



INDIAN COUNCIL OF AGRICULTURAL RESEARCH
A.P.CESS FUND SCHEME

**ROLE OF NEMATODES IN THE INCIDENCE OF
LEAF ROT DISEASE ON ROOT(WILT) AFFECTED
COCONUT PALMS**

FINAL REPORT

1995–1999

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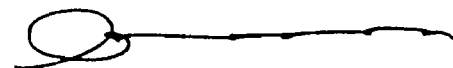
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Kayangulam
15th July 2000



P.K.Koshy
Principal Investigator

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FINAL REPORT

Project Title : **Role of Nematodes in the incidence of leaf rot disease on root (wilt) affected coconut palms**

Sanction No. : **14(13)/93-Hort. I dt. 10-01-1995 and 8-05-1998**

Date of start : **12-7-95**

Date of termination : **11-7-99**

Institute's name : **Central Plantation Crops Research Institute,
Regional Station**

Place : **Kayangulam**

District : **Alleppey**

State : **Kerala**

Dept./Div. Name : **Crop Protection**

Actual location : **Nematology Laboratory
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8. Objectives :

1. To study the nematode fauna (plant parasitic and saprophagous) associated with leaf rot disease of coconut
2. To study the specific role of different species of nematodes as incitant/ aggravator/ carrier of the fungal inoculum
3. To study the effect of nematicides singly and in combination with systemic/contact fungicides
4. To standardise the mode and frequency of application of nematicides and fungicides

Duration of scheme	:	4 years
Total cost of the scheme	:	Rs. 7,58,679/-
Recurring	:	Rs. 1,40,598
Pay of Officer	:	Nil
Year	:	1995

Name of post	Pay scale	No. of post	Total
Research Associate			
1. Dr. Udaya Joseph	Rs. 3000-100-3500+	2	2
2. Kum. D.Jayasree	H.R.A.		

Non-recurring	:	Rs. 58,000/-
11. Total amount sanctioned (in case of extn.)	:	Rs. 9,14,960/-
12. Total amount spent	:	Rs. 7,58,679/-

13. Result of practical/ Scientific value

The root(wilt) disease causes an annual loss of 968 million nuts of which the loss due to leaf rot alone is 461 million nut. (Joseph & Rawther 1991). This loss can be avoided to a great extent if all palms and seedlings in the gardens are treated twice a year for prophylactic and curative effects. This has been proved beyond doubt that palms which were positive to serological test which means palms infected with phytoplasma on treatment with fungicide – insecticide mixture do not succumb to leaf rot infection as well as insect damage under field conditions thereby proving the prophylactic effect (Koshy *et. al.*, 2000).

A series of field trials conducted using various fungicides, bactericides and insecticides having contact and systemic properties led to the development of a very effective, economic, environment friendly and easy integrated method for the control of leaf rot disease and insect pests of coconut for the root (wilt) affected area in Kerala and Tamil Nadu.

1.	Contaf - 5 EC (Hexaconazole) 2ml per palm	Rs. 1.20
OR		
	Dithane - M 45 OR Indofil -- M45-3g per palm	Rs. 0.70
2.	Phorate - 10G -20 gm or Furadan 3G 30gm or Methyl parathion 50gm or Marotti oil cake 100g /palm	Rs. 1.10
3.	Climbing charges for treatment alongwith harvest	Rs. 5.00
		Rs.7.30 or 6.80

Frequency : Twice a year in April-May & October-November.

Mode of application

1. Cut and remove rotten portions of only the spindle and the adjacent two innermost fully opened leaves.
2. Dissolve either of the fungicide (Sl. No. 1 or 2) in 300 ml water and pour into the cavity around the base of the spindle leaf.
3. Apply Furadan 3G – 30g or Phorate - 10 G - 20 g or Folidol dust 50g or Marotti oil cake 100 g mixed in 200 gm sand around the base of the spindle leaf.
4. Treat all palms in the garden (healthy and diseased).
5. Treatment should not be carried out during rainy days.
6. Palms in early stages of disease will recover totally with two or three applications. Palms in advanced stages (with an index of more than 50%) would take 3 years to recover fully. After three years, the treatment is to be given only once in a year in May.
7. Residue analysis done for the chemicals, Contaf, Dithane - M45, Furadan and Phorate 10 G in mature and tender nuts showed that the nut water, kernel, coconut oil and coconut cake are free from residues after 45 days of application at the rates suggested (Koshy, 1999, 2000).

The Institute is demonstrating the technology in 25ha area around CPCRI(R.S) Kayangulam under the NATP as well as in other demonstration plots on the basis of the excellent results obtained in block II and III of the CPCRI campus (the large scale demonstration plot under this scheme). With good propaganda through various extension agencies, if the technology developed is adopted properly the loss due to the root(wilt) disease and insect pests can be avoided considerably since the technology is simple, effective and cheap. Studies on root(wilt) disease was initiated in 1908. Research work has been going on since then and more intensively from 1970 after the formation of CPCRI. This is the most important and useful technology developed which is readily accepted and adopted by the farmers. The technology was developed through this scheme for which the expenditure has been only 7.58 lakhs. Though the Institute has been recommending separate

quarterly application of fungicides and insecticides the farmers had not adopted the same because of labour intensive, cumbersome, and expensive nature as well as their lack of effectiveness. This is the first time an integrated method for the control of diseases and pests was tried, developed and adopted in the history of coconut research. Since the farmers identify a palm to be affected with root(wilt) disease only when leaf rot sets in, the control of leaf rot disease is the control of root(wilt) disease, since the phytoplasma cannot be controlled with the present knowledge.

14. Papers published	:	Three
Manuscript submitted	:	Nil
Papers presented at scientific meeting :		Prophylactic and curative effect of the treatment against the leaf rot disease of coconut – in abstracts of symposium on 'Integrated Plant Disease Management for Sustainable Agriculture' of Indian Phytopathological Society at CPCRI, Kayangulam during 14 – 16 February 2000.
Manuscripts under preparation	:	Integrated management of leaf rot disease and pests on root(wilt) affected coconut palm.
Technical Bulletin/Extension pamphlet published	:	1. Leaf rot disease of coconut (English) Released by Dr.R.N.Pal, Assistant Director General (palms) ICAR on 16 th December 1999 during the group meeting on Root(wilt) disease of coconut at CPCRI, Kayangulam. 2. Ola cheeyal rogam (Malayalam) Released by the Hon. Minister for Agriculture, Kerala during Kisan Mela on 18-12-99.

DETAILED PROGRESS REPORT

ANNEXURE – I

Technical programme

1. Isolation and identification of nematodes from leaf rot affected spindle leaves as well as from healthy seed lings and palms of different ages, varieties and locations.
2. Isolation and identification of fungi carried by the nematodes externally and internally, if any.
3. Multiplication of nematodes on different fungi associated with leaf rot to identify the fungi favouring maximum multiplication of nematodes
4. Inoculation of various species of nematodes and fungi singly and in combination to study the role of nematodes as incitant / aggravator / carrier of the fungal inoculum.
5. Application of various granular nematicides and fungicides in different combinations viz. Phorate or Carbofuran singly 0.5 to 1.0 g ai/palm and in combination with systemic (Contaf) and contact fungicide Dithane M-- 45 (0.3%) twice in May and September in a year under field conditions on seedlings and bearing palms instead of the present three or four sprayings.
6. Laboratory studies on the effect of biocontrol agents like *Metarhizium*, *Pasteuria penetrans*, *Paecilomyces lilacinus* etc. on nematodes.
7. Application of Neem and Marotti oil cake fortified with pathogenic fungi (*Paecilomyces lilacinus*).
8. Large scale demonstration of the most effective combined application of fungicide and nematicide once or twice a year

Treatments

- T1 Nematicide – Carbofuran – (Furadan) 1 g a.i./palm)
- T2 Nematicide - Phorate (Thimmet) 2 g a.i./palm
- T3 Fungicide - Indofil - M45 (Dithane - M45 1%, 300 ml/palm
- T4 Fungicide - Contaf (Rallis) 2ml in 300 ml/palm
- T5 Nematicide + Fungicide - Carbofuran 1 g a.i. + Indofil - M45 1%, 300 ml /palm
- T6 Nematicide + Fungicide - Carbofuran 1 g a.i. + Contaf 2ml in 300 ml/palm
- T7 Nematicide + Fungicide - Phorate 1 g a.i. + Indofil - M45 2gm in 300 ml/palm
- T8 Nematicide + Fungicide - Phorate 1 g a.i. + Contaf 2ml in 300 ml/palm
- T9 Neem oil cake 500 g fortified with biocontrol fungi and bacteria
- T10 Marotti oil cake 500 g fortified with biocontrol fungi and bacteria.
- T11 Control

V. PROGRESS OF RESEARCH

Importance of leaf rot disease

A comprehensive survey was undertaken by the Central Plantation Crops Research Institute in collaboration with the Department of Agriculture, Kerala and other agencies in 1984/85 to estimate the area of spread, intensity of the disease and production loss due to the root(wilt) disease (Anon, 1985). The survey showed that the disease was prevalent in more or less contiguously in 4,10,000 ha in eight southern districts of Kerala. The intensity of the disease in both bearing and non-bearing palms was highest in Kottayam district (75.6%) followed by Alappuzha (70.7%). In the northern district of Thrissur the incidence was 2.6% and in the southern district of Thiruvananthapuram it was 1.5%. The survey also revealed sparse and sporadic occurrence of the disease in the districts of Palakkad, Malappuram, Kozhikode and Kannur. Recently it was reported from Kasaragod district also (Solomon, J.J, 1999, Personal Communication). The incidence of the disease was also reported from the adjoining areas of Tamil Nadu such as Shenkotta, Coimbatore, Kambam, Pollachi and Kulasekharam.

The survey revealed that the annual loss due to the root(wilt) disease was 968 million nuts, in Kerala. Loss of husk per nut was 25.8% and loss of copra and oil per nut was 9.08 and 11.3% respectively. Sixty per cent of the leaves was found damaged due to the malady. Mathew *et. al.* (1993) reported decline in yield to the tune of 45% in West Coast Tall variety and 60% in DxT hybrids and it delayed the onset of bearing in seedlings that took up the infection.

Information on the loss due to leaf rot disease alone is not available or not possible to estimate since it is always associated with root(wilt). The loss due to leaf rot was computed and estimated to be 461 million nuts annually (Anon 1985b, Joseph & Rawther 1991).

Butler(1908) referred to it as "root disease" probably due to the rotting of roots noticed by him in the affected palms. He briefly described the symptoms on unopened spindle, but did not report any pathogen from the affected leaflets. McRae (1916) and Sundararaman (1925) called it the leaf rot disease, Menon (1935) as the coconut leaf disease and Menon and Nair (1948) as the leaf rot disease of coconut. Nagaraj and Menon(1955) felt that the name wilt would be more appropriate taking into account the nature of foliar symptoms. Subsequently the disease came to be known as root(wilt) disease(Shanta *et. al.*,1960; Mathen *et. al.*,1983).

Root(wilt) disease minus leaf rot is not a disease of much economic importance. Radha & Lal(1968) reported close relationship between leaf rot and root(wilt) disease in the field as well as in inoculation trials. Leaf rot was found to develop on palms without root(wilt) also, probably because these plants had latent infection. They observed that nearly 16-40% of the palms in the root(wilt) affected area developed leaf rot. Varghese(1934) reported that both leaf disease and root disease occurred together on the same palm. Srinivasan(1991) reported that leaf rot disease gets superimposed on 65% root(wilt) affected palms. Menon & Nair(1948) and Menon & Pandalai(1958) observed leaf rot disease on palms of all ages. It does not attack seedlings in the nursery. Every root(wilt) affected palm gets leaf rot disease. In certain cases it may occur quickly but in certain palms it may take even 5 or 7 years depending upon the genetic make up, age of the palm, nutritional status of soil, irrigation etc.

Leaf rot is seen to occur within 10 months of field planting of one year old seedling. The rotting of the spear leaf is always the first symptom to appear in seedlings but this has not been reported as such in the past. Flaccidity, yellowing and necrosis occurs later on these seedlings. Normally farmers identify a palm to be root(wilt) affected only when leaf rot sets in. Flaccidity and marginal necrosis of leaflets are not easily recognised by the farmers specially in the early stages.

