INTEGRATED MANAGEMENT OF ERIOPHYID MITE ON COCONUT

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PREFACE

Coconut, *Cocos nucifera* L. is cultivated in more than 80 countries with a total production of around 49 billion nuts. India ranks first in production and productivity of coconut in the world. More than 21 species of mites have been recorded on coconut from different parts of the world. The introduction of the high yielding varieties with subsequent improvement in cultural practices has aggravated the pest problems in coconut. As a result, several species of mites have attained pest status in recent years. Recently, damage by the eriophyid mite *Aceria* (= *Eriophyes) guerreronis* Keifer was reported in 1998 from all the four Southern States of India. This mite is one of the most serious acari pests, recently introduced in India. The estimated loss of copra varies from 10 to 30 per cent. This acarine pest has incidentally created an awareness, of the importance of phytophagous mites among scientists, administrators and farmers.

Considering the importance of the problem Prof. Dr. S. Kannaiyan, Vice-Chancellor of Tamil Nadu Agricultural University constituted a Steering Committee under his leadership, to intensify the research work on this mite to find an early solution. A multidisciplinary Task Force consisting of scientists from various disciplines of Tamil Nadu Agricultural University has generated valuable data on various aspects of coconut eriophyid mite. This technical bulletin presents the results of investigations mainly carried out by the Task Force scientists under the guidance of the Vice-Chancellor.

I greatly appreciate the efforts taken by all the Task Force members and their fellow scientists in conducting the various research activities. The financial support extended by the Indian Council of Agricultural Research under the National Agricultural Technology Project (NATP) on **Development of an Integrated Pest Management package for the eriophyid mite (*Aceria guerreronis* Keifer) of coconut in the Southern States** for conducting the research programme is gratefully acknowledged.

Prof. Dr. S. Kannaiyan
Vice-Chancellor

Acknowledgements

Outbreak of eriophyid mite, *Aceria guerreronis* (Keifer) on coconut was noticed in 1998 in Southern states of Tamil Nadu. The loss of copra varied from 10-30 per cent. A survey was undertaken by the Department of Agricultural Entomology, Tamil Nadu Agricultural University. Based on the survey and considering the importance of the problem a Steering Committee was constituted under the Chairmanship of Prof.Dr.S.Kannaiyan, Vice-Chancellor, Tamil Nadu Agricultural University. The work was intensified and later a Task Force was constituted and scientists from various disciplines tackled the problem and data generated. Later the staff of the State Department of Agriculture was involved in laying out trials for the management of the mite. Trials were laid in Regional Research Stations of Tamil Nadu Agricultural University and farmers holdings. Lot of data were generated by the scientists and the financial support was extended by the Indian Council of Agricultural Reasearch under National Agricultural Technology Project. The authors gratefully acknowledge the scientists for the untiring support for generation of data. Financial support by the ICAR is also gratefully acknowledged. The support extended by the scientists of various departments in Tamil Nadu Agricultural University and farmers is acknowledged.

Coconut mite
Phylum - Arthropoda
class - Arachnida ; Sub class - Acari
Order - ~~Acari~~ Prostigmata
Family - Eriophyidae
Genus - Aceria

CONTENTS

MANAGEMENT OF ERIOPHYID MITE *Aceria guerreronis* (Keifer) ON COCONUT

Introduction

Coconut is extensively grown in about 80 countries of the world with a total production of over 49 billion nuts. India ranks first in the world with 13 billion nuts per year and accounts for 24.5 per cent of the world production. The productivity of the crop is highest in India with 7572 nuts/ha with an area of 1.90 million hectares. Among the coconut growing states, Tamil Nadu ranks second in area, production and productivity. It is grown in an area of 3.2 lakh hectares and the total production is 3716 million nuts with an average yield of 11620 nuts/ha.Several insect and non-insect pests have been reported to affect the coconut palm. Outbreak of an eriophyid mite was noticed in recent years. Although nine species of eriophyid mites have been reported to infest coconut leaves and nuts,only *Aceria (=Eriophyes) guerreronis* (Keifer) (Eriophyidae:Acari) feeding on tender nuts has been found to cause heavy damage in different parts of Tamil Nadu in recent years , resulting in loss of production of nuts.

1. Taxonomy and distribution

Nine species of eriophyid mites have been recorded on coconut from different parts of the world (Amrine, Jr. and Stasny, 1994) and of these only two occur on the nuts. Among them, *A.guerreronis* is considered to be serious. Though symptoms of damage on nuts were first described by Martyn (1949) from Columbia they were attributed to eriophyid mite by Ortega *et al.*, 1965 in Guerrero on the west coast of Mexico. The mite was first described in 1965 from Guerrero State, Mexico by Keifer (1965) and since then it has been reported from many coconut growing areas of the America, West Africa and the Caribbean islands from Cuba to Trinidad and St. Lucia in the West Indies (Moore, 1986).

2. Ecology

The absence of *A. guerreronis* in the presumed area of origin of coconut probably indicates that it has moved from an unknown host onto coconut after its introduction and expansion of areas in the Americas and Africas. Though the geographical distribution of the coconut mite has

expanded greatly in recent decades (Griffith, 1984; Mariau, 1986), it is equally possible that the mite has been present at low population in many localities where coconut is widely cultivated. In recent years, it was observed in many localities, only when the population levels, increased due to favourable unknown ecological factors (Howard *et al.*, 1990). It is likely to be present in other localities too from where it has not yet been reported.

3. Occurrence in South India

During 1984, the occurrence of this mite was first noticed in Srivilliputhur in Tamil Nadu. Recently, heavy damage by eriophyid mite, *A. guerreronis* was reported from a few districts of Kerala in February 1998 (Sathiamma *et al.*, 1998) and from Coimbatore, Dindigul and Erode districts of Tamil Nadu in August 1998. Preliminary surveys indicated that the incidence was widespread in many coconut gardens showing moderate to heavy nut damage. The mites are usually seen under the external bracts of female flowers just after fertilization (Mariau and Julia, 1970 and Moore and Alexander, 1987).

4. Nature of damage

The mites infest and develop on the meristematic tissues of the growing nuts under the perianth by desapping the soft tissues of the buttons (Plate 1). In the infested buttons/nuts, initial symptoms will be exhibited in the form of triangular pale white or yellow patches close to each perianth. Different stages of mites live in the white, tender portion covered by the inner bracts of the perianth and suck the sap continuously. When the feeding activity is on the increase, it results in physical damage to the newly formed tissues which become necrotic. Intensive damage leads to the formation of brown coloured patches later (Plate 2). In addition, as the nut grows , longitudinal fissures and splits occur on the outer surface of the husk (Plate 3). Occasionally, brownish gummy exudate is seen oozing out from the affected surface (Plate 4). Severe infestation results in poor growth, reduced size and copra content and malformed nuts with cracks and hard

ened husk (Plate 5). Mites occur in large numbers only in young buttons (2-6 months). When the age of nut advances, the population of mite decreases. The mites were also found to feed on the innerside of the palmyra tepals (Plate 6).

5. Biology

The eriophyid mites are vermiform with elongate body, distinctly divisible into a cephalothorax and a long, ringed tapering body. The mite posseses two long sinous setae arising from the posterior part of the body. The adult mite is very minute measuring 200-250 µm in length and 36-52 µm in width with two pairs of legs found in the anterior region of the body (Plate 7). It is pale in colour with elongate body and worm like in appearance. The female mite lays approximately 30-50 eggs. The eggs are globular, shiny and round in shape under the microscrope which hatch into larva (protonymph) in two days. The second instar larva is called nymph which subsequently moult into adults. The life cycle of this mite, which consists of egg, two larval instars and an adult stage, is completed in 8-10 days (Plate 8).The mites are found under the bracts of fertilised female flowers and are not usually found in unfertilized flowers. The distribution of eriophyid mite colony is not uniform inside the perianth. Normally in two or three places the mite colonies are congregated under the tepals. In most of the cases old and fresh colonies are found beneath the fourth tepal. Each colony contains hundreds of eggs, larvae, nymphs and adults. The colonies vary in size and shape. After causing damage in a particular spot/area the mites tend to move to fresh areas in meristematic tissue and start colonization.

6. Yield loss

The estimated loss of copra varied from 10 per cent in Benin (Julia and Mariau, 1979), 16 per cent in Ivory Coast (Mariau and Julia, 1979), 30 per cent in Mexico (Hernandez, 1977) and 11-28 per cent in St. Lucia (Moore, 1986).

7. Management

7.1. Host Plant Resistance

Little is known about the host plant factors that make the nuts susceptible or resistant to attack. Mariau (1986) reported that cultivars varied in their susceptibility to coconut mite infestations and trees of a cultivar from Cambodia suffered no attack. This may be due to the fact that tepals were more tightly adpressed to the fruits in rounded nuts than in elongated ones (Moore, 1986; Howard and Rodriquez, 1991). Suarez (1991) reported that while the coconut cv. Criollo was the most susceptible the cv. Indio was least susceptible to *A. guerreronis* attack in Cuba. Hybrids (Dwarf x Tall) were tolerant to *A. guerreronis,* but more susceptible to nut fall caused by *Phytophthora heveae*. Upto 90 per cent of the trees were attacked in the variety Atlantic tall as against lower infestation in Malayan Yellow Dwarf in Costa Rica (Schliesske, 1988).

7.2. Cultural practices

Long periods of drought resulted in greater yield losse due to the mite (Mariau, 1986 and 1997), because fruit growth is slower during dry periods. Well maintained trees, with appropriate fertilizer application, were found to suffer less from mite attack. Moore *et al.* (1991) reported that *A. guerreronis,* damage in general, increased with increase in N levels and decreased with increase in K levels.

7.3. Biological control

The predatory mites *viz., Bdella distincta, Amblyseius largoensis*, *Neoseiulus mumai* and *N. paspalivorus* were reported from inside the perianth (Howard *et al.,* 1990). Moore *et al.* (1989) reported that chemical (Vamidothion), physical (sticky material) and microbial (*Hirsutella thompsonii* [Fisher]) agents tested provided no control of this mite. The entomogenous fungus *H. nodulosa* was found to attack *A. guerreronis* in Cuba in 1984 (Cabrera and Dominguez, 1987). Lampedro and Luis-Rosas (1989) tested seven strains of *H.thompsonii* at concentrations of 7,000 ± 500, 14,000 ± 500 and 26,000 ± 500 conidia/ml and all were found to be pathogenic to *A. guerreronis* and the highest mortality (88.36%) was obtained with the strain HtMOR. Field application of *H. thompsonii* against this mite gave variable results (Moore and Howard, 1996).

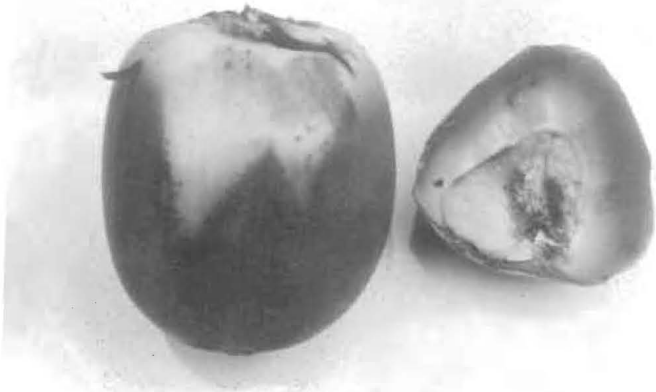


Plate 1. Development of eriophyid mite under the perianth

Plate 2. Young developing buttons (1 to 4 months old) showing triangular yellow and brown patches

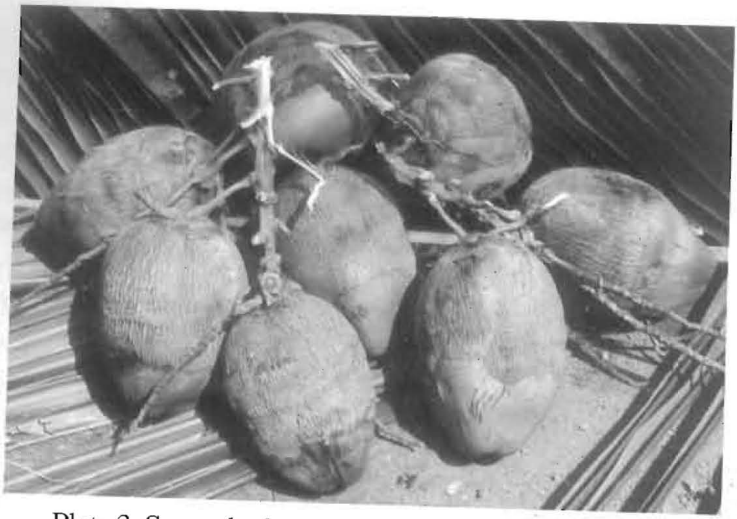


Plate 3. Severely damaged nuts showing longitudinal fissures and splits

Plate 4. Nuts showing brownish gummy exudate from the affected surface

Plate 5. Copra content in uninfested and infested nuts

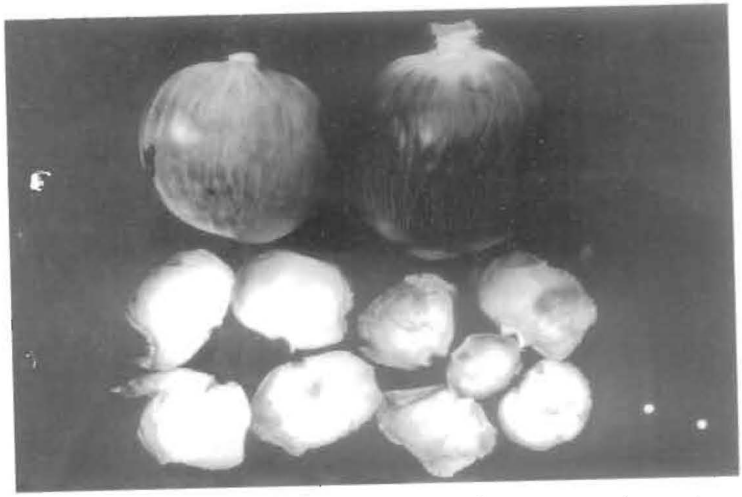


Plate 6. Palmyra, *Borassus flabellifer* - a new alternate host of coconut eriophyid mite

Plate 7. Photomicrograph of an adult eriophyid mite

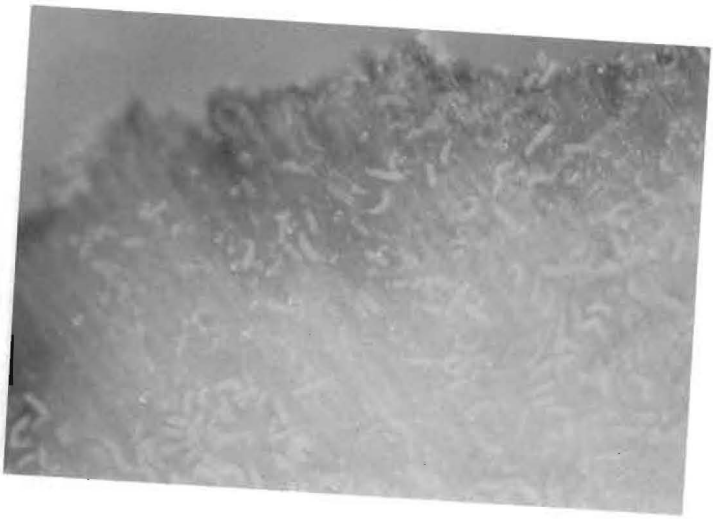


Plate 8. A colony of eriophyid mites - eggs, larvae, and adults

Cabrera (2000) reported *H. thompsonii*, *H. nodulosa*, *Entomobrya* (Collembolan), *N. paspalivorus*, *Proctolaelaps bickleyi* and *Lasioseius* sp. as the natural enemies of *A. guerreronis* from Cuba. He repoted the integration of *Hirsutella thompsonii* with other methods to reduce the mite incidence.

7.4. Chemical control

Dicrotophos, monocrotophos (Nuvacron) or chinomethionate (Morestan) sprayed onto the bunches of developing fruits every 20 and 30 days reduced the damage by *A. guerreronis* (Hernandez, 1977; Julia and Mariau, 1979). Similar results were obtained with other acaricides applied at 15 days intervals (Mariau and Tehibozo, 1973). Julia and Mariau (1979) found that stem injection of monocrotophos at two months interval was effective in young palm. Griffith (1984) reported that the injection of vamidothion into stems gave variable results. Moore and Alexander (1987) concluded that frequent sprays would be required to achieve satisfactory control. Julia and Mariau (1979) reported the slow effect of mancozeb against *A. guerreronis*. Moore and Alexander (1987) reported that vamidothion (Kilval) (4 g a.i./10 lit of water) sprayed trees produced more number of nuts than the control.

Mariau (1977) and Hernandez (1977) reported that it was possible to control *A. guerreronis* on coconut with cyhexatin or fenbutatinoxide, if repeated sprays were given. However, such an approach would hasten the development of resistance. Application of morestan 25 WP @ 4 g/lit of water or morestan 2% dust @ 28g per palm effectively controlled the coconut mite in El Salvador (Anonymous, 1986). Mohanasundaram *et al.* (1999) reported that spraying of triazophos 5 ml or methyl demeton 4 ml or phosalone 3 ml/lit. of water or root feeding triazophos 20 ml + 20 ml water / tree was effective against the coconut mite. Spraying of either dicofol 6 ml/lit. of water or 2% neem oil + 25g garlic extract in one litre of water at monthly intervals recorded satisfactory control of the pest (Nadarajan *et al.*, 2000). Nair *et al.*(2000) reported that root feeding with 10 ml monocrotophos / tree mixed with 10 ml water at monthly intervals, neem azal and neem oil + garlic extract controlled the mite infestation. CIRAD (Formerly IRHO, Cote d'Ivoire) reported that spraying 0.04% monocrotophos at monthly intervals reduced the pest damage con

siderably. However, repeated applications are reommended for the effective management of the pest. Ramaraju *et al.*(1999) reported that spraying of methyl demeton 25EC @ 4ml or triazophos 40EC @ 5ml or monocrotophos 36SL @ 1.5ml per litre once in 30 days or root feeding with monocrotophos 36 WSC 15ml + 15ml water once in 45 days reduced the mite incidence.

