MANAGEMENT OF COCONUT ERIOPHYID MITE *Aceria guerreronis* Keifer USING ECOFRIENDLY METHODS

BY

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THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Agricultural Entomology

COLLEGE OF AGRICULTURE

Vellayani

Thiruvananthapuram

2001

DECLARATION

I hereby declare that this thesis entitled "**Management of coconut eriophyid mite *Aceria guerreronis* Keifer using ecofriendly methods**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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ACKNOWLEDGEMENT

I gratefully acknowledge Dr. K. Saradamma, Professor and Head, Department of Agricultural Entomology, Chairman of the Advisory Committee for her guidance and everwilling help much beyond her formal obligation throughout the course of study, research and preparation of thesis.

My profound gratitude is placed on record to Dr.S. Naseema Beevi, Associate Professor, Department of Agricultural Entomology for her constant encouragement during the course of study and critical evaluation of the thesis.

I deeply express my whole hearted thanks to Dr. Hebsy Bai, Department of Agricultural Entomology for her valuable suggestions, unfailing and genuine interest for the successful completion of this work.

I thankfully acknowledge Dr. M. Suharban, Associate Professor (Plant Pathology), Instructional Farm for her timely help rendered during the course of investigation and scrutiny of the manuscript.

Heartful thanks are due to Dr. T. Nalinakumari, Dr. Thomas Biju Mathew, Dr. C. Nandakumar, Dr. M.S. Sheela and Sri. P.A. Rajan Asari of Department of Agricultural Entomology for the critical suggestions and constant encouragement during the different stages in the preparation of thesis.

I avail this opportunity to thank Dr. C. Gokulapalan, Associate Professor, Department of Plant Pathology and Dr.Thomas George, Assistant Professor, Department of Soil Science and Agricultural Chemistry for the valuable help rendered during the course of study.

I wish to express my sincere gratitude to Anitha teacher, Premila teacher for their moral support and also to each and everyone of the Department for their co-operation and sincere help.

I sincerely thank Mr. C. E. Ajith Kumar, Junior Programmer, Department of Agricultural Statistics for his help in analyzing experimental data.

Words fail to express my deep sense of gratitude to my friends Priya, Ambily, Nisha and Archana for their love, affection, moral support, constant encouragement and whole hearted help during the entire period of my study.

I am also greatful to Manoj. S and Jayakumar for truly help rendered by them in taking photographs.

I thankfully acknowledge the co-operation and help of Bindu chechi, Praveena chechi, Sindhumole chechi, Sindhu chechi, Usha, Rakhee Mohan, Smitha Rose, Beena, Maya, Sheen Jones, Abhilash, Mahesh and to all my friends.

I am also thankful to Kishore.B.Nair for the neat and timely preparation of the thesis.

I am indebted to Achan, Amma, Arun and Kochu for their unbound love, support and encouragement without which this work would not have been successfully completed.

Above all, I bow my head before God Almighty who gave me the courage and strength to pursue this endeavour to completion.

AMRITHA. V. S

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INTRODUCTION

1. INTRODUCTION

Coconut, *Cocos nucifera* L., a perennial palm is one among the twenty most important crop plants in the world. It is Indo-Malayan in origin, spread locally by sea currents and wider dissemination has occurred as a result of human movement (Child, 1974). Globally, India is the largest producer of coconut with an estimated area of 19.0 lakh hectares under the crop, followed by Indonesia and the Philippines.

The coconut palm is considered to be the 'Kalpa vriksha' in Kerala in view of its versatile contribution to the people of this State. Every part of the tree is put to economic use. The coconut palm is a major contributor to the agricultural income of the State.

The coconut palm is prone to infestation by several insects and non-insect pests. Kurian *et al.* (1979) listed a total of 547 species of insects and mites on coconut. The annual loss due to the pest complex in coconut in Kerala has been estimated to be 618.50 million nuts (Abraham, 1994). The instability in the coconut based agro ecosystems brought about by various factors like cultivation of new varieties, meteorological fluctuations, accidental introduction of pests, adoption of unscientific agro-techniques including plant protection has resulted in the emergence of new pests in coconut.

In late 1997, coconut palms in and around Cochin were seen affected by a new pest which was later identified as *Aceria* (*Eriophyes*) *guerreronis* Keifer, an eriophyid mite. The mite infestation had spread in a short time to practically all the coconut growing regions of the State and has assumed the proportion of a national disaster. Low prices for the produce coupled with mite infestation has resulted in an unprecedented economic crisis for the coconut farming community. Preliminary studies have indicated a fall in nut production to the tune of 30 to 40 per cent in the most affected districts of the State. The annual loss due to mite infestation in the State has been estimated between Rs.100 to 150 crores (Nair *et al.*, 2000a).

Based on trials conducted by the Kerala Agricultural University to control the mite, an adhoc recommendation to spray coconut bunches with an ecofriendly plant based pesticide namely neem oil + garlic + soap solution (2 %) alternatively with the synthetic organic chemical, dicofol (0.1 %) was suggested (Saradamma *et al.*, 2000a). This recommendation was put to use in containing the mite in Kerala.

Though these acaricides are effective in mite control, repeated applications pose hazards in the State with homestead based agro ecosystems having a high human population density. The cost of inputs as well as repeated application charges in the coconut crown is prohibitive. This warrants the search for alternative low cost, ecofriendly technologies

to combat the mite menace. In this context, the present investigations were undertaken with the following objectives.

1. To screen easily available botanicals and safe synthetic acaricides in the laboratory with a view to identify the most effective ones and optimum dosages against the mite.
2. To evaluate the efficacy of promising botanicals and safe synthetic acaricides for management of mite in the field.
3. To assess the efficacy of the indigenous technical knowledge and farmer practices for control of the mite in the field.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The coconut palm *Cocos nucifera* L. hosts a large number of insect and mite species, many of which are pests. Of these, mites were considered as minor pests causing damage to foliage, inflorescence and nuts. The status of the mite pests has changed in recent times due to introduction of new mite species in India affecting inflorescence and nuts. The literature pertaining to mite pests of coconut and management practices are briefly reviewed here.

2.1 Mite fauna in coconut

Eriophyids, tetranychids and tenuipalpids are the major group of acarines infesting coconut palm. Even though they are considered only as occasional pests under favourable conditions, sporadic outbreaks cause substantial loss to the coconut palm (Mohanasundaram and Karuppuchamy, 1989).

Acathrix trymatus Keifer, *Scolocenus spiniferus* Keifer, *Dialox stellatus* Keifer and *Notostrix attenuata* Keifer are the eriophyid mites on coconut leaves reported from Philippines (Briones and Sill, 1963). In addition to the above, two other eriophyid mites namely *Amrineus cocofolius* Flechtmann and *A. coconuciferae* Keifer were reported (Flechtmann, 1994). The coconut mites *Aceria guerreronis* Keifer in the

Americas and West Africa and *Colomerus novahebridensis* in Asia and Oceania occur mainly on the fruits (Hall *et al.*, 1980; Kang, 1981). W. N. Dixon reported another eriophyid mite *Acritonotus denmerki* Keifer on the coconut leaves in Florida (Moore and Howard, 1996) further Moore and Howard (1996) themselves listed nine species of eriophyid mites attacking coconut foliage and nuts.

2.2 Coconut eriophyid mite *Aceria (Eriophyes) guerreronis*

2.2.1 Pest status

The coconut eriophyid mite (CEM) *A. guerreronis* Keifer is the only eriophyid mite species causing potential loss to the coconut palm.

The CEM was reported for the first time in 1960 in the west coast of Mexico in the State of Guerrero (Cartujano, 1963) and was described by Keifer (1965) and Ortega *et al.* (1965). It was also reported from Africa (Mariau, 1969) then in Togo, Nigeria, Cameroon and Ivory Coast (Mariau, 1977) where it appeared simultaneously in several coconut plantations far from each other.

Hall *et al.* (1980) and Kang (1981) reported CEM as a pest of coconut from the coconut belt of Americas and West Africa. CEM has been a serious pest in West Africa, Asia and Oceania (Moore, 2000); Cuba (Cabrera, 2000); mainland Tanzania and in the islands of Mafia, Zanzibar and Pembar (Seguni, 2000).

In Asia, CEM was reported first from Ernakulam district of Kerala State (Sathiamma *et al.*, 1998). Within a short span of time the pest spread to most of the districts of Kerala (Saradamma *et al.*, 2000a) neighbouring states like Tamil Nadu, Karnataka (Ramaraju *et al.*, 2000). Andhra pradesh (Reddy and Naik, 2000).

In the same period, occurrence of CEM was also reported from Goa and Islands of Lakshadweep (Haq, 1999), Sri Lanka (Fernando *et al.*, 2000), Andamans (Prasad and Ranganath, 2000).

2.2.2 Biology

The CEM, belonging to the family eriophyidae is a microscopic worm like organism 200-250 microns in length and 40 microns thickness, with cylindrical or carrot shaped body (Keifer, 1965; Mariau and Julia, 1979). They possess two pairs of legs in the anterior portion with head and thorax together called cephalothorax. The abdominal portion is studded with microtubercles in a series of rings. The anal opening is terminal while the genital opening is anteriorily placed below the leg base (Mohanasundaram *et al.*, 1999).

According to Mariau (1977), the development cycle of CEM from egg to adult, extent about ten days. Biology of mite in India was worked by Mohanasundaram *et al.* (1999) and Haq (2000a). A female mite lays about 20-100 eggs during its lifetime. Eggs are round, glossy, transparent and have a diameter of about 35 microns. Eggs hatch in about 3 - 3.5 days. The

first instar nymph moults after two days and the second instar nymph moults as adult in two or three days. Nymphal stages are usually sedentary. CEM complete their life cycle in 10-12 days. Ramarethinam and Loganathan (2000) also reported that an average of 10.50 ± 1.27 days was required by CEM to complete one generation. The adult CEM lives upto 25 days (Haq, 2000a).

Dispersal of CEM is mainly by wind or by phoresy (Moore and Howard, 1996 and Mohanasundaram *et al.*, 1999).

2.2.3 Damage

Adults and nymphs of the CEM colonize and develop under the perianth and feed on the tender meristematic region of the nut. The damage initially appears as an elongated white triangular patch at the level of the perianth and the feeding injury later turn to brownish patches (Julia and Mariau, 1979). As the nut grows, this injury on the nuts leads to warting and longitudinal and T shaped fissures on the nuts surface. Draining of the sap from young buttons result in poor development of the nut, reduction in nut size, kernel content and poor quality husk (Sathiamma *et al.*, 1998). Severe nut infestation in the early button stage leads to heavy button shedding leading to loss in yield of nuts (Mohanasundaram *et al.*, 1999).

2.2.4 Yield loss

Estimated loss of copra due to CEM was reported as ten per cent in Benin (Mariau and Julia, 1970), 30 per cent in Mexico (Hernandez, 1977) and 11-28 per cent in St. Lucia (Moore and Alexander, 1989).

Mariau (1986) reported that the yield losses due to CEM attack are greater from earlier infestations. In Kerala, crop loss due to CEM infestation ranged between 30-40 per cent and severe infestation resulted in more than 50 per cent loss in weight of kernel (Nair *et al.*, 2000b). Reddy and Naik (2000) reported that the CEM damage caused about 25 per cent yield loss in copra content.

CEM infestation caused extensive premature dropping of nuts (Doreste, 1968; Mariau and Julia, 1970; Mohanasundaram *et al.*, 1999). Haq (2000b) analysed a premature nut fall in respect of CEM infested and uninfested farm which revealed a difference of 44.74 per cent.

Cabrera (2000) reported that the CEM causes serious economic losses by reducing the amount and quality of the harvests, which extends upto 100 per cent of nuts during high level of damage.

In addition to the damage on nut, CEM destruct coconut seedlings by feeding on their meristematic tissues (Arruda, 1974).

2.2.5 Other Hosts

Flechtmann (1989) reported CEM from *Lytocaryum weddellianum* (H. A. Wendland), a cocosoid palm species. Palmyra palm *Borassus*

flabellifer Linn. (palmae) was also reported as a new host for CEM in Tamil Nadu (Ramaraju and Rabindra, 2001). The CEM was present only on the tepals of Palmyra palm and the feeding damage resulted in the development of reddish brown patches on the inner side of the tepals and also on the outer surface of the nuts.

2.2.6 Management

2.2.6.1 Innovative Farmer Practices

According to Mariau (1977) monthly treatment of bunches with sea water reduced the mite attack probably by half. Alencar *et al.* (1999) reported that cultural methods including removal of infected plant parts, avoidance of excessive irrigation and fertilizer use. were effective to reduce mite population. Chezhiyan and Ramar (2000) suggested that crown cleaning combined with water spray could lead to low mite infestation.

Nair *et al.* (2000a) have reported on the innovative practices adopted by farmers of the Kerala state *viz.* application of neem cake powder, garlic powder, turmeric powder etc on the crown; generating smoke from farm waste, garbage waste, camphor etc in the garden; hanging sticky traps on the crown, spraying rice water and other sticky materials on the bunches.

2.2.6.2 Natural products

Moore *et al.* (1989) and Moore (2000) reported control of CEM with polybutene (Hyvis-150) on coconut palms.

