7 POPULATION STUDIES

7.1 Introduction:

Studies on population of S. typica were taken up to find out if there were any seasonal fluctuations in abundance in the field, and if so, whether the variations in numbers were correlated with any weather factors. The data were considered useful in timing the insecticidal application for the most effective control of the insect.

7.2 Materials and methods:

The study was conducted during 1960-1962 at the Institute farm on 316 experimental, out of a total of 412 five-year-old coconut seedlings of nearly uniform growth in an area of 3-5 hectares. Eighty of them selected at random were divided into four groups of twenty each. Total number of nymphs and adults of the pest present on individual leaflets of all leaves on each seedling was counted and recorded for one group a week, at the rate of ten seedlings a day, the two days of observation falling in the middle of the weeks grouped as 1 to 7 days of the month to form the first week, 8 to 15 the second, 16 to 22 the third and the remaining days the fourth. A seedling which lodged one nymph/adult on any leaflet was categorised as infested. Meteorological data on temperature, humidity, total hours of bright sunshine and rainfall were recorded daily for two years.

The data collected on abundance of insects included the identity of seedling, total number of leaves per seedling, number of leaves infested with the pest, the position of each infested leaf as counted from the outside toward the spinele,
total number of leaflets per infested leaf, number of infested leaflets, position of infested leaflet as counted from the base to the tip of the rachis and the number of adults/nymphs present per infested leaflet as recorded by 'direct count'.

In spite of the more or less uniform age of the experimental seedlings, the number of leaves per seedling and the number of leaflets per leaf varied considerably. Hence the position of leaves and leaflets attacked was standardized for the purpose of comparison by allotting scores varying from 1-100 obtained by calculating:

\[
100 \times \frac{\text{position of attacked leaf/leaflet}}{\text{total number of leaves for the seedling/total number of leaflets for the leaf}}
\]

A frequency table was then made by grouping these scores into 10 classes of 10 units each. The intensity of infestation was calculated by adding up the frequency of attack on leaf/leaflet under each score group. The density of population was also similarly estimated separately for leaves and leaflets by totalling the actual number of pests observed - adults, nymphs and their total - under each score group to ascertain whether it was related to the frequency of attack.
7.3 Seasonal abundance and its relation to meteorological factors: (tables 11-14 and figs. 12-19).

The average monthly population of adults and nymphs of the pest on the sample seedlings is presented in fig. 12. The abundance of adults and nymphs during the different months of the year showed a well marked fluctuation. The curves of abundance in the total monthly count of adults and nymphs followed nearly the same pattern, the nymphs being always greater in number than the adults. The population was at its highest in March, April and May \((18.6 + 46.1 + 11.6 = 76.3\) per cent of the total for adults and \(16.2 + 41.8 + 16.1 = 74.1\) per cent of the total for nymphs). The pest occurred in maximum numbers in April, and subsided in July (0.5 per cent for adults and 0.4 per cent for nymphs). From August (1.2 per cent for adults and 1.4 per cent for nymphs) onward, there was a gradual increase in population showing a rise in October (6.0 per cent for adults and 7.6 per cent for nymphs). Since then the number dwindled again to the lowest level in December (0.2 per cent for adults and 0.1 per cent for nymphs) before it was rebuilt from January (0.9 per cent for both adults and nymphs) onward. June, September, November and February had, respectively, 0.7, 4.6, 3.9 and 5.7 per cent for adults and 1.2, 5.8, 4.8 and 3.7 per cent for nymphs. The number of adults and nymphs registered by 'direct count' on individual seedlings showed very great variations. The maximum number counted on a per seedling basis (total: 80 seedlings) over a period of two years was: adult, 683; nymphs, 735. The average number of pest recorded on a bearing palm was 490 (Table 28).
The variations of the average meteorological factors for the corresponding period are shown in Table 11 and 12 and figures 13-16 (incomplete lines indicate the trend if the factors were to influence population singly). Correlation of these with variation in population showed that abundance was in general, negatively related to rainfall and humidity, while with temperature and sunshine, the relation was positive. The pest population was kept in check when these factors were unfavourable. In March-April, the population was high, favoured by high temperature, low rainfall, low relative humidity and greater hours of bright sunshine. Population for May considered separately is rather high although relative humidity and rainfall are high (Table 11); but compared to the very high population in the preceding month regulated by low relative humidity, it may be seen that the population has been very much brought down in May (Table 12) through high rainfall, low sunshine and high humidity. June, July and August had the reverse factors, viz. low temperature, high rainfall, high humidity and fewer hours of bright sunshine, and therefore presented a low population. The population remained at a medium level in September, October and November because of the interacting influence of the favourable and unfavourable factors, which in combination contributed to keep it at a medium level. In December, January and February, the population was low because of rather high relative humidity.

