FINAL REPORT

OF

RESEARCH PROJECT

No. ENT VIII (131) PI-87/6-ICI.H 10/2710

DISTRIBUTION OF THE SPINDLE BUG OF ARECANUT *Carvalhoia arecae* Miller and China IN KERALA, ITS BIOECOLOGY, SUSPECTED ROLE AS THE VECTOR OF YELLOW LEAF DISEASE AND CONTROL

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

KASARAGOD, 670124

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FINAL REPORT

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Name and address of research Institute/ centre	: Central Plantation Crops Research Institute, Research Centre, Pacha P.O., Palode, Trivandrum 695562, Kerala State.
Project title	: Distribution of the spindle bug of arecanut Carvalhoia arecae Miller and China in Kerala, its bio-ecology, suspected role as a vector of yellow leaf disease and control.
Name and designation of Project Leader	: S.A. Jacob, Scientist, Selection Grade
Name and designation of project associate	: Not applicable (n.a)
Location of the research with complete address Division/Section/Sub-section	: i) CPCRI (RC), PACHA (P.O), Palode, Trivandrum 695562 ii) CPCRI (RS), E.M. Laboratory, Krishnapuram, Kayamkulam 690533, Alleppey Dist.
Date of start	: 1st April 1987
Date of termination	: 31st December 1989

(a) Objectives:

Areca palm Areca catechu L. is a tropical cash crop mainly in South India and its production is seriously affected by the spindle bug C. arecae. It is also suspected as a vector of Yellow leaf disease of arecanut (YLD) caused by Mycoplasma like organism (MLO). Though the pest is found throughout the year, peak population was found in rainy seasons. Any insecticidal application as spray or granules as per existing recommendations were liable to be washed away. Therefore a better management technology was desired. More information on the bioecology of the pest, its role as a pest and vector (if any) of MLO,

distribution of the insect in different agroclimatic zones of Kerala, seasonal abundance, correlation with weather parameters and seasonal abundance, correlation of the pest and the YLD (if any) etc. were envisaged to be studied.

10(b) Practical/Scientific utility

The information from the project will bring about a better management technology for the spindle bug of arecanut and help to understand the bioecology, nature of damage, plant pest relationship and involvement of the insect as a vector of YLD if any, through mycoplasma like organisms.

The work done on C. arecae has been reviewed recently (CPCRI 1982). The biology and control of the pest were worked out. Chrysalidocarpus lutescens, Pinanga sp. Areca triandra, Loxococcus sp. were recorded as alternate hosts besides A. catechu (Nair and Das, 1962). Nair (1964) recorded Chrysalidocarpus madagascariensis and A. concinna additionally. Elaeis guineensis was added to the above list (CPCRI, 1982).

Shama Bhat Khandige (1955) and Pillai and Kurian (1959) suggested fish oil rosine soap @ 12.4 g/litre of water spray. Nair and Das (1962) sprayed at monthly intervals HCH 0.2% or endrin 0.025% a.i. and kept the areca palms free from the pest. Menon et al. (1962), Nair and Menon (1963) and Nair (1964) tried with different insecticides and recommended suitable foliar sprays but the insects reappeared shortly. Therefore Abraham et al. (1976) tried granular insecticides namely phorate 10G, carbaryl 4G and thiodemeton 5G and found that population of bug in all the treatments was significantly lower compared to that of control. Hence application of any one of the three insecticides in the leaf axils once in four months was recommended for the control of spindle bug in areca palm.

Abdulla Koya et al. (1979) tried granules of lindane, carbaryl + lindane, carbaryl, mephosfolan, thiodementon and quinalphos. All the insecticides gave good control of the pest but quinalphos was superior to mephospholan and thiodementon. Sathiamma et al. (1985) tested granules of phorate, lindane and quinalphos in field and found that insecticides applied in the innermost two or three leaf axils @ 10 g per palm at three months intervals effected significant control of the pest

(CPCRI, 1982). Considering the cost factor, they found lindane was most advantageous.

Later in an extension trial it was found that leaf axil application of phorate granules caused phyto-toxic burns on areca palms. Washing away of the insecticide during rains reduced the effectiveness and the bugs reappeared within one month and reached injurious level in three months time (CPCRI, 1983).

11. Technical programme

(i)(a). The distribution and extent of damage caused by C. arecae in major areca growing **tracts** in Kerala and seasonal abundance of the pest in selected centres of Trivandrum district for two consecutive years were studied adopting standard statistical methods at monthly interval.

(b) Number of bugs and nymphs per palm, number of holes/ bite marks caused on the freshly emerged leaves, intensity of YLD, natural enemies and climatological factors in each location were recorded.

(ii) Detailed biology of the pest on areca palm and alternate hosts were studied. Histological and histochemical changes of the plant tissues at different intervals after feeding were examined to understand the mechanism of the damage caused and the toxemia caused on the host were attempted.

(iii) Evaluating different methods of control:

Foliar sprays with insecticides, leaf axil filling with granular insecticides and insecticides in suitable devices (sachets) as repellants were compared after standardising the quantity required, frequency of application and number of sachets required per palm etc. Other conventional insect repellants like neem cake, suspension of fish oil rosine soap were also evaluated. This was done by conducting field experiments adopting suitable statistical designs. The cost of application of different techniques also was worked out.

(iv) Association of MLO with C. arecae was examined by electron microscopic studies. Suitable tissues and haemo-lymph of insects fed on diseased (YLD) and healthy areca palms were studied.

Final Report of the Project - Summary of results:

The spindle bug, C. arecae and the YLD of arecanut are two most serious problems of arecanut in reducing its production and cultivation. From time to time C. arecae was suspected as vector of the disease. Studies were hence taken up to understand the role played by this bug as a vector and to evolve suitable control measures against the pest.

Distribution and seasonal abundance of C. arecae

1. A survey was conducted in five agroclimatic regions of the State and nine locations from each region adopting stratified sampling. Results showed that the bug was present all over the State except in a few locations. Vadakkancherry and Palghat were free from bugs. YLD free palms and gardens were observed in all the regions. Similarly 100% incidence of the disease was seen in one garden at Palode, Southern Kerala and 86.67% gardens in Irrikkur, Northern Kerala. In Middle Kerala and Northern Kerala 6 out of nine gardens each were without YLD. Minimum mean YLD index seen was 14 in one garden at Kattakkada and maximum at Chithara with 54.17. Irrikkur 53.72, Palode 52.02, Kulathupuzha 51.22, Peechy 44.53 and Peringammala 44.17 are the higher index marks in some of the other centres. The natural enemies noted on the arecanut crown were four species of ants (Fam. Formicidae : Order Hymenoptera) and six species of spiders (Fam. Salticidae : Order Araneae). They were present in all regions.

2. Seasonal distribution of bug population studied for twenty four months at five selected centres of Trivandrum district showed that the bug was present throughout the year from a range of average one to six per palm per monthly observation. Bug population showed some increase in July, October, December and January but were statistically not different though between the five centres they were significantly different.