Application of neem cake @ 2 kg along with bone meal 0.5 kg and mill ash 4 kg on the crown resulted in significant reduction in CEM damage (Muthiah and Bhaskaran, 2000). But no significant reduction in CEM was obtained by application of neem cake on the crown @ one kg palm^{-1} at 45 days interval (Saradamma *et al.*, 2000b).

2.2.6.3 Botanicals

Neem is known to control plant mites (Ramarethinam and Marimuthu, 1998). Saradamma *et al.* (2000a) recommended neem oil - garlic soap emulsion (2 %) an eco-friendly plant based pesticide, as an adhoc measure. This recommendation was found, to be effective in India (in the states of Kerala, Tamil Nadu and Karnataka) and Sri Lanka (Fernando *et al.*, 2000). Further field trials conducted by the same group indicated the effectiveness of a neem based formulation, *viz.*, azadirachtin 0.003 per cent (Neemazal T/S one per cent @ 3 ml litre^{-1}) in managing the CEM while rubber seed oil two per cent and FOIS two per cent were not promising (Saradamma *et al.*, 2001).

Muthiah and Bhaskaran (2000) reported that Neem oil - garlic emulsion (2 %) has effected 63 per cent reduction of the CEM population.

Ramarethinam *et al.* (2000) suggested combination treatments of Nimbecidine (500 ml) and Bio Catch (500 gm) in 200 litres of water could be adopted for CEM control in coconut.

Saradamma *et al.* (2001) evaluated seed oils and their combinations in the laboratory and found mortality upto 60 per cent. Among the various treatments tried, mortality above 50 per cent was observed in six natural products *viz.*, neem oil + castor oil (2:1), neem oil + castor oil (4:1), sesamum oil two percent, illupai oil two per cent, karinjotti oil one per cent and Pongamia oil three per cent. They also recorded a mortality ranging from 30 to 35 per cent on drenching the basin with Neemazal F (Azadirachtin 5 %) @ 2, 3 and 4 ml diluted with 15 litre water palm^{-1} and showed that Neemazal F @ 2 ml palm^{-1} was more effective than its higher doses.

2.2.6.4 Chemical methods

Hernandez (1977) reported that spraying of monocrotophos (Nuvacron), dicrotophos or chinomethionate (Morestan) on bunches of developing nuts every 20 or 30 days or repeated sprays of cyhexation or fenbutainoxide significantly decreased the level of CEM damage. Similar results were obtained with acaricides at 15 days interval, but not at 60 days interval (Mariau and Tchibozo, 1973). Julia and Mariau (1979) found that stem injection with monocrotophos at two months interval was effective in young palm while Griffith (1984) found that the injection of vamidothion gave long lasting control. However, this was found to be ineffective in studies by Moore and Alexander (1987). Application of morestan 25 WP @

4 g litre^{-1} of water or morestan two per cent dust @ 28 g palm^{-1} effectively controlled CEM in El Salvador.

Moore and Alexander (1987) reported that vamidothion (Kilval) 4 g ai 10 l^{-1} of water spray produced more nuts than the untreated control, but frequent application would be required to achieve satisfactory control.

Mohanasundaram *et al.* (1999) reported that spraying of triazophos 5 ml or methyl demeton 4 ml or phosalone 3 ml litre^{-1} of water or root feeding of triazophos 20 ml + 20 ml water palm^{-1} was effective against CEM.

CPCRI (1999) reported that 0.05 per cent of triazophos, carbosulfan and endosulfan applied as spray on the affected bunches controlled the CEM infestation. They also revealed that wettable sulphur 0.4 per cent and azadirachtin 0.004 per cent also gave results comparable to that of chemical pesticides.

According to Ramaraju *et al.* (2000) spraying of triazophos 40 EC (5 ml l^{-1}) or methyldemeton (4 ml l^{-1}) or monocrotophos 36 SL (1.5 ml l^{-1}) significantly reduced the mite population and similar results were obtained with sulphur (Fernando *et al.*, 2000).

Based on the field trials conducted, Nair *et al.* (2000a) and Saradamma *et al.* (2000b) reported that neem oil-garlic mixture two per cent alternatively with dicofol 0.1 per cent, monocrotophos 0.1 per cent and wettable sulphur 0.4 per cent was effective in managing CEM.

Foliar spray and root feeding of chemical pesticides like monocrotophos, triazophos at recommended doses were found to be effective against CEM (Ramarethinam *et al.*, 2000).

Dey *et al.* (2001) evaluated fenazaquin 10 EC (Magister) against CEM under laboratory and field conditions and also described that root feeding with fenazaquin 10 ml palm^{-1} and spraying 200-250 ml in 100 l of water were found to be the most effective dose.

2.2.6.5 Biological control

The biological control agents can also be effectively utilized to suppress CEM (Julia and Mariau, 1979). Microbes and predators attack CEM, but under natural circumstances there effects are minor.

2.2.6.5.1 Microbes

The acarogenous fungus *Hirsutella thompsonii* (Fisher) has been isolated from the samples of CEM from tropical America and West Africa and from samples of *C. novahebridensis* from New Hebrides, New Guinea and Sri Lanka (Hall *et al.*, 1980). Espinosa and Carrillo (1986) reported upto 75 per cent mortality of CEM in Mexico but no success in St. Lucia (Moore *et al.*, 1989). Lampedro and Rosas (1989) tested seven isolates of *H. thompsonii* in laboratory trials of which an isolate recorded 88 per cent CEM mortality.

Cabrera and Dominguez (1987) reported another acarogenous species attacking CEM, *H. nodulosa* Petch from Cuba.

Beevi *et al.* (1999) isolated a local strain of *Hirsutella* sp. from CEM, which was identified as *H. thompsonii* var. *synnematosa*. Saradamma *et al.* (2001) reported CEM mortality of 30-60 per cent in the laboratory and field evaluation of the pathogenicity of fungus. They also reported that among the various entomogenic fungi tested. *Verticellium suchlasporium* was found to infect CEM.

Ramarethinam *et al.* (2000) suggested a neem oil based EC formulation Nimbecidine 0.03 per cent (Azadirachtin) in combination with three entomopathogenic fungus, *H. thompsonii*, *Verticellium lecanii* and Paecilomyces sp. at the dosage of 500 ml, each at 400 g, 300 g and 300 g respectively in 200 l of water for CEM control.

2.2.6.5.2 Predators

2.2.6.5.2.1 Predacious mites

Hall *et al.* (1980) observed predation of adults of CEM and *Colomerus novahebridensis* by two species of *Lupotarsonemus*, but they possess only minor effect on population suppression of either pest species. The predators B*della distincta*, two phytoseiids *Amblyseius largoensis* Muma, *Neoseiulus mumai* Denmark and a tarsonemid species *N. paspalivorus* Deheon were reported by Julia *et al.*, 1979 and Howard *et al.*1990. Few species of phytoseid predatory mites *Amblyseius* (*Neoseiulus*) *paspalivorus* (Nair *et al.*, 2000a) and a tarsonemid mite

(Ramaraju *et al.*, 2000), *Bdella* sp. (Fernando *et al.*, 2000) were found inhabiting the perianth region in very low population. Sardamma *et al.* (2001) also reported predatory mites from infested nut samples and they were identified as *Amblyseius* spp (Phytoseidae), *Bdella* sp. (Bdellidae) and a tarsonemid mite.

Tydeidae mites have also been shown to feed on CEM and have significant impact on other species of eriophyid mites (Moraes, 2000).

2.2.6.5.2.2 Other predators

A coccinellid and a syrphid larva (Nair *et al.*, 2000a), some species of stigmaeidae (Moraes, 2000) thrips and anthocorid bugs (Ramaraju *et al.*, 2000) were also reported whose feeding potential are yet to be assessed.

A species of syrphyid maggot, coccinellid grub and predatory thrips were found in CEM infested colonies (Saradamma *et al.*, 2001).

2.3 Other mites attacking coconut

Perianth mite *Dolichotetranychus vandergooti* Oudemans (Tenuipalpidae) infest tender and mature nuts colonizing inside the perianth leading to abnormal development of nuts and premature nut shedding (Sathiamma, 1985). The palm mite *Raoiella indica* Hirst (Tenuipalpidae), *Tetranychus fijiensis* Hirst and *T. hindustanicus* Hirst (Tetranychidae) are common mites found in the foliage causing severe damage in summer months (Sathiamma, 1989).

Brevipalpus deleoni Pritchard and Baker has also been reported as a nut infesting mite on coconut palm in India (Nageshachandra, 1972).

Amroseius sp. (Cherian, 1938) and *Neocypholaelaps stridulans* Evans (Gupta, 1969) are the mites associated with coconut flowers and green nuts helping in pollination.

2.3.1 Management

Saradamma (1972) evaluated the efficacy of six pesticides against the palm mite *Raoiella indica* on coconut. Significant reduction of pest population was obtained on palms treated with dimethoate and formothion. Though parathion gave immediate reduction in population one day after treatment, there was gradual increase in the same subsequently.

Monocrotophos was found effective against the tenuipalpid mite (*R. indica*) causing 76.39 per cent mortality compared to the quinalphos, endosulfan, dicofol, ethion (at 0.03 % and 0.05 % each) and cypermethrin (at 0.09 % and 0.01 %) in West Bengal, India (Sarkar and Somchoudhury, 1988).

Jayaraj *et al.* (1991) reported that insecticides gave a mean population reduction of palm mite and found that dicofol (0.04 %), monocrotophos (0.05 %), ethion (0.1 %), endosulfan (0.07 %), tetradifion (0.1 %), wettable sulphur 0.25 %) and phosalone (0.07 %) were effective against the coconut palm mite *R. indica*.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study on management of coconut eriophyid mite (CEM) *Aceria guerreronis* Keifer was conducted at Department of Agricultural Entomology and at Instructional Farm, College of Agriculture, Vellayani during 1999-2001.

3.1 Screening of oils, botanicals and acaricides

Five types of oils, three neem formulations and five acaricides were evaluated in the laboratory for their relative efficacy in reducing the population of CEM.

3.1.1 Selection of buttons for bioassay

Uniformly aged coconut palms of West Coast Tall (WCT) variety exhibiting mite damage were selected for the study. Symptoms of the mite damage at different ages of the nuts are shown in Plate 1. The fourth bunch (three months after fertilization) of these palms was observed for mite damage (Plate 2). Buttons showing external symptoms of mite damage *viz.*, yellow triangular patches, which have active CEM colonies were selected from these bunches for bioassay. Fresh infested buttons were excised along with rachis (15 cm length) and brought to the laboratory.

Plate 1. Symptoms of mite infested nuts at different stages

A –Yellow triangular patches extending beneath the perianth

B – Brownish triangular patches

C – Suberised and necrotic brown patches on mature nut

D – T shaped cut on the nut with severe mite infestation

A

B

C

D

Plate 2. **Mite infested nut of fourth bunch with yellow triangular patch**

3.1.2 Maintenance of buttons in the laboratory

The cut end of the rachis of the nut lets were dipped in ten per cent sucrose solution taken in plastic vials of 9.5 x 2.5 cm size for maintaining turgidity. The vials containing the nut lets were held properly by placing them in a prefabricated iron stand of 50 x 50 x 9.5 cm (Plate 3). The ten per cent sucrose solution could keep the nut lets fresh to support the mite population upto 20 days. The solution was changed everyday to avoid fermentation.

3.1.3 Screening of oils and botanicals

Five types of oils (four plant oils and New FOIS (G)) and three neem formulations were the products tested in the laboratory. The four plant oils used were neem oil, samadera oil, custard apple oil and castor oil obtained from Padmanabha pillai & Sons, Chalai, Thiruvananthapuram, each at two and three per cent concentrations. New FOIS (G) obtained from Kerala Soaps and Oils Ltd., Oil Division, Vellayil, Calicut, was tested at five and ten per cent concentrations. Three neem formulations tested, were Nimbecidene 0.03 per cent EC (T.Stanes & Company Ltd.), Neemazal T/S one per cent (EID parry (India) Ltd.) and Soluneem (Vittal Mallaya Scientific Research Foundation, Bangalore) each at 0.2 and 0.4 per cent concentrations. All the treatments were replicated thrice.

Plate 3. Iron stand held with the vial containing nutlets

3.1.3.1 Preparation of spray solutions of oils and neem formulations

The desired concentrations of spray solutions of oils for the experiment were prepared by mixing required quantities of the materials with emulsified water containing 0.2 per cent teepol while neem formulations were obtained by mixing with required quantity of water.

3.1.4 Screening of acaricides

Five acaricides were tested at two doses in the laboratory. Each treatment was replicated thrice. The details of the acaricides are listed below.

No	Treatments	Dose (per cent)	Source
1	Sulphur (Sulfex 80 %W.P)	0.200 & 0.400	Excel Industries
2	Diafenthiuron (Polo 50 SC)	0.025 & 0.050	Novartis India Ltd
3	Profenofos (Curacron 50 EC)	0.025 & 0.050	Hindustan Ciba-Geigy Ltd
4	Fenazaquin (Magister 100 EC)	0.025 & 0.050	Dow Elanco De-Nocil
5	Imidacloprid (Confidor 200 SL)	0.025 & 0.050	Bayer (India) Limited

3.1.4.1 Preparation of spray solutions of chemicals

The insecticide solutions were prepared from the proprietory formulations by mixing with required quantity of water.