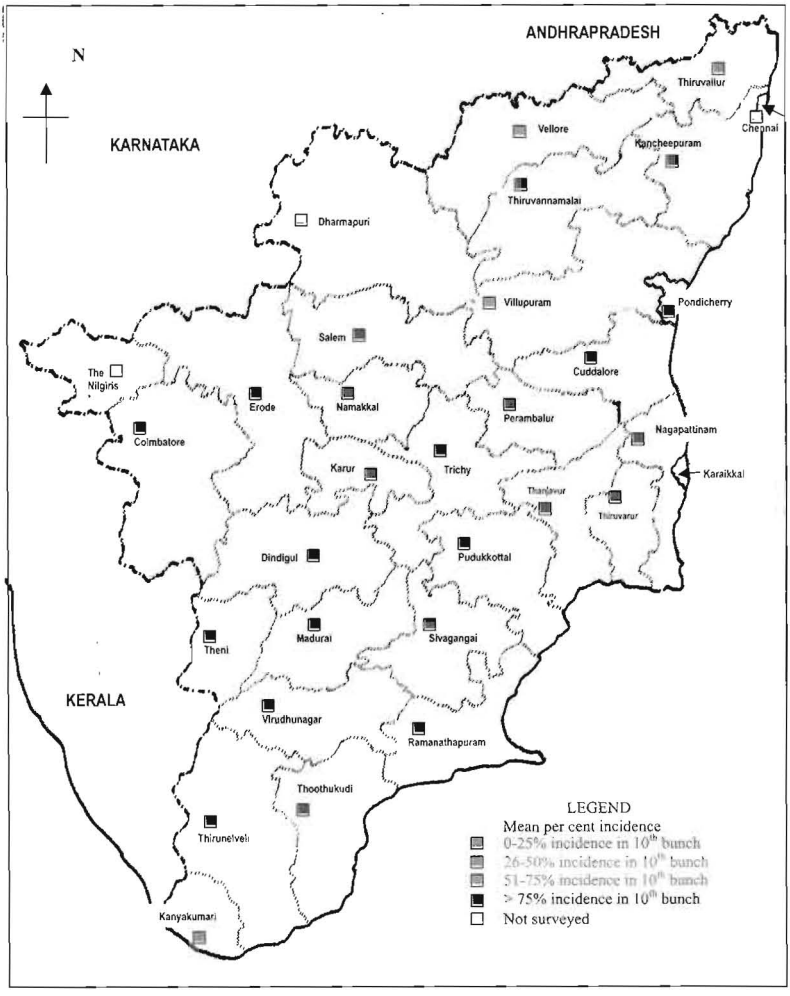
1.Findings at Tamil Nadu Agricultural University

1.1. Survey

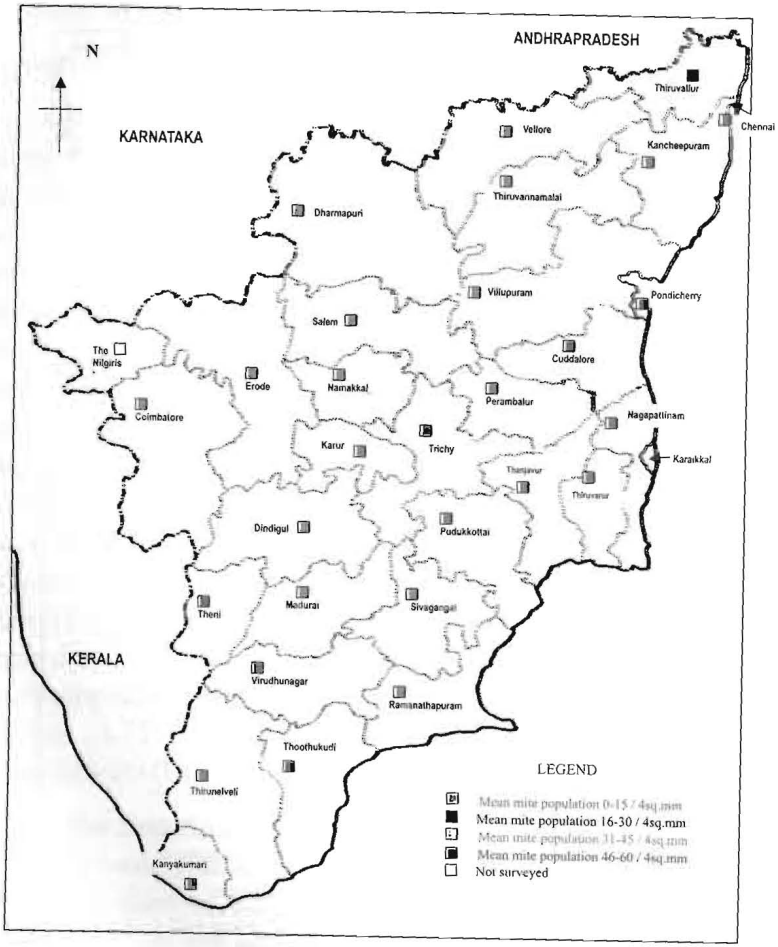
A survey was undertaken in Tamil Nadu by the Department of Agricultural Entomology from June 2000 to October 2000 to estimate the extent of mite infestation.The infestation ranged from 19.75 to 100 per cent in the 10th bunch from top in all the districts. Thiruvallur district recorded the lowest percentage of incidence (19.75) followed by Kanyakumari (32.27) and Dharmapuri (37.07). The mite population ranged from 7.20 to 57.18/ 4 mm^2 in the nut. The 6th and 8th bunches were also severely infested. Both tall and hybrid coconut varieties were infested irrespective of age, height, nut colour, fertilizer application and irrigation patterns, with or without intercrop and coastal or inland ecosystems (Map 1 & 2). To estimate the loss in copra weight, three nuts (11th bunch) were harvested from infested trees and the same were categorised, based on the external damage symptoms, into three grades *viz.*, grade I (0-10%), grade II (11-50%) and grade III (>50%) and the dry copra weight was assessed in Coimbatore, Erode, Namakkal and Salem districts. Preliminary results indicated that the reduction in the weight of copra ranged from 15.57 to 18.75% in grade II and 29.45 to 33.49% in grade III in the above districts (Umapathy *et al.*, 2001).

The Department of Agricultural Economics, TNAU conducted a survey (i) to study the nature and degree of infestation of eriophyid mite in the coconut gardens, (ii) to quantify the effect of the pest on yield and price of coconuts and, (iii) to know the extent of awareness, adoption and rate of success of the various control measures. Affected nuts were grouped into four grades: grade I (less than 10% damage), grade II (11-40% damage) grade III (41-60% damage) and grade IV (above 60% damage). The results of survey is as follows.

Map 1. Coconut eriophyid mite incidence in different districts of Tamil Nadu



Map 2. Population of coconut eriophyid mite in different districts of Tamil Nadu



- Ninetyfive per cent of the sampled farmers in the state were aware of the incidence of eriophyid mite in their farms, out of which about 40 per cent had a fair knowledge of the pest.
- Incidence of the pest was more in Namakkal, Trichy, Cuddalore and Vellore districts with 40 per cent of the nuts exhibiting grade IV damage (above 60 percent).
- Impact of the pest in terms of yield reduction (nuts/tree between the summer months of April-July in the year 1999 and 2000) was severe in Thiruvannamalai, Theni, Dindigul and Thanjavur districts (Table 1).
- Weight reduction of unhusked coconuts due to the attack of mite was more pronounced in Vellore, Thanjavur and Dindigul districts.
- Reduction in price of mite affected nuts over the normal nuts was very severe in Thoothukudi district (42 per cent) followed by Thanjavur and Trichy (35 per cent) and Madurai (33.50 per cent) districts (Table 1).
- Eighty per cent of the sampled farmers were aware of the root feeding method. Awareness percentage was 37 per cent for neem cake application, 35 per cent for foliar spray and 11 per cent for agrobiocide usage (Table 2).
- Root feeding as a method to control eriophyid mite was known to 41 per cent of sampled farmers, with the highest adoption rate in Theni (90), Cuddalore and Thoothukudi (80), Madurai (70), Thanjavur (67) and Vellore districts (60). Non adoption rate of the same method was the highest in Thiruvannamalai, Thirunelveli, Kanniyakumari, Thiruvallur, Namakkal and Salem districts (Table 2).
- Success rate of control methods was high in Namakkal (80), Dharmapuri (70), Kancheepuram (50), Thanjavur (40), Theni (40) and Thiruvannamalai (40) districts (Table 2).
- Survey on the sales of nuts in the sampled centres indicated that 80 per cent of nuts in Namakkal, 70 per cent in Vellore, 68 per cent in Cuddalore and 66 per cent in Trichy were affected.
- Sample traders lost about 80 per cent of their sale value from the affected nuts in Tirunelveli district and 65 per cent in Erode, Kanniyakumari, Thoothukudi and Salem districts.

- Field investigators of the study, in their own judgement, reported that 98 per cent of nuts sold were affectd in Tirunelveli district followed by Madurai, Namakkal, Vellore, Cuddalore and Theni districts.

1.2. Taxonomic identity

The eriophyid mites recovered from the affected nuts from different parts of Tamil Nadu were slide mounted, cleared and studied for taxonomic identity. The eriophyids recovered from the samples were identified and confirmed as *Aceria guerreronis* based on the following diagnostic characters (Keifer, 1965) (Fig. 1).

- Strongly produced median (1/3rd distally from shield anterior), an admedian and one submedian (sinuate); a transverse line across in front of dorsal tubercles
- Six rayed simple featherclaw
- Oval or elongate microtubercles set between rings
- Female genitalia away from coxal bases, coverflap bearing about 7-9 ribs
- Coxal bases having dashes

1.3. Relationship between weather factors and mite incidence

Studies conducted by the Department of Agricultural Meteorology to understand the relationship between weather factors and eriophyid mite incidence from March 2000 to March 2001 revealed that,

- Normal or excess rainfall during South West Monsoon and North East Monsoon reduced the mite incidence.
- Low relative humidity (less than 45 per cent) increased the mite incidence during summer. Such information was not consistent for South West and North East Monsoon seasons.
- The incidence of mite reduced, whenever there was rainfall during January to April.
- Summer rainfall (March to May) was critical for the control of mites in the subsequent months. If the rainfall was lesser than the normal, the bunches produced in the subsequent months had higher incidence of mite.

Table 1. Effect of eriophyid mite infestation on yield and price of coconut (Figures in %)

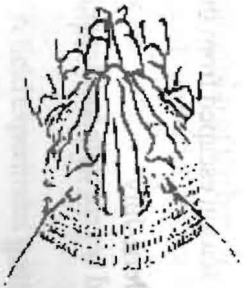
Sl. No.	Districts	Grade III & IV nuts	Reduction in nut yield	Reduction in price (in farm) Rs/100 nuts	Reduction in weight (kg)	Affected nuts (in market)	Reduction in mandi price in market Rs/100 nuts	Affected nuts (by visual observation)
1	Coimbatore	54	14	18	49	32	51	47
2	Cuddalore	56	-	5	49	68	41	68
3	Dharmapuri	4	-	17	47	0	58	0
4	Dindigul	40	25	9	53	21	-	38
5	Erode	46	17	7	37	34	44	51
6	Kancheepuram	47	0	4	40	20	69	35
7	Kanniyakumari	18	5	26	10	18	38	27
8	Madurai	41	14	33	46	50	65	84
9	Nagapattinam	22	11	-	36	27	54	22
10	Namakkal	91	-	29	47	81	47	78
11	Salem	36	18	13	19	28	45	42
12	Thanjavur	21	19	35	53	20	63	29
13	Theni	49	25	22	35	44	53	63
14	Thiruvallur	52	9	6	34	12	29	19
15	Thiruvannamalai	52	9	6	34	6	38	34
16	Thoothukudi	48	17	42	29	17	20	56
17	Tirunelveli	25	7	14	18	17	20	98
18	Trichirappalli	70	-	35	14	2	64	56
19	Vellore	63	10	12	56	70	40	70
	Mean	**44**	**9**	**18**	**37**	**32**	**43**	**47**

Table 2. Awareness, adoption and success rate of control measures among coconut growers
(Figures in %)

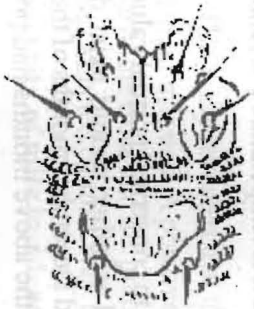
S.No.	Districts	Knowledge about mite	Awareness of			Root feeding adoption	Success rate
			root feeding	neem cake application	Agro biocide application		
1	Coimbatore	51	97	41	11	54	14
2	Cuddalore	50	90	20	0	80	0
3	Dharmapuri	30	50	0	0	50	70
4	Dindigul	40	100	60	70	40	30
5	Erode	57	97	17	3	40	17
6	Kancheepuram	0	100	30	10	50	50
7	Kanniyakumari	43	71	46	14	6	14
8	Madurai	50	70	10	0	70	0
9	Nagapattinam	10	90	50	50	30	0
10	Namakkal	40	50	70	0	20	80
11	Salem	47	93	40	20	27	13
12	Thanjavur	20	100	33	0	67	40
13	Theni	40	100	60	10	90	40
14	Thiruvallur	20	90	30	0	10	0
15	Thiruvannamalai	20	0	10	0	0	40
16	Thoothukudi	29	100	40	60	80	0
17	Tirunelveli	0	0	0	0	0	0
18	Trichy	50	25	45	5	35	0
19	Vellore	30	100	60	0	60	0
	Mean	**40**	**80**	**37**	**11**	**41**	**19**

Fig .1. Diagnostic characteristics of coconut eriophyid mite, *A. guerreronis* K.

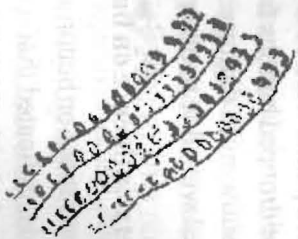
ANTERIOR SIDE-VIEW
OF THE MITE
LENGTH: 200 ± 15 μ



ANTERIOR DORSAL VIEW
SHIELD : WITH PROMINENT MEDIAN, AD-MEDIAN AND SUBMEDIAN LINES
SHIELD SETA: ARCHING BACK



FEMALE GENITALIA
AWAY FROM COXAL BASES
COVERFLAP: WITH 7-9 RIBS
COXAL BASE: WITH COARSE MARKINGS,
COXAL SETA I, II & III PRESENT



SIDE SKIN STRUCTURE
WITH HUMPED, LARGE MICROTUBERCLES

FORELEG : WITH REGULAR SETAE
CLAW: CURVED

FEATHERCLAW
SIMPLE, SIX RAYED

CAUDAL SEGMENT
ACCESSORY SETA PRESENT

- In tall variety, maximum temperature recorded at one or two months earlier to spathe emergence had positive correlation with mite incidence.
- The leaf relative humidity was found to be in higher order against the mite incidence.
- For trees without mite infestation, the leaf temperature (°C) should be lesser than leaf relative humidity (%).

- Weather prevailed should be nearer to concerned normal values of a particular month. Such congenial weather should exist during February, June, July, September and December months of the year. Any deviation from the normal in the above months had positive influence on the mite incidence.
- Maximum temperature had negative correlation three months after the emergence of spathe.
- Survey with pretested questionnaire with farmers at Negamum village in Coimbatore district indicated that
    - Flowers formed during rainy season escaped from the mite attack
    - Infestation was severe during June-July
    - Higher air temperature caused severe mite incidence, while rain minimized the incidence.

1.4. Mite infestation and button shedding

Observations on button shedding in coconut palms infested by mite and healthy palms showed that mite infestation did not contribute significantly to button shedding. The average number of buttons shed in mite infested palms were 39.60 as compared to 42.14 in uninfested palms. Among the dropped buttons from infested trees, only 21.06 per cent were found to show mite damage and the remaining 78.94 per cent of the button shed were due to other causes.

1.5. Varietal influence on button shedding and mite incidence

Observations on button shedding in different varieties *viz.*, tall, dwarf and hybrids, indicated that it was the least in dwarf varieties (19.88%) followed by hybrids (33.94%) and tall varieties (46.18%).

1.6. Severity of mite incidence in relation to age of the trees

To assess the severity of mite incidence in relation to age of the trees, 25 trees each in the age group of 15, 20, 25, 30 and 40 years were observed. In each tree, the total number of bunches and the number of bunches affected by the mites were assessed.

The study revealed that the nuts in coconut palms of all ages were found to be infested. A positive correlation was known to exist between the age of the trees and the percentage of bunches affected by mite. The bunches affected by mite was the highest (95.6%) in 40 year old trees.

1.7. Severity of mite incidence in relation to age of the nuts

The severity of mite incidence in relation to the age of the nuts was assessed in 25 trees in each age group of 15, 20, 30 and 40 years old . In each tree, the total number of nuts and the nuts showing the symptoms of mite attack were recorded and the mean percentage of nuts affected in each age group of the bunches was assessed. The results indicated that as the age of the bunch increased, the severity of the mite incidence also increased.

1.8. Population dynamics

A field experiment is in progress since May 2000 at Millet Breeding Station of the Tamil Nadu Agricultural University to study the population build up of eriophyid mite and the predatory mites and other insects associated . Buttons are being collected from the fourth bunch at 15 days interval from 10 palms to assess the mite population. The results indicated that the population trend is almost constant throughout the year. The population was higher during the second fortnight of May 2000 (32.88 /4 sq.mm) and November (34.26 / 4 sq.mm) and declined during the second fortnight of December and February 2001 (0.80-3.60/ 4 sq.mm). The predatory mite population *viz., A. paspalivorus* and *Bdella* sp. was less during the period of study. Correlation and regression analysis of the data for the year 1998 -1999 revealed no significant relationship between live mite population and weather parameters.

1.9. New alternate host

Palmyra, *Borassus flabellifer* (Palmae) was identified as a new alternate host for coconut eriophyid mite, *A. guerreronis* in Tamil Nadu for the first time (Ramaraju and Rabindra , 2001). Mites were collected from the palmyra fruits from Thondamuthur and Sirugamani areas and the identity of the eriophyid mite as *A. guerreronis* was confirmed. More than 100 mites /4 sq. mm including different stages were recorded from a single palmyra fruit. These mites were found only on the tepals. The feeding damage caused by them results in the development of faint reddish brown or brown coloured patches on the inner side of the tepals. Unlike coconut, no significant feeding marks were seen on the outer surface of the fruit or on the developing tissues .

1.10. Laboratory maintenance of coconut mite

Young bunches (3 to 5 month old) exhibiting mite damage symptoms were maintained successfully at 25 to 28° C keeping the peduncle dipped in water or water containing salicylic acid in the form of aspirin tablet (1 tablet / 1itre) or sucrose solution for 10-15 days.

1.11. Entry of mites into the bracts and monitoring mite population with sticky trap

Regular observations revealed that the mites were found to gain entry into the tepals about 50 days after opening of the inflorescence. In sticky trap set at crown region in the form of vaseline coated cardboards and x-ray sheets, only six mites could be observed.