3. Simple correlation studies of bug population and weather parameters at Palode showed that maximum temperature was negatively correlated while minimum RH% was positively correlated. Rainfall also influenced the bug population. In Tiruvallam also the maximum temperature was found negatively correlated with bug population. Total rainfall, rainy days and

minimum RH% negatively influenced with YLD indices in different months but the bug population did not correlate with the disease.

Biology of bug on different host plants and Nature of damage

4. Egg incubation period of 6-7 days and 5th nymphal period of 1-7 days did not significantly differ among the host plants tried under this experiment. First, second, third and fourth instar nymphs significantly differed in their lifecycle durations on various host plants. The size of different nymphal instars and adults grown on different host plants significantly differed. The bugs bred on E. guineensis were larger (adult male 5.95 mm and female 6.19 mm) followed by the ones bred on C. lutescens. Adults bred on Pinanga sp. were smallest (male 4.65 mm and female 5.05 mm).

5. Leaf tissues fed by the insect compared with healthy were histologically and histochemically examined. The shrinkage of the epidermis and spongy cells near vascular bundles was caused by the sudden removal of cytoplasm. This led to cell collapse and necrosis and finally the total distruction of the lamina except vascular bundles. Pockets of undamaged cells within the lesions persisted up to 120 hours which subsequently dried away. The damaged sites become filled with brownish deposits which may be presumed as phenolic materials. Histochemical analysis also showed increased protein deposits following the feeding injury. Similar brownish deposits were seen at the egg laying sites also. In severe cases of feeding the entire leaflets and the spindle may be dried or the entire crown of the palm may be scarred and spotted. The feeding marks seen on fronds, petiole and stem form smallpox like depressions which become brown, and black in sequence and then dry up. Thus the bug feeding injuries directly impair and reduce photosynthetic efficiency of the palm in addition to the toxins deposited. Such areca seedlings regularly infested by C. arecae become sickly, stunted and may never reach its full vigour.

Chemical control of C. arecae

6. A newly evolved method of checking the pest population by keeping phorate in sachets in the topmost leaf axil was more effective. The optimum quantity of the insecticide in each

sachet and the number of sachets required per palm were studied through field experiments. A dose of 2 g/sachet and 2 sachets per palm was found effective in controlling the bug population and maintain spindle bug free garden.

7. The new insecticidal sachet method was evaluated in comparison with the present recommended methods (spraying and placing granules in leaf axils) in a field experiment. The cost of the different control methods also were studied and the results showed that insecticidal sachet method was the cheapest, most effective and safest treatment.

Association of C. arecae with MLO and YLD

8. The salivary glands of the bug caged on YLD plants, for different durations (20-33 days) for acquisition and incubation of MLO were examined under light microscopy and electron microscopy. Critical examination of ultrathin sections of the glands failed to reveal any mycoplasma like structures. Haemolymph of such bugs were also examined. These studies conclusively proved that the spindle bug may not be acting as a vector of the yellow leaf disease in areca.

PROGRESS OF WORK IN RELATION TO THE TIME TARGETTED FOR COMPLETION OF WORK AND REASONS FOR NONACHIEVEMENT OF TARGETS, IF ANY:

I. DISTRIBUTION OF C. arecae AGRO-CLIMATIC REGIONS OF KERALA

A stratified two stage purposive random survey in the five agro-climatic zones of Kerala namely, North, Middle, South, Hill and Problem zones, covering the entire arecanut growing tracts of Kerala, to evaluate the distribution of C. arecae was done during December 1988. The bug population count of nymphs, adults and injury count of bite marks, natural enemies, and other arthropod fauna in the palm crown were recorded in the prescribed proforma (Appendix - I). The yellow leaf disease (YLD) indices and percentage of affected palms were also recorded.

(a) Bug population: Adult bug population was seen throughout the State except Vadakkancherry and Palghat in Middle Kerala, Vaduvanchal in Northern Hill region, Tellicherry and Kumbla in Northern Kerala where no adults were observed.

Table 1. Distribution of C. arecae in Kerala (southern zone)

locations	total palms observed	number of palms affected by YLD	percentage of palms affected by YLD	mean YLD indices	mean bug population/palm			mean bites per palm
					adults	nymphs	total	
Neyattinkara	21	0	0.00	0.00	1.361 (1.537)	1.819 (1.679)	3.278 (2.068)	77.24 (8.85)
Ettiruthi	8	0	0.00	0.00	1.972 (1.724)	2.445 (1.856)	4.814 (2.411)	67.47 (8.27)
Kattakkada	7	1	14.29	14.00	1.458 (1.568)	0.795 (1.340)	2.559 (1.887)	134.58 (11.64)
Thiruvallam	21	0	0.00	0.00	1.057 (1.434)	1.983 (1.727)	3.083 (2.021)	98.44 (9.97)
Vithura	11	8	72.73	20.66	0.428 (1.195)	1.230 (1.493)	1.790 (1.670)	13.19 (3.77)
Theviyode	10	9	90.00	39.63	0.336 (1.156)	0.609 (1.269)	1.029 (1.425)	47.40 (6.96)
Palode	10	10	100.00	52.02	1.265 (1.505)	1.659 (1.631)	2.815 (1.953)	47.08 (6.93)
Pandianpara	12	11	91.67	46.08	1.408 (1.552)	1.873 (1.695)	3.502 (2.122)	123.63 (11.16)
Pangode	13	6	46.15	39.12	0.416 (1.190)	0.633 (1.278)	1.155 (1.468)	7.92 (2.99)
F test (zones)					S	NS	NS	NS
C.D.					0.150**	--	--	--

S: Significant NS: Not significant ** at 1% level
Figures in parentheses are transformed values ($\sqrt{x + 1}$)

Nymphal populations were not seen in Mukundapuram, Vadakkancherry Palghat in Middle Kerala, Temmala in Southern Hill Zone and Kumbla in Northern zone. Spindle bug bite injury on leaves was not observed in Vadakkancherry and Palghat in Middle Kerala. The total average bug population per palm ranged from one to eight. The total bite marks ranged from zero to 491.78 on top most leaf per palm. No agro-climatic zone was found free from the spindle bug infestation (Table 1 to 5).

(b) YLD: The yellow leaf disease was seen throughout the agroclimatic zones and least in the northern zones as a whole, in agreement with the observations of George et al. (1985). However in Irrikkur in Northern zone the disease was found as severe as in Southern zones. The percentage of YLD affected palms in different locations ranged from zero to 100 and following are some of the places showing maximum YLD indices (percentage in parenthis); Palode (100), Theviyode (90), Mavelikkara (93.33), Peechy (64.29), Irrikkur (86.67), Kulathupuzha (46.15), Chithara (37.5), etc. The mean YLD indices ranged from zero to 54.17 with maximum in some of the following places with indices in parenthesis; Palode (52.02), Theviyode (39.63), Mavelikkara (38.43), Peechy (44.53), Irrikkur (53.72), Kulathupuzha (51.22), Chithara (54.17, etc. Table 1 - 5).