The coconut palm disease of Travancore is locally known as Kattuveezcha (transmitted through wind) spreads along the direction of the wind (Menon & Nair 1951). Spread of the leaf rot disease is aerial. Menon & Nair 1952 collected the spores of the fungus *Helminthosporium halodes* (*Bipolaris halodes*) at a height of 12 M at Kayangulam in aerospore studies.

Symptoms

Fungal spores enveloped in dew-drops or rain water adhere to the cuticle of the tender whitish leaflets and germinate within 24 hrs producing tiny spots of various colours and shapes. These water soaked lesions enlarge, coalesce freely leading to extensive rotting. The rotting may advance into the interior of the spindle. When the spindle grows the rotten portions dry up, turn black, break and get blown off in the wind. The development of the symptoms and rotting is severe at the distal end of the leaf specially 1 to 1.50 M in length. On leaflets also the distal ends are more susceptible. Occurrence of intermittent rotting of leaflets and mid ribs on the same leaf is also seen. In many cases, the rotten distal portions of leaflet adhere to each other from top to bottom on both sides thereby giving a fish bone appearance. On drying these drop off.

Dwivedi *et. al.* (1979) reported whitening and softening of leaflets of the spindle as an important symptom of root(wilt) disease. The leaflets of the spindle of healthy palms are green at the margin and the remaining portion of leaflets is creamy to yellowish or yellowish green whereas in diseased palms the leaflets of spindle are white, devoid of chlorophyll and the margins are pale green. When the leaflets open they are weak and do not have the strength to stand straight. Such white leaflets show large number of orange to brown spots and marginal rotting.

Hardening of the tissues and development of chlorophyll in the maturing leaflets generally slows down the progress of rotting towards the base of the leaflets so that the basal portions of the affected leaflets remain green and normal giving a fan like appearance. Normally the symptoms would appear on each successive spindle there by showing symptoms on all leaves but the disease is never fatal. In the early stages of the disease some spindles escape rotting during summer months. Severity of leaf rot symptom is more during monsoons and trees of all ages are susceptible and during summer months the leaflets show more of dry rot. The disease causes drastic reduction in photosynthetic area thereby reduction in yield.

In some palms the distal ends of leaves at the 4th or 5th position from the spindle, curl (1 - 1.5 M behind the leaf tip) break, hang down, become yellow, dry and drop off. Such palms show many such leaves in a crown without leaf tip and leaf rot is not very severe on such palms. About 15-20 per cent of leaf area probably the most susceptible area for leaf rot is broken and dropped off.

Sudden appearance of bright yellowing of 3-4 leaves in the middle whorl, followed by appearance of large number of brown spots of various shapes with a halo around on all leaflets of yellowed leaves is the first symptom of root(wilt) in certain cases. In the beginning, the yellowing is sometimes restricted from the leaf tips to the middle of the leaf. Shedding of buttons/immature nuts and inflorescence necrosis are the other prominent symptoms in these palms. These yellowed leaves dry up faster and shed when leaves of lower whorls remain green. Yellowing is very bright and conspicuous in the variety Chowghat Orange Dwarfs, their segregants and even in their hybrids. More incidences of mid whorl yellowing is noticed in this variety. These palms invariably develop rotting of spear leaf subsequently. Incidence of leaf rot can be prevented by treating the palms against leaf rot immediately after the appearance of yellowing. However, inflorescence necrosis and total button shedding continue to occur for 6-12 months even after treatment. Application of

50 g Borax alongwith the fungicide was found helpful in faster recovery of affected palms (Koshy, personal observation).

Inflorescence necrosis, lack of ability to produce female flowers and pollen sterility render the palm unproductive (Varghese, 1934, Varkey and Davis 1960). The extent of decline in yield is 43% in disease early and 74% in disease advanced as compared to disease free palms (Anon, 1985c). Shedding of immature nuts even before the appearance of other visual symptoms or after is another important character.

The leaf rot disease is not fatal, but as the disease progresses the palms steadily decline and become unproductive. The disease is more severe during the monsoons and it is observed on trees of all ages (Menon and Nair, 1948, 1951; Menon and Pandalai, 1958).

Etiology

Mc Rae(1916) and Sunderaraman(1925) isolated a penicillium like fungus from diseased leaves in Kochi. *Helminthosporium halodes* (*Bipolaris halodes*) *Gleosporium* sp, *Curvularia* sp *Gliocladium roseum*, *Pestalotia* sp and *Fusarium* sp were isolated from the diseased leaves (Menon and Nair 1948, Anon, 1985). Srinivasan and Gunasekharan (1993) reported isolation and identification by IMI of CAB, UK of the following species viz. *Colletotrichum gleosporioides*, *Exserohilum rostratum*, *Gliocladium vermoeseni*, *Cylindrocladium scopariaum* , *Fusarium solani*, *F. moniliformae* var. *intermedium*, *Thielaviopsis paradoxa*, *Rhizoctonia solani*, *Mortierella elongata*, *Curvularia* sp, *Acremonium* sp, *Thielavia microspora*, *T. terricola*, and *Chaetomium brasiliense*.

Studies on the pathogenicity of the fungi were initiated by Menon and Nair (1948, 1951). Inoculating bits of tender leaves and leaflets of mature leaves with spore suspensions of *H. halodes*, *Gleosporium* sp, *G. roseum* and *Pestalotia* sp. in vitro, they found that *H. halodes* induces infection within 12 hr and the rest in 48 hr. They considered *H. halodes* as the most virulent and the rest only as secondary parasites, aggravating the rotting initiated by *H. halodes*. They confirmed these findings through *in vitro* tests and established the pathogenicity of *H. halodes* using single and mixed inocula. Later Radha and Lal(1968) also confirmed the infectivity of *B. halodes* on coconut. Culture filtrate of *H. halodes* when applied on tender leaves of coconut failed to demonstrate any toxic effect (Anon,1981). The pathogenicity of *C. gleosporioides*, *E. rostratum*, *G.vermoeseni* *F. solani*, *F. moniliformae* var *intermedium* *T. paradoxa*, *R. solani*, *Mortierella elongata* and *Curvularia* sp was established by Srinivasan and Gunasekharan (1996d)

The leaf rot affected spindle leaf is also colonised by mealy bugs, mites, nematodes (Nadakkal, 1965) etc. Individual or collective role played by them as aggravators or synergists or as disseminating agents of the disease to the next spindle is to be studied. The leaf rot affected palms are more prone to red palm weevil infestation. Nematodes such as *Aphelenchoides aligarhiensis*, *Panagrolaimus rigidus* and *Rhabditis* sp. in large numbers are found associated with rotting spindles (Koshy, unpublished). Application of a systemic insecticide that has nematicidal property (Phorate 10 G) alongwith fungicide was found to give better protection against leaf rot and other insect pests.(Koshy, Unpublished).

Epidemiology

Leaf rot infection was found to be more severe during the seasons when atmospheric humidity was at its maximum (Menon and Nair, 1951). Severity of leaf infection with *H. halodes*, *Gleosporium* sp and *G. roseum* was found correlated with high humidity and low temperatures prevalent during the monsoon period (Radha *et. al.*, 1961). Monthly records of observations for 3 years revealed that period of high atmospheric humidity and low temperatures are favourable for natural development of leaf rot disease(Radha and Lal 1968). The incidence of *C. gleosporioides* in LRD infected young palms was consistent and significantly higher than *E. rostratum* (Anon, 1996).

Disease Management

The leaf rot disease is the most important factor in the management of root(wilt) disease, because it is leaf rot which is responsible for the reduction in photosynthetic area, disfiguration of the palm, and reduction in yield. Therefore, an easy, effective and economic control for leaf rot is the most important factor in disease management. Ideally an inflorescence is to be produced from every leaf axil in coconut. The number of female flowers, setting per cent, number and size of nuts, quantity of copra, oil content etc. is directly dependent on the health of the leaf that produced the inflorescence. Hence, the role of the leaf that produced the inflorescence is equivalent to or more than that of the boot leaf of wheat or rice. From the studies conducted earlier it is very clear that a number of fungi are associated with leaf rot but most of them belong to the group, Fungi Imperfecti. Most of the new generation as well as old generation contact and systemic fungicides are effective against all these fungi reported in association with leaf rot. Earlier field trials using the contact fungicides had given excellent results. Menon and Nair (1952) conducted spraying in the field using 1.0% and 0.5% Bordeaux mixture against leaf rot. Half strength was almost as good as the full strength Bordeaux mixture. In a fungicidal trial using copper fungicides it was found that Bordeaux mixture reduced the intensity by 74.5% followed by Kirti Copper

65.6% and Fytolan 59.6%(Anon,1963). Gregory (1960) felt that aerial spraying in Vadayar and Malankara estates was useful in controlling leaf rot, but Samraj *et. al.*,(1966)observed that there was no adequate coverage of the spray fluid on the spindle leaf. George and Samraj (1966) reported that coconut palms affected by leaf rot responded favourably to foliar application of boron suggesting boron deficiency as the factor responsible for development of disease. Prophylactic basal application of systemic fungicides (Actidione, Bavistin, Benlate and MBC) at the rate of 4g per healthy palms twice a year failed to prevent incidence of leaf rot(Anon,1983). Four sequential spraying of Bordeaux mixture 1%, Dithane M 45 0.3%and Fytolan 0.5% on leaf rot affected palms in farmers' gardens resulted in the control of the disease(Anon,1985). Srinivasan and Gunasekharan (1998a) reported moderate impact of pouring of calixin and spraying of Indofil - M45 in the control of leaf rot when applied thrice a year.

In the management of leaf rot the role of the photosynthetic area available in every leaf and its contribution to yield is the most important factor to be considered. The second is the labour requirement for the operation. Difficulty in getting the services of climbers in time of need and the prohibitive cost are the other limiting factors. The fact that the white, soft, achlorophyllous leaflets of spindle alone is susceptible to fungal attack, suggests that the spindle alone is to be protected. The rhinoceros beetle also attacks only the spear leaf. Though the earlier recommendation of sequential spraying of Bordeaux mixture 1%, Dithane - M45 0.3% and Fytolan 0.5% on leaf rot affected palms using rocker sprayer (6 labour) and separate application of BHC 10% or Sevidol 8g for the control of rhinoceros beetle three times a year (3 labour) is effective, farmers had not adopted because of the very high requirement of 9 skilled labours (6+3)and the cumbersome spraying involved.. Therefore, the need for a simpler, environment-friendly and less labour intensive method combining the application of fungicide and insecticide, without the aid of a sprayer was keenly felt.

Methodology

The areas around Central Plantation Crops Research Institute, Regional Station, Kayangulam were surveyed for locating plots having more than fifty leaf rot affected palms and four plots were selected. On the basis of varying disease intensity, age and yield of the palm, regular manuring of the plot and the co-operative nature of the farmer to spare the palms for experimental purposes. Individual palms were selected on the basis of disease index and numbered serially with paint. They are:

1. Krishnapuram, Karthikappally Taluk, Alappuzha District.
2. Valanjanadakavu, Karthikappally Taluk, Alappuzha district

3. Thodiyoor, Karunagappally Taluk, Kollam District.
4. Karunagappally, Karunagappally Taluk, Kollam District.
5. Nambukulangara, Kattanam, Alapuzha district.
6. Puthiyakavu, Karunagappally Taluk, Kollam District
7. Chavara, Kollam District

For indexing, each leaf was indexed and graded according to the following scale (Srinivasan and Gunasekaran, 1996).

Rotting of the laminae of leaflets(per cent)	Grade/ Numerical ratings
1 - 25	1
26 - 50	2
51 - 75	3
76 - 100	4


The disease index was calculated using the following formula

$$\frac{\text{Total numerical ratings}}{\text{Total no. of leaves} \times \text{Maximum no. of grades (4)}} \times 100$$

The leaves were numbered serially on all palms under experiment and disease indices after first and second application calculated according to the formula given in the preceding Individual bunches (inflorescences were numbered and number of female flowers and nuts produced were recorded each application.

The unopened leaf spindle was marked with red paint could be seen from the ground for further observations. These observations were recorded to find out differences if any in the production of leaves, bunches (inflorescences), setting percent of nuts and yield after the treatment.

Before each application, the rotten portion of the spindle was cut and removed. The fungicides viz. Contaf/Indofil - M45/Contaf + Indofil M45 was dissolved in 300 ml water and poured into the well around the base of the cut spindle. In treatments where nematicide is involved it is applied into the well around base of the cut spindle after pouring the fungicide mixture. The insecticide Methyl Parathion - 50 gm (Folidol dust mixed with river sand 200 gm is applied whenever nematicide application was not done to protect from rhinoceros beetle/ red palm weevil attack.