3.1.5 Application of spray solutions

The prepared spray fluid was strained through a muslin cloth and was applied by direct spraying on the excised nutlets using an atomizer of 100 ml capacity. Ten ml spray fluid was required to give a thorough

coverage of a nutlet. Nutlets sprayed with water alone served as the control.

3.1.6 Assessment of mite population

The number of dead and surviving mites (nymphs and adults) in the mite colony was observed at 24 h, 48 h and 72 h after spraying. The mite colonies were counted by observing the fresh colony of the meristematic tissue of nutlet under a compound microscope at a magnification of 10×10x. Mean count of live and dead mites from five spots of CEM colony per lesion was taken. The percentage mortality was determined out using the following formula

$$\text{Mortality percentage} = \frac{\text{Number of dead mites}}{\text{Total number of mites}} \times 100$$

The percentage mortality was corrected using Abbott's formula (Abbot, 1925).

$$\text{Corrected mortality percentage} = \frac{P_0 - P_C}{100 - P_C} \times 100$$

where,

P_0-observed mortality in treatment

P_C-observed mortality in control.

3.1.7 Route of entry of the chemical

A laboratory experiment was conducted to study the mode of entry of materials inside the coconut perianth when applied on the nut surface. Undiluted malachite green dye (10 ml nutlet^{-1}) was sprayed on the fresh

excised nutlets using an atomizer. Three samples of nutlets of the fourth bunch were used. They were maintained in the laboratory as explained in 3.1.2. Twenty-four hours after spraying, tepals were removed and meristematic region of the mite-infested nut was observed.

3.2 Field evaluation

3.2.1 Selection of Palms

West Coast Tall (WCT) coconut palms of 25 years old with more or less uniform CEM infestation were selected (Plate 4). The selected palms had an average height of eight metres and were maintained according to the agronomic practices recommended in the Package of Practices of Kerala Agricultural University (KAU, 1996) excluding the plant protection measures. The coconut garden had tapioca and banana as intercrops.

3.2.2 Labelling of palms and bunches

The selected palms were marked with rings of red paint. Each palm was marked near the base with labels made from sunpac sheet indicating the treatment details. The first six bunches of the selected palms were also tagged with sunpac labels. The label number was given serially from the sixth bunch from bottom to the top onwards, so that the emerging bunches could be serially tagged.

The promising natural products and 'safe' synthetic acaricides selected from the laboratory experiment were evaluated in the field. The

Plate 4. Crown of a mite infested coconut palm

Plate 5. Infestation of coconut eriophyid mite on nuts belonging to 1-5 score


1
2
3
4
5

field trial was conducted during 2000 to 2001 in the Instructional Farm, College of Agriculture, Vellayani.

3.2.3 Layout of the experiment

3.2.3.1 Field Trial – I: Evaluation of selected oils, botanicals and acaricides

The experiment was laid out in a Completely Randomised Design with ten treatments including water spray and an untreated control with three replications. One palm served as a replication. The treatments included in the experiments are listed below

No.	Treatment	Concentration of spray solution (per cent)
T_1	Neem oil	3.00
T_2	Castor oil	3.00
T_3	New FOIS (G)	10.00
T_4	Nimbecidine	0.40
T_5	Neemazal	0.40
T_6	Sulphur WP	0.40
T_7	Fenazaquin	0.05
T_8	Imidacloprid	0.05
T_9	Water spray	
T_{10}	Control	

3.2.3.2 Field Trial – II : Evaluation of Natural Products and Innovative Farmer Practices

A field trial was laid out in completely randomized design with twelve treatments, each replicated thrice. The treatment details are given below.

No.	Treatments	Dose	Method of application
T_1	Neem cake	1 kg palm^{-1}	Crown application
T_2	Marotti cake	1 kg palm^{-1}	"
T_3	Pongamia cake	1 kg palm^{-1}	"
T_4	Wood ash	1 kg palm^{-1}	"
T_5	Kaoline	1 kg palm^{-1}	"
T_6	Sea water	Undiluted	Bunch spraying
T_7	Starch solution	5 per cent	"
T_8	Salt solution	5 per cent	"
T_9	Rubber latex	50 per cent	"
T_{10}	Cow milk	50 per cent	"
T_{11}	Water spray		
T_{12}	Control		

3.2.4 Preparation of spray solutions and application

The desired concentrations of spray solutions of natural products and acaricides were prepared in the same procedure as explained in 3.1.3 and 3.1.4. The cakes of various products, wood ash and kaoline were prepared by mixing 1 Kg of the material with equal quantity of sand and were applied on the crown. The prepared spray solutions were strained through a muslin cloth. Depending upon the crown size, 1.5 – 2 litres of spray fluid was used per palm for uniform coverage. The spray fluid was sprayed on the infested bunches from above with the help of a rocker sprayer. The spraying was focussed towards the perianth region of the nuts. All bunches above 35 days old, upto the size of tender coconut (seven months old) were sprayed. The sprayings were done three times at monthly intervals.

3.2.4 Assessment of mite population

CEM infested nut was collected from the fifth bunch (four months after fertilization) of the selected palm before the application of treatment and one week after each spraying. The tepals of the individual nuts were removed carefully and mite population under the perianth of button was observed under a compound microscope. The number of mites per field area of five spots of the fresh mite colony was taken. The field area (1.207 mm^2) of the microscope was measured using micrometry. The number of mites per 4 mm^2 of the meristematic region was assessed as given below.

$$\text{No. of mites / 4 mm}^2 = \frac{\text{Mean mite population of five field area X 4 mm}^2}{\text{Field area of the microscope}}$$

3.2.5 Assessment of per cent reduction in mite population

Population of mite count before spraying and one week after spraying were collected and the per cent reduction in mite population was assessed.

3.2.6 Assessment of percentage of infestation

Percentage infestation on treated bunches were assessed by taking the following observations.

1. Total number of bunches
2. Total number of nuts per bunch
3. Number of mite affected bunches
4. Number of mite affected nuts per bunch

The percentage of mite infestation on each bunch was estimated based on the number of CEM infested nuts over the total number of nuts of seven tagged bunches, three months after third spraying.

3.2.7 Assessment of intensity of damage

The nuts from each treated bunches were observed for their intensity of damage. The nuts were scored in five damage categories and classified according to visible damage in 1-5 scale as described by Julia and Mariau (1979) (Plate 5). The score details are given below.

Score	Details of the score
1	Nuts with no mite damage (0 per cent)
2	Nuts with superficial mite damage (1-10 %)
3	Nuts with significant mite damage but not much smaller (11-25 %)
4	Nuts with significant mite damage, smaller and with some distortion (26-50 %)
5	Nuts very heavily attacked, very much reduced in size and often greatly distorted (51-100%)

Mean intensity score (MIS) of each tagged bunch was calculated as follows:

$$MIS = \frac{\text{No. of nuts belonging to score 1 x 1 (score of nuts) + ...+ No. of nuts belonging to score 5 x 5 (score of nuts)}}{\text{Total number of nuts}}$$

3.2.8 Assessment of nut fall intensity

The fallen nuts from the coconut basin were collected and observed for CEM damage in the laboratory. Based on symptoms of fallen nuts and CEM colonies under the perianth, nut fall due to CEM infestation was ascertained.

3.2.9 Statistical analysis

The entire data were subjected to statistical analysis, adopting the analysis of variance (ANOVA) for the mortality data in the laboratory screening, percentage reduction in mite population and nut fall data: factorial design for the percentage of infestation and MIS. When the counts of percentage were analysed, the appropriate transformation (square root

transformation and angular transformation) were done where ever necessary (Snedecor and Cochran, 1967)

RESULTS

4. RESULTS

4.1 Efficacy of oils, botanicals and acaricides in reducing population of CEM in the laboratory.

4.1.1 Assessment of route of entry of chemicals

Observation on the laboratory trial to ascertain the entry of chemicals inside the perianth, when it is applied on nut surface, revealed positive indications of the translocations of chemicals. Twenty-four hours after spraying of malachite green dye, 80 per cent of the meristematic region of the CEM infested nut was found to be stained with the dye (Plate 6).

4.1.2 Efficacy of oils and botanicals in reducing population of CEM in the laboratory.

Data on the mean per cent corrected mortality recorded at 24, 48 and 72 hours after spraying are presented in Table 1. Among the five oils and three botanicals, tested at two concentrations, highest mortality of CEM was obtained with castor oil three per cent (35.18 %) when observed 24 hours after spraying. This was closely followed by neem oil three per cent causing 29.71 per cent mortality. Both these treatments were on par while neem oil three per cent was on par with New FOIS (G) ten per cent (28.42 %) which was statistically on par with custard apple oil three per cent (23.86 %). Both the doses of soluneem 0.4 per cent and 0.2 per cent were

Plate 6. Meristematic portion of the nuts stained with and without dye (Malachite green)

Table 1. Effect of oils and botanicals on CEM when applied on infested excised nutlets in the laboratory

Treatments concentration (%)	Mean per cent corrected mortality after different hours		
	24	48	72
Neem oil 2.0 %	12.62 (20.80)	32.10 (34.50)	39.81 (39.10)
Neem oil 3.0 %	29.71 (33.01)	35.92 (36.81)	60.07 (50.79)
Custard apple oil 2.0 %	20.74 (27.08)	26.35 (30.87)	29.21 (32.70)
Custard apple oil 3.0 %	23.86 (29.23)	28.77 (32.42)	40.93 (39.76)
Samadera oil 2.0 %	16.56 (24.01)	25.56 (30.36)	34.75 (36.11)
Samadera oil 3.0 %	18.89 (25.75)	23.41 (28.93)	45.08 (42.16)
Castor oil 2.0 %	19.52 (26.21)	25.48 (30.31)	30.47 (33.49)
Castor oil 3.0 %	35.18 (36.36)	39.45 (38.90)	57.41 (49.24)
New FOIS (G) 5.0 %	17.95 (25.06)	18.97 (25.81)	28.39 (32.18)
New FOIS (G) 10.0 %	28.42 (32.20)	47.90 (43.78)	47.55 (43.58)
Nimbecidine 0.2 %	13.02 (21.14)	26.40 (30.91)	38.95 (38.60)
Nimbecidine 0.4 %	20.01 (26.56)	42.29 (40.55)	49.32 (44.59)
Neemazal 0.2 %	17.60 (24.79)	20.63 (27.00)	39.13 (38.71)
Neemazal 0.4 %	21.56 (27.66)	45.73 (42.54)	57.77 (49.45)
Soluneem 0.2 %	2.02 (8.17)	8.80 (17.25)	24.58 (29.71)
Soluneem 0.4 %	4.23 (11.86)	21.39 (27.54)	28.80 (32.44)
C.D (0.05 %)	(3.80)	(2.43)	(2.96)

Figure in parentheses are angular transformed values

found to cause statistically lower mortality compared to the remaining treatments and recorded a mean per cent corrected mortality of 4.23 per cent and 2.02 per cent.

Forty-eight hours after spraying New FOIS (G) ten per cent showed maximum mortality (47.90 %) and it was on par with neemazal 0.4 per cent causing 45.73 per cent mortality. Next in position was nimbecidine 0.4 per cent (42.29 %) which was on par with neemazal 0.4 per cent (45.73 %) and castor oil three per cent (39.45 %). All the other treatments were significantly inferior.

Statistical analysis on mean percent corrected mortality recorded 72 hours after treatment revealed that neem oil three per cent was the most effective treatment with 60.07 per cent mortality. This was closely followed by neemazal 0.4 per cent and castor oil three per cent, their mortality being 57.77 per cent and 57.41 per cent and the three treatments were on par. All the other treatments gave only less than 50 per cent mortality. Nimbecidine 0.4 per cent and New FOIS (G) ten per cent gave 49.32 per cent and 47.55 per cent mortality and they were at par. New FOIS (G) ten per cent was on par with samadera oil three per cent (45.08 %) while custard apple oil three per cent (40.93 %) was on par with samadera oil three per cent but was significantly different from New FOIS (G) ten per cent. The treatments neem oil two per cent, neemazal 0.2 per cent, nimbecidine 0. 2 per cent and samadera oil two per cent were on par with custard apple oil three per cent and recorded mortality below 40 per cent.

Custard apple oil two per cent. Soluneem 0.4 per cent. New FOIS (G) five per cent and soluneem 0.2 per cent were less effective.

4.1.3 Efficacy of acaricides in reducing population of CEM in the laboratory.

Data on the mean percent corrected mortality recorded at 24, 48 and 72 hours after spraying are shown in Table 2. Twenty-four hours after treatment, fenazaquin 0.05 per cent was the most effective treatment causing a mortality of 58.18 per cent of CEM. This was followed by imidacloprid 0.05 per cent (45.12 %), which was significantly superior to its lower dose imidacloprid 0.025 per cent (34.40 %). Lower dose of imidacloprid was statistically on par with sulphur W.P 0.4 per cent (30.86 %). No significant difference was observed among profenofos 0.05 per cent, sulphur W.P 0.2 per cent and fenazaquin 0.025 per cent, mortality of which ranged from 24.84 to 28.42 per cent. The least mortality was observed in diafenthiuron 0.025 per cent (9.63 %) which was significantly inferior to diafenthiuron 0.05 per cent (21.56 %) and profenofos 0.025 per cent (18.62 %), while diafenthiuron 0.05 per cent and profenofos 0.025 per cent being statistically on par.

