44</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>Cluster</td>
<td>7.65</td>
<td>13.12</td>
<td>20.34</td>
<td>23.52</td>
<td>9.49*</td>
</tr>
<tr>
<td>Kanjirappally</td>
<td>Single</td>
<td>7.56</td>
<td>9.13</td>
<td>10.18</td>
<td>8.81</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Cluster</td>
<td>4.98</td>
<td>10.47</td>
<td>14.79</td>
<td>21.81</td>
<td>11.65**</td>
</tr>
<tr>
<td>Pala</td>
<td>Single</td>
<td>6.64</td>
<td>9.13</td>
<td>10.15</td>
<td>11.17</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>Cluster</td>
<td>5.01</td>
<td>14.36</td>
<td>24.72</td>
<td>26.63</td>
<td>17.04**</td>
</tr>
<tr>
<td>Mannarkad</td>
<td>Single</td>
<td>6.82</td>
<td>9.26</td>
<td>9.02</td>
<td>12.79</td>
<td>1.93</td>
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<tr>
<td></td>
<td>Cluster</td>
<td>7.05</td>
<td>13.06</td>
<td>17.01</td>
<td>23.30</td>
<td>9.26*</td>
</tr>
<tr>
<td>Thaliparampa</td>
<td>Single</td>
<td>6.89</td>
<td>9.59</td>
<td>11.08</td>
<td>9.18</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Cluster</td>
<td>2.71</td>
<td>11.68</td>
<td>18.01</td>
<td>24.50</td>
<td>18.21**</td>
</tr>
</tbody>
</table>

Fig. 3.11 Clustering of TPD trees (Location –Nedumangad)
Fig. 3.12 Clustering of TPD trees (Location – Adoor)

Fig. 3.13 Clustering of TPD trees (Location – Kanjirappally)
Incidence of TPD

Fig. 3.14 Clustering of TPD trees (Location – Pala)

Fig. 3.15 Clustering of TPD trees (Location – Mannarkad)
3.3.2 Incidence of TPD in estate sector

3.3.2.1 Incidence of TPD in different years of tapping

Percentage of TPD trees varied with the year of tapping and in general this increased as the year of tapping progressed. The percentage of trees showing no symptoms of TPD increased in the first year of a new panel. In clone RRII 105, percentage of trees without TPD symptoms increased from 66 to 87% when the panel was changed from BO 1(6th year of tapping) to BO 2 (7th year) and the per cent of TPD trees decreased from 7 to 3 per cent in the category of low intensity TPD and from 11 to 1 per cent in the category of medium intensity TPD and from 4 to 0 per cent in the category of high intensity TPD and from 4 to 0 per cent in the category of very high intensity TPD (Fig. 3.17). But the percentage of TPD trees again showed increasing trend and the number of healthy trees to the decreasing trend a year after panel change (8th year). Percentage of TPD trees increased from 3 to 10 per cent in the category of low intensity TPD, 1 to 15 per cent in the category of medium intensity TPD, 0 to 6 per cent in the category of high intensity TPD and 9 to 25 per cent in the category of very high intensity TPD in the second year of BO 2 (8th year) panel in clone RRII 105 and the percentage of trees showing no TPD symptoms decreased from 87 to 44 per cent during this period (Fig. 3.17). The same trend was observed when the panel was changed from BO 2 to BI 1(13th year). This indicates that TPD trees appear as healthy
without any panel dryness for a short period when the panel was changed, but dryness symptoms appeared again as tapping further advanced.

When the linear trend line of per cent of healthy trees was plotted against year of tapping it showed a definite trend of decrease from the first year to the last year of tapping (Fig. 3.17). The percentage of trees in the category of very high TPD intensity showed a clear trend of increase from the first year to the last year of tapping.

![Graph showing the incidence of TPD in different years of tapping in estate sector](image)

**Fig. 3.17 Incidence of TPD in different years of tapping in estate sector**

### 3.3.2.2 Status of TPD in the same trees as the tapping progress

When individual trees were taken into account, the increase in the incidence within a period of 16 months was 4% in BO 1 (11 to 11.45), 9% in BO 2 (22.2 to 24.2), 18.7% in BI 1 (26.66 to 31.67) (Table 3.5) when trees with >50% TPD was considered. This shows that the scale of increase in TPD incidence is more in older trees than in trees at the initial stages of exploitation.