The selected diseased palms in each plot were indexed individually. It ranged from 5% to 91.07% in plot-1 (Krishnapuram), 4.1% to 75% in plot 2 (Valanjanadakkavu), 11.4% to 71.4% in plot 3 (Thodiyoor), 13.3% to 65.2% in plot-4 (Karunagappaly). In all these plots various fungicides, nematicides and insecticides were applied in different combinations twice a year.

EXPERIMENT No 1**Krishnapuram****(Figure 1)****Treatments****Replications : 7**

1. Contaf (2 ml)
2. Indofil -M45/Dithane - M45 (1 g)
3. Furadan (25 g)
4. Furadan (25 g) + Contaf*(2 ml)
5. Furadan (25 g) + Indofil - M45 (1 g)
6. Contaf (2 ml) + Indofil – M45(1 g)
7. Furadan (25 g) + Contaf (2 ml) + Indofil - M45 (1 g)
8. Control

*Folidol dust (50 g) mixed with river sand (200 g) was applied to the control palms and treatment with fungicide alone to protect from insect pests

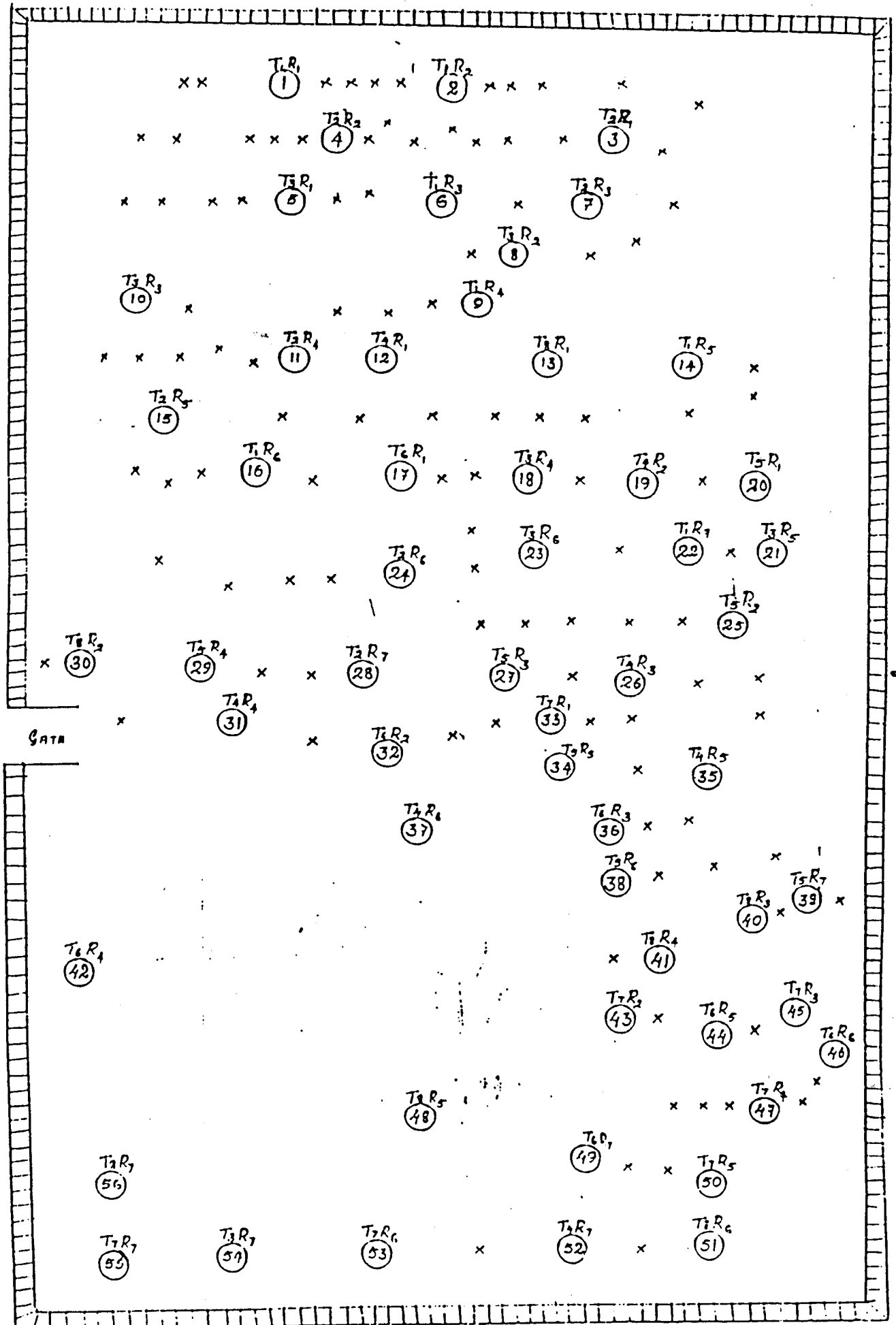
Table I: Showing Leaf rot disease indices of palms at Krishnapuram

Treat ment	Pre- treatment	Disease indices after different rounds of pouring						
		1	2	3	4	5	6	POOLED
1.	30.00	30.00	41.11	19.10	12.21	25.00	18.99	25.20
2.	46.70	44.80	31.80	27.70	21.90	29.20	18.40	31.50
3.	30.00	32.14	37.77	29.80	16.80	18.67	29.27	27.78
4.	45.71	36.90	38.90	33.60	23.24	23.60	14.24	30.89
5.	30.80	30.94	31.74	27.09	10.40	24.70	11.90	23.94
6.	34.29	31.33	41.69	36.04	8.60	25.59	10.80	26.90
7.	52.50	38.40	46.00	37.10	20.80	21.50	15.00	33.04
8.	42.00	58.90	64.10	42.80	32.77	26.00	27.40	42.00
Mean	39.00	37.93	41.64	31.65	18.34	24.28	18.25	30.16
F ratios:		Treatments- 6.33**		Rounds of pouring 21.56**			Interaction-1.03	
CD		6.34		5.93			NS	

Eight treatments , 6+1 rounds of observations and 7 replications..

FIG. 1

FIELD MAP OF PLOT-1 KRISHNAPURAM



The treatment differences are statistically significant. The lowest disease index (averaged over the seven rounds of observations) of 23.9 was observed in T6 – Contaf (2ml) + Indofil (1g) and this was found to be on par with T1 – Contaf (2ml) (25.2), T6 – Contaf (2ml) + Indofil (1g) (26.9) and T3 – Furadan (25g) (27.8). Average disease index which stood at 39.0 at the pre-treatment level was showing a steady declining trend, except after the 2nd and 5th rounds of application. After the sixth round, the average index stood at 18.3.

It is clear from Table 1 that all treatments reduced the disease indices of palms including control. The reduction in disease indices of control palms was mainly due to the removal of infected portions of spindle and the adjoining two leaves. This helped in reducing the fungal spores, nematodes etc., that gets washed down and gets accumulated in the well around the base of the spindle. Application of fungicides and nematicides to this well helps in killing the inoculum collected there.

Application of fungicides and nematicides alone and in combination was effective in reducing the disease indices. The application of insecticide or insecticide with nematicidal properties helped in protecting the palms from insect pests like rhinoceros beetle, red palm weevil, mealy bugs etc. The results also indicated that Contaf 2ml is better than Indofil one gram.

Results in this experiment clearly show that systemic insecticide having nematicidal property – Furadan gives better control of leaf rot compared to phytosanitation with insecticide – Methyl parathion 2% dust application showing indirectly the role of nematodes in leaf rot as an aggravator or synergist or as a passive vector of the fungi. The treatments Contaf 2ml or Indofil 1 gm were equally effective. The combined effect of Contaf 2ml and Indofil 1 gm with Furadan was better than either of them alone. No additional advantage was seen when both Contaf 2ml and Indofil 1 gm was given compared to either of them alone. The experiment has clearly showed that the leaf rot disease can easily be managed by pouring either Contaf 2ml or Dithane – M45 1 gm mixed in 300ml water. Application of Furadan 25g was found to give better protection from leaf rot as well as from insect pests compared to control. The combined application saves 88% labour compared to quarterly applications of fungicides and insecticides separately.

EXPERIMENT No. 2**Valanjanadakavu****(Figure 2)****Treatments****Replications 8**

1. Contaf (2 ml)
2. Indofil - M45 (3 g)
3. Phorate (Thimet) (20 g)
4. Phorate (20 g) + Contaf (2 ml)
5. Phorate (20 g) + Indofil - M45 (3 g)
6. Contaf (2 ml) + Indofil - M45 (3 g)
7. Phorate (20 g) + Contaf (2 ml) + Indofil - M45 (3 g)
8. Control

*Folidol dust (50 g) mixed with river sand (200 g) was applied to the control palms and treatments with fungicide alone to protect from insect pests

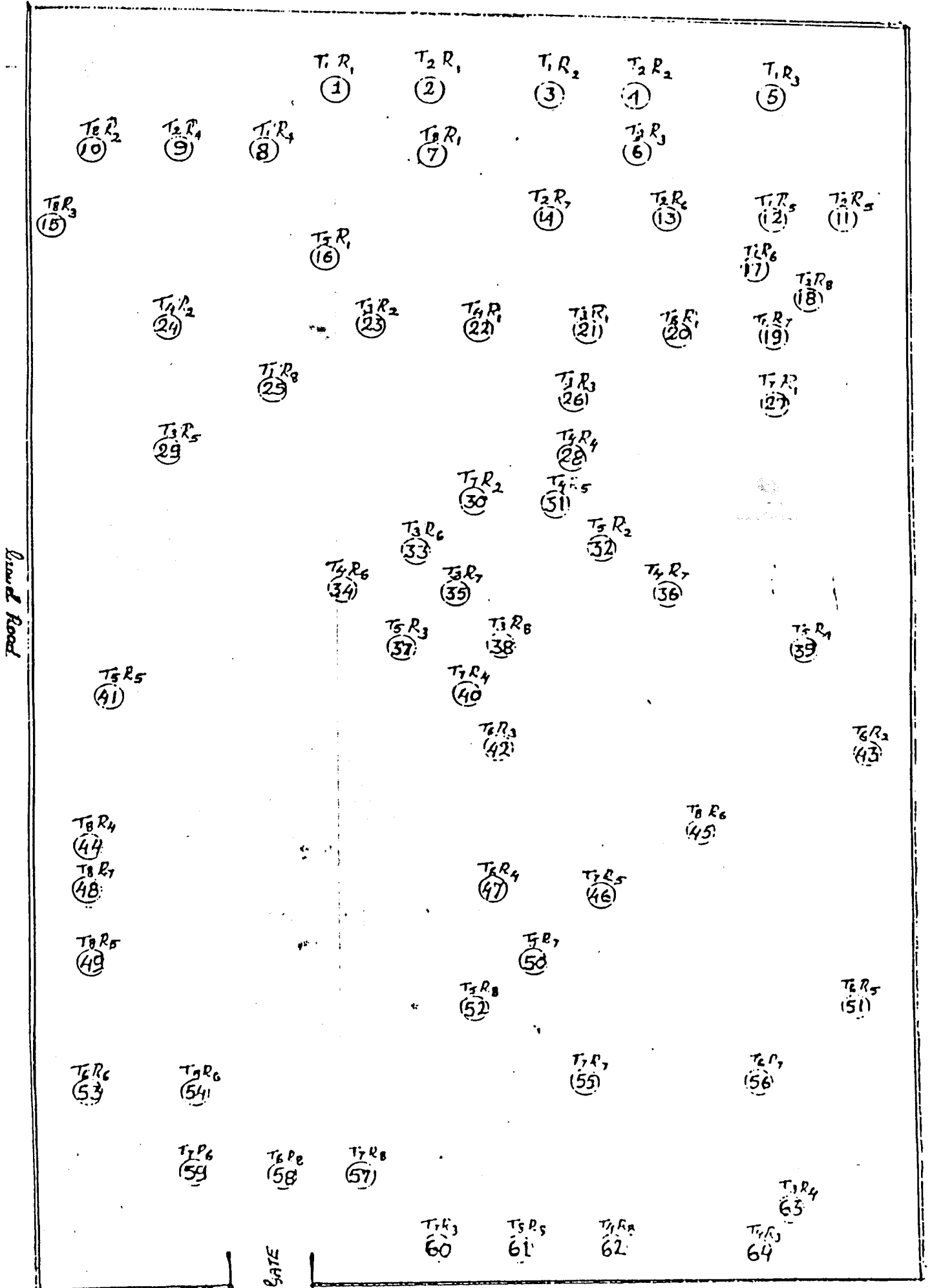
Table II: Showing Leaf rot disease indices of palms at Valanjanadakavu

Treat ment	Pre-treatment	Disease indices after different rounds of pouring						
		1	2	3	4	5	6	POOLED
1.	51.30	29.95	34.38	21.00	14.10	16.70	11.20	25.52
2.	36.70	37.88	23.36	7.00	5.21	7.70	1.00	16.98
3.	55.63	43.75	45.13	36.71	20.00	22.73	17.20	34.45
4.	36.25	39.74	32.14	12.36	3.60	9.90	4.05	19.72
5.	35.00	29.00	24.91	20.60	10.01	9.49	8.81	19.69
6.	38.75	48.67	39.00	29.08	15.89	24.25	11.30	29.56
7.	33.75	36.79	42.26	26.40	13.60	15.60	11.55	25.71
8.	47.50	57.86	52.01	42.46	44.03	35.39	36.10	45.05
Mean	41.86	40.45	36.65	24.45	15.80	17.72	12.65	27.08
F ratios:		Treatments- 18.19**		Rounds of pouring 37.23**			Interaction- 0.82	
CD		6.03		5.64			NS	

Eight treatments , 6+1 rounds of observations and 8 replications.