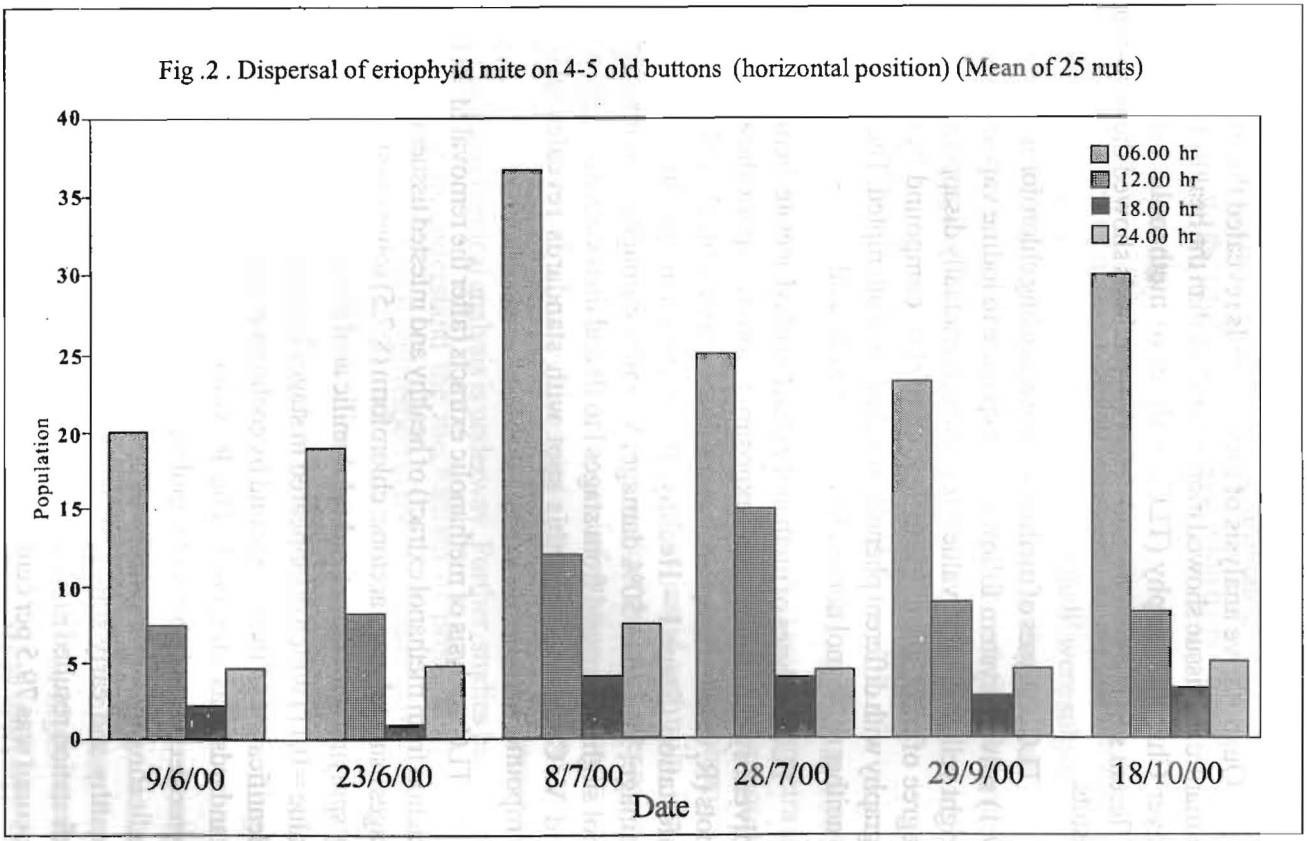
1.12. Movement of mites on the nuts

Laboratory studies indicated that the mite activity was at its highest on the surface of the buttons in the early morning hours (6 a.m). More number of mites were found to move out from the under surface of the bracts during morning hours and this habit may facilitate easy dispersal of the mites within the tree or through wind to other trees or field (Fig. 2).

2. Yield loss

Observations on the copra content indicated that as against 1.6 kg of copra per 10 healthy (uninfested) nuts, it was only 1.16 kg in 10 infested nuts.The estimated loss of copra in Tamil Nadu is 27.5% (Ramaraju *et al.*, 2000).

Fig .2 . Dispersal of eriophyid mite on 4-5 old buttons (horizontal position) (Mean of 25 nuts)



3. Biochemical changes due to mite infestation

3.1. Phenolics

Quantitative analysis of total phenols revealed that the infested immature nut tissue showed more phenolics than the healthy tissue. Thin Layer Chromatography (TLC) analyses of methanolic extract using different solvent systems and detection methods showed the following results.

TLC analyses of methanolic extracts using chloroform : acetic acid (9:1) solvent system followed by exposure to iodine vapour showed a bright yellow spot (R_f value = 0.17) which gradually disappeared with the degree of infestation. Identification of this compound by cochromat ography with different phenolic standards was attempted. The compound is neither resorcinol nor ferulic acid or caffeic acid.

TLC analyses of methanol extract in ethyl acetate: benzene (9:11) solvent system followed by exposure to iodine vapour showed yellow spots (R_f value = 0.06, 0.12) which disappeared at the IV and V stages of infestation (Stage I – Healthy; II – < 10% damage; III – 10 to 25% damage; IV –26 to 50% damage; V->50% damage). The intensity of spot slighly increased from stages I to III and then vanished in stages IV and V. Comparison of this spot with standards revealed that the compound was close to tannic acid.

TLC analysis of methanolic extracts (after the removal of hexane fraction from methanol extract) of healthy and infested tissues of different stages using toluene : acetone: chloroform (8:7:5) solvent system followed by spraying with diazotized sulphanilic acid showed an yellow spot (R_f value = 0.11) which disappeared in stages IV and V of mite infestation. Identification of this compound by cochromatography with the different standards was atempted. The R_f value of *p*-hydroxybenzoic acid, pyrocatechol and phloroglucinol were 0.17, 0.70 and 0.33, respectively, indicating their non-correspondance to the yellow spot observed in the healthy and early stages of infested coconut husk tissues. The mite infestation resulted in water loss in nuts. The moisture content in infested coconut was 79.5 per cent as against 85.20 per cent in healthy nut .

3.2. Identification of biochemical compounds in mite-infested nuts

The mite-infested yellow region just below the tepals was dissected out, extracted with methanol and thin layer chromatography was done to collect the spot from the check sample preparation by preparative TLC.

3.3. Volatile compounds

Mite infested and uninfested tissues of husk from buttons of susceptible varieties and from mite resistant 'Kenthali' were subjected to steam distillation. The distillates were fractionated with petroleum ether and analysed using gas chromatography to compare the volatile substances, if any, in the resistant variety.

Mass Spectrum Data

The compound's negative ion spectrum shows peaks at m/z 335 (M-H) and m/z 371 (M+C1). The molecule identified by mass spectra is Juglone glucoside (5-hydroxy 1-4 napthoquinone β-D-glucopyranose). It has a molecular weight of 336. Juglone is a known allelochemical conferring resistance to certain pests such as jassid and mite. This compound has been reported to be present in walnut shell and other palms. It appears that the coconut mite, upon infestation, converts the endogenous *Juglone*, into its glucoside to avoid adverse effect of the chemical. The confirmation of presence of glucose by glucosidase hydrolysis and chemical analysis is underway. Further, studies have been contemplated to understand the mechanism of production of this glucoside and its implication with respect to coconut infestation (Manickam *et al.*, 2001)

3.4. Toxins

No characteristic toxin, produced either by secondary fungal infection or mite infestation, has been detected.

3.5. Enzymes

Levels of catalase, peroxidase and polyphenol oxidase were compared. The peroxidase activity was three times the higher in the infested tissue over healthy tissue. This observation has indicated the possible role of phenolic compounds in polymerization to produce physical barrier around the infested tissues.

3.6. Carbohydrate

Four-month-old healthy and infested nuts were categorized based on husk colour of the infested portion into four stages for biochemical differentiation: (i) uninfested (ii) infestation with yellow streak (iii) brown colour and (iv) dark brown.

The uninfested and infested tissues at each of the above stage were extracted in methanol. The estimation of total sugar content showed that it increased at the later stage of infestation by three times than in healthy nuts. It is possibly due to increased level of non-reducing sugars which may act as a medium for secondary infestation by pathogens.

4. Management practices

For integrated management of this mite adoption of tactics like biological control, cultural methods, use of other natural, environment friendly pesticides and methods of application would help in the management of the mite with little or no toxic residues in coconut kernel and water.

4.1. Cultural and agronomic practices

The efficacy of *Pseudomonas fluorescens* @ 100 g/tree, biofertilizers and nutrient mixture at 250 ml/tree was compared with root feeding of monocrotophos 15 ml + 15 ml of water and soil application of carbofuran at 250 g/tree. Due to *Pseudomonas* application the population of the mites was reduced 45-120 days after application. However, the data were not significantly different.

4.1.1. Effect of irrigation and intercrop on eriophyid mite incidence

Flood irrigation recorded lesser incidence of the mite in the nuts compared to other irrigations (Table 3). Abundant water supply in flood irrigation and addition of nutrient through incorporation of green manure might have promoted the uptake of more nutrients resulting in increased vigour of the palms.

Table 3. Effect of irrigation methods and green manuring on coconut eriophyid mite

Treatments	% nut damage in bunches of different ages (months) *				
	5	6	7	8	9
Drip irrigation	15^{bc}	18^{b}	20^{a}	24^{a}	25^{a}
Basin irrigation	14^{b}	18^{b}	20^{a}	25^{a}	27^{a}
Flood irrigation	12^{a}	15^{a}	18^{a}	23^{a}	28^{a}
Green manure	15^{bc}	15^{a}	20^{a}	24^{a}	26^{a}

* Means followed by common letter (s) are not significantly different at 5% level.

The following nutrient schedule is recommended for the management of coconut eriophyid mite (Kannaiyan *et al.*, 2000b)

i. Urea 1.3 kg /tree/year

ii. Super phosphate 2 kg /tree/year

iiI. Muriate of potash 3.5 kg/tree/year *

* (Insted of the recommended dose of 2.0 kg/tree/year)

iv. Neem cake 5 kg/tree/year

v. Borax 50 g

vi. Gypsum 1 kg

vii. Magnesium sulphate 0.5 kg

The above fertilizers are recommended based on the concept of keeping the coconut trees healthy and vigorous in order to compensate for the loss caused by the mites. Since potassium and neem cake are known to induce resistance to pests, they are being recommended. Experiments conducted at Coconut Research Station, Veppankulam revealed that higher dose of potassium and neem cake reduced the eriophyid mite incidence. Further, calcium, magnesium and boron are known to induce resistance to mites.

4.1.2. Effect of organic manures on eriophyid mite

The mean damage grade index in the chemical fertilizer treatment was the highest with 50%. The least damage of 29% was seen in the treatment of neem cake 2 kg + bone meal 0.5 kg + mill ash 4 kg (per tree/ year) (Muthiah and Bhaskaran, 2000). Chemical fertilizer + farm yard manure (50 kg per tree) showed a mite damage of 49%.

4.1.3. Effect of cropping system on the eriophyid mite

When high density multiple intercrops was raised, the mite damage was 58-64 per cent (Muthiah and Bhaskaran, 2000). Inter cropping of sunnhemp with coconut reduced the mite incidence upto 13.6 per centand reduced the damage grade.

4.1.4. Root feeding of nutrients and growth regulators for inducing resistance and rejuvenation of coconut palms infested by mite

The nutrient analysis of leaf samples of infested palms, after root feeding of nutrient mixture with NAA (40 ppm) and salicylic acid (200 ppm) recorded higher K, P, Mg, Ca, Zn, Fe, Mn, Cu and B compared to untreated infested control. The nutrient mixture contained urea 10 g, muriate of potash 10 g, zinc sulphate 5 g, ferrous sulphate 2g, magnesium sulphate 2g, copper sulphate 1g, borax 2g, managanese sulphate 2g, sodium molybdate 10 mg, planofix 1 ml, citric acid 10 mg and salicylic acid 20 mg per litre of water.

Higher mineral content definitely provides toughness to resist the attack, particularly K increased from 1.04 to 1.69 per cent. As K is an activator of numerous enzymes, it can enhance the metabolic processes, so as to reduce the mite incidence (Kamala Thirumalaiswamy *et al.*, 2000). Further, the physiological investigations of infested buttons recorded higher amounts of primary and secondary metabolites like total phenols (65mg/ g), ascorbic acid (207mg/g) and total carbohydrates (8.17mg/g) in the above treatment.

Accumulation of polyphenols increase the activity of polyphenol oxidase (PPO) under boron deficient condition. Oxidation of phenolics by PPO lead to production of quinones. Quinones are more toxic than

phenols, which lead to cell damage and cessation of growth. Quinones produced by PPO polymerized to brown pigments leading to browning of tissues . Wax content, acting like a mechanical barriers, was also high in the treatment as compared to control. NAA prevents button shedding by correction of hormonal imbalance.

4.1.5. Physiological changes due to salicylic acid

Salicylic acid induces resistance to pests and diseases. Salicylic acid is known to improve the uptake of P. It protects RNase activity and turn over of proteins. It enhances the growth and reproduction. Salicylic acid reduces IAA oxidase activity which promotes the auxin content and flower production. The spathe production is increased from 10 to 15/palm/year. The treatment in combination of nutrient mixture with NAA and salicylic acid was observed to retain higher percentage of buttons (43) than control (16.3).

4.1.6. Comparison of quality parameters in mite infested and uninfested coconut

The effect of mite on quality aspects *viz.*, reducing sugars, oil content and peroxidase were compared in infested and uninfested nuts. The harvested nuts were categorised, based on the external damage symptoms produced by the mite, into four grades *viz.*, grade 0 (no damage), grade 1 (upto 25% damage), grade 2 (26-50%) and grade 3 (>50% damage). The amount of reducing sugar in coconut water and kernel was found to be more in healthy nuts (0 grade nuts). The per cent reduction in oil content in infested nuts compared to healthy ones did not show much variation. In grade 3 nuts, the per cent reduction in oil content over healthy was 5.81. Peroxidase value was found to be less in healthy nuts (2.0 meq peroxidase /kg sample) while in grade 3 nuts it was 5.0 meq peroxidase/kg sample (Table 4). The increased peroxidase value indicated that the infested nuts may quickly become rancid. As the oil becomes rancid the amount of free fatty acid released from the oil increased which also acts as an indicator of rancidity (Geethalakshmi and Rabindra, 2000).

Table 4. Comparison of quality parameters in mite infested and uninfested coconut

Particulars	Reducing Sugars in coconut water (mg glucose / 100 ml)	Kernel (mg glucose / 100g)	Oil content * (g/100g dry wt)	Peroxidase Value (milli equivalent peroxidase / kg sample)	Free fatty acid (g oleic acid)
Healthy nuts	177	460	63.65	2.0	0.0224
25% infested nuts	155	420	61.63 (3.17)	2.8	0.0252
50% infested nuts	107	365	61.08 (4.04)	4.0	0.0252
100% infested nuts	93.5	275	59.95 (5.81)	5.0	0.0280

* Figures in parentheses indicate per cent reduction in oil content compared to healthy ones

by PPO lead to production of quinones. Quinones are more toxic than

4.1.7. The effect of crown cleaning

The crown cleaning and water spray was found to reduce the mite infestation as compared to uncleaned trees (Chezhiyan and Ramar, 2000).

4.2. Studies on varietal resistance to mite damage - Agricultural Research Station, Aliyarnagar

Studies on screening of germplasm maintained at the Agricultural Research Station, Aliyarnagar, Tamil Nadu showed that the tender coconut cultivar 'Kenthali' recorded the lowest surface damage of 20% compared to other cultivars. Tiptur Tall recorded the highest damage of 84% followed by St. Vincent, ECT and WCT 76%. Among the genotypes, Kenthali recorded the lowest mite population (16.33/8 sq.mm) followed by SCT x COD (19), BSI (27) as against Tiptur Tall (140.33) (Table 5) (Ramaraju *et al.*, 2000).

In another study during 2000-01, the harvested nuts from various germplasms were assessed for their intensity of damage adopting a scale of 1 to 5. A total of 11 assessments was made at each harvest. Kenthali recorded the lowest mean damage grade index (1.17) against West Coast Tall (WCT) (3.86) and FMD (3.85). In case of hybrids, Gangabondam (GBD) x WCT and East Coast Tall (ECT) x GBD recorded the lowest damage grade indices of 2.64 and 2.81, respectively. The hybrid COD x WCT registered the maximum damage grade index of 3.40.

Coconut Nursery, TNAU

An experiment was conducted at Coconut Nursery, TNAU, Coimbatore to investigate the extent of eriophyid mite incidence on different varieties / types of coconut. Among the 11 types tested, the incidence was low in D x T Green type (26.83%) followed by D x T orange (27.52%). In tall varieties, the incidence was high when compared to dwarf, but in hybrids, the incidence was minimum. In general, the green coloured genotypes showed lesser incidence than the other types. The minimum incidence was recorded in T x D green (26.83%) and the maximum incidence recorded in Dwarf Yellow (73.23%) followed by Tall Orange (64.40%). The mite incidence was almost equal in round and cylindrical nuts.

Table 5. Reaction of coconut genotypes / germplasm to coconut mite infestation

Genotypes / germplasm	Nuts in damage categories 3-5 (%)	No. of mites/ 8 sq.mm
Philippines Ordinary	72	111.00 hi
Sanramon	68	77.68 e-h
Gonthembili	64	38.33 abc
WCT x GB	52	38.33 abc
COD x WCT	60	92.00 f-i
Kenthali	20	16.33 a
Andaman Ordinary	72	75.67 d-h
Strait Settlement green	60	52.67 c-f
Tiptur Tall	84	140.33 i
Lakshadeep Ordinary	68	120.67 hi
WCT x COD	52	19.00 ab
ECT x MYD	48	48.33 b-e
Zanzibar	64	44.33 b-e
Java	64	54.00 e-g
St. Vincent	76	45.00 b-e
West Coast Tall (WCT)	76	87.00 fgh
East Coast Tall (ECT)	76	95.00 ghi
Federated Malay States	68	50.33 c-f
British Solomon Island (BSI)	40	27.00 abc

Means followed by common letters are not significantly different at 5% level by DMRT.

In another observation at coconut nursery, TNAU tree number 818 (Philippines) recorded only 2.67% nut damage for the past two years whereas the surrounding palms recorded 45.71 to 90.20 % nut damage (Table 6).

Table 6. Comparison of nut damage and mite population in tree No. 818 (Philippines) with neighbouring trees at Coconut Nursery, TNAU

Tree No./Variety	Percent nut damage	Mite population / 4sq. mm	
		4th bunch	5th bunch
818 (Philippines)	2.67	0.0	14.67
825 (Philippines)	90.20	19.67	46.00
791	78.26	0.0	34.67
792	73.13	8.67	43.33
793	58.82	0.0	48.67
817	45.71	23.33	26.67
819	67.19	14.00	38.33
824 (Andaman)	65.75	75.67	140.00
826 (Andaman)	76.36	20.33	6.33

Coconut Research Station, Veppankulam

The reaction of coconut genotypes available at Coconut Research Station, Veppankulam was studied for their resistance to eriophyid mite under natural conditions. The nuts harvested in each genotype during July 1999 were observed for the damage. The nuts from each genotype were divided in the five damage categories and classified according to visible surface damage as per the method described by Julia and Mariau (1979). Among the 11 genotypes screened for their reaction to the eriophyid mite, Lakshadweep ordinary (4.9%), Cochin China (10.4%), Andaman Ordinary (11.11%) and Gangabondam (12.7%) recorded lesser nut damage. The genotypes Seychelles (100%), St. Vincent (90%) and Nigerian Tall (87.5%) were found to be highly susceptible to mite attack. The resistance/susceptibility of these varieties to eriophyid mite needs further confirmation.