(c) Seasonal abundance: Seasonal abundance of the pest in a few selected centres of Trivandrum district representing heavily diseased (Nedumangad Taluk), moderately diseased (Neyyattinkara Taluk) and apparently healthy areas (Tiruvallam Village of Trivandrum Taluk) were studied for 24 months from May 1987 to April 1989. At Palode range peak population was seen in June-July and October-January in both years. In Vithura the same trend was generally seen and bugs were seen throughout the year. In Kattakkada, least bug population was seen in May 1987 and in 1988 during February-March. In Neyyattinkara least populations were recorded in May-June during 1987 and March in 1988. Lowest bug population in Tiruvallam was seen during May-June in both the years

Table 2. Distribution of *C. arecae* in Kerala (problem zone)

Locations	total palms observed	number of palms affected by YLD	percentage of palms affected by YLD	mean YLD indices	mean bug population/palm			mean bites per palm
					adults	nymphs	total	
Karunagapally	14	7	50.00	25.81	0.107 (1.052)	0.516 (1.231)	0.647 (1.283)	117.52 (10.89)
Karthikapally	8	0	0.00	0.00	0.307 (1.143)	0.106 (1.052)	0.385 (1.177)	120.77 (11.04)
Mavelikkara	15	14	93.33	38.43	0.824 (1.351)	1.084 (1.444)	1.960 (1.721)	230.62 (15.22)
Chengannur	10	2	20.00	43.81	0.532 (1.238)	2.523 (1.877)	2.888 (1.972)	268.41 (16.41)
Aevoor North	8	5	62.50	40.69	0.716 (1.310)	0.961 (1.401)	1.696 (1.642)	225.29 (15.04)
Moncompu	16	1	6.25	20.00	1.265 (1.505)	2.039 (1.743)	3.518 (2.126)	376.33 (19.42)
Kumarakom	18	3	16.67	22.04	0.217 (1.103)	0.252 (1.119)	0.419 (1.191)	12.94 (3.73)
Vaikom	18	5	27.78	18.56	0.477 (1.215)	1.967 (1.728)	2.414 (1.848)	64.50 (8.09)
Vyttila	20	1	5.00	24.00	1.091 (1.446)	1.667 (1.633)	2.874 (1.968)	198.96 (14.14)
F test (zones)					S	NS	NS	NS
C.D.					0.150**	--	--	--

S: Significant NS: Not significant ** at 1% level
Figures in parentheses are transformed values ($\sqrt{x+1}$)

Table 3. Distribution of C. arecae in Kerala (middle zone)

locations	total palms observed	number of palms affected by YLD	percentage of palms affected by YLD	mean YLD indices	mean bug population/palm			mean bites per palm
					adults	nymphs	total	
Alwaye	15	6	40.00	23.53	1.580 (1.606)	4.583 (2.363)	6.401 (2.720)	449.73 (21.23)
Chalakkudy	8	0	0.00	0.00	0.106 (1.052)	3.457 (2.111)	3.678 (2.163)	83.42 (9.19)
Mukundapuram	13	0	0.00	0.00	0.065 (1.032)	0.000 (1.000)	0.065 (1.032)	40.09 (6.41)
Mannuthy	13	3	23.08	36.28	0.122 (1.059)	1.103 (1.450)	1.197 (1.482)	241.16 (15.56)
Peechy	14	9	64.29	44.53	0.814 (1.347)	1.583 (1.607)	2.416 (1.848)	491.78 (22.20)
Pattikkadu	13	0	0.00	0.00	0.769 (1.330)	2.954 (1.988)	3.924 (2.219)	323.34 (18.01)
Vadakkancherry	7	0	0.00	0.00	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)	0.00 (1.00)
Palghat	6	0	0.00	0.00	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)	0.00 (1.00)
Mannarghat	12	0	0.00	0.00	0.557 (1.248)	1.918 (1.708)	2.552 (1.885)	221.31 (14.91)
F test (zones)					S	NS	NS	S
C.D.					0.150**	--	--	3.00*

S : Significant
NS: Not significant
Figures in parentheses are transformed values $(\sqrt{x+1})$

** at 1% level
* at 5% level

Table 4. Distribution of C. arecae in Kerala (hill zone)

locations	total palms observed	number of palms affected by YLD	percentage of palms affected by YLD	mean YLD indices	mean bug population/palm			mean bites per palm
					adults	nymphs	total	
Peringamala	15	6	40.00	44.17	0.665 (1.290)	1.754 (1.659)	2.482 (1.866)	323.74 (18.02)
Chitara	8	3	37.50	54.17	0.106 (1.052)	0.553 (1.246)	0.684 (1.298)	203.25 (14.29)
Pathanapuram	7	3	42.86	40.83	0.122 (1.059)	0.989 (1.410)	1.160 (1.470)	79.33 (8.96)
Kulathupuzha	13	6	46.15	51.22	0.200 (1.096)	0.326 (1.151)	0.555 (1.247)	352.64 (18.81)
Tenmala	6	1	16.67	30.00	0.626 (1.275)	0.000 (1.000)	0.626 (1.275)	1.63 (1.62)
Ernadu	7	0	0.00	0.00	0.707 (1.307)	2.838 (1.959)	3.612 (2.148)	112.71 (10.66)
Vaduvanchal	10	3	30.00	17.47	0.000 (1.000)	0.432 (1.197)	0.432 (1.197)	24.32 (5.03)
Kottappady	7	2	28.57	16.43	0.122 (1.059)	0.122 (1.059)	0.220 (1.105)	101.90 (10.14)
Vythiri	21	0	0.00	0.00	0.693 (1.301)	1.192 (1.480)	1.854 (1,689)	109.42 (10.51)
F test (zones)					NS	NS	NS	NS
C.D.					--	--	--	--

NS: Not significant

Figures within parentheses are transformed values ($\sqrt{x + 1}$)

Table 5. Distribution of C. arecae in Kerala (northern zone)

locations	total palms observed	number of palms affected by YLD	percentage of palms affected by YLD	mean YLD indices	mean bug population/palm			mean bites per palm
					adults	nymphs	total	
Calicut	12	1	8.33	35.56	0.593 (1.262)	5.973 (2.641)	6.736 (2.781)	193.590 (13.949)
Tellicherry	6	0	0.00	0.00	0.000 (1.000)	1.191 (1.480)	1.191 (1.480)	83.580 (9.197)
Koothparamba	13	2	15.38	24.00	0.254 (1.120)	1.664 (1.632)	1.851 (1.688)	168.230 (13.009)
Irrikkur	15	13	86.67	53.72	0.307 (1.143)	1.627 (1.904)	2.883 (1.971)	199.200 (14.149)
Talipparamba	13	0	0.00	0.00	0.357 (1.165)	6.893 (2.809)	7.566 (2.927)	174.180 (13.236)
Koipady	6	0	0.00	0.00	0.588 (1.260)	1.853 (1.689)	2.315 (1.821)	39.650 (6.376)
Kumbla	7	0	0.00	0.00	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)	10.520 (3.394)
Maddhur	13	0	0.00	0.00	0.449 (1.204)	3.953 (2.226)	4.357 (2.315)	207.500 (14.440)
Neerchalu	21	0	0.00	0.00	0.259 (1.122)	2.219 (1.794)	2.454 (1.858)	142.840 (11.993)
F test (zones)					S	NS	NS	NS
C.D.					0.150**	--	--	--