FIG: 2

FIELD MAP OF PLOT-2 YALANJANADAKAVU



The treatment differences were statistically significant, lowest disease index was in T2 - Indofil - M45 (3 g) followed by T3 Phorate (20 g) + Indofil - M45 (3 g) and T4 - Phorate (20 g) + Contaf (2 ml). Highest disease index was noted in T8 - Control

Average disease index observed in the different rounds of observations also differed significantly. The disease index, which stood at 41.9 at the start of the experiment, was showing a more or less steady declining trend, after every round of application, and at the end of this experiment, this stood at 12.7. Superiority of T2 - Indofil - M45 (3 g) was clear after each round of observation. At the end of the experiment, in T2 - Indofil - M45 (3 g) disease index was only 1.0, with 6 out of 8 trees showing no disease symptoms.

This experiment has clearly showed that the leaf rot disease can easily be managed by pouring 3g Indofil - M45 dissolved in 300ml water to the base of the spindle after removing the rotten portions of the spindle, if any. Since rotten portions of the spindle is removed before application of fungicide protection with an insecticide is necessary to save from the incidence of red palm weevil. It is very evident that T3 - Phorate (Thimet) (20 g) is applied after removal of affected portion is better than T8 - Control where Folidol dust (50g) is applied, though in T3 the pre treatment index was 55.6 compared to T8 where it was 47.5. Though both insecticides protected from insect pests attack, application of phorate was more advantages in controlling leaf rot.

EXPERIMENT - 3

Thodiyoor
(Figure-3)

Treatments

Replications - 6

1. Contaf (2 ml)
2. Indofil - M45 (Dithane - M45) (1 g)
3. Phorate (Thimet) (20 g)
4. Bactericide (Streptocycline) (0.2 g)
5. Bactericide 0.2 g) + Contaf (2 ml)
6. Bactericide (0.2 g) + Indofil - M45 (1 g)
7. Bactericide (0.2 g) + Phorate (20 g)
8. Contaf (2 ml) + Indofil - M45 (1 g)
9. Contaf (2 ml) + Phorate (20 g)
10. Indofil - M45 (1 g) + Phorate (20 g)
11. Bactericide (0.2 g) + Contaf (2 ml) + Indofil - M45 (1 g)
12. Bactericide (0.2 g) + Contaf (2 ml) + Phorate (20 g)
13. Contaf (2 ml) + Indofil - M45 (1 g) + Phorate (20 g)
14. Bactericide (0.2 g)+Contaf (2 ml)+Indofil~45 (1g) + Phorate (20 g).
15. Control

*Folidol dust (50 g) mixed with river sand (200 g) was applied to all the above treatments without phorate to protect from insect pests.

Table III: Showing Leaf rot disease indices of palms at Thodiyoor

Treat ment	Pre-treatment	Disease indices after different rounds of pouring						
		1	2	3	4	5	6	POOLED
1.	50.00	29.18	29.10	25.48	16.27	16.68	14.38	25.87
2.	47.50	34.23	33.47	23.62	12.52	11.52	8.82	24.52
3.	46.67	37.72	40.07	36.72	20.83	24.27	14.17	31.49
4.	45.00	25.97	17.32	15.13	20.63	21.13	14.17	22.76
5.	49.20	35.30	31.20	20.20	19.05	21.12	16.30	27.48
6.	50.83	40.90	29.52	24.55	20.48	21.67	15.92	29.12
7.	45.83	34.88	42.37	25.00	25.00	22.40	21.80	31.04
8.	43.33	30.07	23.60	13.75	8.82	3.13	1.05	17.68
9.	45.00	36.80	30.35	25.00	16.47	21.53	23.33	28.35
10.	41.00	42.80	36.47	26.80	11.95	10.65	6.05	25.10
11.	40.83	40.28	35.00	20.68	14.10	25.40	17.00	27.61
12.	42.50	40.93	38.28	20.10	10.65	20.53	13.03	26.58
13.	50.00	49.08	46.62	25.50	24.60	29.90	20.30	35.14
14.	42.50	44.72	43.90	17.65	21.05	21.80	16.50	29.73
15.	47.50	47.80	45.33	34.28	32.18	35.35	28.27	38.67
Mean	45.85	38.04	34.84	23.63	18.31	20.47	15.41	28.08
F ratios:		Treatments- 5.48**		Rounds of pouring 61.87**			Interaction- 0.69	
CD		5.94		4.05			NS	

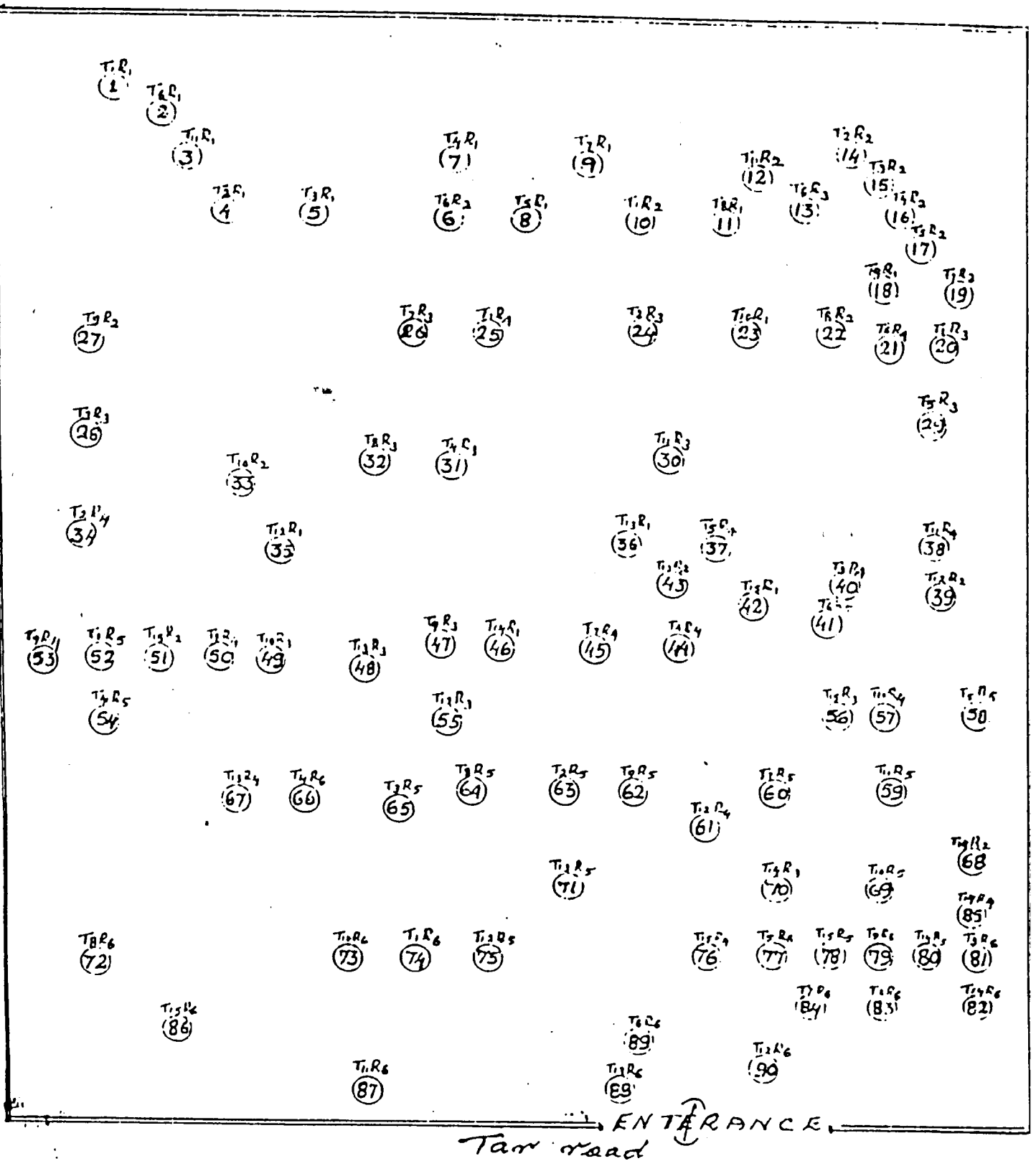
Fifteen treatments, 6+1 rounds of observations and six replications.

The treatment differences (averaged over the seven rounds of observations) and the differences on the different rounds of observations (averaged over 15 treatments) were found to be statistically significant. Among the different treatments, T8 - Contaf (2 ml) + Indofil - M45 (1 g), T4 - Bactericide (Streptocycline) (0.2g), T10 - Indofil - M45 (1 g) + Phorate (20 g) and T2 - Indofil - M45 (Dithane - M45) (1 g) were found to be the best. The average disease index, which was 45.8 at the pre- treatment stage , showed a steady decline and stood at 15.4 at the end of the 6th round.

In this experiment Dithane M45 1g was found to be slightly better than Contaf 2ml alone and in combination with phorate T2 and T10 compared to T1 and T9. Combination of Dithane M45 and Contaf 2ml was found to be the best treatment followed by Dithane M 45 1g and phorate 20g and Dithane M45 1g alone.

FIG:3

FIELD MAP OF PLOT-3 THODIYOOR



EXPERIMENT NO. 4
KARUNAGAPPALLY
(Figure - 4)

Treatments

Replications - 7

1. Contaf (2 ml)
 2. Indofil - M45 (1 g)
 3. Furadan (25 g)
 4. Bactericide (0.2 g) (Streptocycline)
 5. Bactericide (0.2 g) + Contaf (2 ml)
 6. Bactericide (0.2 g) + Indofil - M45 (1 g)
 7. Bactericide (0.2 g) + Furadan (25 g)
 8. Contaf (2 ml) + Indofil - M45 1 g)
 9. Contaf (2 ml + Furadan (25 g)
 10. Indofil - M45 (1 g) + Furadan (25 g)
 11. Bactericide (0.2 g) + Contaf (2 ml) + Indofil - M45 (1 g)
 12. Bactericide (0.2 g) + Contaf (2 ml) + Furadan (25 g)
 13. Contaf (2 ml)+Indofil-45 (1 g) + Furadan (25 g)
 14. Bactericide (o.2 g) + Contaf (2 ml) +Furadan (25 g)) + Indofil - M45 1 g)
 15. Control.
- *Folidol dust (50 g) mixed with river sand (200 g) was applied to all the above treatments without Furadan to protect from insect pests.