As there were large variations in factors like rainfall and sunshine between the corresponding months in the two years of study, (table 13), meteorological factors have also been
considered for their correlation with variation in population in each month (figs. 17-19). The combined influence of meteorological factors on the fluctuations in population of the pest in each month (table 14) was, in general, nearly of the same pattern as given in table 12 for the average values of the two years. The fluctuations in population were more related to variations in temperature and relative humidity than to those of rainfall and sunshine. Variations in rainfall alone seem to have had a very little effect on abundance, since high rainfall was sometimes recorded with greater hours of sunshine. This was because there were bright days with high temperature and rainy nights. Similarly, relative humidity was not exclusively governed by rainfall.

Monthly variations in abundance of the pest (adults) are shown in fig. 17 (incomplete lines indicate identical trend with corresponding period of the other year). From May to September and again from November to March, identical trends were noticed in the variation in population. However, greater rise in population was found during September of first year, February and March of the second year and a comparatively greater fall during November of the previous year. The higher rainfall and low temperature (table 13 and 14) account for the fall in November. The rise in February of the subsequent year, in spite of high rainfall is seemingly because temperature or sunshine was not appreciably reduced. The higher population of March of the first year as compared to that of the same month of the second year, in spite of nearly identical meteorological factors is probably because of the pre-existence of comparatively higher
population of February of first year. Weather data do not seem to fully justify the rise in population in September of the first year. April of first year had a lower population than April of the second year. The high relative humidity of April in the first year accounts for this. April of second year enjoyed all the favourable meteorological factors, viz. low relative humidity, high temperature, low rainfall and greater hours of sunshine in addition to a pre-existing high population of March and hence registered the highest count of the pest. The dip in population in October first year is not explicable. The criticism levelled against the theory that sharp variations in insect populations can be ascribed to ecological influences only (Belanovskii, 1936; Grossheim, 1930) is relevant in this context.
7.4 Pattern of distribution of *Stephanitis typica* on its host plant - coconut

*(Tables 15 to 27 and Figs. 20 & 21)*

The occurrence of *S. typica* on the leaves and leaflets of coconut seedlings as observed in the study on the seasonal abundance of the pest (Chapter 7.3) suggested a distinct pattern of its distribution on the crown. In order to define this pattern, compilation and analysis of the data collected were attempted. The number of times each leaf was recorded as infested was maximum with the leaves occupying the sixth and seventh position as counted from outside, the percentage of frequency being 45.89. Percentage frequency with fifth to seventh leaves was 60.97 and with fifth to eighth 74.90 (table 15). The frequency that 1, 2, 3 or more leaves were attacked at the time of observation is given in table 15. In 54.23 per cent cases, only one leaf was attacked, this being the innermost fully opened leaf. In spite of the uniformity of age of experimental seedlings at the time of selection, it was found that the number of leaves lay within a range of 4 to 14 and that in 78.4 per cent cases, the number varied from 6 to 9 (table 15). Therefore it became evident that the \(n^{th}\) leaf of a seedling with \(n+1\) leaves was not comparable in position to the \(n^{th}\) leaf of a seedlings with \(n+2\) leaves, \(n+3\) leaves etc. This anomaly was got over by transforming the frequency into percentage score groups varying from 1-100 and grouped into 10 classes of 10 scores each (table 16). In the case of leaflets also, transformed frequency table was worked out (table 17 to 20). The intensity of pest present on infested leaves/leaflet was also similarly prepared.
On plotting the frequency of attack and density of population of leaves and leaflets (figs. 20, 21), it was found that the graphic curves were very nearly identical showing that the density of population had a direct bearing on the frequency of infestation in both cases.

The leaves that were infested most frequently were those with scores 91-100, infestation being proportionately lower on leaves with less scores, whereas leaflets with scores 41-60 were more prone to attack than others (table 27 & fig. 20, 21). The frequency of attack on leaves in the score group 71-100 was 83.74 per cent and in the score group 51-100, it was 95.80 per cent. In the case of leaflets, the distribution is more spread out, 88.20 per cent occurring in the leaflets with score 21-80. 92.29 per cent population occurred on leaves in the last four score groups with 91.6 per cent frequency of infestation. Similarly, in the case of leaflets also, 86.81 per cent of the pests were lodged on leaflets in the score group 21-80 having a density of attack of 88.2 per cent. Thus in a seedling with 15 leaves, for example, and a leaf with say, 240 leaflets (120 on either side of the rachis), the frequency of attack and the density of population is as shown in table 27.
7.5 A technique to estimate the field population of *Stephanitis typica*.