Similarly 48 hours after spraying, fenazaquin 0.05 per cent was significantly more effective than the remaining treatments registering 70.26 per cent mortality. Sulphur W.P 0.4 per cent (51.26 %) closely followed by imidacloprid 0.05 per cent (50.58 %) was significantly different from the

Table 2. Effect of acaricides on CEM when applied on infested excised nutlets in the laboratory

Treatments concentration (%)		Mean per cent corrected mortality after different hours		
		24	48	72
Sulphur W.P	0.2 %	25.94 (30.61)	45.13 (42.19)	52.34 (46.32)
Sulphur W. P	0.4 %	30.86 (33.73)	51.26 (45.70)	74.51 (56.95)
Diafenthiuron	0.025 %	9.63 (18.08)	20.55 (26.94)	28.53 (32.28)
Diafenthiuron	0.05 %	21.56 (27.66)	29.21 (32.70)	45.65 (40.17)
Profenofos	0.025 %	18.62 (25.55)	31.69 (34.25)	30.37 (33.43)
Profenofos	0.05 %	24.84 (29.88)	41.77 (40.25)	40.66 (39.60)
Fenazaquin	0.025 %	28.42 (32.20)	39.44 (38.89)	56.20(48.54)
Fenazaquin	0.05 %	58.18 (49.69)	70.26(56.93)	84.73 (66.97)
Imidacloprid	0.025 %	34.40 (35.89)	40.10 (39.28)	43.58 (41.30)
Imidacloprid	0.05 %	45.12 (42.18)	50.58 (45.31)	60.73 (51.17)
CD (0.05 %)		(2.93)	(3.11)	(3.65)

Figure in parentheses are angular transformed values

remaining treatments. Profenofos 0.05 per cent was on par with sulphur W.P 0.2 per cent, imidacloprid 0.025 per cent and fenazaquin 0.025 per cent and recorded a mortality ranging from 41.77 to 39.44 per cent. Other treatments were significantly inferior with more or less similar trend as in the case of 24 hours after spraying.

The same trend was obtained at 72 hours after spraying also indicating maximum mortality in fenazaquin 0.05 per cent (84.73 %) which was significantly superior to all the other treatments (Plate 7 and 8). Sulphur W.P 0.4 per cent was also effective with 74.51 per cent mortality and was superior to all the remaining treatments. Higher dose of imidacloprid 0.05 per cent was statistically on par with fenazaquin 0.025 per cent which in turn was on par with sulphur W.P 0.2 per cent, the mortality being 60.73 per cent, 56.20 per cent and 52.34 per cent respectively. The mortality ranging from 43.58 to 28.53per cent was observed in the case of imidacloprid 0.025 per cent, profenofos 0.05 per cent and 0.025 per cent and diafenthiuron 0.05 per cent and 0.025 per cent.

4.2 Efficacy of selected oils, botanicals and acaricides in the field.

4.2.1 Effect on mite population

The data on the percentage reduction in CEM population one week after each spraying over the precount upon spraying of promising oils, botanicals and acaricides reflected from laboratory trial are presented in Table 3.

Plate 7. Slide mounted view of mite colony before treatment of fenazaquin 0.05 per cent

Plate 8. Slide mounted view of mite colony 72 hours after treatment of fenazaquin 0.05 per cent

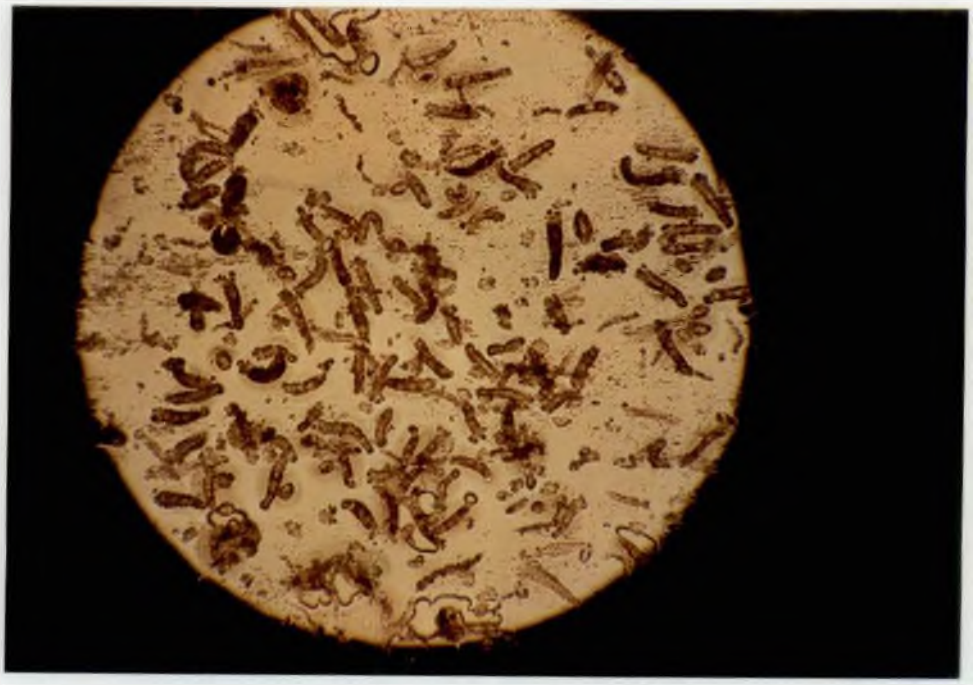

Table 3. Effect of selected oils, botanicals and acaricides on the percentage of reduction of CEM population observed one week after each spraying at monthly intervals

Treatments concentration (%)		Percentage reduction in mite population after each spraying (mean of three replications)		
		1st	2nd	3rd
Neem oil	3.00 %	43.36 (41.17)	59.20 (50.34)	76.87 (61.23)
Castor oil	3.00 %	31.31 (34.01)	64.38 (53.34)	88.95 (70.55)
New FOIS (G)	10.00%	32.40 (34.68)	58.33 (49.78)	70.09 (56.82)
Nimbecidine	0.40 %	49.06 (44.44)	49.01 (44.42)	71.58 (57.76)
Neemazal	0.40%	14.89 (22.69)	51.52 (45.85)	75.48 (60.30)
Sulphur W.P	0.40 %	75.99 (60.64)	83.67 (66.14)	95.42 (77.61)
Fenazaquin	0.05 %	34.57 (36.00)	79.27 (62.89)	96.49 (79.18)
Imidacloprid	0.05 %	28.64 (32.34)	59.82 (50.65)	80.72 (63.93)
Control		4.94 (12.83)	0.75 (4.97)	0.36 (3.46)
CD (0.05 %)		(8.92)	(4.21)	(11.68)

Figure in parentheses are angular transformed values

Sulphur W.P 0.4 per cent was found to be the most promising treatment against CEM resulting in 75.99 per cent population reduction one week after the first spraying of the coconut bunches. All the other treatments were significantly superior over control (4.94 %). But these treatments failed to reduce the CEM population effectively. reduction in population in these treatments ranging from 14.89 per cent to 49.06 per cent only. Nimbecidine 0.4 per cent and neem oil three per cent were found to be on par, with 49.06 per cent and 43.36 per cent population reduction respectively.

Data on reduction in CEM population after the second round of the spraying also revealed that all the treatments were significantly effective in reducing the CEM population over control. Sulphur W.P 0.4 per cent registered maximum reduction (83.69 %) followed by fenazaquin 0.05 per cent causing 79.27 per cent reduction in population, both the treatments being on par. Castor oil three per cent (63.38 %), imidacloprid 0.05 per cent (59.82 %), neem oil three per cent (59.30 %) and New FOIS (G) ten per cent (58.33 %) were on par. New FOIS (G) ten per cent was on par with neemazal 0.4 per cent (51.52 %) which was closely followed by nimbecidine 0.4 per cent having 49.02 per cent reduction both being on par with each other.

After the third round of spraying a different trend was observed where fenazaquin 0.05 per cent was found to be effective with a population reduction of 96.49 per cent closely followed by sulphur W.P. 0.4 per cent

(95.42 %) and castor oil three per cent (88.95 %). No significant difference was observed among them. Imidacloprid 0.05 per cent, neem oil three per cent, neemazal 0.4 per cent and New FOIS (G) ten per cent recorded a population reduction ranging 80.72 to 70.09 per cent. All the treatments were found to be significantly superior over control.

4.2.2 Effect on mite damage on mature nuts

4.2.2.1 Percentage of nuts damaged three months after third application

The data on the percentage of nuts damaged by CEM in seven bunches, three months after third round of monthly spraying, is presented in the Table 4.

Fenazaquin 0.05 per cent was found to be significantly superior to all other treatments, in which the per cent of nut damage recorded was 32.52 per cent. This was followed by sulphur W.P 0.4 per cent (37.23 per cent) which was significantly inferior to fenazaquin 0.05 per cent but superior to all the others. Of the remaining treatments, imidacloprid 0.05 per cent, nimbecidine 0.4 per cent, castor oil three per cent and neemazal 0.4 per cent with a percentage damage ranging from 50.37 to 56.73 per cent were on par and significantly reduced the mite damage in comparison with water spray (68.27 %). The percentage nut damage in control (94.02 %) was significantly higher than all other treatments

Table 4. Effects of selected oils, botanicals and acaricides on the percentage nut damage in seven bunches after three rounds of spraying

Treatments Concentration (%)	Percentage of CEM damaged nuts on seven bunches (mean of three replications)							Mean
	1*	2	3	4	5	6	7	
Neem oil 3 %	26.03 (30.67)	36.45 (37.13)	62.68 (52.33)	64.23 (53.24)	90.43 (71.95)	91.56 (73.08)	97.36 (80.61)	66.96 (57.00)
Castor oil 3 %	18.30 (25.32)	22.42 (28.25)	29.14 (32.66)	45.34 (42.31)	56.64 (48.80)	92.17 (73.72)	98.73 (83.50)	51.82 (47.79)
New FOIS(G) 10 %	23.70 (29.12)	43.48 (41.24)	52.50 (46.41)	60.90 (51.27)	83.07 (65.68)	83.23 (65.80)	100.00 (90.00)	63.84 (55.65)
Nimbecidine 0.4 %	14.81 (22.63)	29.67 (32.99)	49.53 (44.71)	56.18 (48.52)	54.77 (47.72)	84.10 (66.47)	87.77 (69.50)	53.83 (47.51)
Neemazal 0.4 %	16.39 (23.87)	28.12 (32.01)	43.88 (41.47)	55.60 (48.19)	72.42 (58.30)	85.81 (67.84)	94.91 (76.93)	56.73 (49.80)
Sulphur W.P 0.4 %	5.94 (14.10)	8.72 (17.17)	19.34 (26.08)	30.74 (33.66)	34.37 (35.88)	61.51 (51.64)	100.00 (90.00)	37.23 (38.36)
Fenazaquin 0.05 %	1.04 (5.85)	2.61 (9.29)	0.47 (3.92)	20.53 (26.93)	43.76 (41.40)	75.97 (60.62)	83.23 (65.80)	32.52 (30.54)
Imidacloprid 0.05 %	14.25 (22.17)	23.35 (28.88)	27.35 (31.52)	53.41 (46.92)	64.31 (53.30)	74.06 (59.36)	95.87 (78.24)	50.37 (45.77)
Water spray	60.29 (50.92)	59.73 (50.59)	54.71 (47.68)	51.48 (45.79)	73.85 (59.22)	80.63 (63.87)	97.21 (80.34)	68.27 (56.92)
Control	73.50 (58.99)	77.73 (61.82)	80.70 (63.92)	72.40 (58.28)	94.14 (75.96)	88.19 (69.88)	99.20 (84.82)	94.02 (67.67)
Mean	25.40 (28.36)	33.23 (33.94)	42.03 (39.07)	51.08 (45.52)	66.78 (55.82)	81.72 (65.23)	95.43 (79.78)	

CD (0.05 %) for comparing treatment means (6.4)
CD (0.05 %) for comparing between bunches (17.09)
Figure in parentheses are angular transformed values
* Age of the bunch at the time of third spraying

It is interesting to note that the percentage nut damage in younger bunches are comparatively less and the damage gradually increased in mature nuts. The percentage CEM damage in first, second and third bunches of fenazaquin 0.05 per cent (1.04 %, 2.61 % and 0.47 %) were significantly less than the respective older bunches. In the case of nimbecidine 0.4 per cent, New FOIS (G) ten per cent and neem oil 3 per cent only first two bunches were significantly superior over the older bunches.

In the first bunch, all the treatments were found superior to water spray (60.29 %). Fenazaquin 0.05 per cent causing only 1.04 per cent per cent nut damage, was the best which was on par with sulphur W.P 0.4 per cent (5.94 %), imidacloprid 0.05 per cent (14.25 %), nimbecidine 0.4 per cent (14.81 %).

Considering the CEM infestation on second bunch all the treatments except neem oil three per cent (36.45 %) and New FOIS (G) ten per cent (43.48 %) are significantly superior over water spray (59.73 %), however neem oil three per cent and New FOIS (G) ten per cent were superior to control (77.73 %).

Only fenazaquin 0.05 per cent (0.47 %) and sulphur W.P 0.4 per cent (19.34 %) could reduce the per cent nut damage in the third bunch significantly over water spray (54.71 %). However, other treatments except neem oil three per cent (62.68 %) were significantly superior over control (80.70 %) in reducing CEM damage.