S: Significant NS: Not significant ** at 1% level
Figures within parentheses are transformed values ($\sqrt{x+1}$)

(d) Correlation of bug population with weather parameters: Simple correlation of weather parameters namely total rainfall, rainy days, maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity, showed that maximum temperature was negatively correlated with adults, nymphs and total bug population (Table 6). During rains temperature is lowered down and there is increase in the moisture and relative humidity percentage which are thus found to be positively correlated at Palode centre which help increase the bug population. In Tiruvallam maximum temperature was found negatively correlated following the trend at Palode but total rainfall or RH% was not found influencing the bug population. Proximity to rivers and lakes there perhaps help to maintain almost a uniform relative humidity percentage. In Neyyattinkara number of rainy days negatively influenced bug population.

(e) Seasonal fluctuation of YLD and its correlation with bug population:

(i) The YLD palm percentage and indices in different months recorded at Palode and Vithura for 24 months showed variations. At Palode the percentage varied from 60 to 80 and YLD indices from 9 to 56. The increase in the indices was observed from September-October and reached a peak in December-January in the first year and December-March in the second year (Table 6).

(ii) At Vithura percentage of YLD palms were more but indices were less than at Palode region. The percentage ranged from 26.67 to 93.33 and indices ranged from 7.22 to 48.68. The increase in the indices was observed from November-January in the first year and October-February in the second year.

(iii) Simple correlation studies with YLD, weather parameters and bug populations at Palode showed that total rainfall and rainy days and min. RH% were negatively correlated with the disease while maximum temperature was positively correlated with the disease. Bug population did not correlate the disease (Table 7).

Table 6. Seasonal distribution of *C. arecae* and yellow leaf disease at Palode, Trivandrum district, 1987-89

month	number of palms affected by YLD	percentage of palms affected by YLD	YLD indices	mean bug population			mean bites	meteorological data					
				adults	nymphs	total		total rain	rainy days	temperature °C max.	temperature °C min.	R.H. percent max.	R.H. percent min.
May 87	28	80.00	17.19	0.619 (1.272)	0.482 (1.217)	1.062 (1.436)	164.59 (12.87)	209.2	14	34.4	24.0	84.97	58.71
June 87	22	62.85	9.97	0.443 (1.201)	0.764 (1.328)	1.216 (1.489)	28.30 (5.41)	362.4	21	31.4	23.4	91.30	70.67
July 87	29	62.85	16.11	1.037 (1.427)	2.041 (1.744)	3.207 (2.051)	37.82 (6.23)	105.8	9	36.6	23.3	90.64	63.42
Aug. 87	19	54.29	19.35	0.849 (1.360)	1.485 (1.577)	2.284 (1.812)	30.67 (5.63)	331.4	17	30.7	23.0	91.77	68.81
Sep. 87	22	62.85	21.06	0.856 (1.362)	0.997 (1.413)	1.860 (1.691)	51.96 (7.28)	449.2	10	31.8	23.0	90.83	81.12
Oct. 87	22	62.85	28.05	2.062 (1.749)	3.886 (2.210)	5.927 (2.632)	173.62 (13.21)	384.2	18	31.3	23.1	92.35	74.16
Nov. 87	22	62.85	28.35	1.478 (1.574)	2.783 (1.945)	4.217 (2.284)	38.66 (6.30)	366.4	14	31.6	22.8	92.67	68.70
Dec. 87	21	60.00	39.42	1.805 (1.675)	4.033 (2.243)	5.818 (2.611)	195.05 (14.00)	255.2	8	32.1	22.7	91.81	61.32
Jan. 88	21	60.00	55.52	0.457 (1.207)	1.162 (1.470)	1.590 (1.609)	57.46 (7.65)	2.0	9	33.5	20.2	90.16	39.10
Feb. 88	25	71.43	45.57	0.610 (1.269)	0.537 (1.240)	1.128 (1.459)	45.32 (6.81)	155.8	6	34.7	21.3	90.89	40.38
Mar. 88	23	65.71	31.86	0.927 (1.388)	1.241 (1.497)	1.979 (1.726)	54.07 (7.42)	109.4	7	34.3	22.7	92.19	53.38
Apr. 88	24	68.85	40.91	0.399 (1.183)	0.654 (1.286)	0.996 (1.413)	46.23 (6.87)	577.6	20	33.6	24.2	93.40	62.93
F test (months)			S	NS	NS	NS	NS						
May 88	24	68.57	35.23	0.460 (1.208)	0.229 (1.108)	0.672 (1.293)	41.27 (6.50)	108.6	8	32.2	24.8	93.22	63.87
June 88	21	60.00	30.00	1.046 (1.430)	1.419 (1.555)	2.478 (1.865)	88.03 (9.44)	432.4	20	30.8	23.9	94.53	74.20
July 88	21	60.00	32.69	1.483 (1.576)	3.080 (2.020)	4.595 (2.365)	47.16 (6.94)	351.0	13	30.1	23.1	90.10	68.39
Aug. 88	23	65.71	37.37	0.756 (1.325)	1.232 (1.494)	1.950 (1.718)	44.73 (6.76)	269.6	18	30.5	23.9	91.96	71.00
Sep. 88	22	62.85	37.30	0.573 (1.254)	1.371 (1.540)	1.944 (1.716)	88.52 (9.46)	375.6	17	30.5	23.6	92.06	71.30
Oct. 88	24	68.57	46.10	0.487 (1.220)	0.502 (1.226)	1.031 (1.425)	36.93 (6.16)	215.2	7	32.3	23.9	90.32	61.19
Nov. 88	23	65.71	41.42	0.520 (1.233)	0.591 (1.261)	1.118 (1.455)	67.84 (8.30)	224.7	12	31.7	22.9	93.60	64.27
Dec. 88	27	77.14	50.51	0.971 (1.404)	1.316 (1.522)	2.352 (1.831)	46.09 (6.86)	72.2	5	35.5	22.3	89.97	53.10
Jan. 89	26	74.29	45.75	1.522 (1.588)	3.056 (2.014)	4.559 (2.358)	30.69 (5.63)	7.4	1	33.3	21.7	89.70	42.38
Feb. 89	22	62.86	51.38	0.356 (1.164)	0.220 (1.104)	0.573 (1.254)	25.55 (5.15)	0.0	0	30.0	20.9	85.78	29.25
Mar. 89	23	65.71	56.43	0.048 (1.024)	0.212 (1.101)	0.246 (1.116)	35.08 (6.01)	64.5	2	35.2	23.2	90.03	38.00
Apr. 89	23	65.71	48.03	0.664 (1.290)	0.331 (1.154)	1.008 (1.417)	37.18 (6.18)	238.0	14	34.1	24.8	89.80	61.66
F test (months)			S	NS	NS	NS	NS						