Direct counting of all the insects present on the leaflets of all the leaves of coconut palm is laborious, time-consuming and impracticable when the sample size comprises several trees. Estimation of population of *S. typica* was expected to give meaningful results of comparison in:

i) healthy and diseased palms or seedlings under manurial/disease resistance trials,

ii) insecticide sprayed and unsprayed palms/sprayed palms or seedlings before and after treatment in control experiments.

An easy method to count the lace-bug therefore became necessary. The definite pattern of distribution of the insect reported in the previous chapter was hence made use of in order to evolve a sampling technique to estimate the population. Variation in the total number of leaves per palm and the total number of leaflets per leaf made it difficult to compare the leaves/leaflets by their position as counted on individual seedlings/leaves. Hence the sample leaves lodging 70.13 percent pests in a tree (table 27) and the sample leaflets harbouring 37.5 percent of the pests in a leaf were fixed by choosing the leaves in the score group 81-100 and leaflets having the score 41-60 (table 29,30).

Compilation of the recorded population of the insect on 80 seedlings (Chapter 7.3) with various combinations of sampled leaves and leaflets for different sample sizes of seedlings showed that the percentage of pests accounted by leaves or leaflets of different score groups was fairly
steady in the samples comprising not less than five seedlings.

For a group of 10 seedlings or more, sampling 20 per cent leaflets on 20 per cent leaves with the thickest density of population gave sufficiently accurate estimate of the total number of pests present, the error being only plus or minus 5 per cent. The formula for estimating the population in this manner may be expressed as:

\[
T = K \sum_{i=1}^{j} P_i \pm 5\%
\]

where,

- \( T \) = Total population of the pest for the group of palms sampled,
- \( K \) = a constant multiplication factor, 3.75
- \( j \) = 10,
- \( P_i \) = Sample population of individual sample palm obtained by counting the number of pests present on sample leaflets with the score 41-60 on sample leaves having the score 81-100.

The sum of the sample population of ten palms multiplied by the inflation factor 3.75 \((= \frac{100 \times 100}{70.13 \times 38})\) gives the total population, within 5 per cent error.

The variation between the population estimated by this method and the actual population recorded by the complete count on 10 groups of 10 palms each, ranged from -0.11 to +2.5 per cent as given in table 28. Thus the formula worked out from populations on five year old seedlings holds good for adult bearing palms also. Tables 29 and 30 indicate the sample leaves and leaflets to be chosen in trees with leaves
varying in the usual range of 25 to 35 and leaves with leaflets varying in their number, generally from 110 to 130 pairs. The table can be adjusted for trees with greater/lesser number of leaves and for leaves with more/less leaflets.
7.6 Comparison of population of *Stephanitis typica* in healthy and Coconut Root (wilt) diseased palms.

7.6 (i) Introduction: Copinathan Pillai *et al* (1972) mapped out the distribution and intensity of Coconut Root (wilt) disease in Kerala and reported the limit of spread of the disease in the State at Nemum - Maranelloor - Ottasekhararangal um belt on the south in Trivandrum district; Keezhappalli kara - Kalloor - Varandarappally on the north in Trichur district, covering the intermediate areas on the west between Keezhappalli kara and Nemum, and on the east between Kalloor and Ottasekkharamangalam in a north to south direction (fig. 22). At the borders, places of occurrence of the disease are of limited number and scattered; and the intensity of the disease is low as compared to the diseased tract. *Stephanitis typica* has been reported to transmit the disease (Nagaraj and Menon, 1956; Shanta *et al*, 1960, 1964). Joseph *et al* (1972) reported that single insect could transmit the disease under experimental conditions and that maximum infection was obtained with groups of ten test insects on cowpea (*Vigna sinensis* (L) Savi ex Hassk) used as indicator host. It was therefore thought profitable to study the comparative abundance of the pest on healthy and diseased palms at the border where the disease is spreading, in order to make out the role of the lace bug in aerial transmission in nature.