Only fenazaquin 0.05 per cent (20.53 %) was found to be significantly superior over water spray (51.48 %) considering the CEM damage on fourth bunch, while sulphur W.P 0.4 per cent (30.74 %) was significantly superior over control (72.40 %). All the other treatments could not significantly reduce CEM damage on the fourth bunch.

In the case of fifth bunch significant reduction in CEM damage was observed in sulphur W.P 0.4 per cent (34.37 %) and fenazaquin 0.05 per cent (43.76 %).

In the older sixth and seventh bunches, none of the treatments were superior to water spray (80.63 % and 97.21 %) in reducing the CEM damage except the sixth bunch in the case of Sulphur W.P 0.4 per cent (61.51 %).

4.2.2.2 Intensity of damage

The data on the mean intensity score of CEM damage on seven bunches recorded three months after the third spraying are presented in Table 5.

A trend similar to that of per cent reduction in CEM damage was observed in the mean intensity score of damaged nuts. Fenazaquin 0.05 per cent recorded the least score (1.93) indicating only less than ten per cent (Plate 9) CEM damage and was significantly superior to all the others. Sulphur W.P 0.4 per cent (2.31) (Plate 10) was ranked next followed by neem oil three per cent (2.46) which was on par with neemazal 0.4 per cent

Table 5. Effect of promising oils, botanicals and acaricides on the intensity of nut damage in seven bunches after three rounds of spraying

Treatments concentration (%)	Intensity of damage (mean intensity score) on seven bunches (mean of three replications)							Mean
	1*	2	3	4	5	6	7	
Neem oil 3 %	1.84 (7.78)	1.80 (7.70)	2.57 (9.22)	2.39 (8.89)	2.32 (8.76)	2.79 (9.62)	3.54 (10.83)	2.46 (8.97)
Castor oil 3 %	1.31 (6.56)	2.55 (9.18)	2.98 (9.94)	3.82 (11.27)	3.25 (10.38)	3.11 (10.15)	4.12 (11.71)	3.02 (9.87)
New FOIS(G) 10 %	2.13 (8.38)	2.99 (9.95)	3.43 (10.67)	4.07 (11.63)	4.05 (11.61)	3.04 (10.03)	4.00 (11.53)	3.39 (10.54)
Nimbecidine 0.4 %	3.06 (10.07)	2.50 (9.09)	3.38 (10.59)	3.31 (10.48)	3.62 (10.96)	2.76 (9.56)	4.50 (12.23)	3.30 (10.43)
Neemazal 0.4 %	1.43 (6.87)	1.51 (7.05)	2.17 (8.47)	2.57 (9.22)	3.59 (10.92)	3.53 (10.82)	4.15 (11.75)	2.71 (9.30)
Sulphur W.P 0.4 %	1.66 (7.39)	1.31 (6.58)	1.70 (7.49)	1.78 (7.66)	2.37 (8.85)	2.96 (9.90)	4.41 (12.11)	2.31 (8.57)
Fenazaquin 0.05 %	1.07 (5.93)	1.35 (6.67)	1.26 (6.45)	1.74 (7.59)	1.81 (7.73)	2.64 (9.35)	3.67 (11.04)	1.93 (7.82)
Imidacloprid 0.05 %	1.68 (7.44)	1.77 (7.64)	2.37 (8.85)	2.74 (9.52)	3.34 (10.52)	3.57 (10.89)	4.48 (12.21)	2.85 (9.58)
Water spray	2.97 (9.92)	3.41 (10.64)	2.82 (9.67)	3.17 (10.26)	3.48 (10.75)	3.84 (11.29)	4.08 (11.65)	3.40 (10.56)
Control	3.24 (10.37)	3.50 (10.78)	3.17 (10.25)	3.07 (10.09)	3.62 (10.96)	4.53 (12.28)	4.89 (12.77)	3.72 (11.07)
Mean	2.04 (8.07)	2.27 (8.53)	2.59 (9.16)	2.87 (9.66)	3.15 (10.15)	3.27 (10.39)	4.54 (11.79)	

CD (0.05 %) for comparing treatment means (0.7)
CD (0.05 %) for comparing between bunches (1.86)
Figure in the parentheses are square root transformed values
* Age of the bunch at the time of third spraying

Plate 9. Recovery of mite damage on nuts treated with fenazaquin 0.05 per cent and control (three months after third round of spraying)


Fenazaquin
Control

Plate 10. Recovery of mite damage on nuts treated with sulphur W.P 0.4 per cent and control (three months after third round of spraying)


Control
Wettable sulphur

(2.71) and imidacloprid 0.05 per cent (2.85). Castor oil three per cent (3.02) was effective when compared to water spray (3.40) and control (3.72).

Nimbecidene 0.4 per cent and New FOIS (G) ten per cent which recorded a MIS of 3.30 and 3.39 were less effective and were statistically on par with water spray and control.

Effect of the treatments manifested in the younger bunches more evidently registering very low MIS on them. Intensity of damage was less than ten per cent in the case of first five bunches for fenazaquin 0.05 per cent (1.07, 1.35, 1.26, 1.74, 1.81), first four bunches for sulphur W.P 0.4 per cent (1.66, 1.31, 1.70, 1.78), first two bunches in neem oil three per cent (1.84, 1.82), neemazal 0.4 per cent (1.43, 1.51) and imidacloprid 0.05 per cent (1.68, 1.77) but in castor oil three per cent less than ten per cent damage was observed only in the first bunch with a MIS of 1.31.

4.2.2.3 Extent of nut fall

The data on the fallen nuts for six months (from first spraying to three months after third spraying) presented in Table. 6 showed least nut fall in palms sprayed with fenazaquin 0.05 per cent (2.74), which was closely followed by neemazal 0.4 per cent (3.97). All the treatments were on par and significantly effective in reducing the nut fall when compared to water spray (17.17) and control (18.18).

Table 6. Effect of promising oils, botanicals and acaricides on the extent of nut fall due to CEM attack

Treatment concentration (%)		Mean number of fallen nuts due to CEM attack during seven months after the first spraying
Neem oil	3.00 %	6.05 (2.46)
Castor oil	3.00 %	6.61 (2.57)
New FOIS (G)	10.00 %	6.74 (2.60)
Nimbecidine	0.40 %	7.20 (2.68)
Neemazal	0.40 %	3.97 (1.99)
Sulphur W. P	0.40 %	7.08 (2.66)
Fenazaquin	0.05 %	2.74 (1.66)
Imidacloprid	0.05 %	4.00 (2.00)
Water spray		17.17 (4.14)
Control		18.18 (4.26)
CD (0.05 %)		(1.25)

Figure in the parentheses are square root transformed values

4.3 Efficacy of natural products and innovative farmer practices in the field

4.3.1 Effect on mite population

Results of the effect of natural products and innovative farmer practices on the percentage reduction in CEM population one week after each interval of spraying over the precount are presented in the Table 7.

Among the eleven treatments, starch solution five per cent (68.22 %) recorded maximum population reduction after first spraying, which was closely, followed by marotti cake one kg palm^{-1} (68.76 %). Per cent reduction in CEM population on neem cake one kg palm^{-1} and salt solution five per cent were 62.49 per cent and 59.50 per cent respectively. All the above four treatments were statistically on par. Application of pongamia cake one kg palm^{-1} could reduce 53.29 per cent of CEM population, which was statistically on par with neem cake one kg palm^{-1} and salt solution five per cent above and also with wood ash one kg palm^{-1} (47.51 %) and rubber latex 50 per cent (44.29 %) below. Seawater (undiluted) (40.67 %), kaoline one kg palm^{-1} (37.61 %), cows milk 50 per cent (34.73 %) were comparatively less effective even though they were significantly superior over control (0.44 %).

After the second round of application all the treatments were found to be superior over the control (7.78 %), the reduction in population ranging from 49.02 to 79.30 per cent. Neem cake one kg palm^{-1} (79.30 %)

Table 7. Effect of natural products and innovative farmer practices on the percentage of reduction of CEM population observed one week after each spraying at monthly intervals

Treatments	Dose	Percentage reduction in CEM population after each spraying (mean of three replications)		
		1st	2nd	3rd
Neem cake	1 kg/palm	62.49 (52.21)	79.30 (62.91)	88.33 (69.10)
Marotti cake	1 kg/palm	68.76 (55.10)	68.06 (55.57)	61.51 (51.63)
Pongamia cake	1 kg/palm	53.29 (46.87)	49.02 (44.42)	27.07 (31.34)
Wood ash	1 kg/palm	47.51 (43.56)	61.96 (51.90)	64.90 (53.65)
Kaoline	1 kg/palm	37.61 (37.81)	68.41 (55.78)	89.85 (71.39)
Sea water	Undiluted	40.67 (39.61)	62.12 (51.10)	78.94 (62.66)
Starch solution	5 %	68.22 (55.67)	73.21 (58.80)	90.67 (72.18)
Salt solution	5 %	59.50 (50.46)	71.25 (57.55)	84.94 (67.14)
Rubber latex	50 %	44.29 (41.70)	62.70 (52.33)	73.96 (59.30)
Cows milk	50 %	34.73 (36.10)	59.19 (50.27)	65.63 (54.08)
Control		0.44(3.80)	7.78 (16.19)	11.54 (19.85)
	CD (0.05 %)	(9.60)	(3.10)	(13.14)

Figure in the parentheses are angular transformed values

was found to be the most effective treatment followed by starch solution five per cent and salt solution five per cent having a per cent reduction of 73.21 and 71.25. No significant differences were observed among them. While salt solution five per cent was statistically on par with the remaining treatments (62.12 to 68.41 %) except cows milk 50 per cent (59.19 %) and pongamia cake one kg palm^{-1} (49.02 %).

After the last round of application all the treatments except pongamia cake one kg palm^{-1} (27.07 %) were effective in reducing the CEM population ranging from 61.51 to 90.67 per cent but it was significantly superior over control (11.54 %). Starch solution five per cent registered maximum population reduction of 90.67 per cent closely followed by kaoline one kg palm^{-1} (89.85 %), neem cake one kg palm^{-1} (88.33 %) and salt solution five per cent (84.94 %) which were statistically on par. Next in position was sea water (78.94 %) which was on par with salt solution five per cent above and rubber latex 50 per cent below (73.96 %). The percentage reduction in CEM population in cows milk 50 per cent, wood ash one kg palm^{-1} and marotti cake one kg palm^{-1} were 65.63, 64.90 and 61.51 per cent respectively, which were on par with rubber latex 50 per cent.

4.3.2 Effect on mite damage on mature nuts

4.3.2.1 Percentage of damaged nuts three months after third application

Data on the percentage of damaged mature nuts on seven bunches three months after third application and results of the statistical analysis are presented in Table 8.

Among the different bunches, maximum reduction in damage was noticed in the third bunch treated with salt solution five per cent with only 0.87 per cent damage. This was followed by the fifth bunch (1.28 %), first bunch (3.53 %), second and fourth bunch (5.10 %). Starch solution five per cent was found to be the best treatment, which was superior to all the other treatments. Only 19.36 mean per cent of the total nuts on all the seven bunches treated with starch solution five per cent were found to be damaged by CEM. Salt solution five per cent with 32.86 mean per cent nut damage and sea water undiluted (34.41 %) ranked second and third which were statistically on par. Rubber latex 50 per cent (46.21 %) is on par with sea water undiluted (34.41 %) and kaoline one kg $palm^{-1}$ (46.68 %). Application of neem cake one kg $palm^{-1}$ (50.77 %), marotti cake one kg $palm^{-1}$ (53.30 %) and wood ash one kg $palm^{-1}$ (53.33 %) were significantly superior over water spray (68.26 %) and control (83.61 %) while cows milk 50 per cent (62.14 %) and pongamia cake one kg $palm^{-1}$ (63.86 %) were on par with water spray but superior to control.