NS : not significant S : significant C.D. value given in Appendix

Figures within parentheses are transformed values ($\sqrt{x+1}$)

Total palms surveyed per month: 35

Table 7. Correlation between C. arecae population and weather parameters

parameters	adults	nymphs	total population	bites on leaves	YLD indices
		Palode			
rainfall	0.0660	0.0760*	0.8190*	0.0758*	-0.531**
rainy days	0.0519	0.0492	0.0600	0.0566	-0.636**
max. temp.	-0.1147**	-0.1763**	-0.1745**	0.0508	0.636**
min. temp.	-0.0141	-0.0634	-0.0519	-0.0011	-0.355
max. RH%	-0.0060	-0.0021	-0.0039	-0.0582	-0.196
min. RH%	0.1328**	0.1493**	0.1619**	0.0961*	-0.635**
total bug population					-0.235
		Tiruvallam			
rainfall	-0.0043	0.0779	0.0628	0.0260	
rainy days	-0.0623	0.0532	0.0225	-0.0311	
max. temp.	-0.1459**	-0.2276**	-0.2379**	0.0907	
min. temp.	-0.1176**	-0.0622	-0.0917	0.0364	
max. RH%	-0.0233	-0.0385	0.0238	-0.1164**	
min. RH%	-0.0928	-0.0110	-0.0409	-0.0200	
		Neyattinkara			
rainfall	-0.0523	-0.0170	-0.0307	-0.0188	
rainy days	-0.1170**	-0.0420	-0.0718**	-0.0888**	
		Kattakkada			
rainfall	-0.0460	-0.0103	-0.0660	-0.0520	
rainy days	-0.0992	-0.0307	-0.0579	-0.0170	
		Vithura			
rainfall	0.0404	0.0001	0.0134	0.0848	
rainy days	0.0587	0.0309	0.0456	0.1262**	

* significant at 5% level

** significant at 1% level

II. BIOLOGY OF C. arecae ON ALTERNATE HOST AND NATURE OF DAMAGE

(i) In order to study the effect on the lifecycle and size of C. arecae, they were reared on A. catechu, A. triandra, Pinanga sp. and Chrysalidocarpus lutescens for atleast two generations and the details were recorded (Table 8). On A. catechu and A. triandra average life span from egg to adult stage was 24.07 and 24.21 days respectively whereas in Pinanga sp. and C. lutescens it was 31.66 and 25.83 days respectively. Average fecundity among the different palms were 20.12, 18.0, 14.4 and 15.66 eggs per female in A. catechu, A. triandra, Pinanga sp. and C. lutescens respectively. The adult male longevity was 24.0, 18.00, 12.86, 13.75 and adult female longevity was 27.75, 23.33, 25.50 and 21.0 days respectively on the above palms.

(ii) Body measurements of early instars from egg to second instar nymph did not statistically differ among the palms on which they were bred (Table 9 & 10). The eggs measured from 1.40 to 1.67 mm long, the first instar nymphs measured from 0.91 to 1.62 mm and the second instar nymphs measured from 1.73 to 2.20 mm in the different palms. The third instar nymphs to fifth instar nymphs sizes in the different palms differed significantly. The length of third instar nymphs ranged from 2.27 to 3.33 mm, the fourth instar nymphs ranged from 3.05 to 4.76 mm, the fifth instar nymphs ranged from 4.0 to 6.19 mm. Adult males differed in the sizes among the palms whereas in female it did not statistically differ. The adult males measured from 4.41 to 6.9 mm and the females measured from 4.68 to 7.14 mm.

(iii) Nature of damage: The damage caused by C. arecae on areca palm was described by Khandige (1955), Nair and Das (1962), Menon et al. (1962), Nair and Menon (1963), Abraham et al. (1976), Abdulla Koya et al. (1979) and others.

(a) The main features can be summarised with certain additional points as follows: The injury to the palm by C. arecae begins with egg laying with the ovipositor and extends to all life stages. The injury is made on tender tissues and older tissues are more or less resistant. When

Table 8. Effect of different host plants on the biology of C. arecae

host plants	egg period	mean duration of nymphal instars (days)					nymphal period	egg to adult duration	fecundity (eggs/ female)	adult longevity	
		first	second	third	fourth	fifth				male	female
A. catechu	6.67 (6-7)	2.00 (2)	4.67 (3-6)	5.25 (4-7)	2.33 (2-3)	2.83 (1-7)	17.08 (16-20)	24.08 (23-27)	20.12 (9-28)	24.00 (23-28)	27.75 (23-37)
A. triandra	6.50 (5-8)	2.64 (2-4)	3.93 (2-6)	5.64 (4-8)	4.07 (3-5)	1.42 (1-2)	17.71 (14-20)	24.21 (21-28)	18.00 (17-20)	18.00 (11-22)	23.33 (18-26)
Pinanga sp.	7.20 (6-8)	3.00 (3)	6.33 (4-8)	8.11 (8-12)	4.44 (2-6)	2.55 (2-5)	24.44 (20-27)	31.66 (27-36)	14.40 (12-17)	12.86 (11-13)	25.50 (22-29)
C. lutescens	7.00 (7)	4.00 (4)	3.50 (2-5)	5.00 (4-6)	3.83 (3-4)	2.50 (2-3)	18.83 (16-21)	25.83 (23-28)	15.66 (12-19)	13.75 (12-15)	21.00 (20-23)
F. test	NS	S	S	S	S	NS	S	S	NS	S	NS
		C.D. for comparison of									
A.catechu vs A.triandra	..	0.47**	1.11	1.25	0.77**	..	1.81	1.67	..	4.43**	..
A.catechu vs Pinanga sp.	..	0.52**	1.25**	1.41**	0.86**	..	2.03**	1.87**	..	4.04**	..
A.catechu vs C.lutescens	..	0.60**	1.41	1.36	0.83**	..	1.97	1.81	..	4.72**	..
A.triandra vs Pinanga sp.	..	0.51	1.21**	1.59**	0.97	..	2.31**	2.12**	..	3.92**	..
A.triandra vs C.lutescens	..	0.59**	1.38	1.56	0.95	..	2.25	2.07	..	3.92**	..
Pinanga sp. vs C.lutescens	..	0.60**	1.48**	1.68**	1.03	..	2.43**	2.23**	..	3.48	..

** significant at 1% level

figures within parentheses are the range

S : significant

NS : not significant

the feeding injury is seen on tender leaf tissues, it develops a longitudinal narrow decolourised zone and progressively extends between the parallel veins. As a result of the feeding, the cells get collapsed due to shrinkage which become necrotic and dry. The affected portion is seen flaked off leaving shot holes. When injury is made on fronds or spathe, it forms circular smallpox like depressions which become necrotic, black and dry up. During rainy season, the affected spindles are seen invaded by saprophytic flies, fungi, and bacteria causing complete decay. The severely affected crown is fully scarred with dried up necrotic patches and shot holes inhibiting the photosynthetic activity leading to stunted, sickly palms which may never reach to their full vigour.