7.6 (ii) Materials and Methods: Groups of 10 palms belonging to the apparently healthy, early diseased and advanced diseased categories, classified according to the disease indexing system described by George and Radha (1973) were selected at the
northern and southern borders in places mentioned above and at the eastern border in Aryancavu area at the foot of Western Ghats midway between Varandarappally and Ottasekkaramangalam. These palms were located in different gardens in the border areas, but care was taken to select from the same garden, palms of apparently healthy, early diseased and advanced diseased categories in each group of ten observations. Another group of 10 healthy palms was also selected 10 or more kilometers away from the border towards the healthy belt. Population of the insect was recorded on these palms individually according to the method described in chapter 7.5. The counts were made in the months of March, April and May corresponding to the peak period of abundance in the field (chapter 7.3) in 1972 through 1974, the three months of observations being distributed in the three borders in each year to take care of annual variation in population. In March, April and May, 1973 and September, 1972 and 1973, count was made on categories of palms from all the three borders in all these months. Corresponding to each observation at the border the pest was also counted on 10 palms each under apparently healthy, early diseased and advanced diseased categories in a diseased tract at the farm of the Central Plantation Crops Research Institute, Regional Station, Kayangulam. There were thus seven sets of observations from each border and 11 from the diseased tract. The total count of lace-bugs on groups of 10 palms under each category was compiled and compared statistically by the Analysis of Variance technique after transforming the counts into log \((x + 1)\) where \(x\) = mean number of counts per palm.
7.6 (iii) Results: Table 31 shows the consolidated data of numerical strength of sample population of *S. typica* under each category at the different centres of observation. Table 32 gives the summary of analysis of variance, combined over categories, eliminating the effect of year, border and month, for mean number of count per palm. Diseased group (comprising early and advanced stages) gave significantly higher (10% level) adult population than the healthy group (comprising apparently healthy and healthy). Of the two categories of disease, the early disease category harboured significantly more adults than the healthy (disease-free) palms. Between early and advance diseased categories, there was no significant difference.

On a yearwise basis, adult population in 1972 was significantly higher than in 1973 and 1974. Nymphal and total populations figured significantly higher in 1972 than in 1974.

The month of March registered the highest population for adults, nymphs and their total in the overall analysis. April and May showed sequential reduction in these years. Mean population in March was significantly higher than in May. At Kayangulam, a diseased tract, the peak period of occurrence of the insect was in April as seen from an average value for two years and abundance of the lace-bug in the field was correlated directly with temperature and sunshine and inversely with Relative Humidity and rainfall (chapter 7.3). Variations in counts are, here, reflected differently in a pooled analysis of data of 1973 over months. In 1973, April recorded a significantly higher (10% level) population of nymphs than in March.
in the south, east and at Kayangulam and a higher adult population at Kayangulam. Similarly, adults occurred in greater numbers on the north in May than in April. May, 1973 also gave significantly higher population of nymphs than March in the east.

Monthwise analysis of data of the seven sets of observations in the three borders revealed that the adults were less abundant in healthy palms and more in diseased palms in general in the three borders considered together. Considered separately, (table 33) healthy category of northern border invariably registered a significantly lower population. In the south, abundance in diseased category was less pronounced. In the east, however, only in one out of seven instances, this was true. Among the borders, the number of insects was low in the east; the incidence of disease was also low at this border as compared to the other two.

The nymphal population rarely followed this pattern; the more common occurrence was greater numbers in healthy palms. This indicates that the healthy or diseased condition of the palm had little influence on oviposition by the lace-bug, but the mobile adults were seen in greater numbers on diseased leaves.

A comparison of the count of the insect on all the leaflets of sample leaves on 35 seedlings under different nutritional levels described in the subsequent chapter (7.7), which were healthy in 1975 but had become diseased (disease index score above 10) in 1976 also showed that the number was greater
in the diseased seedlings as given below:

<table>
<thead>
<tr>
<th></th>
<th>Adults</th>
<th>Nymphs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy seedlings (1975)</td>
<td>42</td>
<td>156</td>
<td>198</td>
</tr>
<tr>
<td>Same seedlings, diseased (1976)</td>
<td>119</td>
<td>296</td>
<td>415</td>
</tr>
</tbody>
</table>

Increase over healthy x2.8 x1.9 x2.1

Annual variation in population in the two years of observation has, however, not been taken care of in this comparison. Consolidated data on the total number of lace-bugs on a leafwise basis on groups of 10 palms for five sets of observations, each in the three borders and Kayangulam (diseased tract)/Kasaragod (healthy tract) in September, 1972, March, April, May and September, 1973, during which months, counts are available in all these places for categories of healthy and diseased palms, are presented in table 34. Figure 23 brings out the pattern of distribution of the insect in increasing numbers from the outer to the inner leaves. It confirms the pattern designed in chapter 7.4 independently for adults and nymphs and also for their total value, irrespective of the healthy/diseased condition of the palm. It also cross-checks the soundness of the method described in chapter 7.5 for sampling the pest population in the field. In Table 34 and figure 23, the inner eight leaves have been renumbered as 1-8 as counted from the spindle outwards for the sake of indicating uniformity of their position. The data on these leaves were recorded on leaves as counted from outside towards the spindle. Since the total number of leaves of these palms varied, the actual leaf number of one palm would not be comparable in position to the corresponding leaf number of another
palm with a different number of total leaves if the leaf position is indicated as counted from the outer to the inner. The leaves renumbered as 1-8 here may be taken as the innermost eight leaves.