FIG. 4 FIELD MAP OF PLOT 4, KARUNASAPALLY

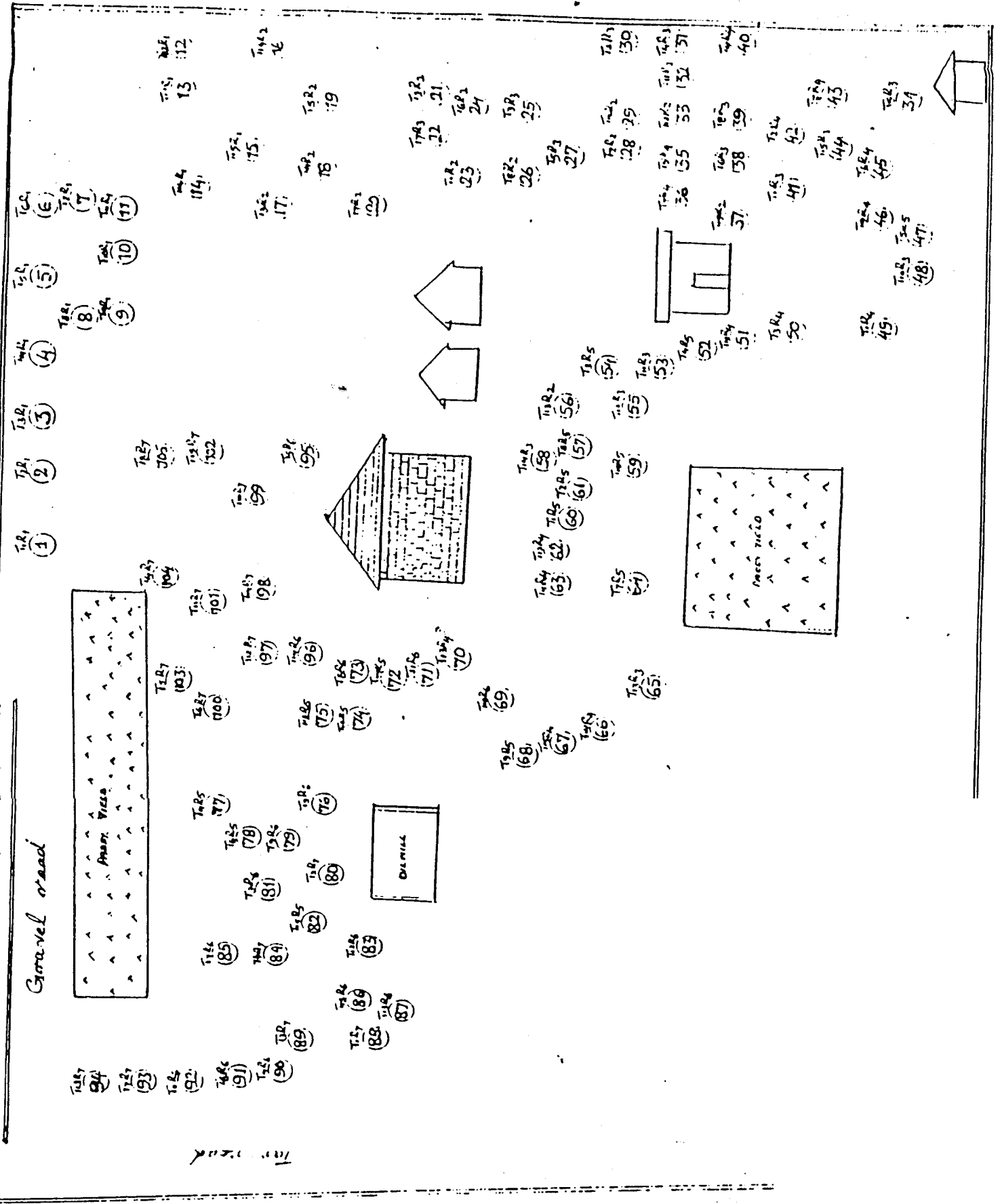


Table IV: Showing Leaf rot disease indices of palms at Karunagappally

Treat ment	Pre-treatment	Disease indices after different rounds of pouring						
		1	2	3	4	5	6	POOLED
1.	44.29	28.00	43.29	22.26	14.64	24.64	20.00	28.16
2.	41.43	36.70	31.13	25.00	20.01	13.80	11.10	25.60
3.	35.71	27.74	34.90	20.23	21.01	21.51	20.34	25.92
4.	48.57	38.13	42.13	24.84	18.04	24.96	19.00	30.81
5.	55.00	41.77	36.01	23.84	18.77	31.31	24.20	32.99
6.	33.57	39.04	23.70	14.73	13.51	15.60	13.61	21.97
7.	38.57	31.70	27.43	13.99	17.87	30.89	20.80	25.89
8.	50.00	37.69	36.90	27.56	20.36	30.27	14.87	31.09
9.	54.29	38.93	50.17	28.61	22.50	27.09	31.00	36.08
10.	47.86	36.24	43.20	26.91	19.47	29.76	29.73	33.31
11.	39.29	34.13	25.51	16.04	13.57	12.54	14.04	22.16
12.	51.43	38.51	41.41	24.37	14.29	25.60	22.50	31.16
13.	43.57	35.34	26.04	24.73	17.50	27.36	24.43	28.42
14.	42.14	42.49	28.29	22.14	21.09	32.20	19.77	29.73
15.	47.86	53.34	54.76	33.36	29.11	25.09	27.81	38.76
Mean	44.90	37.32	36.32	23.24	18.78	24.84	20.88	29.47
F ratios:		Treatments- 5.48**		Rounds of pouring 51.38**		Interaction- 0.76		
CD		6.09		3.85		NS		

The treatments differed significantly. The lowest disease index was recorded in T2 Indofil - M45 (1 g) (11.10) followed by T6- Bactericide (0.2 g) + Indofil - M45 (1 g) (13.61), T11 - Bactericide (0.2 g) + Contaf (2 ml) + Indofil - M45 (1 g) (14.04), T8 - Contaf (2 ml) + Indofil - M45 1 g (14.87). The average disease index which was 44.9 at pretreatment came down to 20.9 by the end of 7th round. The effect of sanitation, that is the removal of leaf rot affected portions of the spindle in bringing down the disease intensity was very clear in this experiment also. Indofil M45 was slightly better than Contaf 2ml. Even after 6 rounds of pouring Indofil M45 1g in 300ml water the disease could only be brought down to a disease index around 10. This indicates the need for raising the dosage to 3gm in 300ml water as in experiment No. 3 where 6 out of 8 trees became free of leaf rot.

The two fungicides (Contaf and Indofil - M45) when applied together decrease in disease indices is observed in all the four plots after the fourth application (Tables 1,2,3 and 4).The treatment Furadan alone in plot I and IV showed reduction in disease indices where as Furadan when applied together with Indofil - M45 and Contaf also resulted in reduction of disease indices (Tables I and IV). Application of systemic insecticide Phorate alone also showed decrease in disease indices, when phorate is applied along with Indofil - M45 or with Contaf also reduction in disease indices was noticed (Tables II and III). In Plots 3 and 4 where bactericide (Streptocycline) alone is used reduction in disease indices was noticed but there was no additional advantage compared to sanitation alone. When bactericide is applied along with Contaf, Indofil -45 or Phorate or Furadan there was not much additional advantage specially compared to control.

EXPERIMENT NO. 5
Nambukulangara, Kattanam
(Figure-5)

A separate experiment involving leaf rot affected coconut seedlings of four to ten years was initiated at Kattanam to study the effect of application of these pesticides in to the root zone in addition to the crown. Fifty six leaf rot affected coconut seedlings were selected from the plot and indexed for disease. The disease indices ranged from 10.0% to 70.8%. In this plot also various nematicides, fungicides and insecticides in different combinations were applied twice a year. Details of the experiment giving the number of treatments, replications, fungicides and pesticides used, their dosage, field map (fig.5) pre-treatment index, (Table 5) are given below.

Treatments

Replications - 8

1. Contaf (2 ml + Indofil - M45 1 g) - Spindle application
2. Contaf (10 ml + Foltaf 20 g) - Soil application
3. Contaf (2 ml) + Indofil - M45(1 g), Contaf (10 ml) + Foltaf (20 g) Spindle + Soil application
4. Furadan (25 g) + Contaf (2 ml) Indofil - M45 (1 g) + Foltaf (20 g) - Spindle application and soil application
5. Furadan (100g) Foltaf (20 g) + Contaf(10 ml) + Soil application
6. Furadan (25 g) + Contaf (2 ml) + Indofil - M45 (1 g); + Furadan(100g) + Contaf (10 ml) - Spindle + Soil application
- 7 Control

*Folidol dust (50 g) mixed with river sand (200 g) was applied to seedlings of all treatments without Furadan to protect from insects.

Table V: Showing Leaf rot disease indices of palms at Kattanam

Treat ment	Pre- treatment	Disease indices after different rounds of pouring						
		1	2	3	4	5	6	POOLED
1.	27.50	44.51	42.78	15.70	8.34	19.20	8.80	23.83
2.	20.95	48.90	31.20	29.80	14.00	18.06	15.58	25.50
3.	25.00	29.20	14.38	14.48	19.50	14.90	8.30	17.96
4.	27.30	49.10	19.00	18.50	14.30	25.00	12.40	23.66
5.	28.94	32.55	14.85	13.55	12.49	19.37	10.70	18.92
6.	28.25	41.50	27.30	20.96	10.73	19.40	19.40	23.93
7.	27.39	41.61	38.10	24.40	22.60	19.10	23.89	28.16
Mean	26.47	41.05	26.80	19.63	14.56	19.29	14.15	23.14
F ratios:		Treatments- 4.63**	Rounds of pouring 31.82**				Interaction- 1.77	
CD		4.62	4.62				12.23	

Seven treatments , 8 replications, (6+1) rounds of observations.

The treatment differences were statistically significant . Treatment 3 and 5 were found to be superior to the rest. A general declining trend in index was noticed after each round of application. At the close of the experiment , in T3, T1 and T5 , the index was in the range of 8.3 to 10.7.

In this plot application of the two fungicides together in the spindle and in soil – T3 showed maximum reduction of disease indices followed by combined application of fungicides to the spindle – T1. Application of fungicides to the soil also showed some reduction in disease indices T2.

FIELD MAP OF PLOT-5 - KATTANAM (NAMBUKUNANGARA)

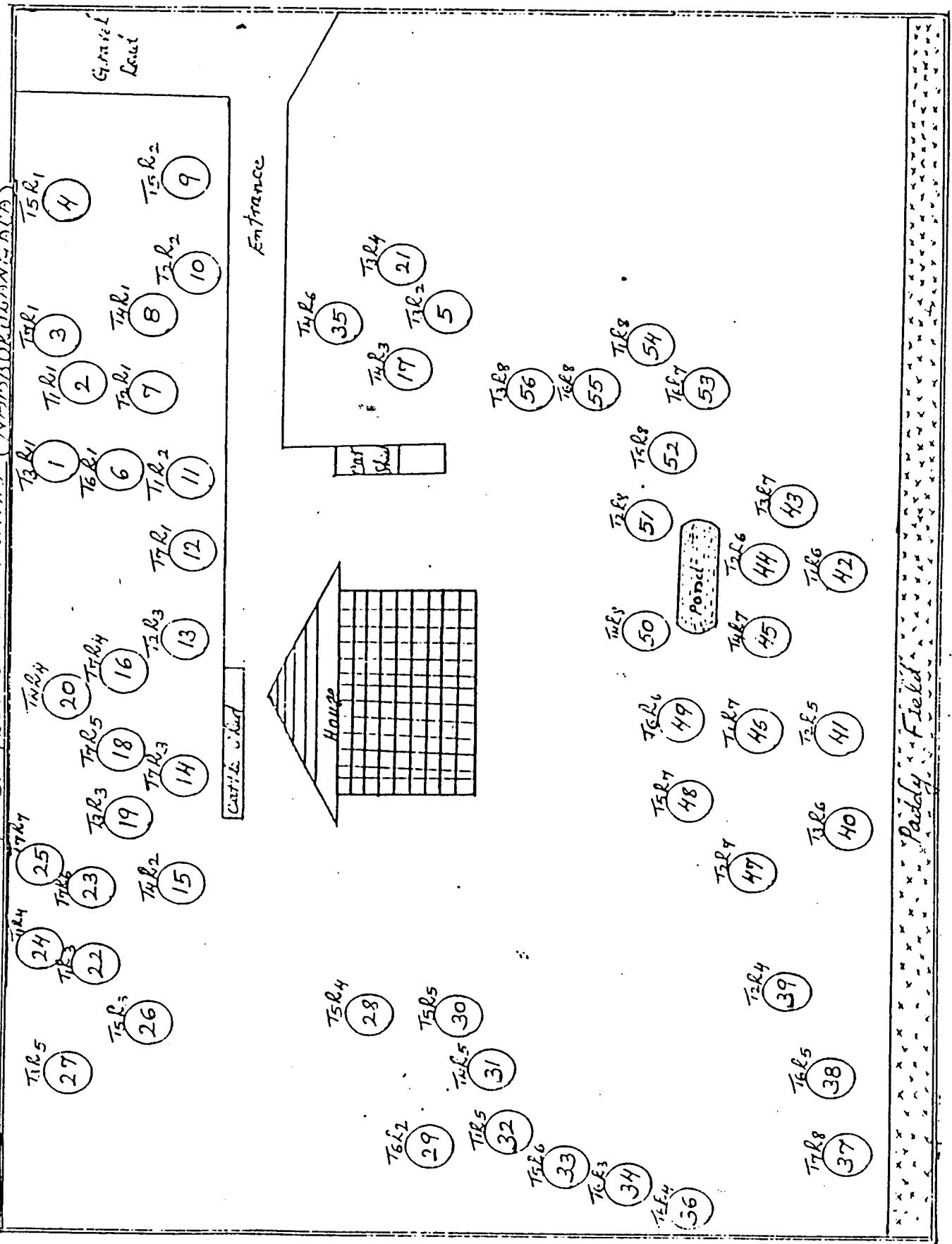


FIG:5

EXPERIMENT NO. 6

Puthiyakavu

(Figure-6)