(b) The histological studies showed that the leaf of areca is dorsi-ventral with pallisade parenchyma on the adaxial side. The first noticeable change in the morphology of the leaf is the slight shrinkage of the epidermis at the site of feeding near the vascular bundle. The shrinkage is probably due to the sudden removal of water from thin walled spongy cells. This reduces the water tension in the cells and causes the collapse of the cell walls. Islands of undamaged cells within the lesions showing the actual feeding sites are evident even after 120 hours of feeding. The damaged sites become filled with brownish deposits (probably phenolic materials) and do not show any persisting cells except the xylem and sclerenchymatous elements of the vascular bundles. The collapse of the cells and the eventual disruption of the cells are suggestive of the substance released by the bug which disrupts the compartmentalisation in the cells by altering the integrity of the membrane system. The elevated activity of acid phosphatase a hydrolytic enzyme detected in the cells at the vicinity of the biting site induced by the bug Cryptopeltis tenuis, Heteroptera : Miridae (Raman and Sanjayan, 1984) in tomato stem indicated a similar phenomenon as noted in A. catechu.

(c) Histochemical localisation of proteins and lipids was studied which revealed that there is a heavy accumulation of amorphous proteins after 12 hours of insect feeding. This indicates that in response to injury caused by the bug both mechanical as well as chemical, the cells synthesise a higher

Table 9. Effect of different host plants on the size of eggs and early nymphs of C. arecae (measurements in mm)

host plant	eggs				first instar nymph			second instar nymph		
	length	width	length of trachael tubes longer	shorter	length	width	length of antenna	length	width	length of antenna
A. catechu	1.51 (1.44-1.58)	0.36 (0.34-0.38)	0.66 (0.62-0.75)	0.13 (0.15-0.23)	1.33 (0.91-1.55)	0.63 (0.50-0.82)	0.93 (0.68-1.05)	1.98 (1.86-2.14)	1.09 (1.05-1.36)	1.23 (1.00-1.59)
A. triandra	1.56 (1.50-1.64)	0.32 (0.32)	0.68 (0.64-0.73)	0.19 (0.18-0.23)	1.19 (1.09-1.27)	0.63 (0.59-0.68)	1.02 (0.99-1.09)	2.00 (1.77-2.14)	1.07 (0.95-1.27)	1.23 (1.14-1.32)
Pinanga sp.	1.57 (1.45-1.64)	0.36 (0.32-0.41)	0.66 (0.50-0.77)	0.18 (0.14-0.23)	1.55 (1.43-1.62)	0.71 (0.48-0.91)	1.05 (0.95-1.23)	2.00 (1.73-2.18)	1.09 (0.91-1.18)	1.15 (1.05-1.23)
C. lutescens	1.50 (1.40-1.65)	0.36 (0.34-0.38)	0.63 (0.58-0.68)	0.16 (0.15-0.20)	1.33 (1.14-1.50)	0.72 (0.68-0.77)	1.00 (0.95-1.05)	2.13 (2.09-2.18)	1.20 (1.18-1.23)	1.23 (1.23)
E. guineensis	1.60 (1.55-1.67)	0.36 (0.34-0.38)	0.64 (0.65-0.70)	0.18 (0.16-0.21)	1.34 (1.20-1.60)	0.63 (0.53-0.73)	0.91 (0.83-1.00)	2.13 (2.05-2.20)	1.19 (1.08-1.30)	1.20 (1.10-1.35)
F. test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS : not significant

figures within parentheses are the range

Table 10. Effect of different host plants on the size of nymphs and adults of C. arecae (measurements in mm)

host plants	third instar nymph			fourth instar nymph			fifth instar nymph			adult male			adult female		
	length	width	antenna length	length	width	antenna length	length	width	antenna length	length	width	antenna length	length	width	antenna length
A. catechu	2.89 (2.82-3.05)	1.85 (1.77-1.91)	2.03 (1.91-2.18)	3.69 (3.45-3.95)	2.20 (1.86-2.50)	2.75 (2.55-2.91)	4.74 (4.18-5.23)	2.35 (1.91-2.68)	2.73 (2.50-3.00)	4.97 (4.77-5.18)	2.65 (2.41-2.82)	3.68 (3.32-4.09)	5.32 (5.14-5.50)	3.10 (2.86-3.27)	3.74 (3.41-4.09)
A. triandra	2.52 (2.27-2.73)	1.52 (1.36-1.68)	1.66 (1.55-1.82)	3.20 (3.05-3.45)	1.84 (1.59-2.14)	2.25 (2.00-2.50)	4.39 (4.00-4.64)	2.35 (2.00-2.73)	2.77 (2.59-2.86)	4.74 (4.41-5.15)	2.39 (2.36-2.50)	3.36 (3.32-3.43)	4.97 (4.77-5.18)	2.61 (2.41-2.82)	3.52 (3.52)
Pinanga sp.	2.65 (2.55-2.73)	1.53 (1.36-1.73)	1.68 (1.59-1.82)	3.50 (3.41-3.64)	2.49 (2.41-2.55)	2.97 (2.91-3.05)	4.57 (4.09-4.50)	2.33 (2.27-2.41)	2.76 (2.59-3.10)	4.64 (4.27-4.86)	2.46 (2.36-2.71)	3.06 (2.59-3.45)	5.05 (5.05)	2.68 (2.68)	3.86 (3.86)
C. lutescens	2.45 (2.41-2.50)	1.57 (1.50-1.64)	1.61 (1.50-1.72)	4.12 (3.95-4.25)	2.49 (2.35-2.60)	2.72 (2.65-2.80)	5.34 (5.09-5.95)	2.12 (1.90-2.28)	3.07 (2.62-3.47)	6.12 (5.24-6.90)	2.67 (2.38-3.19)	3.79 (3.57-4.05)	6.35 (4.68-7.14)	2.90 (2.76-3.09)	4.04 (3.99-4.09)
E. guineensis	3.16 (3.00-3.33)	2.02 (1.90-2.14)	2.50 (2.14-2.86)	4.55 (4.29-4.76)	2.56 (2.38-2.86)	2.85 (2.71-2.95)	5.83 (5.48-6.19)	2.78 (2.62-2.82)	3.13 (2.86-3.33)	5.95 (5.71-6.43)	2.78 (2.71-2.86)	3.87 (3.81-4.05)	6.18 (5.71-6.90)	2.96 (2.86-3.11)	3.67 (3.33-3.81)
F. test	S	S	S	S	S	S	S	S	S	S	NS	S	NS	NS	NS
							C.D. for comparison of								
A.catechu vs A.triandra	0.14**	0.12**	0.23**	0.22**	0.28**	0.19**	0.35*	0.22	0.23	0.56	..	0.47	..	..	..
A.catechu vs Pinanga sp.	0.16**	0.14**	0.25**	0.26	0.30*	0.22*	0.45	0.28	0.27	0.56	..	0.44**	..	..	..
A.catechu vs C.lutescens	0.16**	0.14**	0.24**	0.27	0.26**	0.20	0.42**	0.26	0.25**	0.56**	..	0.44	..	..	..
A.catechu vs E.guineensis	0.21**	0.18	0.31**	0.28**	0.25**	0.23	0.40**	0.25**	0.25**	0.51**	..	0.41	..	..	..
A.triandra vs Pinanga sp.	0.21	0.18	0.31	0.24**	0.26**	0.20**	0.37	0.23	0.21	0.51	..	0.41	..	..	..
A.triandra vs C.lutescens	0.23	0.19	0.32	0.24**	0.28**	0.19**	0.46**	0.29	0.26**	0.51**	..	0.37**	..	..	..
A.triandra vs E.guineensis	0.21**	0.18**	0.31**	0.26**	0.28**	0.21**	0.41**	0.25**	0.25**	0.56**	..	0.44**	..	..	..
Pinanga sp. vs C.lutescens	0.21	0.18	0.30	0.22**	0.24	0.18**	0.37**	0.23*	0.21**	0.56**	..	0.44**	..	..	..
Pinanga sp. vs E.guineensis	0.23**	0.19**	0.32**	0.27**	0.25	0.24	0.46**	0.29**	0.26**	0.56**	..	0.41**	..	..	..
C.lutescens vs E.guineensis	0.26**	0.23**	0.37**	0.24**	0.22	0.18	0.41**	0.26**	0.24	0.51	..	0.37	..	..	..