Count of lace bugs on eight 4 year old west coast tall coconut seedlings planted in the diseased tract in 1972 in various cultivators' gardens within a maximum distance of 30 Km from the research institute and had become diseased by 1976 was compared with the count on eight seedlings which had not contracted the disease, selecting one pair of diseased and healthy seedlings from the same garden. Lace bugs present on all the leaflets of all the leaves were counted. The number which occurred on the diseased seedlings was about four times the number recorded on the healthy in the case of both adults and nymphs. The actual figures were:

<table>
<thead>
<tr>
<th></th>
<th>Adults</th>
<th>Nymphs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy seedlings;</td>
<td>49</td>
<td>30</td>
<td>79</td>
</tr>
<tr>
<td>Diseased seedlings:</td>
<td>189</td>
<td>108</td>
<td>297</td>
</tr>
<tr>
<td>Increase over healthy:</td>
<td>x3.9</td>
<td>x3.6</td>
<td>x3.8</td>
</tr>
</tbody>
</table>

In vitro studies were conducted to find out whether the bugs showed any preference for diseased material, by releasing adults collected from field and starved for two hours prior to liberation from the centre of the cage (same as used for food plants in chapter 5) in which, coconut leaflets removed from healthy and Root (wilt) diseased palms were placed singly and in combination. The following results were obtained.
Number of adult *S. typica* counted on coconut leaflets (total of five replications with 20 insects per replication) after

<table>
<thead>
<tr>
<th></th>
<th>2 hours</th>
<th>4 hours</th>
<th>6 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Diseased and healthy leaflets in combination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on diseased leaf</td>
<td>61</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>on healthy leaf</td>
<td>30</td>
<td>31</td>
<td>28</td>
</tr>
<tr>
<td>unsettled</td>
<td>9</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td><strong>B. Diseased leaflets alone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>leaflet - 1</td>
<td>46</td>
<td>44</td>
<td>42</td>
</tr>
<tr>
<td>leaflet - 2</td>
<td>44</td>
<td>42</td>
<td>46</td>
</tr>
<tr>
<td>unsettled</td>
<td>10</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td><strong>C. Healthy leaflet alone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>leaflet - 1</td>
<td>45</td>
<td>44</td>
<td>46</td>
</tr>
<tr>
<td>leaflet - 2</td>
<td>43</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td>unsettled</td>
<td>12</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

It may be seen that when similar material was available in duplicate, the insect was distributed more or less equally between them, whereas in the case of both diseased and healthy material being available together, the insect showed a preference for diseased material, assembling in about twice the number that chose the healthy leaflet.
7.7 Comparison of population of *Stephanitis typica* on coconut seedlings under different nutritional levels of N, P, K, Ca & Mg.

7.7 (i) Introduction:

Since Coconut Root (wilt) disease was considered to be complex in its nature (Menon and Nair, 1951) and is still so (Shanta and Radha, 1975), investigations on its etiology at the Central Coconut Research Station (later Central Plantation Crops Research Institute) at Kayangulam were undertaken from different angles of approach - pathological, physiological and nutritional. Earlier findings of soil and tissue analyses indicated that:

a) the status of nitrogen and phosphorus in the soil was not correlated with the incidence of the disease (Sankarasubramoney et al, 1954, 1955),

b) There was a higher concentration of available and exchangeable potassium in the soil and leaf samples from healthy areas as compared to samples from diseased areas and that the symptoms exhibited by palms affected by the 'root' disease appeared to have resemblance to those generally attributed to a deficiency of potassium (Sankarasubramoney et al, 1956),

c) the status of Ca and Mg was higher in palms of healthy areas (Cecil, 1975).

In the light of the above background information, a count of the population of the pest was made to find out whether there was a higher abundance of the insect in coconut seedlings under different nutritional levels of N, P, K, Ca & Mg so that it could, if possible, be correlated with the incidence of the disease and/or with the nutritional status of coconut.
7.7 (ii) Materials and Methods:

Population count was made individually on 648 six year old West Coast Tall coconut seedlings planted as one year old seedlings at the Institute farm in October, 1970 under a nutritional experiment with the following layout:

**Design**: $3^3 \times 4$ factorial split experiment

**Main plots**: 27

- $N_1 - 0.50\, \text{Kg N}$
- $N_2 - 0.75\, \text{Kg N}$
- $N_3 - 1.00\, \text{Kg N}$

- $P_1 - 0.30\, \text{Kg } P_2O_5$
- $P_2 - 0.45\, \text{Kg } P_2O_5$
- $P_3 - 0.60\, \text{Kg } P_2O_5$

- $K_1 - 1.0\, \text{Kg } K_2O$
- $K_2 - 1.5\, \text{Kg } K_2O$
- $K_3 - 2.0\, \text{Kg } K_2O$

**Sub-plots**: 4

- $Mg_0 - \text{No Mg}$
- $Mg_1 - 0.50\, \text{Kg } MgO$
- $Ca_0 - \text{No Ca}$
- $Ca_1 - 12\, \text{Kg } Ca(OH)_2$ per plant, broadcast in the area.