Two more plots having more than ninety leaf rot affected coconut palms were selected at Puthiyakavu Plot VI and Chavara Plot VII Kollam district. In these two plots, instead of fungicide and nematicide the Neem and Marotti oil cake fortified with fungi *Metarhizium anisopliae*, *Verticillium chlamyosporium* and bacteria *Pseudomonas fluorescence* were applied to the crown of the experimental palms. Details of the experiment giving the treatments, replications, oil cakes, fungi and bacteria used, field maps, (figures 6 and 7), pre treatment index, (Table VI and VII) are given below. The disease indices ranged from 28.8% to 90.0% in Plot-VI (Puthiyakavu) and 23.8% to 79.8% in plot-VII (Chavara) (Tables VI and VII). Individual bunches (inflorescences) were numbered and the number of female flowers (buttons) and nuts produced were also recorded.

Treatments

Replications-6

1. Neem oil cake (250 g)
2. Marotti oil cake (250 g)
3. Neem oil cake (250 g) + *Pseudomonas fluorescence*
4. Marotti oil cake (250 g) + *Pseudomonas fluorescence*
5. Neem oil cake (250 g) + *Verticillium chlamyosporium*
6. Neem oil cake (250 g) + Synthetic Bordeaux mixture 10 g)
7. Marotti oil cake (250 g) + *Verticillium chlamyosporium*
8. Marotti oil cake (250 g) + Synthetic Bordeaux mixture (10 g)
9. Neem oil cake (250 g) + Synthetic Bordeaux mixture (5 g)
10. Marotti oil cake (250 g) + Synthetic Bordeaux mixture (5 g)
11. Neem oil cake (250 g) + *Metarhizium anisopliae*
12. Marotti oil cake (250 g) + *Metarhizium anisopliae*
13. Neem oil cake (125 g) + Marotti oil cake (125 g)
14. Synthetic Bordeaux mixture (10 g) + Folidol dust (50 g)
15. Sanitation + Folidol dust (50 g)
16. Control

*River sand (100g) was mixed with Neem and Marotti oil cake (250 g) before application.

Table VI: Showing Leaf rot disease indices of palms at Puthiyakavu

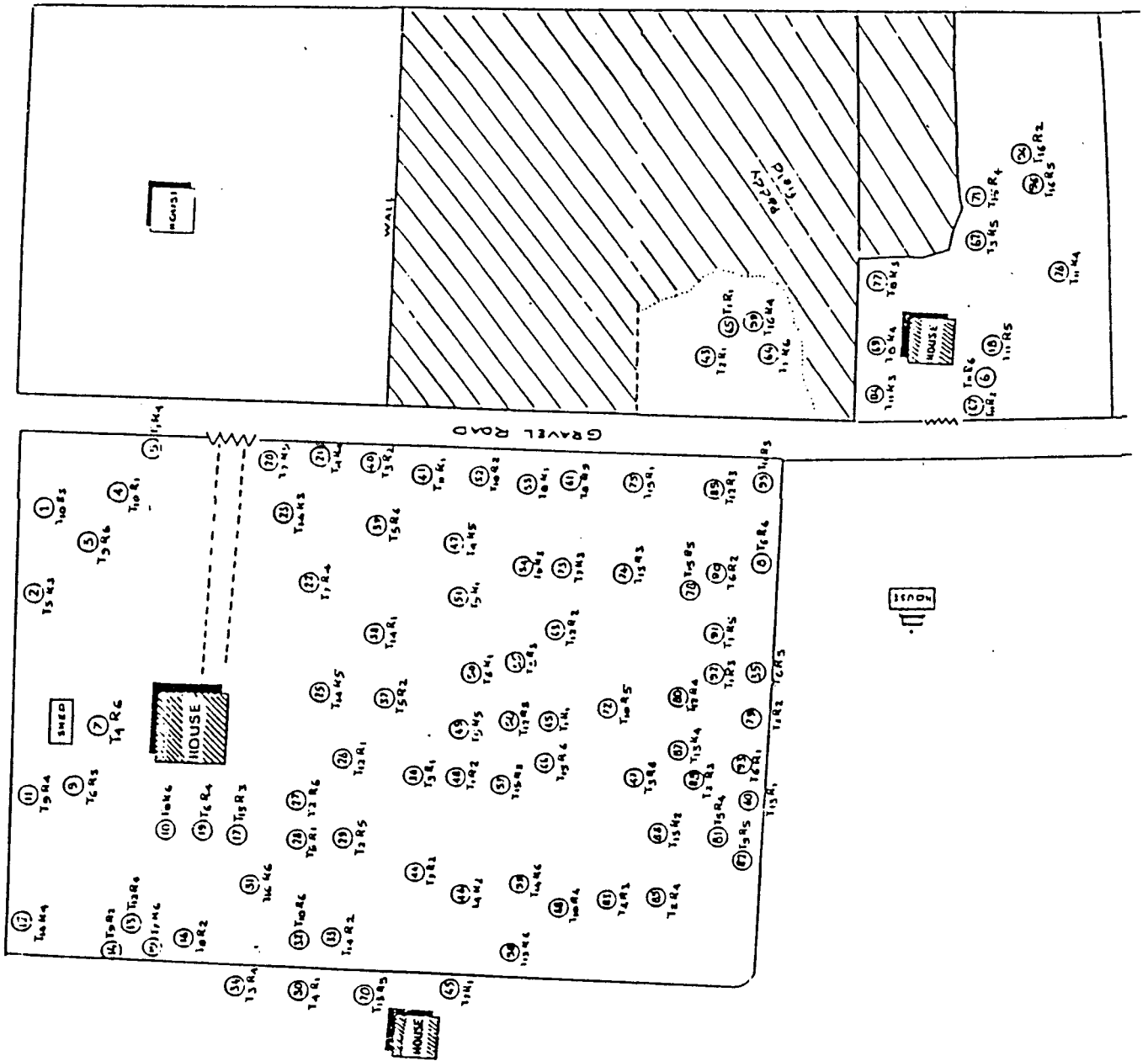
Treatment	Pre-treatment	Disease indices after different rounds of pouring				
		1	2	3	4	POOLED
1.	54.87	27.97	23.75	20.80	13.02	28.08
2.	55.28	22.90	16.88	29.80	10.00	27.97
3.	64.58	31.53	24.88	36.55	29.87	37.48
4.	38.88	17.88	19.18	21.93	17.93	23.16
5.	52.08	31.25	31.05	26.30	19.22	31.98
6.	48.62	28.43	20.83	21.08	13.82	26.56
7.	38.33	16.90	17.90	15.67	16.23	21.01
8.	47.22	21.62	19.40	20.63	21.32	26.04
9.	40.27	31.18	29.07	26.97	19.75	29.45
10.	47.93	25.90	25.97	35.47	30.57	33.17
11.	55.55	29.43	21.27	36.77	23.58	33.32
12.	52.78	38.52	22.23	25.75	21.93	32.24
13.	47.22	25.18	15.83	29.27	32.73	30.05
14.	51.38	29.02	15.83	11.67	17.60	25.10
15.	63.88	32.37	28.13	39.40	35.52	39.86
16.	49.25	40.45	34.40	35.55	39.00	39.73
Mean	50.51	28.47	22.91	27.10	22.63	30.32
F ratios:		Treatments- 4.00 **	Rounds of pouring 55.38**	Interaction- 0.74		
CD		7.73	4.32	NS		

Sixteen treatments x 6 replications x (4+1) rounds of observations.

The treatment differences were statistically significant. Lowest disease index was in T7 Marotti oil cake (250 g) + *Verticillium chlamyosporium* (21.0), closely followed by T4 Marotti oil cake(250 g) + *Psejdomonas fluorescence* (23.2), T14 Synthetic Bordeaux mixture (10 g) + Folidol dust (50 g) (25. 1), T8 Marotti oil cake (250 g) + Synthetic Bordeaux mixture (10 g) (26.0) , T6 Neem oil cake (250 g) +Synthetic Bordeaux mixture 10 g) (26.6) and T2 Marotti oil cake (250 g) (28.0).

Average disease index observed in different rounds of observations also differed significantly. The disease index which stood at 50.5 at the start of the experiment was showing a more or less steady declining trend, after every round of application, and at the end

Fig. 6. FIELD MAP OF PLOT- 6. PUTHIYAKAVU



of the expt. this stood at 22.6. In T2 , the index came down to 10.0, while in T15 and T16, it remained as high as 35.5 and 39.0.

But in T15 the intial index was 63.8 compared to 49.25 in T 16. Synthetic Bordeaux mixture 10g/palm was found effective in checking leaf rot. In general Marotti oil cake was slightly better than Neem oil cake. The greatest advantage in using Marotti oil cake is their organic nature and insect repellent quality. Both insecticide and fungicide can be avoided by using Marotti oil cake. Availability of Marotti oil cake in large quantity is the only difficulty in using them.



EXPERIMENT NO. 7

Chavara (Figure- 7)

Treatments	Replications - 6					
1. Contaf (4 ml)						
2. Indofil -M 45 (3 g)						
3. Furadan (30 g)						
4. Contaf (4 ml) + Fytolan (5 g)						
5. Contaf (4 ml) + Furadan (30 g)						
6. Fytolan (5 g) + Furadan (30 g)						
7. Neem oil cake (250 g) + Contaf (4 ml)						
8. Marotti oil cake (250 g) + Contaf (4 ml)						
9. Neem oil cake (125 g) + Marotti oil cake (125 g)						
10. Contaf (4 ml) + Indofil M45 (3g) + Furadan (30g)						
11. Contaf (2 ml)						
12. Fytolan (5 g)						
13. Contaf (2 ml) + Fytolan (5 g) + Furadan (30 g)						
14. Contaf (2 ml) + Fytolan (5 g) + Phorate (20 g)						
15. Sanitation + Folidol dust (50g)						
16. Control.						

*River sand 100g was mixed with Neem and Marotti oil cake (250 g) before application.

Folidol dust 50gm mixed with 200g sand was applied to treatments with fungicides alone.