Such a definite trend of increase was not observed in trees with less than 50% TPD. In BO 1 and BI 1 panel the percentage of trees in that group actually got reduced as some of the trees did not show symptoms of TPD or turned to show more than 50% TPD. It was interesting to note that reversion of TPD symptoms was observed only at a younger age as evidenced by higher number of symptomless trees at the final stage in BO 1 panel.
Table 3.5 Status of TPD in the same trees as the tapping progress

<table>
<thead>
<tr>
<th>Panel</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO 1</td>
<td>71.67%</td>
<td>78.44%</td>
</tr>
<tr>
<td>BO 2</td>
<td>59.60%</td>
<td>55.20%</td>
</tr>
<tr>
<td>BI 1</td>
<td>53.67%</td>
<td>52.00%</td>
</tr>
</tbody>
</table>

3.3.2.3 Incidence of TPD in different panels

It was observed that the number of trees in the category of very high TPD intensity (>75%) showed an increasing trend from BO 1 to BI 1 panel (Table 3.6). The percentage of TPD trees in the category of very high TPD intensity (>75%) increased from 8.5 per cent in BO 1 to 17.2 per cent in panel BO 2 and to 22.36 per cent in panel BI 1. The number of TPD trees in the lower categories (low, medium and high) did not show such a remarkable trend of increase from BO 1 to BI 1 (Table 3.6).

Table 3.6 Occurrence of TPD (%) at varying intensity in different panels

<table>
<thead>
<tr>
<th>TPD intensity</th>
<th>Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BO 1</td>
</tr>
<tr>
<td>No incidence</td>
<td>71.67</td>
</tr>
<tr>
<td>Low</td>
<td>12.43</td>
</tr>
<tr>
<td>Medium</td>
<td>4.90</td>
</tr>
<tr>
<td>High</td>
<td>2.50</td>
</tr>
<tr>
<td>Very high</td>
<td>8.50</td>
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</table>

3.3.2.4 Forward spread of TPD

In order to study the spread of TPD in the forward direction of tapping in plantations, clustered occurrence of TPD trees corresponding to the direction of tapping was recorded. In some cases there was a cluster of 6 to 8 TPD trees in the experimental plots. The number of single occurrence of TPD trees did not show a remarkable increase when the linear trend was analysed from the first panel to the last although the total number of TPD trees increased as the year of tapping increased. But, the number of TPD trees in clusters of two or more showed a remarkable increase compared to the
Incidence of TPD

single TPD trees, from the first year of tapping to the last when the linear trend was analysed (Fig. 3.18) showing that there is a chance of spread of TPD from one tree to the neighbouring tree. The chance of occurring TPD trees in clusters of two or more increased as the tapping year advanced.

Fig. 3.18 Clustered occurrence of TPD trees in clone RRII 105

An attempt was also made to study the spread of TPD from one tree to the other by continuously monitoring the trees tapped immediately next to the TPD affected trees. It was observed that some of the healthy trees tapped immediately after tapping a TPD tree turns to TPD after a few months. For example at Vaikundam Agrotech, healthy trees (tree number 8, 30, 63 and 78) tapped immediately after tapping a TPD tree, exhibited partial dryness after two years of tapping (Fig. 3.19). Partially dry trees (tree number 28 and 51) tapped immediately after tapping a TPD tree turned to be fully dry after two years of tapping. It was observed that TPD trees in clusters increased from 6 to 11 when fully dry trees were only considered and it increased from 13 to 22 when partially dry trees were also considered (Fig. 3.19).
Fig. 3.19 Forward spread of TPD

Location: Vaikundam Agrotech
Panel: B4

- No. of trees (Total: 100)
  - Fully dry: 15
  - Partial dry: 10
  - Fully dry trees in clusters: 6
  - Fully dry trees in singles: 9
  - TPD Trees in clusters (partial included): 13
  - TPD Trees in singles (partial included): 12

Panel: B6 (same trees after two years)

- No. of trees (Total: 100)
  - Fully dry: 17
  - Partial dry: 8
  - Fully dry trees in clusters: 11
  - Fully dry trees in singles: 6
  - TPD Trees in clusters (partial included): 22
  - TPD Trees in singles (partial included): 3
3.3.3 Management of TPD trees

3.3.3.1 Smallholdings, Location: Meenachil Taluk

Only 23.8% of the small holders give rest to trees by leaving them untapped in all the panels when TPD is observed (Table 3.7). 29.5% of the small holders give rest to the trees when TPD is observed in BO 1 panel and follow the same in BO 2 panel also but do upward tapping when TPD is observed in BI 1 panel.