S : significant
NS: not significant
** significant at 1% level
* significant at 5% level
figures within parentheses show the range

amount of protein for healing the wound. The cells in the leaf after 12 hours of feeding up to 24 hours get heavily loaded with lipids. The accumulation of lipids in response to the insect bite probably indicates that the cells lose their machinery for mobilisation of reserve materials because of the toxin released by the bug and hence the cells are heavily loaded with reserve materials.

III. EVALUATION OF DIFFERENT METHODS OF CONTROL

a) Evaluation of insecticidal sachets: Application of insecticidal sachets irrespective of the insecticides and the number of sachets used, in the tendermost leaf axils of areca palms resulted in very low or zero bug population for a number of months compared to control palms (Table 11). Control palms (10 palms) regularly showed bug as per Poisson distribution in the range of 0.35 to 5.41 total average bug (adult and nymph) per palm per month. In case of phorate sachet treated palms (4 treatments x 10 palms) no nymphal population could be seen for eight months except in case of treatment with one phorate sachet containing 2 g per palm, where nymphal population could be seen on second month and seventh month (Table 11). This result suggested that bug could breed only in a partially protected palm or control palm. Well protected palm with two sachets in two tendermost leaves were free from any nymphs. The presence of an adult on a palm as such is not seriously considered as that of a nymphal population which breed on the palm. In case of carbofuran sachet treated palms (4 treatments x 10 palms) nymphal population could be seen from second month onwards regularly but very few compared to control palms at the same time suggesting the inferiority over phorate sachets.

b) Comparison of phorate sachets with other conventional methods namely sprays and leaf axil application of granular insecticides:

Conventional recommendations of foliar sprays of HCH, endosulfan, fish oil rosine soap, neam cake suspension and leaf axil application of granular insecticides phorate 10G and carbofuran 3G were compared with phorate sachet method of application against C. arecae for control. The conventional recommendations were applied once in two months and phorate

Table 11. Control of *C. arecae* using granular insecticides kept in leaf axils of crown in sachets

treatments	mean number of *C.arecae* / palm observed at different intervals after treatments (months)										total of ten months
	1	2	3	4	5	6	7	8	9	10	
control	0.40	3.30	2.20	1.40	4.20	7.40	1.80	0.90	5.155 (2.481)	2.608 (1.899)	28.741 (5.454)
one phorate sachet of 2g/palm	0.10	0.40	0.00	0.00	0.00	0.10	1.40	0.00	2.956 (1.989)	0.587 (1.260)	4.568 (2.360)
two phorate sachets of 2g/palm	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.636 (1.279)	5.929 (2.632)	7.248 (2.872)
one phorate sachet of 4g/palm	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.440 (1.200)	0.000 (1.000)	0.621 (1.273)
two phorate sachets of 4g/palm	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.959 (1.400)	0.484 (1.218)	2.135 (1.771)
one carbofuran sachet of 2g/palm	0.10	0.60	0.00	0.10	0.50	1.40	0.00	0.00	1.088 (1.445)	3.447 (2.109)	6.921 (2.815)
two carbofuran sachets of 2g/palm	0.00	0.70	0.20	0.00	0.50	0.70	0.00	0.30	2.552 (1.885)	1.301 (1.517)	6.732 (2.781)
one carbofuran sachet of 4g/palm	0.10	0.30	0.00	0.00	0.70	0.70	0.20	0.20	4.876 (2.424)	1.907 (1.705)	18.346 (4.398)
two carbofuran sachet of 4g/palm	0.00	0.00	0.00	0.00	0.20	0.30	1.50	0.30	2.973 (1.993)	2.976 (1.994)	9.161 (3.188)
F. test									NS	S	S
C.D.									1.176	0.834**	1.450**

* significant at 5% level ** significant at 1% level NS: not significant

figures in parentheses are transformed values $\sqrt{x + 1}$ S: significant

Table 13. Control of *C. arecae* with different insecticides used as foliar sprays, as granules in leaf axils directly and in sachets (effect on total bug population)

treatments	mean number of total bug population/palm/month observed at different intervals after treatment (months)											mean total population/palm
	1	2	3	4	5	6	7	8	9	10	11	
HCH 0.2% ai (spray)	0.63	3.38	0.69	0.13	1.31	0.44	0.06	0.56	0.00	0.00	0.00	7.0940 (2.8450)
endosulfan 0.05% ai (spray)	0.38	1.88	0.50	2.25	0.00	0.44	0.00	0.00	0.00	0.00	0.19	5.5280 (2.5550)
fish oil rosine soap 5% (spray)	0.63	2.56	0.44	0.69	0.25	1.56	0.00	0.75	0.00	0.00	0.00	6.6591 (2.7675)
neem cake suspension 5% (spray)	2.31	2.50	2.63	2.19	0.31	1.06	0.00	0.00	0.06	0.00	0.00	10.3064 (3.3625)
phorate granules 10% ai @ 5g placed in leaf axils	0.00	1.69	0.00	0.03	0.00	0.50	0.00	0.00	0.00	0.00	0.00	2.3306 (1.8250)
carbofuran granules 3% ai @ 5g placed in leaf axils	1.31	2.13	0.13	1.75	0.06	2.06	0.00	1.31	0.00	0.00	0.00	8.0300 (3.0050)
two sachets of 2g phorate granules each placed in leaf axils	0.00	0.00	0.00	0.00	0.06	0.00	0.13	0.00	0.00	0.00	0.00	0.1664 (1.0800)
control	3.25	3.38	1.63	2.81	1.88	2.56	0.81	0.88	0.25	0.44	0.00	16.8929 (4.2300)
F. test												S
C.D.												0.7014**