In another trial the reaction of 31 coconut genotypes was studied for their resistance to the eriophyid mite under natural conditions. The nuts harvested in each genotype during March 2001 were observed for the damage. The data on extent and influence of mite attack in each genotype is shown in Table 7. The results indicated that all the genotypes were susceptible to mite damage and the damage intensity ranged from 4.9 to 100 per cent.

the damage. The data on extent and influence of mite attack in each genotype is shown in Table 7. The results indicated that all the genotypes were susceptible to mite damage and the damage intensity ranged from 4.9 to 100 per cent.

Table 7. Nuts harvested in each damage category in selected genotypes

Genotypes	% of nuts damaged by mite
West Coast Tall	18.6
Lakshadweep Ordinary	4.9
Andaman Ordinary	11.4
Gangabondam	12.7
Cochin China	10.4
Malaysian Yellow Dwarf	28.5
Malaysian Green Dwarf	40.1
St. Vincent	90.4
Seychelles	100.0
Nigerian Tall	87.5
VHC 2	37.2

4.3. Management by Ecofriendly Agents

4.3.1. Botanicals

Results of a field experiment conducted at Sundapalayam on the management of the coconut mite with some botanicals showed that spot application of neem oil 3% and pungam oil 3% were effective in suppressing the mite population on tepals as well as on the surface of the nuts. Other treatments *viz.*, pinnai oil 3%, illuppai oil 3%, neem oil 2% + garlic extract 2.5% and triazophos 40 EC 5 ml/lit were also equally effective in reducing the damage by mites to the nuts (Table 8).

Table 8. Efficacy of certain botanicals in the management of coconut eriophyid mite at Sundapalayam

Treatments	Mean mite population (Nos./ 4mm²)		% damage to nuts after 3 applications
	Tepal	Nut surface	on 7th bunch
Neem oil 3%	4.89[a]	14.25[a]	18.75[a]
Pinnai oil 3%	9.65[c]	20.92[cd]	18.25[a]
Pungam oil 3%	5.89[ab]	18.05[abc]	25.00[ab]
Iluppai oil 3%	8.67[c]	15.97[ab]	25.00[ab]
NSKE 5%	7.83[bc]	20.47[cd]	37.50[bc]
Ipomaea leaf extract 5%	10.22[c]	24.00[d]	40.00[bc]
Jatropha leaf extract 5%	10.28[c]	21.58[cd]	38.75[bc]
NO 2% + garlic extract 2.5%	8.69[bc]	19.58[bc]	16.75[a]
Triazophos 40 EC 5ml/l	14.61[d]	24.33[d]	27.50[ab]
Untreated Control	19.03[e]	33.17[e]	55.00[c]

* In a column, means followed by similar letters are not different statistically (P<0.5) by DMRT

4 .3.2. Commercial neem formulations

Among the various neem formulations evaluated, Arishtau, Nimbecidin, Neem azal TS, Econeem and Neemarin all at 4 ml/l were found effective in that order in reducing the population of eriophyid mite 30 days after three applications. The damage on the nuts was minimum in Arishtau 4 ml/l treated trees (1.93) followed by Nimbecidin, Econeem, Neem azal TS and Neemarin (1.95, 1.95, 1.98 and 2.02 respectively) which were all on par. Control recorded a damage score of 3.70 (Table 9).

4.3.3. Fish Oil Rosin Soap

Among the ecofriendly agents, TNAU neem oil, neem azal, fish oil rosin soap and garlic+ neem oil as spray and neem seed kernel extract as root feeding tested in two locations *viz.*, T.V.S. Nagar and Somanur of Coimbatore district. Spraying of fish oil rosin soap (FORS) @ 4% twice

Table 9. Efficacy of commercial neem formulations on coconut eriophyid mite (Location : Sundapalayam)

Treatments		Population of eriophyid mite on nut surface (No./4mm²)*			Percent damaged nuts	Damage grading
		15	30	45		
Neemarin	4 ml/l spray	15.33 ^{ab}	26.18 ^{f}	23.80 ^{cd}	26.17 ^{bcd}	2.02^{a}
Neem azal TS	4 ml/l spray	16.83 ^{c}	18.33 ^{d}	28.80 ^{f}	26.49 ^{bcd}	1.98^{a}
Aristau	4 ml/l spray	14.15 ^{a}	16.25 ^{bc}	18.05 ^{a}	22.44 ^{abc}	1.93^{a}
Neem gold	4 ml/l spray	24.65 ^{e}	23.93 ^{e}	38.40 ^{hi}	35.09 ^{f}	2.26^{a}
Econeem	4 ml/l spray	19.90^{d}	15.15^{bc}	26.50^{e}	28.83^{de}	1.95^{a}
Nimbecidin	4 ml/l spray	15.08^{ab}	14.80 ^{ab}	22.58 ^{c}	20.50 ^{a}	1.95^{a}
Carbosulfan	15 ml + water 15 ml root feeding	15.33^{ab}	13.60 ^{a}	18.40 ^{ab}	21.71 ^{ab}	2.25^{a}
Neem oil 2% + garlic extract 2.5%	spray	26.33 ^{f}	32.48 ^{g}	30.58 ^{g}	36.22 ^{fg}	03.15^{b}
Untreated check		30.90 ^{g}	37.40 ^{h}	38.33 ^{h}	46.52 ^{h}	3.70^{bc}

* In a column, means followed by similar letters are not different statistically (P<0.5) by DMRT

at 60 days interval reduced the population of *A. guerreronis* to an extent of 78.6 per cent (with mean reduction of 55.08 and 59.24 per cent in two locations respectively (Palaniswamy *et al.*, 2000). Besides, garlic +neem oil, TNAU neem oil and neem azal spray recorded 63.00 and 60.42, 65.46 and 52.86, 54.02 and 44.69 per cent reduction in mite population over control in two locations respectively (Table 10). Among the chemicals, carbosulfan 25 EC @ 2ml/litre of water was highly effective in the control of mite population in both the locations (83.26 and 71.25 per cent reduction over control) and also recorded higher percentage of undamaged buttons (77.05%) in the fourth and fifth bunches 60 days after second spray. Wettable sulphur, FORS, TNAU neem oil recorded 50.29, 49.20 and 46.92 per cent undamaged buttons as against only 26.44 undamaged buttons in the untreated check.

Table 10. Evaluation of ecofriendly agents against coconut eriophyid mite

Treatments	Method of application	% reduction in mite population over check*		% of undamaged buttons
		TVS Nagar	Somanur	
Monocrotophos 36 WSC 15ml+15ml water	Root feeding	82.94 (45.71-96.10)	58.41 (8.81-79.19)	35.97
NSKE 25% 100 ml/tree	-do-	46.77 9.47-88.87)	45.31 (10.06-74.50)	29.70
Carbosulfan EC 2 ml/litre	Spot application	83.26 (49.27-98.88)	71.25 (37.89-99.38)	77.05
Wettable sulphur 80 WP 5 gm/litre	-do-	86.38 (76.34-98.88)	71.25 (13.83-62.08)	50.29
TNAU NO 60 EC (C) 3 %	-do-	65.46 (11.59-93.39)	52.86 (36.47-63.54)	46.92
Neem azal 5ml/litre	-do-	54.02 (3.20-87.80)	44.69 (28.30-63.08)	44.69
FORS 40 gm/litre	-do-	55.08 (15.09-74.83)	59.24 (0.0-78.60)	49.20
Garlic+neem oil 25 gm+20ml/litre	-do-	63.00 (27.61-96.74)	60.42 (49.68-78.53)	44.73
Untreated check	-	-	-	26.44

* Mean of 10 observeations. Figures in the parenthesis are ranges.

An ecofriendly formulation *viz.*, TNAU Agrobiocide containing plant extracts, plant based oils and fungal culture filtrate was developed at Azolla laboratory, TNAU. It was tested for its efficacy against eriophyid mite in coconut under field conditions. A total of 156 evaluation trials were conducted in Tamil Nadu by the Department of Agriculture and in various research stations and Krishi Vigyan Kendras by TNAU scientists. The formulation was applied as root feeding @ 30 ml/tree which recorded a reduction in mite population of 65.1-75.0%, 89.6-94.9% and 64.7-100% over untreated check on 15, 30 and 45 days after treatment (DAT) (Kannaiyan *et al.*, 2000a & b).

The TNAU Agrobiocide was released for sales by Thiru. Veerapandi S.Arumugam, Hon'ble Minister for Agriculture, Government of Tamil Nadu, Chennai on 18.08.2000.

Kerala Agricultural University, Vellanikkara developed an organic acaricide with the following ingredients.

Neem oil	200 ml	
Garlic	200 g	To prepare 10 litres of the organic emulsion
Washing soap	50 g	

The garlic is made into a paste by adding sufficient water, then sieved through a cloth to get the extract. The specified quantity of soap is cut into small pieces and then dissolved in hot water. The soap solution should also be sieved through a cloth. The soap solution is then mixed with neem oil and stirred well to make a good emulsion. This is further mixed well with the garlic extract and then made upto 10 litres by adding water and stirring well to make the neem garlic soap emulsion for spraying. This formulation controlled *A. guerreronis* and is recommended in Kerala (Nadarajan *et al.*, 2000).

4.4. Biological control

4.4.1. Predatory mites

Two species of predatory mites *viz., A. paspalivorus, Bdella* sp. and a tarsonemid were found inhabiting nuts underneath the perianth at a low population of 5-10/nut. But their predatory potential was not encouraging (Ramaraju *et al.,* 2000).

4.4.2. Effect of pathogens against coconut eriophyid mite

Studies conducted at the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore indicated that the entomogenous fungi, *Verticillium suchalosporium* and *Metarhizium anisopliae* were able to reduce the population of *A. guerreronis.*

Five entomogenous fungi *viz., Beauveria bassiana, Paecilomyces fumasoroseus, Catenaria* sp, *M. anisopliae* and an unknown culture isolated from dead mite (N/MS) were grown in the PDA broth and sprayed on the eriophyid mite affected nuts at Maruthamalai area, Coimbatore. The observations were recorded at 7 and 17 days after spraying (DAS). One nut from a bunch of each treatment was taken and the perianth was removed and the mite was extracted and fixed in Hoyer's medium on the slides and observed under the microscope. The unknown culture collected from dead mite (N/MS+Glycerine) was effective at 7 DAS. Out of 16 mites taken, only two were observed with hyphae ramified through genitalia (12.50%).

Field evaluation indicated that *Paecilomyces lilacinus* recorded high percentage of mortality (38.70%) followed by new fungus isolated from dead mite (U/DM-21.93), *V. suchalosporium* (15.90%) and *V. chlamydosporium* (10.32%). However, the untreated nuts also had 5.29% of mortality.

Another field trial was laid out with 16 treatments in TNAU. The mite population was recorded one, two and three months after spraying. The treatment combinations of *Pseudomonas fluorescens* @ 200g as soil application and *Fusarium* sp. (as spray) had 26.9 per cent mortality. Soil application of neem cake had 24.9 % followed by *Fusarium* sp. (spray) (16.70%) 30 days after application (Table 11).

Table 11. Biological control of eriophyid mite

Treatments	Mean mortality % (months after spraying)			
	1	2	3	mean*
Agrobiocide (Root feeding)	8.8	9.5	14.3	10.8^{cd}
Verticillium lecanii (foliar)	7.5	6.5	9.1	7.7^{cd}
V. suchalosporium (foliar)	10.4	9.8	12.8	11.0^{cd}
Pseudomonas fluorescens (soil)	7.8	6.0	9.3	7.7^{cd}
New isolate (*Fusarium* spp.)	16.7	13.0	19.2	16.3^{ab}
Agrobiocide + *V. lecanii*	10.5	6.3	7.3	8.1^{cd}
Agrobiocide + *V. suchalosporium*	10.1	8.1	12.0	10.1^{cd}
Agrobiocide + *P. fluorescens*	7.5	10.1	11.1	9.6^{cd}
Agrobiocide + New isolate (*Fusarium* spp.)	8.1	8.5	12.9	9.9^{cd}
P. fluorescens + *V. lecanii*	8.8	6.9	10.6	8.7^{cd}
P. fluorescens + *V. suchalosporium*	21.7	8.4	8.8	13.0^{bc}
P. fluorescens + New isolate (*Fusarium* sp.)	26.9	13.8	15.4	18.7^{a}
Neem cake (soil application)	24.9	12.2	12.7	16.4^{ab}
Mycohit	6.9	7.5	10.1	8.2^{cd}
Biocatch	9.2	8.5	8.5	8.7^{cd}
Untreated check	6.5	5.3	5.8	5.9^{d}

* Means followed by a common letter are not significantly different at the 5% level by DMRT.

Talc formulations were prepared for the *Fusarium* sp. and combinations of *Fusarium* and *P. fluorescens*. The survival of these organisms was tested by serial dilution technique. The fungus survived in the formulation upto two months.

The number of colony forming units in *Fusarium* sp. after two months was 20 x 10^5 cfu/g. The number of colony forming units in *Pseudomonas fluorescens* + *Fusarium* sp. after two months was 8 x 10^5 cfu/g.

4. 4.3. Effects of microbial antagonists

4.4.3.1. Selection of antagonistic microflora effective against coconut eriophyid mite

An experiment was conducted to isolate the antagonistic microflora from the eriophyid mite affected coconut buttons and screen them for their effectiveness in reducing the population of the eriophyid mite in coconut. Two bacterial isolates and seven fungal isolates were obtained from eriophyid mite affected tissues of coconut by following standard microbiological procedures. The bacterial isolates were tentatively identified as *Serratia marcescens* and *Pseudomonas* sp. and the fungal isolates were identified as *Rhizopus* sp., *Fusarium* sp. , (Plate.9) *Aspergillus niger, Aspergillus flavus, Aspergillus terreus, Trichoderma* sp. and *Penicillium* sp. The cell free extracts of bacterial isolates and the culture filtrates of fungal isolates were prepared and they were tested for their efficacy against the eriophyid mite in coconut by conducting bioassay studies. The results of the study (Table 12) revealed that the culture filtrate of *Fusarium* was more effective in reducing the population of eriophyid mite compared to the cell free extracts and culture filtrates of the other isolates (Kumar *et al.*, 2000).

Table 12. Effect of cell free extracts / culture filtrates of the bacterial / fungal isolates on the population of eriophyid mite in coconut buttons

Cell free extract / culture filtrate	Mean no.of mites/4 sq.mm	
	On nut surface*	On tepals*
Pseudomonas sp.	28.0 (18.4)	16.0 (14.0)
Serratia marcescens	37.3	19.6
Aspergillus flavus	24.3 (29.2)	7.3 (60.8)
Aspergillus niger	26.6 (51.6)	11.3 (39.2)
Aspergillus terreus	28.3 (17.5)	13.3 (28.5)
Fusarium sp.	8.30 (75.8)	2.0 (89.2)
Penicillium sp.	28.6 (16.6)	15.3 (17.7)
Rhizopus sp.	21.0 (38.8)	10.0 (46.2)
Trichoderma sp.	26.0 (24.2)	12.0 (35.5)
Untreated check	34.3	18.6

* Figures in parentheses represent per cent reduction over control

4.4.3.2. Effect of some plant extracts, agrochemicals and fungal and bacterial cultures on the eriophyoid mite population in coconut

A bioassay was conducted on the effect of some plant extracts, agrochemicals, fungal and bacterial cultures on the eriophyid mite population on coconut. The experiment was conducted with thirteen treatments (with some code Nos.). The bioassay was conducted by swabbing the upper surface of the perianth in the eriophyid mite affected coconut buttons with the cotton dipped in 10 ml of the solution containing the plant extracts (alcohol based), agrochemicals, fungal and bacterial cultures. After swabbing, the cotton dipped in the solution was placed on the perianth itself. The eriophyid mite population in the coconut buttons treated with the plant extracts, agrochemicals, fungal and bacterial cultures was recorded on 3rd and 6th day after the treatment. The observation recorded on the 3rd and 6th day of treatments is furnished in Table 13. The results showed that among treatments, the treatment with code No. ALE 16 was the most effective in reducing the eriophyid mite population followed by ALE17, ALE18 and ALE21.

4.4.3.3. Evaluation of TNAU Agrobiocide for its efficacy against eriophyid mite

A formulation containing plant products, biocides and agrochemicals was developed based on the bioassay studies conducted earlier and it was tested for its efficacy against eriophyid mite population in coconut under field conditions. The formulation was applied as root feeding and crown spraying. Separate control without root feeding / crown spraying was also maintained. Samples of coconut buttons were collected on 15, 30 and 45 days after root feeding / crown spraying and the population of the eriophyid mite in 2 mm^2 area was counted using the stereozoom microscope. A reduction in population over the untreated control ranging from 65.1-75.0%, 89.6- 94.9% and 64.7-100% was observed on 15, 30 and 45 days after treatment respectively in the root feeding treatment (TNAU Agrobiocide). However, severe shedding of buttons and flowers was observed in the trees in which crown spraying was undertaken.