Table 3.7 Management of TPD trees in smallholdings

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Group</th>
<th>No of blocks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>BO 1 → above BO 1 downward → BO 2 → above BO 2 downward → rest → BI 1 → UT</td>
<td>37</td>
<td>17.6</td>
</tr>
<tr>
<td>2.</td>
<td>BO 1 → above BO 1 downward → BO 2 → above BO 2 downward → UT</td>
<td>30</td>
<td>14.3</td>
</tr>
<tr>
<td>3.</td>
<td>BO 1 → BO 2 → UT on BO 1</td>
<td>19</td>
<td>9.0</td>
</tr>
<tr>
<td>4.</td>
<td>BO 1 → BO 2 → UT on BO 2</td>
<td>12</td>
<td>5.7</td>
</tr>
<tr>
<td>5.</td>
<td>BO 1 → rest → BO 2 → rest → BI 1 → UT on BI 1</td>
<td>62</td>
<td>29.5</td>
</tr>
<tr>
<td>6.</td>
<td>BO 1 → rest → BO 2 → rest → BI 1 → rest → BI 2 → rest → slaughter tapping</td>
<td>50</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td><strong>210</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

UT – Upward tapping
Fig. 3.20 Tree showing TPD in BO 1 panel and shifted tapping to BO 2 panel

Fig. 3.21 Tree showing TPD in BO 1 panel, tapped downward above BO 1 and currently tapped on BO 2 panel

Fig. 3.22 Trees showing TPD in BO 1 panel, tapped upward above BO 1

Fig. 3.23 Tree rested when both BO 1 and BO 2 panels showed TPD
3.3.3.2 Management of TPD in estate by adopting upward system of tapping

When the TPD affected trees were tapped in the upward system of tapping, more than 50 per cent of the trees showed dryness after four months of tapping (Fig. 3.25). The occurrence of TPD trees in the category of very high intensity TPD was 31% (Fig. 3.25).
3.4 DISCUSSION

It is essential to have an exact knowledge about the extent of the prevalence of TPD in a particular clone for selection of clones for planting and for adopting suitable management practices. When the occurrence of TPD trees in different years and on different panels were analysed it was observed that the number TPD affected trees increased as the year of tapping progressed at all the locations both in small holdings and in estates. The linear trend line of per cent of healthy trees plotted against year of tapping showed a definite trend of decrease from the first year to the last year of tapping. The results clearly showed that maximum TPD incidence is seen in older panels as observed by Chan (1996). He observed 2.1% TPD in the first year of BO 1 panel and 8.5% in the sixth year for the rubber clone PB 260 while on panel BO 2, it was 16.0 and 18.6% in the third and sixth years, respectively. The maximum dryness in individual fields reached 23.5% on panel BO 1 and 44.6% on panel BO 2.

Percentage of trees without TPD symptoms was high when the panel was changed but it again decreased a year after the panel change. TPD trees appeared as healthy without any panel dryness for a short period when the panel was changed, but dryness symptoms appeared again as tapping further advanced. This shows that once a tree succumbs to TPD, it does not recover from it, though symptom remission for short periods can sometimes be noticed.

The percentage of trees in the category of very high TPD intensity (>75%) showed a clear trend of increase from the first year to the last year of tapping at all the locations. The number of TPD trees in the other categories (low, medium and high) did not show such a remarkable trend of increase from BO 1 to BI 1. This could be since such trees were converted to more than 75 per cent TPD during the course of time as the age of the tree advanced and tapping progressed. The increase in the percentage of trees with more than 75% of panel affected by TPD leads to considerable loss of revenue to the grower. Therefore, it is very important to give the best management care at a young age.

The increase in incidence within a period of 16 months was 4% in BO 1, 9% in BO 2, 18.7% in BI 1 when trees with >50% TPD was considered. This shows that the scale of increase in TPD incidence is more in older trees than in trees at the initial stages of tapping.
Incidence of TPD

Such a definite trend of increase was not observed in trees with less than 50% TPD. In BO 1 and BI 1 panel the percentage of trees in that group actually got reduced as some of the trees did not show symptoms of dryness or turned to show more than 50% TPD. It was interesting to note that reversion of TPD symptoms was observed only at a younger age as evidenced by higher number of symptomless trees at the final stage in BO 1 panel. This finding also suggests that it is very important to give the best management care at a younger age. de Fay and Jacob, (1989) reported that certain forms of bark dryness are transitory and do not display the characteristic symptoms of the formation of tylosoids or activation of the phenolic metabolism. Remission of symptoms have been reported in virus diseases. In pepper plants infection with Pepper golden mosaic virus, the newly emerged leaves showed a reduction in severity of symptoms (Carrillo-Tripp et al., 2007).