Table 8. Effects of natural products and innovative farmer practices on the percentage nut damage in seven bunches after three rounds of spraying

Treatments dose	Percent of CEM damaged nuts on seven bunches (mean of three replication)							Mean
	1*	2	3	4	5	6	7	
Neem cake 1 Kg/palm	12.85 (20.99)	35.34 (36.46)	33.33 (35.25)	81.92 (64.81)	50.00 (44.98)	57.85 (49.50)	84.10 (66.47)	50.77 (45.50)
Marotti cake 1 Kg/palm	35.26 (36.41)	39.35 (38.84)	41.48 (40.08)	33.55 (35.38)	57.97 (49.57)	85.81 (67.84)	79.71 (63.20)	53.30 (47.33)
Pongamia cake 1 Kg/palm	19.63 (26.29)	42.61 (40.73)	54.21 (47.39)	72.40 (68.28)	85.81 (67.84)	84.10 (66.47)	88.29 (69.96)	63.86 (53.85)
Wood ash 1 Kg/palm	32.79 (34.92)	45.18 (42.22)	49.70 (44.81)	40.22 (39.34)	73.60 (59.06)	50.29 (45.15)	81.53 (64.52)	53.33 (47.15)
Kaoline 1 Kg/palm	17.84 (16.26)	13.55 (21.59)	32.54 (34.77)	70.54 (57.11)	75.02 (59.99)	48.00 (42.82)	79.29 (62.90)	46.68 (42.35)
Sea water (undiluted)	5.96 (14.12)	16.60 (24.04)	31.31 (34.01)	18.98 (25.82)	50.60 (45.32)	32.90 (34.99)	84.55 (66.83)	34.41 (35.02)
Starch solution 5 %	3.53 (10.82)	5.10 (13.04)	0.87 (5.36)	5.10 (13.04)	1.28 (6.49)	30.04 (33.22)	89.57 (71.13)	19.36 (21.87)
Salt solution 5 %	12.85 (20.99)	12.07 (20.32)	9.20 (17.65)	14.47 (22.35)	32.90 (34.99)	65.28 (53.88)	83.23 (65.80)	32.86 (33.71)
Rubber latex 50 %	6.82 (15.13)	8.12 (16.55)	23.00 (28.64)	43.02 (40.97)	65.78 (54.18)	81.22 (64.29)	95.53 (77.76)	46.21 (42.50)
Cows milk 50 %	25.08 (47.68)	28.50 (45.77)	80.44 (63.72)	61.65 (51.72)	65.78 (54.18)	95.27 (77.41)	78.23 (62.17)	62.14 (53.07)
Water spray	60.29 (50.92)	59.73 (50.59)	54.71 (47.68)	51.42 (45.79)	73.85 (59.22)	80.63 (63.87)	97.19 (80.32)	68.26 (56.91)
Control	73.50 (58.99)	77.73 (61.82)	80.70 (63.92)	72.40 (58.28)	94.14 (75.96)	88.19 (69.88)	99.20 (84.82)	83.61 (67.67)
Mean	24.70 (27.99)	31.99 (33.20)	40.96 (38.61)	44.97 (42.74)	60.56 (50.98)	66.63 (55.86)	86.70 (69.66)	

CD (0.05 %) for comparing treatment means (8.32)
CD (0.05 %) for comparing between bunches (22.01)
Figure in the parentheses are angular transformed values
* Age of the bunch at the time of third spraying

Considering the percentage damaged nuts in different bunches it was seen that starch solution five per cent could protect all the bunches except seventh bunch significantly (3.53, 5.10, 0.87, 5.10, 1.28 and 30.04 per cent). Salt solution five per cent could protect first to fifth bunch significantly. (12.85, 12.07, 9.20, 14.47 and 32.90 per cent) while sea water undiluted (5.96 % and 16.60 %), rubber latex 50 per cent (6.82 % and 8.12 %) and kaoline one kg palm^{-1} (17.84 % and 13.55 %) could protect first and second bunches respectively. In the case of neem cake one kg palm^{-1} (12.85 %) and pongamia cake one kg palm^{-1} (19.63 %) significant protection was obtained in the case of first bunch only.

4.3.2.2 Intensity of damage

Table 9, represents the data on MIS of CEM on seven bunches recorded three months after third spraying.

Starch solution five per cent could reduce the surface damage to less than ten per cent with a MIS of 1.89, which was statistically significant over all the other treatments. It was followed by salt solution five per cent (2.32), kaoline one kg palm^{-1} (2.54) and neem cake one kg palm^{-1} (2.44) which were on par. Pongamia cake one kg palm^{-1} (2.64) was on par with rubber latex 50 per cent, marotti cake one kg palm^{-1} and sea water (undiluted) with a MIS of 3.01, 3.06, 3.18 respectively and sea water is on par with water spray (3.45). Wood ash one kg palm^{-1} (3.47) and cows milk

Table 9. Effect of natural products and innovative farmer practices on the intensity of nut damage in seven bunches after three rounds of spraying

Treatments	Intensity of damage (mean intensity score) on seven bunches (mean of three replications)							Mean
	1*	2	3	4	5	6	7	
Neem cake 1 Kg/palm	1.36 (1.17)	1.82 (1.35)	1.45 (1.20)	1.49 (1.22)	3.05 (1.75)	3.28 (1.81)	4.60 (2.15)	2.44 (1.52)
Marotti cake 1 Kg/palm	2.24 (1.50)	2.81 (1.68)	2.51 (1.58)	2.94 (1.71)	3.66 (1.91)	3.64 (1.91)	3.65 (1.91)	3.06 (1.74)
Pongamia cake 1 Kg/palm	1.65 (1.28)	1.73 (1.31)	2.17 (1.47)	2.88 (1.70)	3.04 (1.74)	3.06 (1.75)	3.93 (1.98)	2.64 (1.61)
Wood ash 1 Kg/palm	2.42 (1.55)	2.95 (1.72)	3.36 (1.83)	3.74 (1.93)	3.78 (1.94)	4.46 (2.11)	3.57 (1.89)	3.47 (1.86)
Kaoline 1 Kg/palm	1.54 (2.29)	2.16 (1.47)	2.00 (1.41)	2.44 (1.56)	2.59 (1.61)	3.87 (1.97)	3.20 (1.79)	2.54 (1.58)
Sea water (undiluted)	2.29 (1.51)	2.95 (1.72)	2.80 (1.67)	3.16 (1.78)	3.28 (1.81)	3.57 (1.89)	4.22 (2.05)	3.18 (1.78)
Starch solution 5 %	1.36 (1.17)	1.10 (1.04)	1.22 (1.10)	1.17 (1.08)	1.02 (1.01)	3.22 (1.79)	4.13 (2.03)	1.89 (1.32)
Salt solution 5 %	1.23 (1.11)	1.65 (1.28)	2.34 (1.53)	2.19 (1.48)	2.50 (1.58)	3.13 (1.77)	3.20 (1.79)	2.32 (1.52)
Rubber latex 50 %	2.12 (1.46)	1.99 (1.41)	2.58 (1.61)	2.38 (1.54)	3.57 (1.89)	3.56 (2.89)	4.85 (2.20)	3.01 (1.71)
Cows milk 50 %	2.97 (1.72)	2.48 (1.57)	3.28 (1.81)	3.66 (1.91)	4.05 (2.01)	3.66 (1.91)	4.86 (2.20)	3.57 (1.88)
Water spray	2.97 (1.72)	3.41 (1.85)	2.82 (1.68)	3.17 (1.78)	3.48 (1.86)	3.84 (1.96)	4.08 (2.02)	3.45 (1.84)
Control	3.24 (1.86)	3.50 (1.87)	3.17 (1.78)	3.07 (1.75)	3.62 (1.90)	4.53 (2.13)	4.89 (2.21)	3.72 (1.92)
Mean	2.12 (1.44)	2.38 (1.52)	2.48 (1.56)	2.69 (1.62)	3.14 (1.75)	3.57 (1.91)	4.10 (2.02)	

CD (0.05 %) for comparing treatment means (0.09)
CD (0.05 %) for comparing between bunches (0.26)
Figure in the parentheses are square root transformed values
* Age of the bunch at the time of third spraying

50 per cent (3.57) were ineffective being on par with water spray (3.45) and untreated control (3.72).

There was only less than ten percent damage in the first bunch of the palms treated with salt solution five per cent (1.23), starch solution five per cent (1.36), neem cake one kg palm^{-1} (1.36), kaoline one kg palm^{-1} (1.54) and pongamia cake one kg palm^{-1} (1.65) and are significantly superior over water spray (2.97). All the remaining five treatments having MIS ranging from 2.42 to 2.97 were on par with water spray.

Considering the intensity of damage on the second bunch, starch solution five per cent (1.10), salt solution five per cent (1.65), pongamia cake one kg palm^{-1} (1.73), neem cake one kg palm^{-1} (1.82), rubber latex 50 per cent (1.99) and cows milk 50 per cent (2.48) were found to be superior to the water spray (3.41).

In the case of starch solution five per cent, all the first five bunches were effectively protected and in this case less than ten percent damage were observed with MIS of 1.36, 1.10, 1.22, 1.17 and 1.02 respectively. Application of neem cake one kg palm^{-1} could protect all the four bunches with a MIS of 1.36, 1.82, 1.45 and 1.49 respectively. Less than ten per cent damage intensity was observed in the first two bunches in pongamia cake one kg palm^{-1} and salt solution five per cent.

4.3.2.3 Extent of nut fall

The data on the nut fall collected within six months after first spraying is shown in Table 10. Nut fall due to CEM attack was least in neem cake one kg palm^{-1} (1.63) and it was on par with marotti cake one kg palm^{-1} (2.17), salt solution five per cent (2.64), kaoline one kg palm^{-1} (3.73), wood ash one kg palm^{-1} (4.13), pongamia cake one kg palm^{-1} (4.52) and rubber latex 50 per cent (4.66). In all the treatments, nut fall due to CEM attack was significantly low when compared to water spray (16.80) and control (18.52).

Table 10. Effect of natural products and innovative farmer practices on the extent of nut fall due to CEM attack

Treatments	Dose	Mean number of fallen nuts due to CEM attack during seven months after the first spraying
Neem cake	1 kg/palm	1.63 (1.28)
Marotti cake	1 kg/palm	2.17 (1.47)
Pongamia cake	1 kg/palm	4.52 (2.13)
Wood ash	1 kg/palm	4.13 (2.03)
Kaoline	1 kg/palm	3.73 (1.93)
Sea water	Undiluted	6.70 (2.59)
Starch solution	5 %	6.32 (2.51)
Salt solution	5 %	2.64 (1.63)
Rubber latex	50 %	4.66 (2.16)
Cows milk	50 %	4.91 (2.22)
Water spray		16.80 (4.08)
Control		18.52 (4.30)
CD (0.05 %)		(1.18)

Figure in the parentheses are square root transformed values

DISCUSSION

5. DISCUSSION

The eriophyid mite, *Aceria guerreronis* (Keifer) has become a serious pest of coconut in many important coconut growing countries in the world. It was first described by Keifer in 1965 from specimens collected from Guerrero state, Mexico.

In India, the pest was first reported in the later part of 1997 from Ernakulam district of Kerala State (Sathiamma *et al.*, 1998). The outbreak and rapid spread of coconut eriophyid mite throughout Kerala and the neighbouring states of Tamil Nadu and Karnataka has resulted in substantial loss in the productivity of crop. It has become a threat to coconut growers, large and marginal, of these states necessitating urgent remedial measures against this mite pest.

Even though acaricides are reported as effective in controlling the pest, requirement of repeated application of chemicals at short interval would be economically unviable and environmentally hazardous. The present studies are hence taken up to identify non-hazardous ecofriendly components including non-chemical methods and safer synthetic acaricides which could be integrated in developing a sustainable long term strategy in the management of this mite pest. The findings are discussed below : -

5.1 Laboratory screening of oils, botanicals and synthetic acaricides

For identifying an effective method of application of acaricides for controlling this mite pest inhabiting below the perianth. the route of movement of the spray solutions to the meristematic region had to be ascertained. Howard and Abreu (1991) had conducted an ink penetration test to determine the physical space between tepals, which is important in CEM infestation. As the mites remain well protected inside the perianth, the acaricide sprayed on the surface has to reach inside within the perianth for effective management. It was ascertained in the laboratory trial with Malachite green dye that the spray fluid on the nut surface could reach the meristematic region through capillary movement where the CEM colonies are found. For conducting these studies, nuts from fourth bunch of uniformly aged coconut palms exhibiting uniform CEM damage were maintained in the laboratory for the experiments.

5.1.1 Screening of oils and botanicals

The acaricidal activity of oils and botanicals was studied in view of the high level of safety attributed to them. The effect of eight different oils and botanicals at two doses is presented in para 4.1.2. Considering the mean percent mortality at different intervals after spraying, maximum mortality was obtained at 72 hours (Fig.1) compared to 24 and 48 hours. It was also seen that higher doses of all the treatments recorded higher mortality. Out