Table 13. Effect of plant extracts, agrochemicals, fungal and bacterial cultures on the eriophyid mite population in the affected tissues of the coconut buttons and inner surface of the tepals

Code No. of Treatment	Mean No. of mite population / 4 mm²			
	On nut surface		On tepals	
	3 DAT	6 DAT	3 DAT	6 DAT
AL E 3	2.00	21.00	4.33	9.67
AL E 6	7.34	6.34	1.00	2.67
AL E 10	34.34	9.34	11.00	8.00
AL E 13	37.34	-	3.00	10.34
AL E 14	16.00	10.00	5.67	19.67
AL E 15	7.34	28.00	11.33	15.34
AL E 16	-	-	1.00	-
AL E 17	-	19.00	-	3.00
AL E 18	-	1.67	-	10.67
AL E 19	1.34	5.00	2.00	11.00
AL E 20	4.00	4.34	1.67	11.34
AL E 21	0.34	2.67	0.34	-
AL E 22	2.67	16.00	0.34	4.34

TNAU Research Stations

The TNAU Agrobiocide was tested in 25 locations by the scientists of TNAU at various Research Stations (Table 14a). The results revealed that the population reduction ranged from 62 to 100 per cent after the first round of root feeding (Agrobiocide) in 75 per cent of the tested centres. Similarly, in the carbosulfan (second round of treatment) root feeding, the population ranged from 59 to 99 per cent. Also in the third round of Agrobiocide treatment, the distribution in population was from 61 to 95 per cent. After three rounds of the treatment, the population reduction in the final stage was 70 per cent. In all the tested centres, the damaged buttons on the fourth bunch was 39.80 per cent in the treated palms compared to 60 per cent damage in the untreated check. On an average of 33 per cent reduction of damaged buttons over untreated check

Table 14a. Evaluation of TNAU Agrobiocide against coconut eriophyid mite by Research Stations of TNAU

	Places	Mean reduction of mite population over control 45 DAT (%)			Bunch damage assessment			
		TNAU Agrobiocide I round	Carbosulfan II round	TNAU Agrobiocide III round	Mean percentage of damaged buttons* Treated		Untreated	
					4th bunch	5th bunch	4th bunch	5th bunch
1.	i. ARS, Aliyarnagar	60.31	79.30	61.47	58.88	59.78	90.88	92.50
	ii. Aliyarnagar	78.26	54.27	67.05				
	iii. Navamalai	64.49	44.96	51.47				
	iv. Arasur	65.21	70.13	56.40				
	v. Palani	78.57	51.94	72.52				
	vi. Odaiyakulam	83.40	67.47	59.18				
2.	Tindivanam	62.12	75.05	80.22				
3.	Killikulam	38.82	46.95	30.35	81.00	—	93.78	—
4.	Aruppukottai	100.0	99.20	—	19.15	—	12.09	—
5.	Trichy	60.59	75.41	—	—	—	—	—
6.	Madurai	68.04	91.23	—	—	—	—	—
7.	Puduthamaraipatti	64.71	—	—	—	—	—	—

8.	Kovilpatti	99.32	93.44	99.54	22.00	—	85.40	—
9.	Veppankulam	97.20	—	—	—	—	—	—
10.	Cuddalore	64.03	59.64	—	—	—	—	—
11.	Srivilliputhur	34.40	33.5	—	59.20	—	100.00	—
12.	Paiyur	81.60	67.6	—	—	—	—	—
13.	Periyakulam	28.20	56.41	—	9.50	—	25.00	—
14.	Yethapur (Salem)	76.67	—	—	—	—	—	—
15.	Bhavanisagar	57.89	59.40	67.61	—	—	—	—
16.	Virinjipuram	94.36	83.34	100	—	—	—	—
17.	Sirugamani	48.30	23.72	52.79	66.00	—	60.00	—
18.	Aduthurai	86.01	92.41	94.16	3.05	—	28.70	—
19.	Coimbatore - I	00.00	62.75	61.52	79.37	95.00	69.61	90.00
	Coimbatore - II	77.58	45.16	94.41	00.00	25.00	28.75	85.00
	Mean	66.80	65.92	69.91	39.82	59.92	59.42	89.10

* Per cent reduction over control in 4th bunch- 33.00 and in 5th bunch- 32.80

was observed in the treated palms (Table 14a).

Department of Agriculture

The results obtained from the TNAU Agrobiocide multilocation trials (14 centres) conducted by the Joint Directors of Agriculture of Thiruchirappalli and Thanjavur districts indicated that the mean per cent of damaged buttons in the fifth bunch after three rounds of treatment was 55.00 as against 76.60 in the untreated check. The percentage reduction in nut damage over untreated check was 28.20. The results of the multi-locational trials conducted in two districts are given in Table 14b.

4.4.3.4. Studies on translocation of TNAU Agrobiocide using ^{86}Rb tracer in eriophyid mite infested coconut tree

Root feeding of TNAU Agrobiocide in coconut has been found to be one of the effective measures in controlling eriophyid mite infestation. With a view to understand translocation of TNAU Agrobiocide within the coconut tree, a study was conducted using radioactive ^{86}Rb tracer in TNAU Agrobiocide.

Rubidium being group I element, physiologically it is similar in action to that of potassium in plants and due to non availability of suitable K isotopes, ^{86}Rb is used as a tracer in K studies. Since TNAU Agrobiocide contains 0.6 per cent water soluble potassium ^{86}Rb was used as a tracer in this study.

Methodology for ^{86}Rb trace studies

Two coconut trees (Tree nos.386 and 384) infested with Eriophyid mite were selected at coconut nursery of Tamil Nadu Agricultural University, Coimbatore. The particulars of trees are as follows :

Particulars	Tree No.386	Tree No.384
Variety	Hybrid	Hybrid
Age	27 years	27 years
Height	11.50 m	14.10 m
Average girth	0.90 m	0.97 m
No. of leaves	34	37
No. of bunches	12	12

Table 14b. Evaluation of TNAU Agrobiocide against coconut eriophyid mite
(Results of multi-location trial conducted by Department of Agriculture, T.N)

District	Block	Mean percentage of damaged buttons in	
		Treated	Control
Trichy	Thiruverambur	37.5	75.0
	Manapparai I	57.7	74.7
	II	68.3	78.8
	Andanallur	85.6	95.0
	Srirangam	68.8	97.9
	Lalgudi	60.1	87.2
Thanjavur	Thanjavur	74.0	67.0
	Thiruvaiyaru	55.8	98.0
	Orathanadu	19.2	43.5
	Papanasam	37.8	58.3
	Kumbakonam	28.0	76.0
	Thiruvidaimaruthur	20.0	76.0
	Pattukkottai I	70.8	62.2
	II	86.6	82.2
Mean		55.0	76.6

Per cent reduction in damage over control - 28.2

Root feeding

^{86}Rb tagged TNAU Agrobiocide was fed through roots at the rate of 30 ml/tree. The total radioactivity in 30 ml of ^{86}Rb tagged TNAU Agrobiocide was 1.9576 mCi (72.43MBq) on the day of root feeding. Specific activity of the material was 65.27 mCi/ml (2.41MBq/ml).

Sampling

Plant samples were collected after complete absorption of ^{86}Rb tagged TNAU Agrobiocide by trees. Three and five days were taken by coconut tree No. 386 and 384 respectively for complete absorption. Samples were drawn from trees 386 and 384 on 1, 2, 3, 4, 5, 6, 7 and 10 and 1, 2, 3, 5 and 8 day, respectively. The plant parts sampled were nuts from one, two, three, four, five and six months old bunches, upper most, 14 and lower most leaves and tender coconut water (Tables 15 and 16).

*Specific activity in 5g of dry matter for samples 1to 9 and in 300ml of coconut water for sample 10 on the day of sampling.

It is seen from the results that

(i) Radioactivity was observed in all plant parts sampled from day one onwards which indicated that the material fed in roots was translocated to crown within a day.

(ii) There was an increasing trend in activity until fifth day and thereafter declined in all plant parts sampled (Table 15 and 16).

(iii) Higher levels of activity was observed in nuts of different bunches than in leaves. Tender coconut water registered lower level of activity among the plant parts sampled. This might be due to preferential movement of TNAU agrobiocide to physiologically more active young bunches (Table 15 and 16).

(iv) Among leaves, the 14th leaf recorded higher level of activity.

(v) Though there was a general decline in activity after 5th day in all plant parts, on 10th day in tree No. 386, leaves recorded higher activity than other samples which may be due to either higher translocation of material to leaves after 5th day or redistribution (Table 15). However, this trend was not observed in leaves of tree No.384. Instead, increasing trend in activity continued until 8th day in leaves (Table 16).

(vi) Among the trees, higher activity was observed in tree No.386 than 384 which indicated difference, in translocation of the material in a given time between trees, which might be due to difference in height, biomass and absorption efficiency of roots.

Table 15. Specific radioactivity*(Bq) in different parts of coconut tree No.386 (Mean of three samples)

Sample details	Day							
	1	2	3	4	5	7	10	Mean
Nuts (One month old)	25.60	33.87	53.81	140.18	64.71	185.72	56.61	08.68
Nuts (Two months old)	28.01	43.42	144.74	135.92	383.21	274.7	361.28	53.04
Nuts (Three months old)	24.66	71.04	92.23	159.37	283.90	264.36	100.04	56.51
Nuts (Four months old)	39.59	71.39	24.15	178.89	356.70	310.61	135.13	73.78
Nuts (Five months old)	35.91	51.64	138.08	170.33	221.44	199.27	183.12	42.83
Nuts (Six months old)	26.19	54.59	75.04	155.41	259.19	233.67	166.73	38.69
Upper leaf	3.97	22.02	27.55	28.95	163.57	115.96	149.88	73.13
14th leaf	17.66	21.71	50.36	68.21	222.52	123.26	174.25	96.85
Lower leaf	14.31	17.78	39.09	51.78	169.46	92.45	138.80	74.82
Tender coconut water	6.48	29.68	41.92	27.45	18.47	12.97	10.08	21.01
Mean	22.24	41.71	88.69	111.65	234.32	181.30	117.62	113.93

*Specific activity in 5g of dry matter for samples 1to9 and in 300ml of coconut water for sample 10 on the day of sampling.

Table 16. Specific radioactivity*(Bq) in different parts of coconut tree No.384 (Mean of three samples)

Sample details	Day					
	1	2	3	5	8	Mean
Nuts of 1 month old	43.67	47.81	68.99	278.58	84. 19	104.65
Nuts of 2 months old	46.21	50.25	78.57	252.48	97.12	104.93
Nuts of 3 months old	51.58	48.11	83.34	186.09	130.72	99.97
Nuts of 4 months old	51.92	49.96	76.96	338.41	190.14	141.48
Nuts of 5 months old	42.73	36.24	41.87	246.33	73.85	88.20
Nuts of 6 months old	36.07	34.71	43.06	148.47	49.09	62.28
Upper leaf	21.20	20.40	33.90	40.28	44.32	32.02
14th leaf	17.20	20.40	29.09	42.58	70.90	36.03
Lower leaf	12.03	16.46	26.70	32.62	64.24	30.41
Tender coconut water	14.47	19.47	36.93	11.48	7.83	18.04
Mean	33.72	34.38	51.94	157.73	81.24	71.80

4.4.3.5. Effect of inoculation of spore suspension of *Fusarium* on their colonization on the bracts and inner tissues of the bract in coconut buttons

An experiment was conducted to study the effect of swabbing/ spraying the spore suspension of the *Fusarium* isolate on its colonization on the bracts (upper and lower surface) and the tissues below the bracts in coconut buttons with typical symptoms of eriophyid mite incidence. The *Fusarium* isolate was grown on Czapeck's Agar medium in a Petri plate and after profuse sporulation the growth was scraped with the help of sterile inoculation needle and transferred to 100 ml sterile water containing 2 % sucrose. The conical flask containing the spore suspension was kept on a rotary shaker and thoroughly shaken for 1 hour for uniform distribution of spores.

The coconut buttons with symptoms of eriophyid mite incidence collected from the coconut nursery were arranged in a tray containing sand which was saturated with water. The buttons were arranged at 10 / tray. Two trays with 10 buttons in each tray was used for the experiment,

one for treatment with spore suspension and other for control (Sterile water with 2% sucrose only). Two sets of trays were used for studying the effect of colonization by swabbing 10 ml of the spore suspension with cotton on the top of the bract and by spraying 10 ml of the spore suspension on the surface of the bract. Suitable controls were maintained by swabbing the buttons with the cotton dipped in sterile water with 2 % sucrose only and by spraying the button with 2% sucrose solution in sterile water. The buttons sprayed / swabbed with spore suspension were covered with an incubation cabinet to avoid contamination. Samples were collected from 2 buttons in each tray daily till 5th day after treatment for studying the colonization of *Fusarium* on the surface and inner tissues of the bract and tissues of the bract and tissues below the bract by placing the bracts on the surface of the Czapeck's agar medium. Serial dilution of the tissue samples was also undertaken for estimating the population of *Fusarium* in the different tissues by stand plate count.

The results showed that the colonization of *Fusarium* occurred both on the upper and lower surface of the bracts and also in the tissues below the bracts right from the first day after treatment of the spore suspension either by swabbing / spraying (Plates 10, 11). The plating of the samples treated with spore suspension showed the typical growth of *Fusarium* colonies, whereas in the plates with control samples, there was no growth of *Fusarium* colonies. Only, a few colonies of *Aspergillus* were observed. The results indicated the colonization of *Fusarium* in the tissues below the bracts in the coconut buttons swabbed / sprayed with spore suspension right from first day after treatment.

4.4.3.6. Selection of suitable carrier materials for dust formulation of *Fusarium* sp.

A laboratory experiment was conducted to develop a dust formulation of *Fusarium* spore inoculum as a biocontrol agent against eriophyid mite in coconut. Different materials such as sorghum bran, wheat bran, maize bran, rice bran, maize flour, powdered sugarcane waste and talc were tried as carrier materials for developing the dust formulation of *Fusarium* spore inoculum. *Fusarium* spores were collected by filtering sporulated *Fusarium* culture (previously grown in Czapeck's broth at 26 ± 1° C for a period of 15 days) through a Buchner funnel with Whatman

No.1 filter paper. After filtration, the mycelial mat with spores were transferred to aluminium foil and air dried at 26 ± 1° C for a day followed by ovendrying at 60° C for overnight. The *Fusarium* spores were mixed at 0.1g each with 35 g of sorghum bran, 22.7g of wheat bran, 33g of maize bran, 35 g of rice bran, 21 g of maize flour, 10g powdered sugarcane waste and 25 g of talc powder based on the bulk density of the carrier material. Carboxy methyl cellulose at 0.1 g and 4 ml of Czapeck's broth were also added as sticking and moistening agents respectively. Then, the mixture was ground well in a sterile pestle and mortar under aseptic conditions and the contents were packed in a polythene bag and stored at 26 ± 1° C for one week. After storing for a week, the survival of the *Fusarium* in the spore inoculum was studied by following serial dilution plate technique using Czapeck's Dox Agar medium.

The results of the study indicated that talc supported the survival of *Fusarium* in the dust formulation of the spore inoculum better than the other carrier materials (Table 17 and Plate 12). The population of *Fusarium* in the talc based dust formulation was 64.5 x 10^3 g^{-1} of inoculant followed by maize bran (52.0 x 10^3 g^{-1} of inoculant) and maize flour (50.5 x 10^3 g^{-1} of on inoculant). However, contamination by *Aspergillus flavus* and some bacteria was also observed in the plates which might have been encountered during the air drying and blending processes of the *Fusarium* spores.

Table 17. Survival of *Fusarium* in the dust formulation of the spore inoculum prepared with different carrier materials

Carrier materials used	Population *x 10^3 g^{-1} of inoculant
Sorghum bran	36.0
Wheat bran	40.0
Maize bran	52.0
Rice bran	42.0
Maize flour	50.5
Sugarcane waste	40.0
Talc	64.5

* Population recorded after a week's storage of inoculum

4.4.3.7. Investigations on the profile of volatile compounds in infected and uninfected coconut buttons

Ten grams each of tissues were cut from underneath the perianth of infected and uninfected coconut buttons and steam distilled for 30 minutes. Using a separating funnel, the distillates were extracted with two 50 ml fractions of petroleum ether (40-60), condensed to 10 ml and stored for analysis. Gas chromatographic analysis of the above samples was done using FID and FFAP (15%) column with N_2 as carrier gas. The gas flow was set at 30 ml / min. The isocratic temperature setting was 90° C, 100° C and 110° C for column, injector and detector respectively. The values of the peaks are expressed as milli volts (Y axis) and the retention time is expressed as minutes (X axis). The preliminary gas chromatographic analysis of the petroleum ether extracts revealed some variations in the composition of a few volatile and distillable compounds in the eriophyid mite infected and uninfected coconut buttons (Fig. 3). A component, that has a retention time of 6.4 min found in the sample tissues from unifected coconut buttons is totally missing in the sample tissues from infected coconut buttons, whereas the components those having the following retention times *viz.*, 8.5, 9.1, 9.8 and 10.5 min show considerable reduction in the peak areas suggesting that the reduced levels of these components might play a role in the susceptibility.

4.4.3.8. Development of TNAU – Biocide

A talc based dust formulation of *Fusarium* inoculum known as TNAU – Biocide was developed as a biocontrol agent against coconut eriophyid mite. The inoculum was prepared with *Fusarium* cultures isolated from the infected tissues of coconut buttons and cadavers of coconut eriophyid mite. This *Fusarium* isolate is capable of sporulating profusely with abundant production of macro and microconidia. The population load of *Fusarium* in the dust formulation was estimated and the inoculant was found to have a population 2.5 x 10^6 per gram of inoculum (Table 18). A bioassay study was conducted to evaluate the effectiveness of TNAU – Biocide on coconut eriophyid mite by dusting the TNAU-Biocide on coconut buttons. When the tissues below the perianth from the coconut buttons applied with TNAU – Biocide, were plated on

Czapeck'sAgar medium, the *Fusarium* was reisolated from the tissue samples collected on the 3rd day after application of the dust formulation, which indicated the colonization of *Fusarium* within 3 days after application of dust formulation (Table 19). The observations on the population of eriophyid mite recorded on 3rd, 6th and 9th day after application of TNAU- Biocide in the coconut buttons showed that the dead mites in the coconut buttons applied with TNAU – Biocide was in the range of 41.37 to 93.75% (Table 20). The dust formulation may be applied at 200g / tree.

4.4.3.9. Development of a spray formulation for eriophyid mite

A spray formulation containing the plant based oils was also developed and tested for its efficacy against the eriophyid mite in a bioassay study. The results of the bioassay study indicated that 1:1 and 1:5 dilution of the spray formulation with water, when sprayed on the coconut buttons, resulted in the death of mites considerably. The dead mites / 4 sq. mm area in the coconut buttons sprayed with 1:1 and 1:5 dilution of spray formulation was in the range of 75.0 to 93.0 % and 60.5 to 85.3% respectively (Table 21).

4.4.3.10. Effect of Actinomycetes on the eriophyid mite population in coconut

Seventeen different cultures of actinomycetes were isolated and purified from the soil samples collected from the rhizosphere of coconut trees that are not infested by mites. The cell free extracts and the cell homogenates of the cultures grown in Ken knight's medium were taken and applied directly on the tepals of the infected coconut buttons of same size (10 cm height x 18 cm girth) by placing dipped cotton wads. The treated coconut buttons were kept in a cool place to prevent drying. The observations for eriophyid mite mortality was made on second, third, fourth and fifth day after treatment. The results showed no mortality of eriophyid mites.