Among the Nedumangad, Adoor, Kanjirappally, Pala, Mannarkadu and Thaliparampa regions in which observation were recorded from small holdings, Adoor and Nedumangad region showed the highest number of TPD trees and Kanjirappally the lowest. The field management practices in Adoor and Nedumangad was in general poor compared to Kanjirappally. For instance, the planting density is in general higher than the recommended (450 to 500 trees /ha) in Nedumangad. The proximity of trees may have an influence on disease spread. The occurrence of TPD affected trees in clusters was maximum in Nedumangad indicating such probability.

Progressive occurrence of TPD in clusters suggests the possibility of tree to tree spread of a biotic agent. De Fay and Jacob (1989) reported the occurrence of rows of four or five TPD trees in rubber plantations. The transmission of a biotic agent through the tapping knife could be the reason for the occurrence of TPD trees in clusters and the spread of TPD from one tree to the neighbouring tree. On continuous monitoring of the trees tapped immediately next to the TPD affected trees, it was observed that some of the healthy trees tapped immediately after tapping a TPD tree turned to TPD after a few months. This observations shows that, though at a limited level TPD is spreading from one tree to the tree tapped immediately next. Viral contamination by the tapping tool and the existence of micro conditions in the soil were suggested to account for the rows of dry trees (De Fay and Jacob, 1989). In a study of TPD affected trees with bark scaling (RRIM 605) out of the ten healthy immediate next trees to the bark scaled, seven became TPD affected by the fourth year of tapping (RRII, 2003). Several field and greenhouse studies have demonstrated that viroids are easily transmissible by
mechanical inoculation and efficiently spread by contact with contaminated pruning tools, farm implements, clothing, and human hands (Barbosa et al., 2005; J. Th. J. Verhoeven et al., 2010). Earlier attempts on disinfection of tapping knife (Mathew et al., 2006b) were by a dip in fungicides or disinfectants that has little effect on molecular pathogens.

The most commonly recommended practice to manage TPD is taping rest (leaving the trees untapped) (de Silva, 1961). But, in the present study, it was observed that only 23.8% of the small holders give rest in all the panels when TPD was observed. This could be due to their experience that resting cannot not cure TPD. Nair, (2004) reported the re-occurrence of TPD in majority of the TPD affected trees left untapped for varying periods. Paranjothy and Yeang (1977) observed that the practice where TPD affected trees are rested and periodically re-opened is not considered beneficial and it was shown that any latex obtained from trees which ‘recover’ after tapping rest is derived largely from regenerated bark beneath diseased tissues. It was therefore recommended that TPD trees be exploited on yielding bark without a tapping rest. But, in the present study it was observed that when the TPD affected trees were tapped in the upward system of tapping, more than 50 per cent of the trees showed dryness after four months of tapping. Hence, this system is not a long term solution for TPD management as also evident from the work of Lukman (1992) in which panel change resulted in high percentage of TPD incidence. Eschbach et al., (1994) also reported the increase in the intensity of bark necrosis with panel change. Krishnakumar et al., (2002) reported that in almost all cases when one panel is fully affected, the other panel also gets affected upon tapping.
3.5 CONCLUSIONS

TPD incidence increased as the year of tapping progressed at all the locations both in small holdings and estates. The results clearly showed that maximum TPD incidence is seen in later panels of tapping. The percentage of trees in the category of very high TPD intensity showed a clear trend of increase from the first year to the last year of tapping at all the locations. The number of TPD trees in the lower intensity categories (low, medium and high) did not show such a remarkable trend of increase from BO 1 to BI 1 panels. The percentage of trees showing no symptoms of TPD increased in the first year of a new panel but again showed decreasing trend a year after the panel change showing the irrecoverable nature of TPD. The pattern of increase in the incidence within a period of 16 months in different panels showed that the scale of increase in TPD incidence in the category of more than 50% TPD is more in older trees than in trees at the initial stages of exploitation. Reversion of TPD symptoms in the category of less than 50% was observed only at a younger age as evidenced by higher number of symptomless trees at the final stage in BO 1 panel. This finding also suggests that it is very important to give the best management care at a younger age.

Higher number of TPD trees were observed in locations where field management practices were poor. Progressive occurrence of TPD in clusters suggests the possibility of tree to tree spread of a biotic agent. The observation that some of the healthy trees tapped immediately after tapping a TPD tree turned to TPD after a few months shows that, though at a limited level TPD is spreading from one tree to the tree tapped immediately next. It was observed that only 23.8% of the small holders give rest when TPD was observed. It was also observed that when the TPD affected trees were tapped in the upward system of tapping, more than 50 per cent of the trees showed dryness after four months of tapping. Hence, this tapping system is not a long term solution for TPD management.