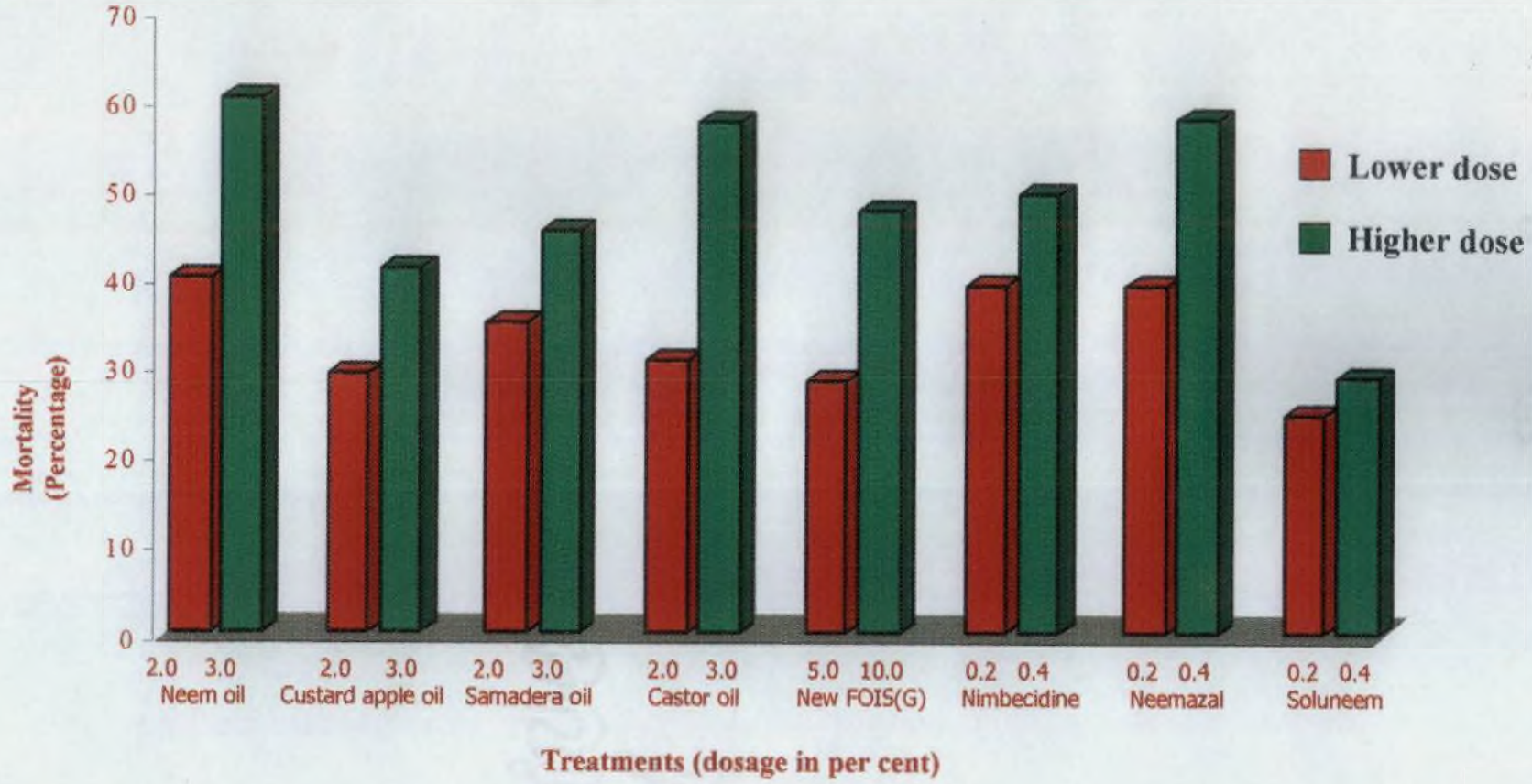

Fig. 1. Mean corrected mortality percentage of CEM treated with two doses of oils and botanicals in the laboratory 72 hours after application

of the eight organic products, neem oil three per cent was ranking first with 60.07 per cent mortality. Among the other neem formulations tested, the higher dose of Neemazal 0.4 per cent and nimbecidine 0.4 per cent showed significant mortality while Soluneem 0.2 per cent was inferior to all the other treatments. Castor oil three per cent was equally effective as neem oil three per cent. It may be noted that New FOIS (G) ten per cent recorded maximum mortality at 48 hours after treatment but at 72 hours after treatment there was no subsequent increase in mortality unlike the other treatments.

Efficacy of neem products in controlling plant mites is well documented (Ramarethinam and Marimuthu, 1998). Saradamma *et al.*, 2001 tested the efficacy of different seed oils and their combinations in controlling CEM in the laboratory and the mortality of adults and nymphs ranged from 10.0 to 92.7 per cent. Azadirachtin 0.004 per cent and castor oil three per cent were effective with 92.7 per cent and 86 per cent mortality respectively. Neem oil two per cent and pongamia oil three per cent were also found to be promising. Palanisamy *et al.*, 2000 reported the efficacy of FORS four per cent and Neemazal one per cent. These are in conformation with the present findings.

5.1.2 Screening of synthetic acaricides

Two doses of five acaricides were screened against CEM in the laboratory and the results presented in para 4.1.3. showed that fenazaquin 0.05 per cent was most effective with 84.73 per cent mortality after 72 hours of spraying (Fig.2). Dey *et al.*, 2001 also reported that fenazaquin possess high acaricidal action against CEM with a very low LC_{50} value of 0.0000021. Efficacy of fenazaquin against CEM was also reported by Saradamma *et al.*, 2001. Imidacloprid 0.05 per cent could bring 60.73 per cent mortality of CEM. It is evident from the results presented in Table 2 that there is a linear increase in mortality at different intervals in all the treatment except in the case of profenofos 0.025 per cent and 0.05 per cent in which the mortality per cent was declining after 48 hours. However, the higher dose of all the acaricides was more effective than the lower dose.

Predatory mite *Amblyseius* sp (Plate 11) was seen inhabiting in the meristematic region of the nut but no feeding of CEM was observed. The numbers of predatory mites in the CEM colonies varied among different treatments (Table 11). Predatory mites were observed only in mite colonies, treated with oils and botanicals and also in fenazaquin among synthetic acaricides at different intervals after spraying.

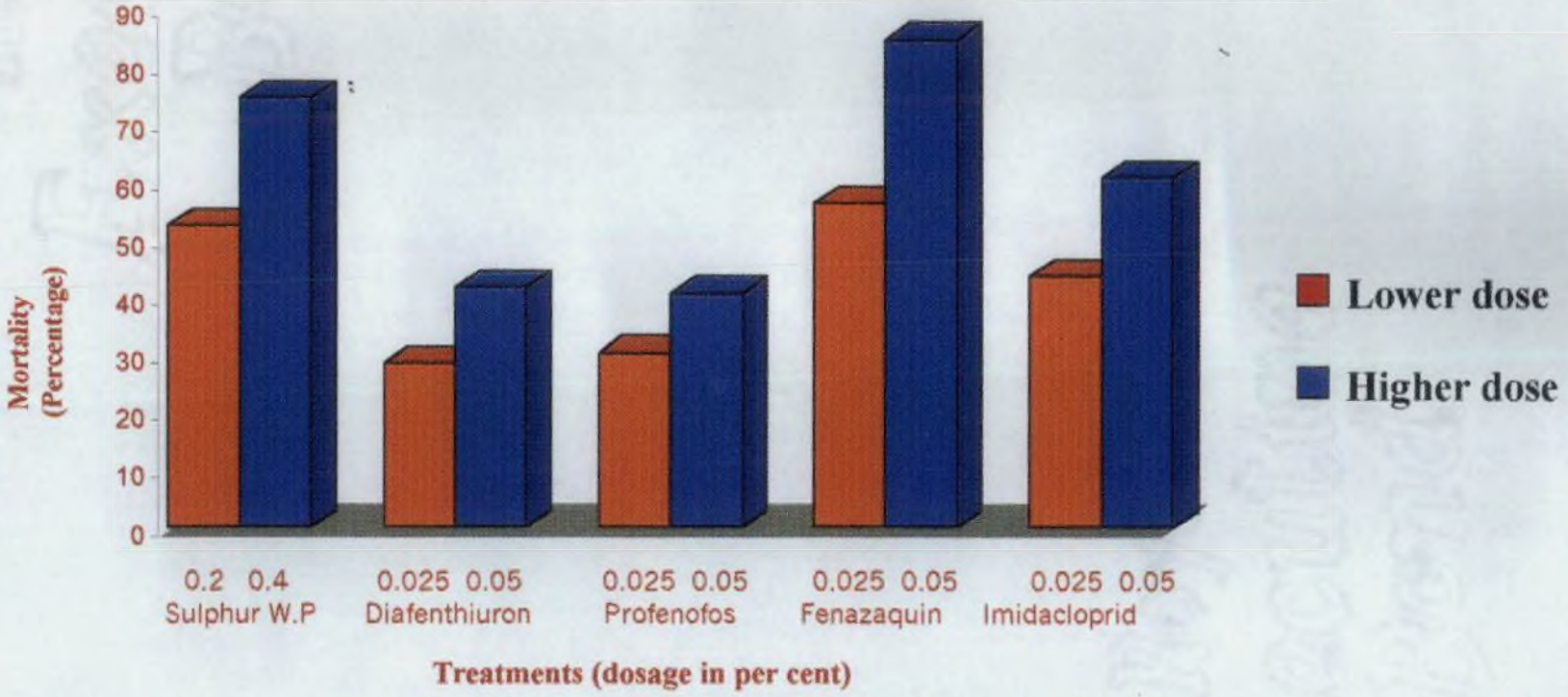

Fig. 2. Mean corrected mortality percentage of CEM treated with two doses of acaricides in the laboratory 72 hours after application

Plate 11. Predatory mite *Amblyseius* sp.

Table 11. Mean number of predatory mites per nut at different intervals after spraying

Treatments	Hours after spraying		
	24 hours	48 hours	72 hours
Neem oil 3 %	3.33	6.33	4.66
Castor oil 3 %	12.66	10.33	8.33
New FOIS (G) 10 %	-	-	-
Nimbecidine 0.4 %	-	-	-
Neemazal 0.4 %	5.66	5.66	4.66
Sulphur W.P 0.4 %	-	-	-
Fenazaquin 0.05 %	5.33	6.66	6.00
Imidacloprid 0.05 %	-	-	-
Control	10.33	18.66	15.00

Similar results were obtained by Dey *et al.*, 2001 where fenazaquin was found to be a safer acaricide being selective in action, sparing the predominant predatory mite, *Amblyseius* sp.

5.2 Field evaluation

The promising oils, botanicals and synthetic acaricides were evaluated in the field.

5.2.1 Field evaluation of selected oils, botanicals and synthetic acaricides

Fig.3 illustrates the highlights of three sprayings with selected oils, botanicals and synthetic acaricides in reducing CEM population. At the end of third spraying, all the eight treatments could reduce the mite population significantly with a reduction above 70 per cent. A cumulative increase in percentage reduction of CEM population was observed after each spraying. The superiority of fenazaquin 0.05 per cent in reducing the CEM population over all the other treatments was confirmed in the field trial also. Field evaluation of fenazaquin against CEM by Dey *et al.* (2001) using fenazaquin 10 EC (Magister) @ 200 – 250 ml 100 litre^{-1} of water indicated 92.77 per cent reduction in mite population eight days after treatment. Fenazaquin is also reported to be giving high satisfactory control of a number of other phytophagous mites as in *Panonychus ulmi* on apple, *Oligonychus coffeae* on tea, *Tetranychus urticae* on okra and *Polyphagotarsonemus latus* on chilli (Solomon *et al.*, 1993, Saha *et al.*, 1999, Dhar *et al.*, 2000 and Somchoudhury *et al.*, 2000).

Sulphur W.P 0.4 per cent and castor oil three per cent also could reduce the CEM population significantly. Field trials on the management of CEM by Nair *et al.* (2000) showed that sulphur W.P 0.4 per cent and azadirachtin 0.004 per cent were effective in managing CEM. The potentiality of sulphur W.P 0.4 per cent and azadirachtin 0.004 per cent was reported by Saradamma *et al.*, 2000. They also recommended neem oil

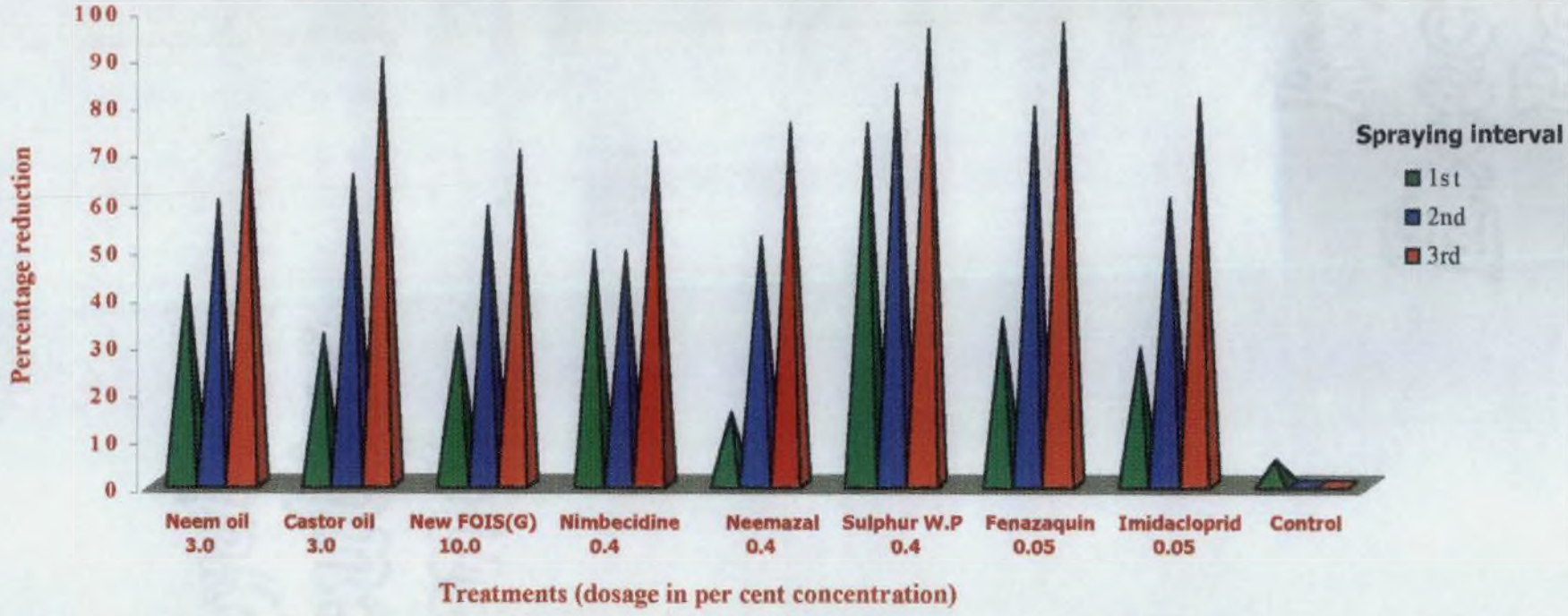

Fig. 3. Percentage reduction of CEM population sprayed with selected oils, botanicals and acaricides at monthly intervals of spraying

+ garlic soap emulsion (2 %) alternatively with a synthetic chemical, dicofol (0.1 %) at fortnightly intervals against CEM. Neem oil + garlic soap emulsion (2 %) and Neemazal one per cent which could reduce mite population by 60 per cent was recommended by Fernando *et al.* (2000) in Sri Lanka. However, in the present investigation neem oil three per cent (without garlic) could give a mean per cent population reduction of 59.84 over three rounds of spraying. In the present study, New FOIS (G) ten per cent recorded more than 70 per cent reduction in mite population at the end of third spraying. This is in accordance with the findings of Palanisamy *et al.* (2000) and Karuppuchamy *et al.* (2001) reporting the effectiveness of FORS four per cent in reducing the mite population.