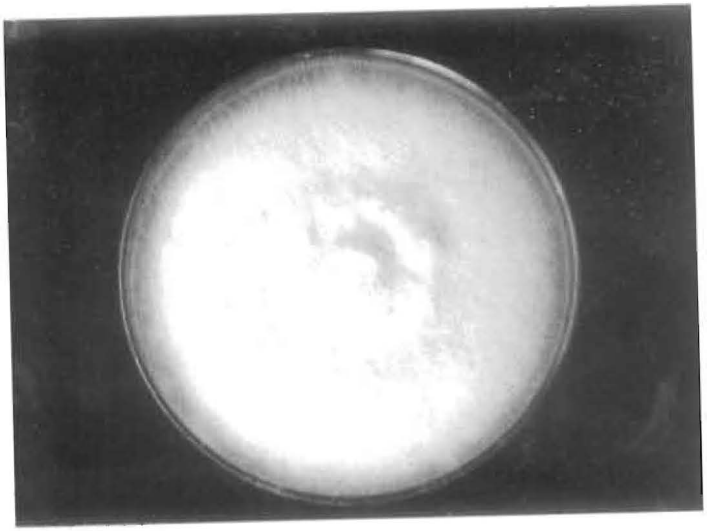


Plate 9. *Fusarium* sp.

Plate 10. Bioassay of *Fusarium* spore suspension on colonization of mite in the bracts and inner tissues of coconut buttons (Swabbing)

Plate 11. Bioassay of *Fusarium* spore suspension aginst mite colonization in the bracts and inner tissues of coconut buttons

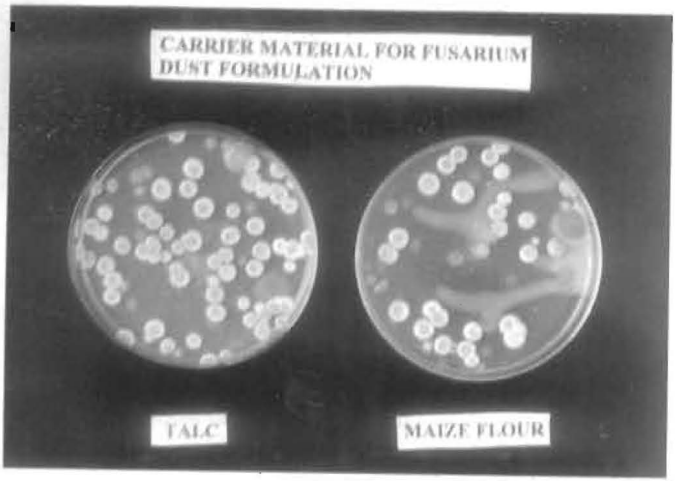
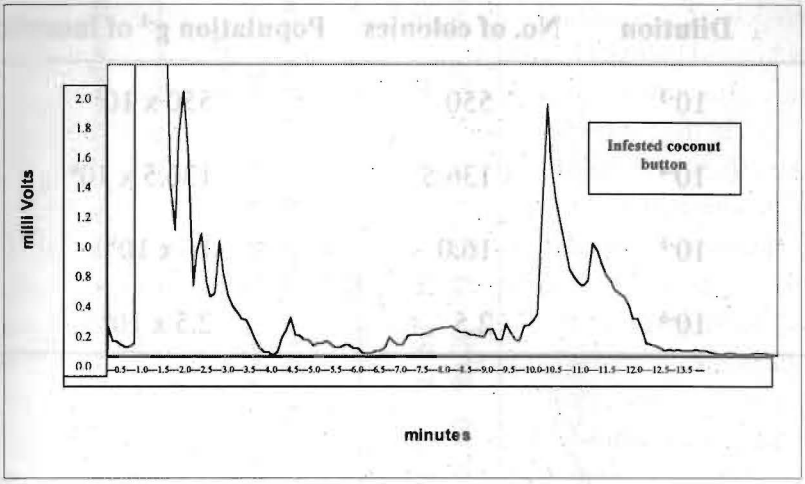


Plate 12. Carrier material for *Fusarium* dust formulation

Fig. 3. HPLC Profile of eriophyid mite infested and uninfested tissues of coconut buttons



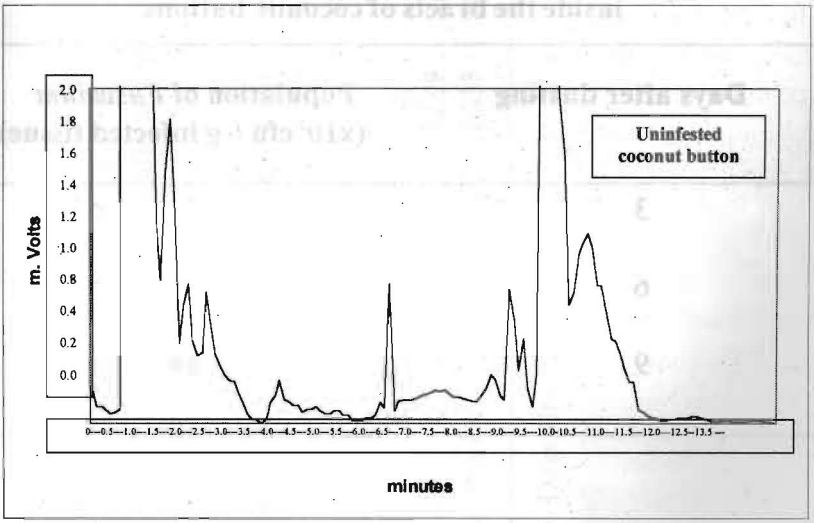


Table 18. Population of *Fusarium* sp. in the TNAU – Biocide (Talc based dust formulation)

Dilution	No. of colonies	Population g^{-1} of inoculant
10^{-3}	550	550×10^3
10^{-4}	136.5	136.5×10^4
10^{-5}	16.0	16×10^5
10^{-6}	2.5	2.5×10^6

Table 19. Effect of dusting TNAU – Biocide (Talc based dust formulation) on the colonization of *Fusarium* inside the bracts of coconut buttons

Days after dusting	Population of *Fusarium* ($x10^2$ cfu / g infected tissue)
3	4
6	12
9	28

Table 20. Effect of dusting TNAU - Biocide (Talc based dust formulation) on the population of eriophyid mite in coconut buttons (No.of mites / 4 sq. mm)

Treatment	3 DAD				6 DAD				9DAD			
	Live mites	Dead mites	Total mites	% of dead mites	Live mites	Dead mites	Total mites	% of dead mites	Live mites	Dead mites	Total mites	% of dead mites
Control	23.33	9.66	32.99	29.28	19.33	2.33	21.66	10.75	21.33	4.66	25.99	17.92
TNAU - Biocide	11.00	13.33	24.33	54.78	17.00	12.00	29.00	41.37	1.00	15.00	16.00	93.75

DAD - Days after dusting

Table 21. Effect of spray formulations on the population of eriophyid mite on coconut buttons (4 sq. mm)

Treatment	3 DAD				6 DAD				9 DAD			
	Live mites	Dead mites	Total mites	% of dead mites	Live mites	Dead mites	Total mites	% of dead mites	Live mites	Dead mites	Total mites	% of dead mites
Control	23.33	9.66	32.99	29.28	19.33	2.33	21.66	10.75	21.33	4.66	25.99	17.92
Spray formulation	32.66	17.00	49.66	34.94	1.00	4.00	5.00	80.00	2.00	30.00	32.00	93.75
Spray formulation + Water (1 :1)	12.66	30.66	43.32	70.77	1.00	3.00	4.00	75.00	1.66	22.83	24.49	93.22
Spray formulation + Water (1:5)	8.66	13.33	21.99	60.61	5.33	12.33	17.66	69.81	4.66	27.00	31.66	85.28
Spray formulation + Water (1:10)	8.00	9.00	17.00	52.94	36.00	4.66	40.66	11.46	2.00	20.66	22.66	91.17

DAD - Days after dusting

4.4.3.11. Effect of certain biocontrol agents against eriophyid mite

Field experiments conducted at Coconut Research Station, Veppankulam with two fungal pathogens (*Fusarium* sp and *V. lecanii* @ 10^6 spores/ml) and fish oil rosin soap (FORS) 4 per cent revealed that fish oil rosin soap 4 per cent either alone (57% population reduction) or in combination with *Fusarium* sp. significantly reduced the mite population by 57 and 61 per cent respectively, 30 days aftere spraying. The combination of fungal pathogen with FORS recorded higher reduction in mite population than spraying with fungal pathogen alone (Muthiah *et al.*, 2001).

4.5. Chemical control

Many field experiments were conducted to evaluate the efficacy of different insecticides / acaricides by the University, for the management of *A. guerreronis*. The experiments were conducted in the farmers field at Avalur (Erode district), Thathur, Cheripalayam, T.V.S. Nagar, Madampatthy, Somanur (Coimbatore district) and two research stations *viz.*, Agricultural Research Station (ARS), Aliyarnagar and Bhavanisagar. Two rounds of insecticide/acaricide spraying / root feeding were given at 60 days interval.

The results of Aliyarnagar indicated that the highest mortality (70.29%) was observed in triazophos spray 5 ml/l and monocrotophos 1.5 ml/l (57.98%) at 7 and 15 DAT respectively. At 23 DAT, differences among treatments were not significant in the first round of treatments, but in the second round of spraying, methyl demeton 4ml/l (72.49), triazophos 5 ml/l (70.92%) and phosalone 3 ml/l (68.07%) were effective and on par with each (Table 22).

Table 22.Bioefficacy of insecticide/acaricides against coconut mite, *Aceria guerreronis*
(Place : ARS, Aliyarnagar)

Treatments	Per cent mortality (DAT)*				
	I Round		II Round		
	7	15	7	15	23
Monocrotophos 36 WSC 1.5ml/l	23.28^{bc}	57.98^{a}	54.34^{a}	49.75^{ab}	62.68^{abc}
Dimethoate 30 EC 2.0ml/l	25.21^{bc}	15.78^{cde}	38.74^{a-d}	29.61^{b-f}	47.73^{a-f}
Dicofol 18.5 EC 2.5 ml/l	15.77^{bc}	38.38^{abc}	30.19^{a-d}	26.46^{c-f}	65.10^{ab}
Wettable sulphur 80WP 2g/l	14.66^{bc}	15.91^{cde}	19.75^{bcd}	21.14^{def}	36.91^{b-g}
Ethion 50 EC 2ml/l	28.10^{bc}	36.70^{a-d}	32.57^{a-d}	18.12^{def}	31.31^{d-g}
Dichlorvos 76 EC 1ml/l	13.55^{bc}	8.40^{e}	25.96^{a-d}	15.45^{ef}	32.58^{c-g}
Endosulfan 35 EC 2ml/l	23.32^{bc}	18.73^{b-e}	39.89^{a-d}	30.70^{b-f}	45.94^{a-f}
Phosalone 35 EC 2ml/l	14.59^{bc}	31.22^{a-d}	16.51^{cd}	35.46^{a-e}	31.93^{d-g}
Acephate 75 SP 1g/l	28.46^{bc}	12.97^{de}	36.03^{a-d}	38.31^{a-d}	20.97^{f-g}
Triazophos 40 EC 1.5m/l	32.82^{b}	33.68^{a-d}	24.25^{a-d}	33.74^{b-e}	48.81^{a-f}
TNAU Neem oil 60 EC (C) 3%	12.44^{bc}	28.07^{b-e}	38.06^{a-d}	25.91^{c-f}	55.65^{a-e}
TNAU Neem oil 0.03% EC	11.03^{bc}	28.66^{b-e}	15.73^{cd}	13.48^{f}	13.53^{g}
Methyldemeton 25 EC 2ml/l	26.53^{bc}	33.61^{a-d}	39.28^{a-d}	25.38^{c-f}	29.90^{d-g}
Fenthion 100 EC 1ml/l	21.48^{bc}	29.42^{b-e}	41.15^{abc}	38.16^{a-d}	58.08^{a-d}
Triazophos 5ml/l	70.29^{a}	42.79^{ab}	34.43^{a-d}	49.97^{ab}	70.92^{a}
Methyldemeton 4ml/l	31.46^{bc}	44.59^{ab}	39.20^{a-d}	31.68^{b-f}	72.49^{a}
Phosalone 3ml/l	16.75^{bc}	32.13^{a-d}	35.22^{a-d}	33.51^{b-e}	68.07^{a}
Monocrotophos 3ml/l	—	—	50.29^{ab}	56.75^{a}	51.71^{a-e}
Dicofol 6ml/l	—	—	41.30^{abc}	47.76^{abc}	63.53^{ab}
Neem oil 2%+garlic extract 25 g/l	—	—	25.14^{a-d}	32.69^{b-f}	45.52^{af}
Untreated check	9.85^{c}	13.38^{de}	11.91^{d}	15.27^{ef}	26.33^{efg}

DAT - Days after treatment

* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

At Thathur, dicofol 2.5 ml/l (41.79%), triazophos 5 ml/l (68.16%) (Table 23) and methyl demeton 4.0 ml/l (61.89%) showed the highest per cent mortality at 7, 15 and 23 DAT, respectively. At Avalur, TNAU Neem oil 60 EC (C) 3% was superior to all other treatments recording the highest per cent mortality (46.50 and 58.57% after first and second rounds, respectively)(Table 24) at 7 DAT and triazophos 1.5 ml/l recorded the highest mortality of 51.07% at 15 DAT after second round of spray. At Aliyarnagar, among the root feeding treatments, monocrotophos 15 ml + 15 ml of water was significantly superior to all other chemicals by recording a maximum mortality of 61.57 and 73.55% (Table 25) 15 DAT of first and second rounds, respectively (Ramaraju et al., 1999).

The results of the studies conducted at Agricultural Research Station, Bhavanisagar and a farmer's field at Cheripalayam revealed that root feeding with monocrotophos 15 ml + 15 ml water was the most effective treatment against the mites recording maximum population reduction of 80.25 to 92.89 per cent. Carbosulfan 15 ml+ 15 ml of water recorded a maximum of 79.09 to 89.87 per cent reduction followed by profenofos 15 ml+15 ml of water (75.82%) and triazophos 15 ml + 15 ml of water (74.13%) (Philip Sridhar *et al.*, 2000; Tables 26-28).

Six insecticides at higher concentrations (5 ml /litre of water) were evaluated as spot application on the bunches for their efficacy against coconut mite along with FORS and monocrotophos root feeding at Madampatty (Karuppuchamy *et al.*, 2001). Among the spot applications, triazophos 5 ml/l., carbosulfan 5 ml/l and monocrotophos 5 ml/l were found to be highly effective recording 67 to 100, 58.93 to 90.57 and 44.37 to 100 per cent reduction in mite population over control, after second round of spray. The nut damage at 60 days after second spray showed higher undamaged buttons of 100, 100 and 73.61%, respectively, in the fourth and fifth bunches (Tables 29, 30).

Table 23.Bioefficacy of insecticides/acaricides against coconut mite, *Aceria guerreronis* (Place: Tathur)

Treatments	Per cent mortality (DAT)*				
	I Round			II Round	
	7	15	23	15	23
Methyl demeton 2ml/ l	27.09^{b-e}	19.57^{c}	20.77^{a-d}	48.07	40.91 ^{abc}
Methyl demeton 4 ml/l	34.55^{abc}	52.63^{abc}	24.12 $^{a-d}$	61.11	61.89^{a}
Phosalone 2 ml/l	15.42^{d-e}	35.01^{bc}	17.99^{cd}	43.57	47.80 ^{abc}
Phosalone 3 ml/l	31.17^{a-d}	39.34^{bc}	14.02^{cd}	54.05	40.21 ^{abc}
Triazophos 2 ml/l	19.33^{cde}	54.76^{abc}	29.59^{a-d}	50.58	43.71 ^{abc}
Triazophos 5 ml/l	37.84^{abc}	68.16^{ab}	51.29^{ab}	60.86	52.07 ^{abc}
Dimethoate 2 ml/l	31.64^{a-d}	30.61^{c}	33.57^{a-d}	59.67	44.07 ^{abc}
Monocrotophos 1.5 ml/l	40.90^{ab}	51.23^{ab}	52.35^{a}	60.09	45.56 ^{abc}
Dicofol 2.5 ml/l	41.79^{ab}	39.10^{bc}	31.91^{a-d}	68.50	41.37 ^{abc}
Dichlorvos 1 ml/l	35.79^{abc}	24.47^{c}	19.35^{bcd}	39.71	43.46 ^{abc}
TNAU Neem oil 60 EC (C) 3%	31.80^{a-d}	28.52^{c}	33.44^{a-d}	33.52	55.14 ^{ab}
Triazophos 20 ml + 20 ml water	30.08^{bcd}	50.56^{ab}	23.21^{a-d}	64.34	33.46 ^{abc}
Triazophos 10 ml + 10 ml water	39.73^{ab}	47.03^{abc}	43.51^{abc}	57.06	14.62 ^{c}
Monocrotophos 10ml+10ml water	36.59^{abc}	37.61^{bc}	45.20^{abc}	63.96	31.53 ^{abc}
Methyl demeton 10ml+10ml water	43.00^{ab}	75.77^{a}	22.55^{a-d}	59.41	35.80 ^{abc}
Dimethoate 10 ml+10 ml water	52.65^{a}	45.64^{abc}	21.12^{a-d}	39.61	18.33 ^{bc}
Monocrotophos 3ml/l	—	—	—	53.39	56.75 ^{ab}
Dicofol 6ml/l	—	—	—	44.05	46.05 ^{abc}
Neem oil 2%+garlic extract 25 g/l	—	—	—	31.29	28.49 ^{abc}
Untreated check	11.62^{e}	36.22^{bc}	10.84^{d}	28.06	31.57 ^{abc}
				NS	

DAT - Days after treatment

* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 24. Bioefficacy of insecticides/acaricides against coconut mite, *Aceria guerreronis* (Place: Avalur)

Treatments	Per cent mortality (DAT)* I Round		II Round	
	7	15	7	15
Monocrotophos 10ml+10ml water	26.46 ab	41.57	56.44 ab	32.37 abc
Methyldemeton 10ml+10ml water	20.85 ab	11.20	20.19 c	24.76 abc
Dimethoate 10ml+10ml water	22.19 ab	24.91	24.31 c	24.92 abc
Phosphamidon 5ml+5ml water	23.15 ab	31.49	22.35 c	31.29 abc
Monocrotophos 1.5 ml/l	26.54 ab	17.65	0.75 d	20.38 bcd
Dimethoate 2ml/l	15.89 b	13.43	31.96	29.49 abc
Dicofol 2.5ml/l	23.52 ab	33.61	26.47 bc	26.76 abc
Wettable sulphur 2g/l	28.74 ab	17.47	32.62 abc	36.93 abc
Ethion 2ml / l	22.69 ab	6.85	16.47 c	29.60 abc
Dichlorvos 1ml/l	38.19 ab	33.34	17.41 c	43.01 ab
Endosulfan 2ml/l	14.75 b	23.78	19.13 c	8.34 d
Phosalone 2ml/l	35.53 ab	27.10	17.49 c	21.36 bcd
Acephate 1 g/l	36.59 ab	18.63	31.26 abc	51.07 a
Triazophos 1.5 ml/l	31.42 ab	18.80	58.57 a	14.98 cd
TNAU Neem oil 60EC (C) 3%	46.50 a	25.50	26.71 bc	11.77 cd
TNAU Neem oil 0.03% EC	16.34 ab	3.73	13.58 cd	33.81 abc
Untreated check	12.17 b	7.26	10.93 cd	20.30 bcd
		NS		