**Number of replications**: 1.

**Number of main plots/Block**: 9.

**Number of seedlings per main plot**: 24.

**Number of seedlings per sub-plot**: 6.

**Seedling dose**: 1 year after planting 1/3 adult dose

- 2 years after planting 2/3 adult dose.
- 3 years after planting onwards - full adult dose.

**Mode of application of nutrients**: $N$, $P$, $K$ and $Mg$ applied in two splits of 1/3 and 2/3 doses, respectively during pre-monsoon (April-May) and post-monsoon (September-October) periods in the basins, and $Ca$ broadcast uniformly in the entire plant areas including the basins during every year.
Source of nutrients: N & P$_2$O$_5$ - 'Ammo-Phos B' + Urea.
K$_2$O - Muriate of potash.
CaO - Slaked lime.
MgO - Magnesium sulphate.

Since the number of seedlings per subplot was only six, which is less than the number required to give not more than 5% error in the estimate of total population as described in chapter 7.5, pests present on all the leaflets of 20% leaves selected as per sample leaves according to table 30 were counted. Totals of number present in groups of six seedlings in each subplot were compiled and statistically analysed for comparison.

7.7 (iii) Results:

Observations on the count of lace bugs occurring on coconut seedlings under different levels of treatment of N P K Ca and Mg are summarised in table 35. Statistical analysis of the data is presented in table 36.

Main effect of Mg is found significant at 10% level for adults. Mg$_1$ gave significantly less count than Mg$_0$. For nymphs and adults + nymphs categories, main effect of Mg is highly significant. In both cases, Mg$_1$ gave significantly lesser population than Mg$_0$. Main effect of P is found significant at 10% level for adults. P$_3$ gave significantly lesser count of adults than P$_2$. Between P$_1$ and P$_2$, there is no significant difference.

Interactions between NP and NK were found significant at 10% and 5% levels respectively. N$_1$P$_3$ combination gave the minimum and significantly lesser count of adults than all other combinations except N$_3$P$_1$ and N$_3$P$_3$. The main effect of P$_3$ in
reducing the numbers is apparently counterbalanced by a higher dose of N. N\textsubscript{2}K\textsubscript{1} similarly gave less counts as compared to N\textsubscript{1}K\textsubscript{1}, N\textsubscript{2}K\textsubscript{2} and N\textsubscript{2}K\textsubscript{3}. In the case of adults, the interaction of Ca with P was found highly significant. It may be observed that Ca\textsubscript{1}P\textsubscript{2} gave significantly lesser population than Ca\textsubscript{0}P\textsubscript{2}. The role of P, Mg and Ca in reducing the population of the pest thus seems to be evident.

Confirmation of this indication is possible by correlating the incidence of disease in these experimental seedlings with nutritional treatment on the one hand and the number of insects on the other. Because of the role of \textit{S. typica} in inducing the disease through its feeding probes, one would expect the groups of seedlings under lower doses of Mg and P (Main effect) to become diseased, provided, the greater number of the lace bug governs the quicker rendering of the seedlings to the diseased category. The total number of 49 incidence of disease, spread in 648 seedlings under 27 main treatments with four treatment combinations of Ca and Mg was found to be inadequate in drawing any statistically valid conclusion in this regard. It is hoped that correlation between incidence of disease and the abundance of the insect in relation to the nutritional status of the seedlings will be relevant when more of them get diseased in due course of time.
7.8 Discussion