Table VII: Showing Leaf rot disease indices of palms at Chavara

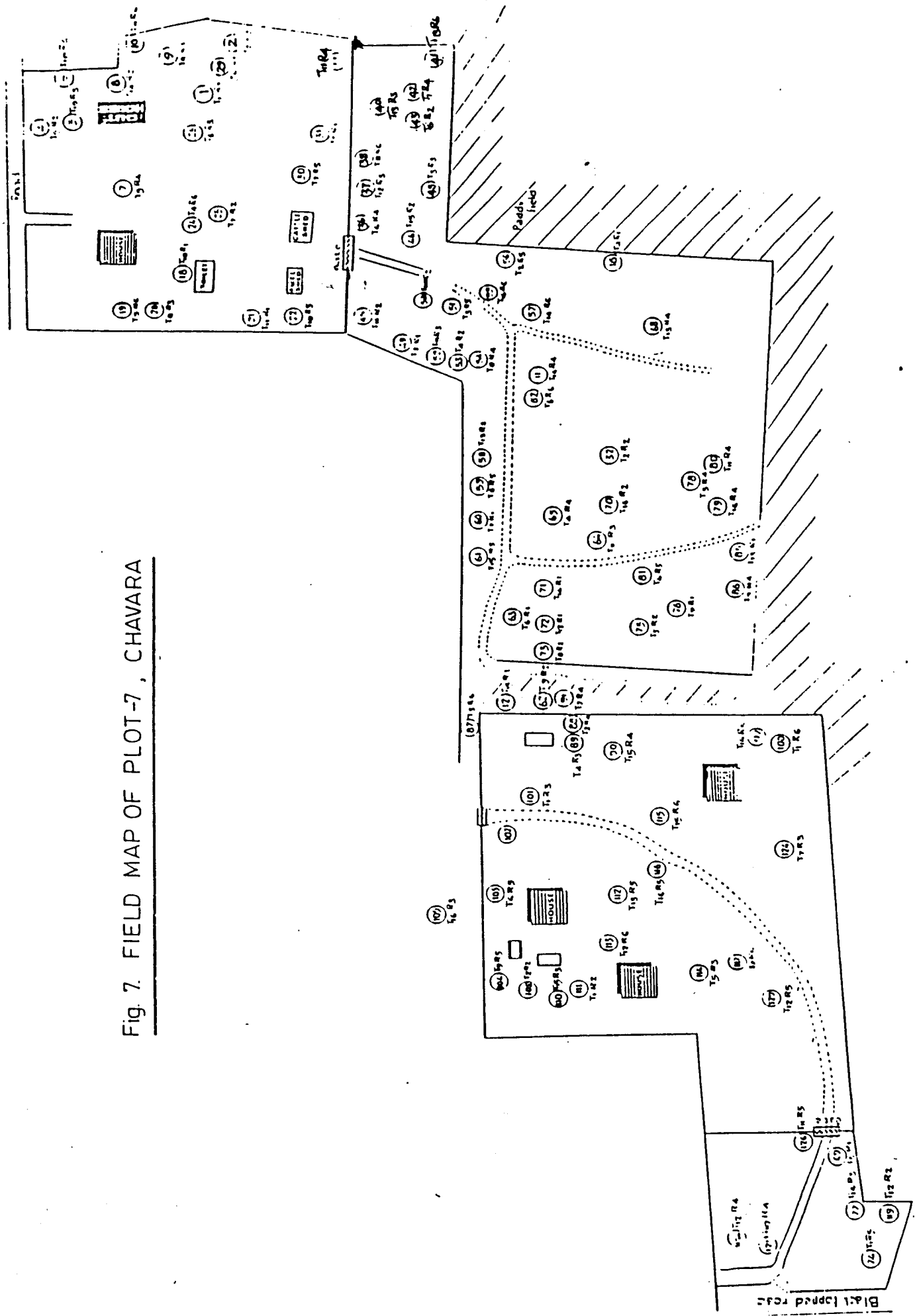
Treatment	Pre-treatment	Disease indices after different rounds of pouring				
		1	2	3	4	POOLED
1.	56.67	21.15	13.33	10.33	14.87	23.27
2.	58.33	22.95	21.88	21.62	20.70	29.10
3.	57.50	27.40	18.98	26.58	26.93	31.48
4.	58.33	32.30	30.67	23.70	8.20	30.64
5.	54.17	35.13	20.22	16.23	18.45	28.84
6.	54.17	34.58	22.00	20.50	29.00	32.05
7.	62.50	33.30	19.47	15.42	10.83	28.30
8.	51.67	28.03	26.47	27.50	14.58	29.65
9.	57.50	36.18	26.67	27.10	17.50	32.99
10.	55.83	29.93	17.92	26.05	17.10	29.37
11.	49.17	29.12	24.90	21.77	20.42	29.07
12.	62.50	31.70	25.70	20.85	28.47	33.84
13.	62.50	35.20	21.68	19.85	21.52	32.15
14.	54.17	28.35	27.08	28.42	33.33	34.27
15.	62.50	38.32	32.92	41.10	33.90	41.75
16.	59.17	39.72	41.67	39.67	45.40	45.12
Mean	57.29	31.46	24.47	24.17	22.58	31.99
F ratios:		Treatments- 4.34**	Rounds of pouring 107.94**		Interaction- 0.88	
CD		6.97	3.89		NS	

Sixteen treatments x 6 replications x (4+1) rounds of observations

The treatment differences were significant, lowest disease index was in T1 - Contaf (4 ml), followed by T7 - Neem oil cake (250 g) + Contaf (4 ml), T5 - Contaf (4 ml) + Furadan (30 g), T11 - Contaf (2 ml), T2 - Indofil -M 45 (3 g) and T10 - Contaf (4 ml) + Indofil - M45 (3g) + Furadan (30g).

Average disease index , in general , showed a declining trend , after every round of application . In T15 and T16 the decline in disease index was only marginal . Superiority of T1 was visible after each round of application. In T4, at the close of the experiment ,the index stood at 8.2 while in T16 it was 45.1.

Fig. 7. FIELD MAP OF PLOT-7, CHAVARA



This experiment has shown that there was no significant difference in effect between Contaf 4ml and Contaf 2ml. Fytolan 5g was not equivalent to Contaf 2ml or Indofil 3g. There was no additional advantage in using Contaf 4ml with Neem oil cake or Fytolan 5g or Contaf 4ml or Contaf 2ml with Fytolan 5g. Furadan 30g and Phorate 20g also did not differ much but Furadan 30g was definitely better than Folidol dust 50g in reducing the leaf rot index.

A Laboratory experiment was conducted to study the multiplication of nematode *Aphelenchoides aligarhiensis* on different isolates from leaf rot samples (*Fusarium solani*, *Colletotrichum gloeosporioides* and *Exserohilum rostratum*).

The cultures of fungi were raised on Potato Detrose Agar plates for 48hrs. One cm diameter mycelial discs were cut from the growth and placed in PDA plates. After a week twenty adult female nematodes *Aphelenchoides aligarhiensis* after surface sterilisation were inoculated into the above PDA plates. Each treatment was replicated five times. The plates were kept in BOD incubator at a temperature range of 24 – 27° C.

Nematode populations were estimated after two weeks and multiplication factor was calculated using the formula

$$\text{Multiplication factor} = \frac{\text{Final count}}{\text{Initial count}}$$

Multiplication of *Aphelenchoides aligarhiensis* on three fungi (*Colletotrichum gloeosporioides*, *Fusarium solani* and *Exserohilum rostratum*) isolated from leaf rot samples.

Table VIII. Showing the multiplication of *Aphelenchoides aligarhiensis* on three fungi.

Fungi	Initial inoculum (Adult females)	Final inoculum/ Population	Multiplication factor
<i>Colletotrichurn gloeosporioides</i>	20	9180	459.0
<i>Fusarium solani</i>	20	14760	738.0
<i>Exserohilum rostratum</i>	20	5280	264.0

PATHOGENICITY STUDIES

Pot Experiment

This pot experiment has been initiated during the second year of the Scheme. The aim of the experiment was to study the pathogenic effect of bacterin, fungi and nematodes isolated from the leaf rot affected coconut palms. Eight month old seedlings raised in sterile soil was used for this experiment. Nematode and fungal inoculum were prepared from respective and uninoculated plants served as control. There were twelve treatments and each treatment was replicated five times. The treatments are

- T1. *Aphelenchoides aligarhiensis*
- T2. *Panagrolaimus sp.* + *Rhabditis sp.*
- T3. *Fusarium sp.* + *Colletotrichum sp.* + *Exserohilum sp.*
- T4. *Bacillus megaterium*
- T5. *Fusarium sp.* + *Colletotrichum sp.* + *Exserohilum sp.* > *Aphelenchoides aligathiensis*
- T6. *Fusarium sp.* + *Colletotrichum sp.* + *Exserohilum sp.* > *Panagrolaimus sp.* + *Rhabditis sp.*
- T7. *Bacillus megaterium* > *Aphelenchoides aligarhiensis*
- T8. *Bacillus megaterium* > *Panagrolaimus sp.* + *Rhabditis sp.*
- T9. *Aphelenchoides aligarhiensis* + *Panagrolaimus sp.* + *Rhabditis sp.* + *Fusarium sp.* + *Colletotrichum sp.* + *Exserohilum sp.* + *Bacillus megaterium*
- T10. *Bacillus megaterium* + *Fusarium sp.* + *Exserohilum sp.*
- T11. *Fusarium sp.* + *Colletotrichum sp.* + *Exserohilum sp.* + *Bacillus megaterium* > *Aphelenchoides aligarhiensis* + *Panagrolaimus sp.* + *Rhabditis sp.*
- T12. Control

Observations were recorded regularly. Initial symptoms of leaf spots which later coalesced on the outer margin of the spindle leaves of coconut seedlings were observed under the following treatments:

- (1). the simultaneous application of the three fungi, one bacterium and three nematodes, (2). bacterium and three fungi followed by three nematodes and (3). three fungi followed by three nematodes. The coconut seedlings in the treatments with simultaneous application of three fungi, bacterium and three nematodes produced these initial symptoms earlier (two months after first inoculation) than the rest of the treatments and in all the five replications. Control plants were free of this type of symptoms. The fungi *Fusarium solani* and *Exserohilum sp.* were reisolated from the infected tissue of other inoculated plants.

Though the inoculated seedlings developed symptoms they were not typical of the field symptoms. Probably the inoculated seedlings had not reached the correct susceptible age (split leaves), hence typical symptoms were not produced. So another experiment is initiated under field conditions with one year old coconut seedlings with split leaves.

Field Experiment

This experiment was initiated in June 1998. Coconut seedlings raised in steam sterilised soil were used for the experiment. These seedlings were transplanted one each into cement tubs (50 cm. diameter) filled with sterilised soil. Plants were grouped under 10 treatments with six replications each. (RBD) Growth parameters such as stem height, girth, number of leaves, length and breadth of individual leaves were recorded at the time of initiation of the experiment. The last fully opened leaf was marked with red paint.

TREATMENTS

T1 - 3 F

T2 - B

T3 - 3 N

T4 - 3 F + B

T5 - 3 F + 3 N

T6 - B + 3 N

T7 - B + 3 F + 3 N

T8 - *Fusarium* sp. alone (Soil)

T9 - Suspension (from leaf rot samples- large numbers of spores of all the three dominant fungi and the three nematodes)

T10 - Control

3F - *Colletotrichum gloeosporioides*, *Fusarium* -3 species *Fusarium solani*, *Fusarium oxysporum*, *Fusarium moniliforme*, *Exserohilum rostratum*

3N - *Aphelenchoides aligarhiensis*, *Panagrolaimus* sp. *Rhabditis* sp.