S: significant

** significant at 1% level

figures within parentheses are transformed values ($\sqrt{x+1}$)

Table 12. Cost of controlling C. ; recae infesting tall/small arecanut palms with different insecticides using different methods of application

treatments	dose/palm/ treatment (a.i)	number of treatment per year	formulations of pesticide required/year	cost of pesticide/year/palm (Rupees) (a)	labour required/ treatment man h/ palm	labour cost/ palm/year (Rupees) (b)	total cost of treatment/year (Rupees)
tall palms (treatment by climbing							
phorate granules (applied in leaf axils)	1.0g	6	60g of 10% granules	2.040	0.080	1.86	3.90
carbofuran granules (applied in leaf axils)	0.3g	6	60g of 3% granules	1.980	0.080	1.86	3.84
phorate granules (placed in leaf axils in sachets)	0.8g	1	8g of 10% granules	0.660	0.106	2.46 (c)	3.12
carbofuran granules (placed in leaf axils in sachets)	0.24g	1	8g of 3% granules	0.660	1.106	2.46 (c)	3.12
HCH (foliar spray)	0.2%	6	6g of 50% WP	0.055	0.040	0.93	0.99
endosulfan (foliar spray)	0.05%	6	2.1ml 35% EC	0.220	0.040	0.93	1.15
fish oil rosine soap (foliar spray)	5.0%	6	75g fish oil rosine soap	1.500	0.040	0.93	2.43
neem cake suspension (foliar spray)	5.0%	6	125g neem cake	1.500	0.040	0.93	2.43
young palms (treatment from ground)							
phorate granules (applied in leaf axils)	0.5g	6	30g of 10% granules	1.020	0.046	1.07	2.09
carbofuran granules (applied in leaf axils)	0.15g	6	30g of 3% granules	0.990	0.046	1.07	2.06
phorate granules (placed in leaf axils in sachets)	0.4g	1	4g of 10% granules	0.490	0.064	1.49 (c)	1.98
carbofuran granules (placed in leaf axils in sachets)	0.12g	1	4g of 3% granules	0.480	0.064	1.49 (c)	1.97
HCH (foliar spray)	0.2%	6	3g of 50% WP	0.030	0.016	0.37	0.40
endosulfan (foliar spray)	0.05%	6	1.07ml 35% EC	0.110	0.016	0.37	0.48
fish oil rosine soap (foliar spray)	5.0%	6	37.50g fish oil rosine soap	0.750	0.016	0.37	1.12
neem cake suspension (foliar spray)	5.0%	6	62.50g neem cake	0.750	0.016	0.37	1.12

(a) cost of insecticides as on 30-5-1989. (b) labour charges as on 30-5-1989 Rs. 31.00/8 man h. (c) cost of elevating sachets six times a year also included.

sachets once in eleven months but elevated to new leaf axils as and when they emerged in about 30-45 days time. Phorate sachets were significantly superior to all other treatments (Table 13). Neem cake suspension and fish oil rosine soap, HCH 0.2% and endosulfan 0.05% ai. spray were almost on par with control. Phorate 10G granules applied in tendermost leaf axils of arecanut once in two months showed appearance of the bug in second month but was superior to control and sprays.

c) Cost of application, for tall palms and young palms treated from ground have been worked out (Table 12). Cost of insecticidal sachet method of application was found to be Rs. 3.12/palm/year for tall palms and Rs. 1.98 for young palms. Though 0.2% HCH foliar spray was the cheapest method it was not effective.

d) In order to keep the phorate sachets on tall areca palms, a sachet placing device or 'thotta' with a bent hook, like an umbrella hold, was deviced with g.i rod of 10 mm diameter and 1 ft long fixed on agricultural waste material like tapioca stem/reed/etc. The phorate sachet was fixed on the hook and hung in the tendermost leaf axil of arecanut and tied at the opposite end of thotta with the arecanut stem. With care when used, this improved the method of application and may last for 1-2 years.

IV. ASSOCIATION OF C. arecae WITH MLO AND YLD

The ability of spindle bug to acquire the phloem limited mollicute and sustain its multiplication in the body system and possibly act as a vector of the disease was assessed/ Critical examination of ultrathin sections of the gland having acquisition and incubation period (A + IP) in the range of 20-33 days on YLD affected palms failed to reveal any mycoplasma like structures. As the mycoplasma in most insects is carried in the haemolymph in some stage or other in its transmission cycle, the blood of the insects which were given a minimum A + IP of 10 days on YLD affected palms was also examined. MLOs could not be observed in any of the haemolymph preparations also. These studies conclusively prove that the C. arecae may not be acquiring the organism and acting as a vector of the disease.

/under electron microscope.

14. List of publications:

a) Research papers : Nil

b) Popular articles :
1. "KAMUKINTE KURUNNILACHAZI" KISSAN MELA, CPCRI, PALODE, S.A. JACOB, January 1986.
2. "KAMUKINTE KURUNNILACHAZI" KERALA KARSHAKAN, 1987 NOVEMBER, 16. Page 14-15.

c) Reports : Spindle bug of arecanut. Extension folder No. 10, published by Director, CPCRI, Kasaragod. (Text prepared by S.A. Jacob).

15. Details of field/laboratory note book and their final location:

Primary project file	:	One
Subproject file	:	Nil
Experimental log book	:	Two
Laboratory note book	:	One
Field note book	:	Two

(S.A.Jacob)
Signature of
Principal Investigator.

(Dr.K.U.K.Nampoothiri)
Signature of Station
in charge.

(G.B. Pillai)
Signature of Head
of Division.

(Dr. M.K. Nair)
Signature of Director.

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SURVEY PROFORMA FOR ESTIMATION OF FIELD POPULATION OF SPINDLE BUG

DISTRICT-WISE, AND SEASON-WISE ON ARECA PALM

MONTH:

DATE :

(1) DISTRICT

(2) MAXIMUM CROPPED TALUK

(3) CROPPING PATTERN : MIXED/ INTER/MONO/ CROP

(4) VILLAGE :

(5) ADDRESS OF OWNER

(6) TOTAL NO. OF PALMS IN PLOT:

Sl. No.	Category wise	Appx. age of Palm	Spindle bug population			NATURAL ENEMIES COUNT									Remarks
			Adults	Nymphs	Bite Count	Spiders 1	2	3	4	Ants A	B	C	D	Earwigs	Others	

P.T.O.

YLD INDICES OF PALMS

Palm No.	Yellowing of lower leaves (Y)					Necrosis(N)					Reduction of Crown (R)	Formula: $I = \left[\frac{(Y+N)}{L} + R\right] \times 10$ L = 50% leaves in crown.	INDEX
	1	2	3	4	Total	1	2	3	4	Total			