DAT - Days after treatment

* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 25.Bioefficacy of insecticides against coconut mite, *Aceria guerreronis* (Place: ARS, Aliyarnagar)

Treatments	Per cent mortality (DAT)*			
	I Round		II Round	
	7	15	7	15
Monocrotophos15ml +15ml water	39.88^{b}	61.57^{a}	33.98^{abc}	73.55^{a}
Monocrotophos10ml +10ml -do-	31.62^{ab}	38.94^{bc}	41.33^{a}	45.93^{bc}
Methyldemeton15ml +15ml -do-	33.24^{ab}	44.48^{b}	14.83^{c}	48.12^{bc}
Methyldemeton10ml +10ml -do-	22.96^{ab}	30.87^{bc}	45.77^{a}	40.42^{bc}
Dimethoate 15ml +15ml -do-	29.08^{ab}	27.08^{bc}	47.01^{a}	33.58^{bc}
Dimethoate 10ml +10ml -do-	33.77^{ab}	29.86^{bc}	38.19^{ab}	31.23^{bc}
Phosphamidon 10ml +10ml -do-	26.34^{ab}	45.45^{b}	28.10^{abc}	47.40^{bc}
Phosphamidon 5ml +5ml -do-	20.42^{ab}	44.51^{b}	33.18^{abc}	51.94^{b}
Triazophos 20ml +20ml -do-	31.86^{ab}	41.03^{b}	28.27^{abc}	36.39^{bc}
Triazophos 10ml +10ml -do-	46.16^{a}	36.05^{bc}	44.47^{a}	31.10^{bc}
Untreated check	11.76^{b}	15.29^{c}	17.32^{bc}	24.88^{c}

DAT - Days after treatment

* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 26. Bio-efficacy of insecticides against coconut mite
(Place : Bhavanisagar - I round)

Treatments		15 DAT		30 DAT		45 DAT	
		Mean mite population	% reduction over control	Mean mite population	% reduction over control	Mean mite population	% reduction over control
Monocrotophos 36 WSC 15ml+ 15ml water	Root feeding	1.67 [a]	90.57	3.25[a]	89.87	1.00[a]	92.89
Ethion 50 EC 15ml+15ml water	Root feeding	4.50[ab]	74.40	9.88[ab]	69.35	10.50 [bcd]	25.44
Imidacloprid 200 SL 5ml+5ml water	Root feeding	18.17[ab]	-	9.66ab	69.86	3.83[ab]	72.78
Carbosulfan 25 EC 15ml+15ml water	Root feeding	14.83[ab]	15.64	3.25[a]	89.87	8.17[bc]	42.00
Econeem 15ml+ 15ml water	Root feeding	15.42[ab]	12.31	14.33[abc]	55.335	12.42[bcd]	11.82
TNAU NO 60 EC (C) 15ml+15ml water	Root feeding	12.00[ab]	31.75	9.58[ab]	70.13	19.50[d]	-
Profenofos 50 EC 15ml+15ml water	Root feeding	4.25[ab]	75.82	9.67[ab]	68.86	6.92[bc]	50.88
Carbofuran 3G 20 gm (in 4 sachets @ each 5 gm)	Crown Placement	23.67[b]	-	9.83[ab]	69.35	12.00[cd]	14.79
Phorate 10 G 10 gm (in 4 sachets @ each 2.5 gm)	Crown Placement	2.67[ab]	84.83	25.08[bc]	21.81	8.50[bc]	39.64
Control		17.85[ab]	-	32.08[c]	-	14.08[cd]	-

DAT - Days after treatment ;* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 27. Bio-efficacy of insecticides against coconut mite
(Place : Bhavanisagar - II round)

Treatments		15 DAT		30 DAT		45 DAT	
		Mean mite population	% reduction over control	Mean mite population	% reduction over control	Mean mite population	% reduction over control
Monocrotophos 36 WSC 15ml+15ml water	Root feeding	5.92^{ab}	65.53	10.83^{ab}	35.32	3.00	91.44
Ethion 50 EC 15 ml+15ml water	Root feeding	12.33^{bcd}	28.15	21.25^{b}	-	12.67	63.89
Imidacloprid 200 SL 5ml+ 5ml water	Root feeding	5.83^{ab}	66.02	6.00^{ab}	64.17	5.50	84.32
Carbosulfan 25 EC 15ml+ 15ml water	Root feeding	21.67^{d}	-	10.25^{ab}	38.80	7.33	79.09
Econeem 15 ml+15ml water	Root feeding	16.00^{bcd}	6.79	6.67^{ab}	60.19	15.50	64.37
TNAU NO 60 EC (C) 15ml+ 15ml water	Root feeding	17.75^{cd}	-	6.83^{ab}	59.20	12.33	55.82
Profenofos 50 EC 15 ml+ 15ml water	Root feeding	4.25^{a}	75.24	6.83^{ab}	59.20	3.80	64.84
Carbofuran 3G 20 gm (in 4 sachets @ each 5 gm)	Crown Placement	9.75^{a-d}	43.20	9.92^{ab}	40.79	11.33	67.69
Triazophos 15 ml+15 ml water	Crown placement	7.67^{abc}	44.66	4.33^{a}	74.13	13.00	64.32
Phorate 10 G 10 gm (in 4 4 sachets @ each 2.5 gm)	Crown placement	13.92 ^{bcd}	18.93	13.42^{ab}	19.89	12.69	63.42
Control		17.17^{bcd}	-	16.75^{b}	-	35.08	-

DAT-Days after treatment ;* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 28. Bio-efficacy of insecticides against coconut mite (Cheripalayam)

Treatments		15 DAT		30 DAT		45 DAT		60 DAT	
		Mean mite population	% reduction over control	Mean mite population	% reduction over control	Mean mite population	% reduction over control	Mean mite population	% reduction over control
Monocrotophos 36 WSC 15ml+ 15ml water	Root feeding	6.08[a]	78.71	5.68[ab]	80.25	14.83[a]	40.26	15.75[ab]	65.94
Ethion 50 EC 15 ml+15ml water	Root feeding	9.33[a]	67.34	10.00[abc]	65.21	12.92[a]	47.98	20.00[ab]	56.75
Carbosulfan 25 EC 15ml+15ml water	Root feeding	18.25[ab]	36.15	5.33[a]	81.45	16.75[a]	32.54	13.33[a]	71.17
Econeem 15 ml+ 15ml water	Root feeding	7.60[a]	73.41	23.00[bc]	20.00	24.00[a]	3.35	32.75[ab]	29.18
Profenofos 50 EC 15ml+15ml water	Root feeding	16.25[ab]	43.14	14.00[abc]	51.30	11.92[a]	52.01	22.67[ab]	50.99
Carbofuran 3G 20 gm	Crown placement	8.25[a]	71.13	13.83[abc]	51.88	9.03[a]	63.42	47.58[b]	-
Phorate 10 G 10gm	Crown placement	9.42[a]	32.94	27.50[c]	4.34	21.92[a]	11.74	41.92[ab]	9.36
Control		28.58[b]	-	28.75[c]	-	24.83	-	46.25[ab]	-

DAT-Days after treatment ;* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 29. Evaluation of insecticides against coconut eriophyid mite
(Place : Madampatty - I round)

Treatments		15 DAT		30 DAT		45 DAT		60 DAT	
		No. of mites / 4 sq.mm	Reduction over control (%)	No. of mites /4 sq.mm	Reduction over control(%)	No. of mites /4sq.mm	Reduction over control(%)	No. of mites 4/ sq.mm	Reduction over control(%)
Monocrotophos 36 SL 15ml+ 15ml water	Root feeding	41.00[a]	43.58	29.00[a]	57.56	25.33[a]	61.43	19.67[ab]	67.58
Monocrotophos 5ml/l	Spot application	41.00	43.58	35.33[a]	48.30	32.00[a]	51.27	29.33[b]	51.66
Methyldemeton 25 EC 5ml/l	-do-	43.33[a]	40.37	32.67[a]	52.19	32.67[a]	50.25	26.67[b]	56.07
Dicofol 18.5 EC 5 ml/l	-do-	36.00[a]	50.46	37.33[a]	45.37	28.33[a]	56.86	24.33[ab]	59.90
Profenofos 50 EC 5 ml/l	-do-	51.33[ab]	29.37	26.67[a]	60.97	25.67[a]	60.91	18.33[ab]	69.79
Triazophos 40 EC 5 ml/l	-do-	41.00[a]	43.58	31.00[a]	54.63	25.67[a]	60.91	14.00[a]	76.92
Carbosulfan 25 EC 5 ml/l	-do-	34.67[a]	52.29	29.00[a]	57.56	29.67[a]	54.82	28.00[b]	53.35
Fish Oil Rosin Soap 40 g/l	-do-	33.33[a]	54.14	27.33[a]	60.06	25.00[a]	61.93	19.00[ab]	68.68
Untreated check		72.67[b]	-	68.33[b]	-	65.67[b]	-	60.67[c]	-

DAT-Days after treatment ;* Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Table 30. Evaluation of insecticides against coconut eriophyid mite
(Place : Madampatty - II round)

Treatments	15 DAT		30 DAT		45 DAT		60 DAT		
	No.of mites /4 sq.mm	% reduction over check	No.of mites /4 sq.mm	% reduction over check	No.of mites /4 sq.mm	% reduction over check	No.of mites 4/ sq.mm	% reduction over check	% of unda-maged buttons*
Monocrotophos 15 ml+15ml water	1.67^{a}	96.47	0.00^{a}	100.00	1.33^{ab}	96.24	28.00^{d}	44.37	59.59
Monocrotophos 5 ml/l	1.67^{a}	96.47	0.00^{a}	100.00	0.33^{a}	99.07	3.33^{ab}	93.38	100.00
Methyldemeton 5ml/l	46.00^{c}	2.81	8.00^{ab}	72.10	16.00^{c}	53.78	45.67^{e}	9.26	74.90
Dicofol 5 ml/l	19.00^{bc}	59.86	1.67^{a}	94.18	9.33^{c}	73.59	12.00^{bc}	75.50	78.96
Profenofos 5 ml/l 13.33^{b}	71.84	26.33^{bc}	8.13		18.33^{c}	48.12	19.33^{cd}	61.59	69.66
Triazophos 5 ml/l	15.67^{bc}	66.99	0.00^{a}	100.00	1.33^{ab}	96.24	1.67^{a}	96.68	100.00
Carbosulfan 5 ml/l	19.33^{bc}	59.86	7.67^{ab}	75.00	3.00^{b}	90.57	20.67^{cd}	58.93	73.61
FORS 40 g/l	21.67^{bc}	54.22	18.67^{c}	34.88	13.67^{c}	61.31	25.00^{d}	50.33	69.83
Untreated Check	47.33^{c}	-	28.67^{c}	-	35.33^{d}	-	50.33^{e}	-	42.66

DAT-Days after treatment

* Percentage of infested buttons in the 4 / 5 month old bunches

Means followed by common letter (s) are not significantly different at 5% level by DMRT.

Experiments conducted at Coconut Research Station, Veppankulam revealed that spraying of triazophos 5 ml/l and carbosulfan 2ml/l significantly reduced the mite population by 70 and 68 per cent respectively, 30 days after two rounds of spraying. FORS at 4% either alone or in combination with *Fusarium* sp significantly reduced the mite population by 51 and 55 per cent respectively, 15 days after spraying. The spray treatments of chemicals are more effective than the root feeding treatments (Muthiah and Bhaskaran, 2000).

The bioefficacy of insecticides/acaricides against coconut eriophyid mite was studied at ARS, Aliyarnagar based on the damage symptoms on nuts. Three rounds of insecticide treatments were given at 60 days interval. The percentage of infestation on green nuts (bunches 3-6) on the trees was assessed. The nuts harvested from the treated palms six months after the commencement of treatment were graded based on the following scale adopted by Julia and Mariau (1979)

Intensity of damage	Surface area infested	Grades
Nuts with no mite damage	(0%)	1
Nuts with superficial damage	(1-10%)	2
Nuts with significant mite damage, but not greatly reduced in size	(11-25%)	3
Nuts with significant mite damage showing diminished size and distortion in shape	(26-50%)	4
Nuts very heavily attacked, very much reduced size and often greatly distorted	(>50%)	5

The results showed that spot application of triazophos 5 ml/l recorded the highest per cent of undamaged green nuts on the trees *viz.*, 90.62, 89.45, 90.18 and 81.36 on bunch 3, 4, 5 and 6 respectively (Table 31). In harvested nuts the percent infestation was less in monocrotophos 3.0 ml/l (12.50%), monocrotophos 10+10 ml (56.25%) and methyl demeton 4 ml/l (57.14%) as against untreated control (93.10%) (Ramaraju *et al.*, 2000).

Table 31. Effect of insecticides on mite damage to nuts

	Percentage of nuts in							
	Bunch 3		Bunch 4		Bunch 5		Bunch 6	
Treatments	**Damaged**	**Undamaged**	**Damaged**	**Undamaged**	**Damaged**	**Undamaged**	**Damaged**	**Undamaged**
Monocrotophos 10ml+10ml (RF)	50.39^{ab}	49.61	42.38^{abc}	57.62	69.45^{cd}	30.55	73.64^{bc}	26.36
Monocrotophos 15 ml+ 15 ml (RF)	37.15^{ab}	62.85	51.74^{abc}	48.26	52.93^{ad}	47.07	65.20^{bc}	34.80
Triazophos 10 ml+ 10 ml (RF)	68.75^{b}	31.25	65.63^{bc}	34.37	60.72^{bcd}	39.28	73.61^{bc}	26.39
Monocrotophos 1.5 ml/l	61.10^{ab}	38.90	45.00^{abc}	55.00	20.72^{ab}	79.28	47.72^{abc}	52.28
Monocrotophos 3 ml/l	40.00^{ab}	60.00	25.00^{ab}	75.00	25.00^{abc}	75.00	37.50^{ab}	62.50
Triazophos 5 ml/l	9.38^{a}	90.62	10.55^{a}	89.45	9.82^{a}	90.18	18.64^{a}	81.36
Methyl demeton 4 ml/l	36.97^{ab}	63.03	36.27^{abc}	63.73	63.79^{bcd}	36.21	42.21^{abc}	57.88
Dicofol 2.5 ml/l	35.27^{ab}	64.73	87.50^{c}	12.50	84.82^{d}	15.18	85.42^{c}	14.58
Dicofol 5 ml/l	45.83^{ab}	54.17	75.92^{bc}	24.08	68.66^{cd}	31.34	61.54^{abc}	38.46
Monocrotophos 1.5ml+ Phorate 10 G @ 10 g/tree	27.08^{ab}	72.92	45.25^{abc}	54.75	75.17^{d}	24.83	75.17^{bc}	24.83
Phorate 10g/tree	46.33^{ab}	53.67	85.00^{c}	15.00	76.04^{d}	23.96	75.00^{bc}	25.00
Untreated check	45.59^{ab}	57.41	69.01^{bc}	30.99	87.50^{d}	12.50	83.20^{bc}	16.80

Mens followed by a common letter(s) are not significantly different at the 5% level by DMRT

RF-Root Feeding

Similarly, the mean damage grade in monocrotophos 3.0 ml/l spray was the lowest (1.12) followed by root feeding of monocrotophos 10 ml + 10 ml (1.88), triazophos 10 ml+ 10ml and dicofol 5.0 ml/l spray (2.13), and monocrotophos 15 + 15 ml (2.25) root feeding as against 4.07 in monocrotophos 1.5 ml + phorate 10 G @ 10 g sachet/tree. The mean damage grade recorded in the untreated check was 3.79.

4.6. Integrated management practices for eriophyid mite

Chemical control is the only method so far followed by the farmers for managing the eriophyid mite in coconut. However, it is felt that it may not be always safe to depend totally on chemicals and also the mite may develop resistance to the chemicals. Continuous use of chemicals lead to accumulation of insecticide residues over a period of time. Therefore, a decision was taken by the Tamil Nadu Agricultural University to develop an integrated package consisting of cultural practices, nutrient management methods, biological methods and ecofriendly chemical methods to manage the coconut eriophyid mite.Thus a new integrated package of practices was proposed (Kannaiyan *et al.*, 2000b).

i.	Urea	1.3 kg /tree/year
ii.	Super phosphate	2 kg /tree/year
iii.	Muriate of potash	3.5 kg/tree/year
iv.	Neem cake	5 kg/tree/year
v.	Borax	50 g
vi.	Gypsum	1 kg
vii.	Magnesium sulphate	0.5 kg

viii. Grow sunhemp as intercrop two times per year

As per the decision of NATP - Sensitization workshop meeting held at Bangalore, a decision was taken to give a pesticide holiday for one year from July 2001.

4.7. Testing of small hand sprayers for their suitability to carry and spray on coconut trees

4.7.1. Ganesh sprayer

In the one litre capacity Ganesh sprayer there is no provision for directing the nozzle alone towards the required position. No provision to carry the sprayer on shoulder. Moreover the compression has to be done frequently by pressing the lever with thumb, which is not liked by the operators.

4.7.2. Concorde Sprayer

This sprayer is completely made of plastic and the farmers in Dindigul area have purchased this sprayer to carry it to the top of the coconut tree for spot application of chemicals. The capacity is 2 lit. and the weight is only 1.3 kg. The sprayer can be carried on shoulder. But when the piston is continuously operated to obtain the required pressure, cracks are formed in the piston. The life of the sprayer is also very short.

4.7.3. Maruti Sprayer

This sprayer is made of brass and hence the life is more. The capacity is 3 lit. and the weight is 2.75 kg. About 2/3rd of the tank can be filled with the required chemical and required pressure can be created on the ground it self. The sprayer along with chemical can be easily carried on the shoulder of the operator, he can climb easily and spray the chemical by directing the nozzle to the required position since the nozzle along with control lever is connected to the tank by hose.

4.7.4. Spraying devices for spot application of pesticides on coconut bunches

In the tractor mounted coconut tree sprayer developed at TNAU, the spray gun is taken to the required height upto 15 m and the chemical can be sprayed in the form of mist to the canopy of the tree, thereby the drifting is avoided. In addition, the up and down movement of the telescopic pipes about its vertical axis through 360° to spray the chemical in any direction and oscillating movement (up and down through 70°) of the

spray guns to target the required position of the canopy are provided to spray the chemical at any height, at any angle, and in any position. These features of the sprayer ensure that the entire canopy at the top of tree can be sprayed without any difficulty. But the disadvantage is that a lot of spray fluid is wasted during spot application of chemical on the bunches (Manian *et al.* 2000).