B - *Bacillus megaterium*

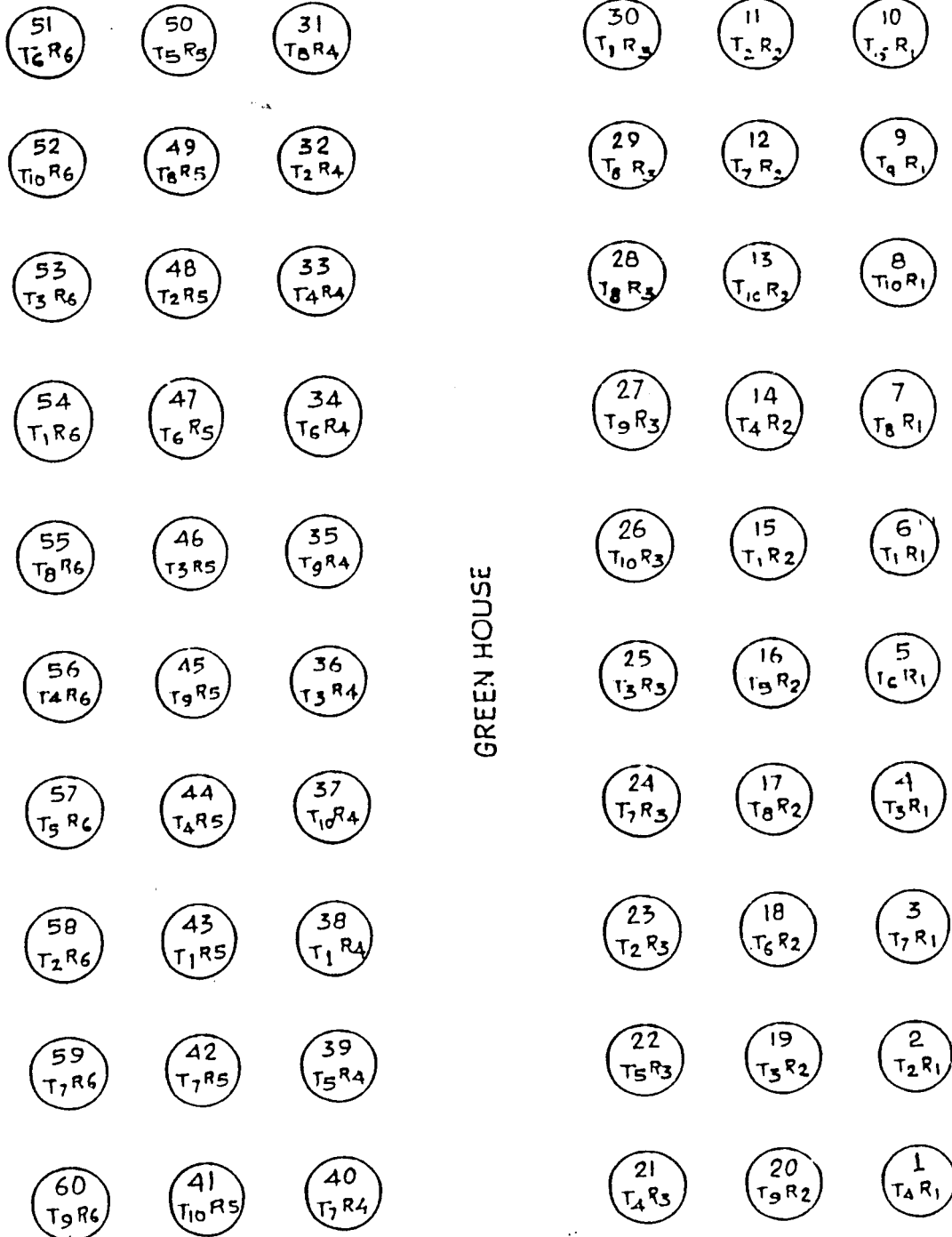
Production of typical leaf rot symptom in one seedling is an indication that leaf rot can be reproduced by pouring the suspension (washings from the leaf rot affected seedlings obtained from natural incidence) that contain the fungi and nematodes. Development of symptoms in the other replicates of the same treatment and in seedlings of other treatments need to be watched and confirmed.

FIELD TRIAL

PATHOGENICITY EXPERIMENT

Crop: Coconut
Treatments : 10

Design : RBD
Replication : 6



SUMMARY
ANNEXURE II

The leaf rot symptoms manifest only on the unopened spindle leaves. Only these white, tender, non-chlorophyllous leaflets of the unopened spindle is susceptible to the fungal infection. In many root (wilt) affected palms, before the leaf rot symptoms appear the leaf tips break about a meter from the distal end, hang down, turn yellow then brown on drying and drop. As such many leaves on the crown are seen without leaf tips.

Most of the treated palms show reduction in the intensity of leaf rot. Pouring of fungicide is more effective than spraying since it is applied directly on to the susceptible, tender leaves resulting in better protection. The cumbersome spraying and need of a sprayer is avoided. The quantity of spray fluid is reduced from 3000 ml to 300 ml. The leaf rot disease affected palms are more prone to red palm weevil infestation.

The rhinoceros beetle attack to leaf is also confined only to the spindle. Application of a systemic insecticide that has nematocidal property (Furadan 3G or Phorate 10G) along with fungicide was found to give better protection against leaf rot and insect pests. Instead of separate quarterly spraying of fungicides (6 labour) and insecticide (3 labour) both can be applied together, twice in a year (April-May/October-November) saving 88% labour cost. The cost of two applications will work out to be Rs.13.60 compared to separate quarterly applications of fungicides and insecticides (Rs.50/- + Rs.29/-) costing Rs.79/- per year. Other operations such as harvesting cleaning of crown and tying of bunches can be combined with this to reduce the labour cost in May and October. Palms in the early stages of disease will recover with two or three applications of the combined treatment. Palms in advanced stages (with an index of more than 50%) take about 3 years to recover. After 3 years, prophylaxis alone is necessary. The same treatment can be given to unaffected healthy palms once a year in May as a prophylactic measure.

Residue analysis done for the chemicals, Contaf, Indofil --45, Furadan and Folidol dust in mature and tender nuts show that nut water, kernel, coconut oil and coconut cake are free from residues after 45 days of application at the rates suggested. The method is detailed below:

- | | | |
|----|--|----------|
| 1. | Contaf - 5 EC (Hexaconazole) 2ml per palm | Rs. 1.20 |
| | OR | |
| | Dithane - M 45 OR Indofil -- M45-3g per palm | Rs. 0.70 |
| 2. | Phorate - 10G -20 gm or Furadan 3G 30gm or
Methyl parathion 50gm or Marotti oil cake 100g /palm | Rs. 1.10 |

systemic insecticide that has nematocidal property (Phorate - 10 G) along with fungicide was found to give better protection against leaf rot, rhinoceros beetle, red palm weevil, coreid bug, ash weevil, mealy bugs and nematodes.

7. Instead of separate quarterly spraying of fungicides (6 labour) and insecticides (3 labour) both can be applied together, two times in a year (April-May) and (October-November) saving 88 per cent labour cost.
8. The cost of two applications will work out to be Rs.14.60 when Contaf is used and 13.60 when Dithane is used compared to separate quarterly applications of fungicides and insecticides (Rs.50 + Rs.29) costing Rs.79 per palm per year.
9. The combined application of insecticide and fungicide did not affect the effectiveness of each other.
10. Other operations such as harvesting and tying of bunches can be combined with this in May and November to reduce the labour cost.
11. The same treatment may be given to all unaffected healthy palms also twice a year as a prophylactic measure.
12. The mid whorl yellowing (quick yellow decline) affected palm succumbs to leaf rot and inflorescence necrosis within two months of the appearance of initial symptoms of yellowing, immature nut fall and abnormal button shedding. Combined application of fungicides, Contaf 5 EC - 4 ml OR Dithane/Indofil M45 - 3g in 300 ml water and systemic insecticide Phorate 10G - 20g mixed in 200 g sand per palm immediately after the appearance of the initial yellowing symptoms can protect the palm from the incidence of leaf rot. The treatment needs to be repeated twice a year. Though the inflorescence necrosis disappears with one or two treatment the female flowers produced on subsequent inflorescence are small and shed quickly for another 6-12 months (Koshy, 2000).

The treatment suggested above for leaf rot will be very effective against Spear Rot of Oil Palm and Arecanut Yellows that exists in Kerala, since the fungi and other organisms associated with leaf rot and spear rot are the same. Here again, more research efforts should be concentrated immediately on field control of spear rot and yellow leaf diseases. In a new area, the arecanut yellows always appear first and coconut leaf rot appears later, many times after 10-15 years, which was also mentioned by Butler (1908) in his report.

The group meeting on root(wilt) disease of coconut held at CPCRI, RS, Kayangulam on 21st and 22nd April, 1998 and the plenary session of the Research Council Meeting held at CPCRI Kasaragod on 30th April, 1998 recommended the above method for complete plant protection of coconut in root(wilt) disease prevalent areas.

Antagonistic activity of *Pseudomonas fluorescence* against *C. gleosporioides* and *E. rostratum* is being tested in vitro (Srinivasan *et. al.*, 1998). The bacteria *P. fluorescence* and *Bacillus subtilis* was multiplied on Neem and Marotti oil cake and applied around the base of the leaf rot affected spindle leaf twice a year did not give encouraging results (Koshy, Unpublished).

The leaf rot affected spindle leaf also yielded three fungi, a bacterium and three species of nematodes. The individual or collective role played by them as incitants or aggravators or synergists or as disseminating agents of the disease is under study.


The preliminary studies on the pathogenicity of fungi, bacterium and nematodes singly and in combination conducted under green house condition show that combined application of fungi, bacteria and nematodes produced leaf spot symptoms on all the replications. Another pathogenicity experiment was initiated under field conditions with one year old coconut seedlings with split leaves. The laboratory studies conducted revealed that the nematode *Aphelenchoides aligarhiensis* multiplies very well on all the three fungi studied and *Fusarium solani* supported maximum multiplication of the nematode the highest multiplication of the nematode. The nematode may help in carrying the fungus to the next spindle or may even help in providing infection sites. Reduction in leaf rot index after application of nematicides indirectly supports this theory. Production of symptoms occur early when the nematodes and fungi are inoculated simultaneously or even before and after also indicate this.

As such more research efforts in future should be directed towards management of leaf rot disease by taking into consideration the following:- (1) the unopened, white, tender, leaflets of spindle alone are susceptible and they become resistant on development of chlorophyll. (2) the palms in advanced stages(above 70% index) of leaf rot do not respond to treatments quickly. (3) Palms in early stages of the disease respond quickly to treatment (4) all palms in disease prevalent areas irrespective of their health status need to be treated for curative and prophylactic action continuously (twice a year), (5) difficulty in getting the services of climbers in time and the prohibitive cost involved. (6) the cost benefit ratio. and (7) environment pollution and residual toxicity in nuts, if any, born on palms treated with systemic fungicides and insecticides.

Future Thrust Areas of Research

1. Popularisation of the simple, effective and cheap integrated management method for leaf rot disease and insects developed in the scheme through the Depts. of Agriculture, Kerala and Tamil Nadu and mass media like news paper, Radio, Television and Agricultural magazines.
2. Development of methods by which systemic fungicides can be administered through root feeding/stem injection avoiding the employment of climbers.
3. Development of easy methods for determining the susceptible/resistant nature in seedlings to leaf rot before planting.
4. Studies on the biochemical nature of apparently healthy and leaf rot affected palms.
5. Use of modern molecular methods in the investigation of leaf rot disease such as identification of resistance linked markers in seedlings and development of diagnostic PCR tests for the various associated fungi.
6. Development of serodignostic tests for the detection of important fungi such as *Exserohilum rostratum*, *Colletotrichum gleosporioides*, *Fusarium solani* and *Fusarium moniliformae* var. *intermedium* in coconut seedlings.
7. Use of tolerance available in certain varieties like Andaman Ordinary, Kenthali, CGD and individual palms of WCT, CGD and COD for production of hybrids because of their early response to management practices in terms of quick recovery and yield.
8. Development of environment friendly control methods using bioagents/plant products.
9. Studies on the role of mealy bugs, nematodes, bacteria, mites etc. found associated with the rotting spindle.

Name: Dr. Dr.P.K.Koshy
Designation: Principal Scientist (Nema.) & Head
(PRINCIPAL INVESTIGATOR)


Signature:

Kayangulam,
Date: 15 - 07 - 2000


HEAD OF INSTITUTION

1. Name of the Scheme : Role of Nematodes in the incidence of leaf rot disense on root(wilt) affected coconut palms.
2. Sanction Number : F.14(13)/93-Hort.I dated 10-011995 and 08-05-1998
3. Amount Sanctioned : Rs. 9,14,960/-
4. Date of Start : 12-07-1995
- 5 Date of Expiry : 11-07-1999

Details of Expenditure

Sl. No.	Budget heads	Sanctioned outlay	1995-96	1996-97	1997-98	1998-99	1999-00	Total
01	Fellowship incl. HRA	5,15,360	49,633	48,494	89,148	2,27,965	92,716	5,07,956
02	Travelling allowance	40,000	60	3,518	--	32,197	1,006	36,781
03	Recurring contingency	2,65,000	15,998	8,884	11,983	89,817	13,956	1,40,598
04	Non-recurring Cont.	58,000						
05	Institutional charges	36,000			19,000	10,000	44,344	73,344
Total		9,14,960	65,691	60,856	1,20,131	3,59,979	1,52,022	7,58,679

1. Remittance received from Council Rs. 8,06,920/-
2. Amount Spent Rs. 7,58,679/-
3. Balance with the Institute Rs. 48,241/-*

*Since council have enhanced the rate of Institutional charges from 10% to 15% the amount unspent is retained in the Institute.

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