Knowledge about the natural abundance of an insect pest becomes useful in attempts to exercise a check on its population. Fluctuations in the field populations of insects have been, in several instances, correlated with influence of weather, availability (abundance or dearth) of food and natural enemies. Gibbs and Leston (1970) studied the seasonal variations in the population of 36 species of insects on cocoa and correlated them with the above mentioned factors. De Fluitier (1954) correlated the variations in abundance of the strawberry aphid with spring, summer, autumn and winter seasons. Livingstone (1968b) observed that the population of *Tingis buddleiae* Drake reached the peak during winter months of November to March when the maximum average temperature ranged between 65 and 80 degrees Fahrenheit. The maximum density of population was recorded when the average temperature showed the lowest value during the whole period of study for three years. Annual variations in population occurred; however, study of population in different plots showed that when there was a fall in population in one plot or on one bush of the same plot, there was a rise in population in another plot or another bush of the same plot in the subsequent year. When the bugs were entirely missing in one locality, they were found heavily infesting the bushes of another locality. He suggested a possible cyclic periodicity of the tingid population. *Monosteira minutula* M. on the other hand, made its first appearance on *Ziziphus jujuba* (Ber.) in the middle of March and its multiplication took place very rapidly to the level of infesting the whole tree, reaching as
high a density as an average of four adults and seven immature insects on a single leaf by middle of April (Livingstone, 1962a). During the middle of June, when the leaves were shed, no insect could be found, but soon after monsoon (middle of July), with the emergence of new foliage, the insects also reappeared and multiplied rapidly. The population again shot up to the peak during the middle of August, but steadily decreased towards the end of September and the insects altogether disappeared by end of October, thus presenting a summer species. Similarly for Cadmilos retiarius Dist., Livingstone, (1962b) reported a summer population; the insect made its appearance on Helianthus annuas during middle of March and steadily increased in number during April, spread on the adjoining annuals during middle of May, infestation all the food plants becoming heavy during July, by the middle of August, there was a steady decline in the population, disappearing completely by the beginning of September, when the seasonals completely decayed. The density of population depended entirely on the onset of monsoon, the peak being reached soon after the first fall. The population pattern of S. typica, as reported here, appears to be in agreement with the latter two instances, with the greater abundance being governed as a rule, directly by temperature and sunshine. Relative humidity and rainfall had a reverse effect on the population of S. typica at Kayangulam, a tropical tract on the sea coast belt on the West, with only two markedly different seasons, the rainy season and the summer season. Annual variations were evident. On a monthly basis, the variations in numerical abundance could be explained
mostly by a balancing interaction of factors favourable for build up or unfavourable contributing to a decline. Food is always available to the insect on coconut crown. Hence, apart from meteorological factors, natural enemies alone seem to be capable of exerting influence on population abundance.

Phenological study of insect population has very great value in predicting the advent of vectors and virus diseases. Carter (1930) used winter temperatures and populations of the vector surviving hibernation to predict outbreaks of curly top of sugarbeet. In a perennial crop like coconut, it may not be immediately feasible to correlate the population density with appearance of disease and intensity of symptom expression. But it would definitely be of help when more knowledge on seasonal fluctuations of S. typica in relation to symptom expression and incubation period of Coconut Root (wilt) disease is available.

Numerical abundance of an insect can be an important criterion in determining its role as a pest or vector of a plant disease. Naturally, higher the number of insect present on a crop, greater the damage it can cause and higher the chances of disease transmission. As a single group, S. typica outnumbers all other insect pests of coconut foliage (Shanta et al 1960). Moreover, it is present on the coconut crown throughout the year with the seasonal fluctuations reported herein and throughout the coconut plantations in Kerala State with variation in abundance between localities, unlike the black headed caterpillar (Nephantis serinona Meyr.) or the slug caterpillars (Parasa lepida Cram., Contheyla rotunda Hirst.) which under
favourable climatic conditions break out sporadically in large numbers but are endemic to certain areas only.

The distribution of *S. typica* on the host plant showed a definite pattern. There was always, a progressive increase in the number of insects from the outer to the inner whorls of the leaves. On individual leaves, the middle leaflets harboured more numbers than the end ones. Takeda and Hukusima (1961) studied the spatial distribution of the pear lace-bug *Stephanitis nashi* Esaki & Takeya on apple and reported that the bugs were not usually distributed in any definite part of the tree, but were scattered on all parts with about the same amount of individuals. In coconut, the difference in the nature of the host plant is the main factor governing a definite pattern. As the outer leaves become older, the adults emerging from a previous generation presumably abandon the leaf in search of better pasture, toward the inner tender leaves. For fresh infestation, the flying or the wind carried insect has quicker and ready access to the middle and inner leaves which stand out with their lower surfaces exposed. (The bugs are seen only on the lower surface of leaves). The leaves of the whorls below the middle whorl are so disposed on the crown of the palm that they are either parallel to the ground or at an acute angle with the stem so that the lower surfaces of the leaflets are concealed. The greater concentration of the pest in the middle of the leaf is probably due to the larger area of the broader, longer middle leaflets.

Insect populations can be properly studied only by sampling. There is, however, no universal sampling method and no unanimity
in the techniques of sampling adopted. This is not at all surprising since no single method is applicable to all. Insects vary widely in their individual size, size of the population and pattern of distribution on the host plant. When the insect involved is large and sparsely distributed, direct counting is easy and also very accurate. When otherwise, sampling per unit area, counting of representative samples caught in traps, population index method, counting in quadrants (as in the case of locusts), sequential sampling, random sampling, Lincoln index or the capture-release-recapture method, nearest neighbour/closest individual technique (Southwood, 1966) are some of the methods described by different workers on insect population. In the present investigation, moults or feeding marks on the leaves were thought of as possible indices to estimate the populations. But it was soon realized that many of the exuviae were dislodged by wind and that the feeding marks are permanent and therefore do not indicate the actual strength of the population at the time of counting. In order to estimate the population of *S. typica*, data obtained from direct count of the insect on 80 five year old seedlings were hence used to devise a method. The definite pattern of the distribution of the insect on the host plant made this possible. The advantage of this technique is that it reduces the sample size and makes it unnecessary to count the insect on all the leaflets of all the leaves.