The following two models of slip on type ring devices were developed for easy clamping and removing to the top of the tree trunk (Manian *et al.* 2000).

a. Model I

The unit consists of three parts *viz.*,

i. Clamp
ii. Circular ring
iii. Lance with nozzle and hoses

The clamp is mainly for fitting the circular ring at the top of the tree. It is adjustable to suit any size of the coconut trees. The circular ring is designed based on the average distance of the bunches from the tree. Four number of spray lances in the bending posture are fitted to this circular ring to cover all the bunches. The nozzles are fitted to the lance and position of the nozzles can be adjusted to suit the bunch position. Each nozzle is connected with plastic hose and the four hoses from the nozzle are connected with main delivery line which extends upto the bottom of the tree so that it can be attached with the commercially available rocker sprayer or portable engine operated sprayer for spraying the chemical. The portable engine operated sprayer consists of 3.1 hp petrol start kerosine run engine with 3600 rpm speed connected to ASPEE HSP-TS 18 spray pump (Horizontal single piston pump) with a suction capacity of 12 litres per hour. The maximum pressure developed by the pump is 28 kg/cm^2. To cover more bunches, the spray lances are hinged to the circular frame with springs so that they can be oscillated from the bottom. The cost of the unit is Rs. 750/- (Fig. 4).

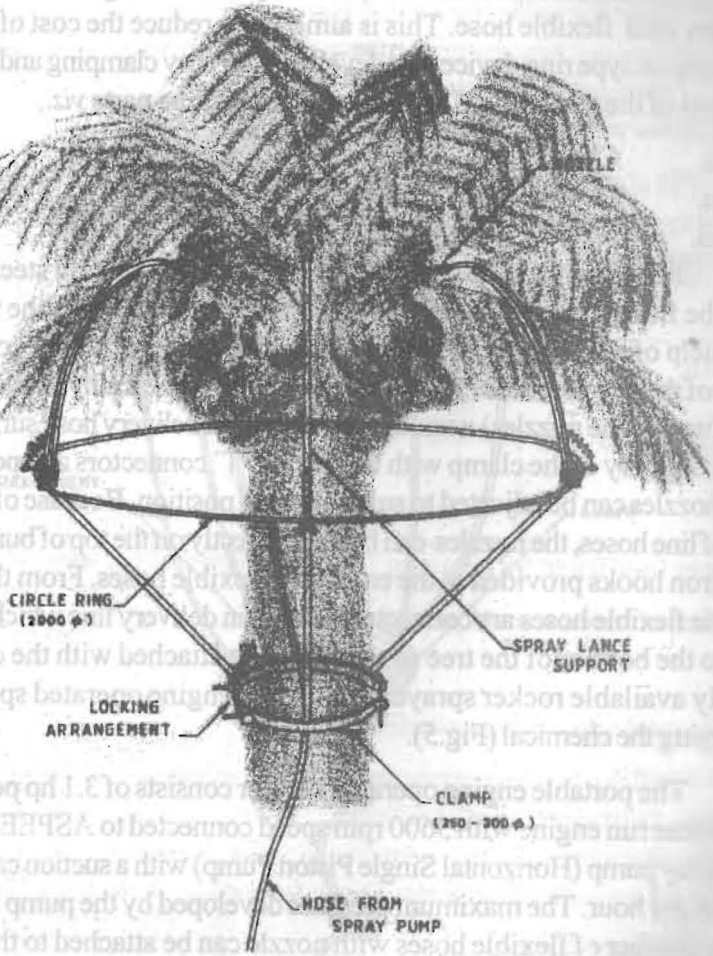


Fig 4. SPRAYER FOR SPOT APPLICATION ON COCONUT BUNCHES

b. Model II

The model I is further simplified by eliminating the iron ring and lances with flexible hose. This is aimed at to reduce the cost of the unit. The slip on type ring device was developed for easy clamping and fitting to the top of the tree trunk. The unit consists of three parts *viz.*,

i. Clamp
ii. Flexible hoses
iii. Nozzles

The clamp is an oval shaped structure made of mild steel flat and can be fitted at the top portion *i.e.* just below the crown of the tree with the help of ratchet type locking arrangement. It is adjustable to suit any size of the coconut trees. Flexible hoses with commercially available plastic (broad cone nozzles) nozzles are fixed to the delivery hose surrounding the periphery of the clamp with the help of 'T' connectors and position of the nozzles can be adjusted to suit the bunch position. Because of flexibility of line hoses, the nozzles can be fixed directly on the top of bunch using the iron hooks provided at the end of the flexible hoses. From the clamp all the flexible hoses are connected with main delivery line which extends up to the bottom of the tree so that it can be attached with the commercially available rocker sprayer or portable engine operated sprayer for spraying the chemical (Fig.5).

The portable engine operated sprayer consists of 3.1 hp petrol start kerosene run engine with 3600 rpm speed connected to ASPEE HSP-TS 18 spray pump (Horizontal Single Piston Pump) with a suction capacity of 12 lit. per hour. The maximum pressure developed by the pump is 28 ksc. Any number of flexible hoses with nozzle can be attached to the clamp. The cost of the unit for covering two to six bunches works out to Rs. 150-300 with out the spraying unit. One set of clamp with required number of flexible hoses and nozzles, delivery pipe from the bottom of the tree have to be permanently fitted to each tree. With rocker sprayer 20 to 25 trees can be sprayed per hour and with engine operated sprayer 25 to 30 trees can be sprayed in an hour. The salient features of the unit are:

- Required quantity of chemical can be applied in the desired spot without wastage.

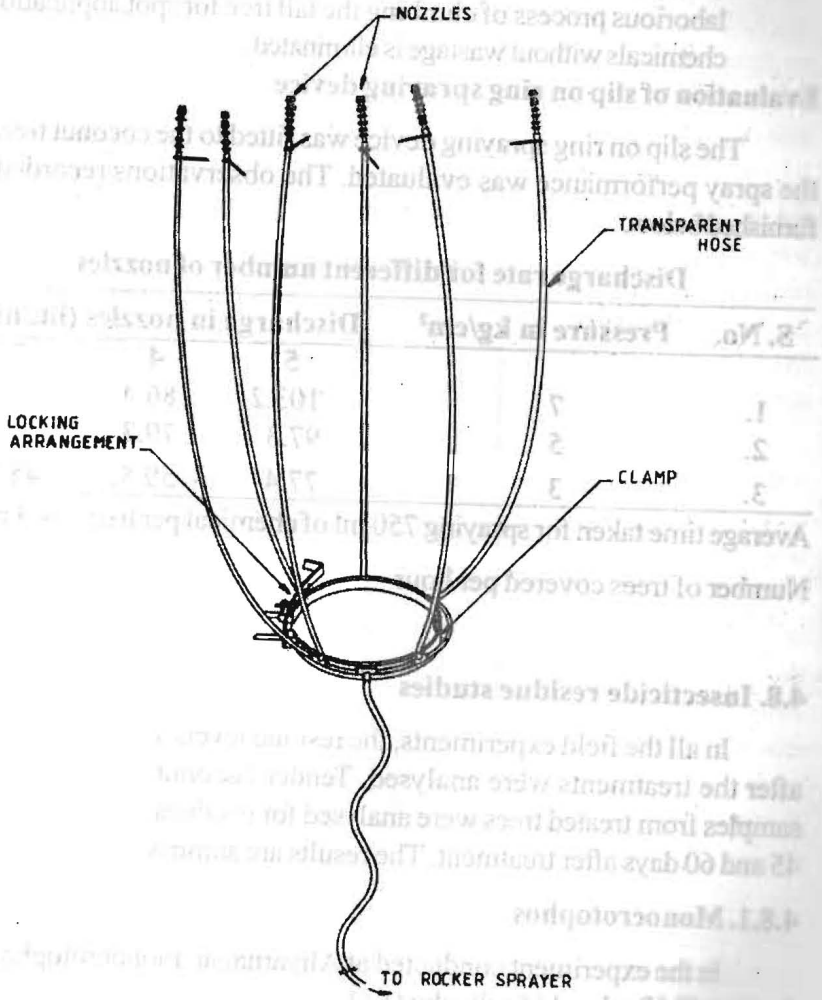


Fig 5. SPRAYING ATATACHMENT TO COCONUT TREE

- Position of the clamp and the nozzle can be adjusted to the required position during harvest of nuts or cleaning the crown.
- Since the spraying device is permanently fixed in the tree the laborious process of climbing the tall tree for spot application of chemicals without wastage is eliminated.

Evaluation of slip on ring spraying device

The slip on ring spraying device was fitted to the coconut tree and the spray performance was evaluated. The observations recorded are furnished below.

Discharge rate for different number of nozzles

S. No.	Pressure in kg/cm²	Discharge in nozzles (lit./hr.)		
		5	4	3
1.	7	103.2	86.4	62
2.	5	97.3	79.3	54.8
3.	3	77.4	59.5	45.2

Average time taken for spraying 750 ml of chemical per tree = 3 min.

Number of trees covered per hour = 20

4.8. Insecticide residue studies

In all the field experiments, the residue levels at different periods after the treatments were analysed. Tender coconut water and kernel samples from treated trees were analysed for residues 0, 3, 7, 10, 15, 30, 45 and 60 days after treatment. The results are summarised in Table 32.

4.8.1. Monocrotophos

In the experiment conducted at Aliyarnagar, monocrotophos root feeding @ 10 ml and 15 ml/palm (1 : 1 v/v with water) was given twice at 60 days interval to 10 year old palms in mound system. No detectable quantities of residues were found either in coconut water or in kernel at the lower dose (10 ml root feeding) upto 60 days following first and second round of application. But at the recommended dose (15 ml/ palm as root feeding) measurable amounts of residue were detected only on 15 and 30 days after first and second application in coconut water (0.0200

Table 32. Residue profile of insecticides applied by root feeding @ 15 ml + 15 ml of water

Insecticide	Location	Max. residue observed (µg/g)		Wating period (days)	MRL (µg/g)
		Water	Kernel		
Monocrotophos	Aliyarnagar	0.05	0.28	45	0.01
	Bhavanisagar	0.04	0.03	45	0.01
	Cheripalayam	0.02	0.28	45	0.01
Triazophos	Aliyarnagar	0.06	0.28	60	0.10
Profenophos	Bhavanisagar	0.03	0.19	60	0.01
	Cheripalayam	0.04	0.04	60	0.01

– 0.0497 µg/g) and coconut kernel (0.1977 – 0.2830 µg/g). The residues were more in kernel than in water. Considering maximum residue limit for related crops as 0.1 µg/g, the level observed in the kernel on 15th and 30th day following each round of effective dose application is quite high. But no detectable residues were found on 45th day of application in coconut-water and kernel. Hence, a waiting period of 45 days is recommended for safe consumption after root feeding with monocrotophos.

In the experiments conducted at Bhavanisagar and Cheripalayam, the effective dose of 15 ml monocrotophos + 15 ml water root feeding was administered to 20-25 year old palms. No detectable amounts of residues were found in coconut water and kernel in Cheripalayam experiment, while, at Bhavanisagar measurable quantities of residues were found in coconut water (0.0373 µg/g) and kernel (0.0275 µg/g) and were well below the prescribed tolerance limit of 0.1 mg/g (Kuttalam *et al.*, 2000).

4.8.2. Triazophos

Root feeding with triazophos @ 10 ml and 20 ml (1 : 1 v/v with water) was applied twice at 60 days interval to 10 year old palms at Aliyarnagar. At the lower dose, the triazophos residues were in detectable amounts in coconut water only on 30th day after first application (0.0486 µg/g), 15 and 30 days after second application (0.0271-0.0387µg/g). But at higher dose, measurable residues were found in coconut water and kernel on 30 and 45 days after first application and 15 and 30 days after second application. Considering the tolerance limit for related crops as 0.1 µg/g for oil seed crops, the level observed after 45 days of application is well below the tolerance level (Kuttalam *et al.*, 2000).

Triazophos fed through coconut root @ 10, 15, 20 and 40 ml / palm did not record any residue in coconut water. Residue in kernel was below detectable level (BDL)when tried @ 10 and 15 ml / palm. Residue of 0.05 and 0.06 ppm respectively were seen when fed at 20 and 40 ml / palm. This however was below the maximum residue limit (MRL) of 0.1 – 0.2 ppm (Narasimha Rao, 2000).

4.8.3. Carbosulfan

Carbosulfan residue in both trials at Bhavanisagar and Cheripalayam were BDL up to 60 days in both coconut water and kernel samples after root feeding of 15 ml + 15 ml of water (Kuttalam *et al.*, 2000).

4.8.4. Profenofos

The residue of profenofos were in detectable amount 3 days after application in coconut water at Bhavanisagar and Cheripalayam (0.0153 – 0.0205 µg/g). However, the residue was detected both in coconut water and kernel from 7 days after application upto 30 days in both the experiments. No detectable amount of residue was observed 45 days after application in Bhavanisagar, while coconut kernel in Cheripalayam trial contained 0.0215mg/g of profenofos residue. Considering the MRL of 0.05 µg/g in kernel, the profenofos residue observed at 45 days after application was below the tolerance limit (Kuttalam *et al.*, 2001)..

5. Extension and other activites

5.1. Radio Talk / Farm Advisory Service

- Radio talks were given by Prof. Dr. S. Kannaiyan, Vice-Chancellor, TNAU, Dr.Sabitha Doraiswamy, Director, Centre for Plant Protection Studies, Dr.S.Uthamasamy, Director of Extension Education and scientists from the Department of Agricultural Entomology during 2000-2001 on the management of coconut eriophyid mite.
- Plant protection recommendations were given to the coconut farmers who visited the University with the problems of mite and other pests on coconut.

5.2. Video programme

- A 20 minute video film on the management of mite was produced by the university and the same was telecast in Doordarshan for the benefit of the farmers repeatedly.

5.3. Group meeting and other activities on the management of coconut eriophyid mite

- One day group meeting on the management of coconut mite involving 50 scientists from Tamil Nadu was conducted at TNAU campus, Coimbatore on 15.05.2000. The Vice-Chancellor, TNAU, Coimbatore chaired the meeting. Fifteen research papers on the workdone on the management of coconut mite were presented and package of practices for the management of mite was developed.
- One day workshop on the management of coconut mite was held on 19.05.2000. A total of 120 scientists and officers of the Department of Agriculture attended the meeting. Prof. Dr. S.Kannaiyan, Vice-Chancellor chaired the workshop. Th. N.Athimoolam, Secretary to Government, Agriculture Department, Chennai gave a brief introduction regarding the management of coconut mite in Tamil Nadu. The Vice-Chancellor, TNAU made a presentation on the problem solving activities in coconut mite undertaken by TNAU. A package of recommendations for the management of the coconut mite was prepared and sent to the Secretary, Department of Agriculture, Secretariat, Chennai and Director of Agriculture, Chennai for adoption.
- The Secretary, Agriculture Department to Government of Tamil Nadu, reviewed the progress of work on the management of coconut mite on 05.07.2000 at Tamil Nadu Agricultural University, Coimbatore-641 003.
- A one day training programme on symptom, population assessment, damage and root feeding technique was conducted to the University staff on 28.07.2000. The Task Force Members and the scientists working on mite management participated.
- A one day workshop on coconut mite management was held on 18.08.2000 at TNAU. Ninety four staff from Department of Agriculture, 49 university research scientists and 229 progressive and marginal farmers participated. Hon'ble Minister for Agriculture released the Agro-biocide developed by TNAU to the farmers. Hon'ble Minister for Environment, pollution control and sports also participated in

the meeting. The Secretary to Government of Tamil Nadu, Department of Agriculture also participated. The Vice-Chancellor highlighted the inter-disciplinary research and an interim recommendation developed by the University was given to the Department of Agriculture for adoption. The views of farmers were also discussed.

- The package for the management of coconut eriophyid mite was presented by the Vice-chancellor, Tamil Nadu Agricultural University in the Scientific Workers Conference on 19 and 20.07.2000.
- Detailed discussions on coconut mite management were made with the scientists of the university and extension functionaries in the Scientific Workers Conference during 2001. The Vice-chancellor presented an overview of eriophyid mite and its management in Tamil Nadu.
- A two day training on coconut eriophyid mite management was given to 50 Agricultural Officers, Department of Agriculture, Tamil Nadu on 19.12.2000 and 20.12.2000.
- The Vice-chancellor participated in the Inter Institutional Group Meeting on Coconut eriophyid mite management at CPCRI, Kasaragod on 23.01.2001.
- A state level collaborative training on IPM in coconut was conducted by the Directorate of Extension Education. Dr. Sabitha Doraiswamy, Director, Centre for Plant Protection Studies gave a special lecture on IPM of coconut pests. Various scientists from CPPS delivered lectures during August 2001.
- About 600 leaflets on TNAU Agro-biocide (English and Tamil) and more than 1000 leaflets on coconut mite management (English and Tamil) were distributed to the farmers.
- Popular articles on coconut mite were published in Valarum Valanmai, news papers and other magazines .
- The live specimens on coconut mite, symptoms of damage and management practices were exhibited in AGRI-INTEX 2000 and 2001, Farmers day 1999,2000,2001 and 2002 and during VIP visits. Thousands of farmers were benefited during the Farmers day and AGRI-INTEX.
- Skill demonstrations on root feeding of TNAU-Agrobiocide and carbosulfan were conducted for the staff of the Department of Agriculture and Horticulture in August 2000.

5.3. Important events

- A series of seven task force meetings with scientists were held and the Vice-chancellor, TNAU reviewed the progress of research on management of coconut mite from October 1998 – December 2001.
- The Vice-Chancellor, TNAU along with other scientists participated in the Inter Institutional Group Meeting on coconut eriophyid mite management held at Lalbagh, Bangalore on 06.05.2000. Hon'ble Minister for Horticulture, Karnataka presided over the meeting.
- The scientists met the Hon'ble Minster for Agriculture, Government of India at Vellanikara on 23.05.2000 and apprised the ongoing research programmes on coconut mite.
- The Director, CPPS, TNAU attended the group discussion cum review meeting on the progress of management of coconut eriophyid mite organised by Coconut Development Board (CDB) at Thiruvananthapuram on 30.06.2000. The meeting was chaired by the Secretary to Government of India, Department of Agriculture and cooperation, New Delhi.
- Four scientists from TNAU under the leadership of Director, CPPS participated in the International Coco-Tech Workshop on July 25-26, 2000 at Chennai.
- Dr. R. J. Rabindra, Principal Investigator of NATP attended the SAP meeting/ workshop at Bangalore during July , 2001.
- Dr. R. J. Rabindra, Principal Investigator of NATP attended the Inter Institutional Steering Committee meeting / workshop at Bangalore on 01.09.2001. The meeting was presided by the Hon'ble Minister for Horticulture, Karnataka. Dr. H. P. Singh, Horticulture Commissioner, Government of India and Th. M.B.Pranesh, Secretary, Department of Agriculture, Government of Tamil Nadu participated.

Summary

Based on the data generated the future research will focus on evolving ecofriendly technologies for sustainable management of the mite which should encompass developing new genotypes, identification of natural enemies including pathogens and selective use of chemicals.

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