Davies (1932) estimated aphid population by examining 100 leaves at random from the plant. To avoid variation in size and position of leaves, some workers (Bald et al., 1946,
attempted estimates of aphids per plant. Broadbent (1953) estimated aphid density by multiplying the number of aphids on upper, middle and lower leaf by the average number of leaves for each zone. Shan et al. (1954) counted wingless aphids by using two sub-units: one consisted of terminal and two opposite basal leaflets from three leaves taken from the top, middle and bottom of the plant; the other one, half of each of those leaflets, and found the results comparable. Strickland (1954) developed aphid counting grid after testing volumetric methods. The standard units for determining populations of sugarbeet leaf hoppers on wild and cultivated hosts has been for many years, 50 sweeps of a net. Livingstone (1968b) studied the population fluctuations and incidence of Tingis buddleiae Drake in Agra over a period of three years by selecting only a particular plot of its host plant Buddleia asiatica and making fortnightly random collection of infested leaves. The number of individuals on each leaf was recorded and the average count was taken for ten leaves. Most of the above methods have the drawback that they do not give the accuracy of the estimates made, but are based on the principle of lack of variation when the same method is used over again for comparison. In the method mentioned here, the error of estimation is less than 5 per cent. The insect is counted in situ. The iridescence of the wings of the adults and the gregariousness of the nymphs make this easy. Moreover the adults are sluggish and do not fly away with slight disturbances.
On West Coast Tall palms and seedlings, an appreciably higher number was always found on diseased ones than on healthy ones. This result suggests two probabilities: either the palm gets diseased due to the abundance of the insect, or the diseased palms attract more insects to them. This aspect needs to be studied in detail. A correlative study of the nutritional requirements of the insect and a comparison of the nutritional status of the leaves of diseased and healthy palms can perhaps throw more light on this aspect. A higher percentage of sugars is indicated in the diseased leaves as compared to the healthy (Annual Report, CPCRI). According to Friend (1958), sugars constitute the sole food of some phytophagous insects and may play a role in governing their feeding behaviour and orientation on host plants. However, in the light of the report (Joseph et al, 1972) that about 16% of the field population of the lace bugs are infective, it would appear reasonable to conclude that a greater abundance of the insect contributes to greater chances of the coconut palms getting diseased.

Davies (1934) reported that when there was a rapid increase of the virus disease among potato stocks, index count of *Myzus persicae* per 100 leaves always exceeded 100. When there was no infection, the figure never exceeded 25. Henner and Schreiner (1952) found some correlation between total number of *M. persicae* on potato leaves and the incidence of virus disease, but some low counts (less than 20 per leaf) were obtained in some areas of high disease incidence. Broadbent (1950) found correlation between potato leaf roll
incidence and maximum counts per 100 leaves of \textit{M. persicaca}. Thresh (1966) reported denser population of the gall mite vector \textit{Phytoptus ribis} in the case of Black Currant Reversion Virus. In a preliminary study, Shanta et al. (1960) observed a higher incidence of \textit{S. typica} on Root (wilt) diseased palms than on healthy ones. They also found that palms harbouring a larger number of insects got diseased earlier. In Kerala, efforts are in progress to plant hybrids and disease resistant varieties in an attempt to improve coconut cultivation. The sampling technique described herein can be profitably employed in studies to compare the abundance of the vector on disease resistant and susceptible seedlings. \textit{Stephanitis (Leptobyrsa) rhododendri} Horvath, according to Johnson (1937), feeds from many hybrids and species of rhododendron; but the insect has definite preferences and may never be seen on certain rhododendrons in nature. \textit{R. ponticum} is quite immune to the attack while \textit{R. maximum} is very susceptible and few hybrids are prone to the attack. A preliminary examination of certain hybrids and cultivars of coconut seedlings planted in the farm of the research institute showed that West Coast Tall, Malay Dwarf (green, red and yellow), Chawkat Dwarf (green and orange), Lacadive ordinary, Java Giant cultivars and Tall x Dwarf, Dwarf x Tall and Tall x Gangabondam hybrids were not free from infestation by \textit{S. typica}. The study, however, demands more elaborate observations.