In the case of CEM, the colony size at the susceptible stage of the nuts is a major factor in yield loss. Hence population reduction has much impact on the intensity of damage. In Fig. 4, the mean value of the percentage reduction in mite population after the third spraying, the percentage nut damage and intensity of damage on mature nuts were compared. It is evident from the figure that as the percentage reduction in population increases, the percentage damaged nuts and mean intensity score decreases.

Effect of bunch spraying with selected acaricides on the percentage nut damage is presented in para 4.2.2.1. Fenazaquin 0.05 per cent and sulphur W.P 0.4 per cent were the top ranking treatments in reducing the nut infestation. A perusal of the data (Table 4) indicated that the age of

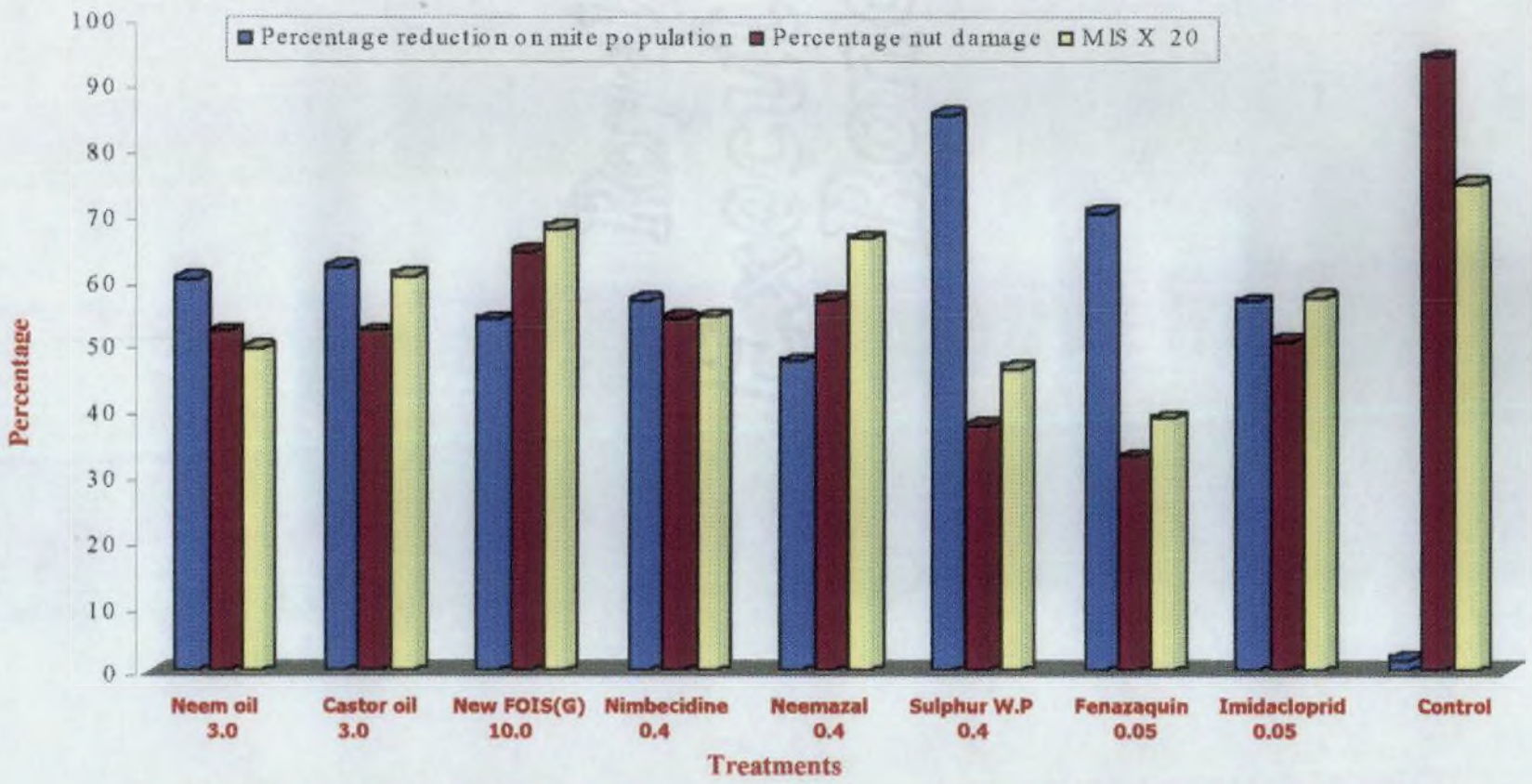

Fig. 4. Effect of promising oils, botanicals and acaricides on the percentage reduction on mite population, percentage nut damage and Intensity of damage on nuts

the bunches at the time of spraying is an important factor influencing the effect of the pesticide application. The number of nuts damaged in younger bunches were less compared to mature nuts. This may be due to the fact that young buttons of three to five months old are harbouring maximum mite population and are the critical age of the buttons to be targeted for spraying.

Effect of the bunch spraying on the surface damage and size reduction on treated bunches is presented in para 4.2.2.2 and in Table 5. As in the case of percentage nut damage, fenazaquin 0.05 per cent and sulphur W.P 0.4 per cent was found to be the most promising treatments in reducing MIS of treated nuts which reflects on yield loss. Similar results were reported earlier by Saradamma *et al.* (2000). Their observations on the level of infestation on the treated bunches at harvest using 0-4 scale revealed that wettable sulphur 0.4 per cent was found effective in reducing the damage. Karuppuchamy *et. al.* (2001) reported that spot application of triazophos, monocrotophos and carbosulfan all at five ml litre^{-1}, recorded the mean grade index on treated nuts ranging from 1.09 to 1.38, 1.16 to 1.76 and 1.13 to 2.45 respectively as against 1.78 to 3.24 in untreated control.

Premature nut fall due to CEM attack is one of the factors contributing to yield loss. There are several reports on extensive nut fall due to CEM infestation (Doreste, 1968; Mariau and Julia, 1970;

Mohanasundaram *et al.*, 1999). Most of them are contradictory. Seguni (2000) reported that losses due to premature nut fall were between 10 to 100 per cent with wide variation between localities. However, Haq (2000b) indicated the influence of CEM to the tune of 41.36 per cent of total premature nut fall due to mite attack. In contrary, Geethalakshmi and Rabindra (2000) have attributed only 2.45 per cent nut fall to eriophyid mite attack. The effect of pesticide application in reducing the extent of nutfall due to mite attack is presented in Fig.5. There is significant reduction in nutfall due to mite attack by the application of oils, botanicals and acaricides. Effect of Hostathion 40 EC in reducing, the nutfall due to mite attack, was reported by Mohanasundaram *et al.*, 1999.

5.2.2 Field evaluation of natural products and innovative farmer practices

Natural products are reported to have acaricidal effect on phytophagous mites. Farmers adopt several innovative farmer practices like application of neem cake; garlic etc on the crown and similarly rice water, salt water, other sticky materials on bunches for lessening mite damage (Nair *et al.*, 2000a). However, precise information on the effectiveness on this information is lacking. In view of the safety of these products in the ecosystem, selected natural products and innovative farmer practices were tested under field conditions to evolve an ecofriendly technology innovation maximizing the natural resource utilization.

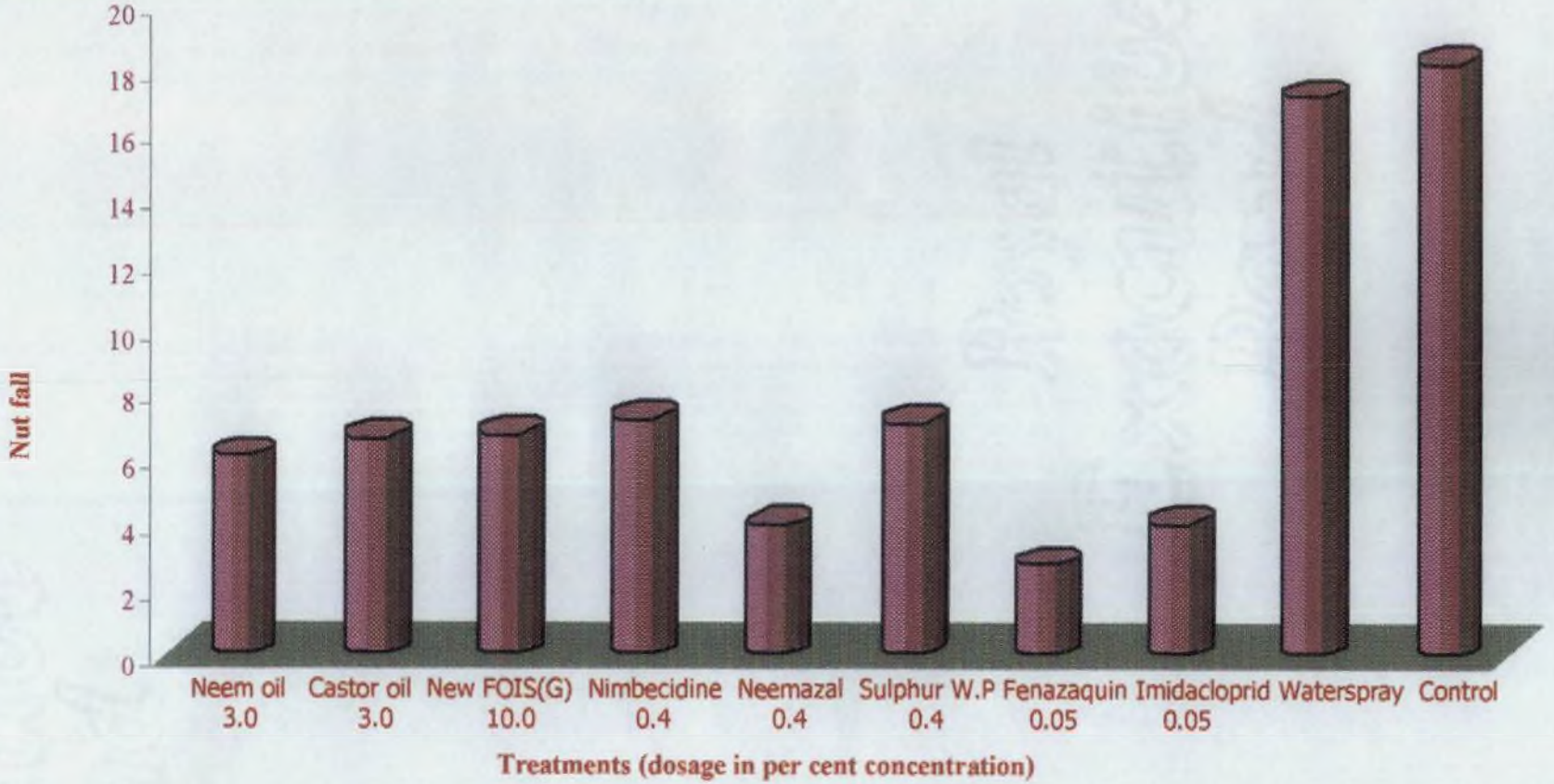

Fig. 5. Extent of nutfall on CEM infested coconut palms sprayed with selected oils, botanicals and acaricides

The present studies revealed that starch solution five per cent was most effective in reducing the mite damage when sprayed on bunches under field condition (Fig.6). Spraying of salt solution five per cent also reduced mite infestation appreciably. This may be due to effect of starch and salt solution acting as physical barriers against migrating mites. Sticky materials when sprayed on to the surface of young nuts physically prevent the movement of mites to and from the nuts sealing the gap between the tepal and nut surface.

Table 8 and 9; illustrate the extent of prevention of mite damage on young buttons by the application of starch and salt solution. It was seen that starch solution five per cent could protect all the young bunches which received spraying at critical stage of mite infestation. Among the seven bunches, which received three sprayings at monthly intervals, only the oldest bunch (seventh) which was the fifth bunch at the time of first spraying was not protected by the application of starch solution (Fig. 7). This indicated the mites which entered already within the perianth could multiply and colonize on the meristematic tissues causing severe damage. Salt solution five per cent also could protect young bunches significantly which is in confirmation with results of the trials conducted by a progressive farmer using 100 per cent salt solution reducing mite population and rejuvenating the palm from pest attack. Application of undiluted sea water was effective in reducing the mite population and also the percentage of damaged nuts moderately. Mariau (1977) has also

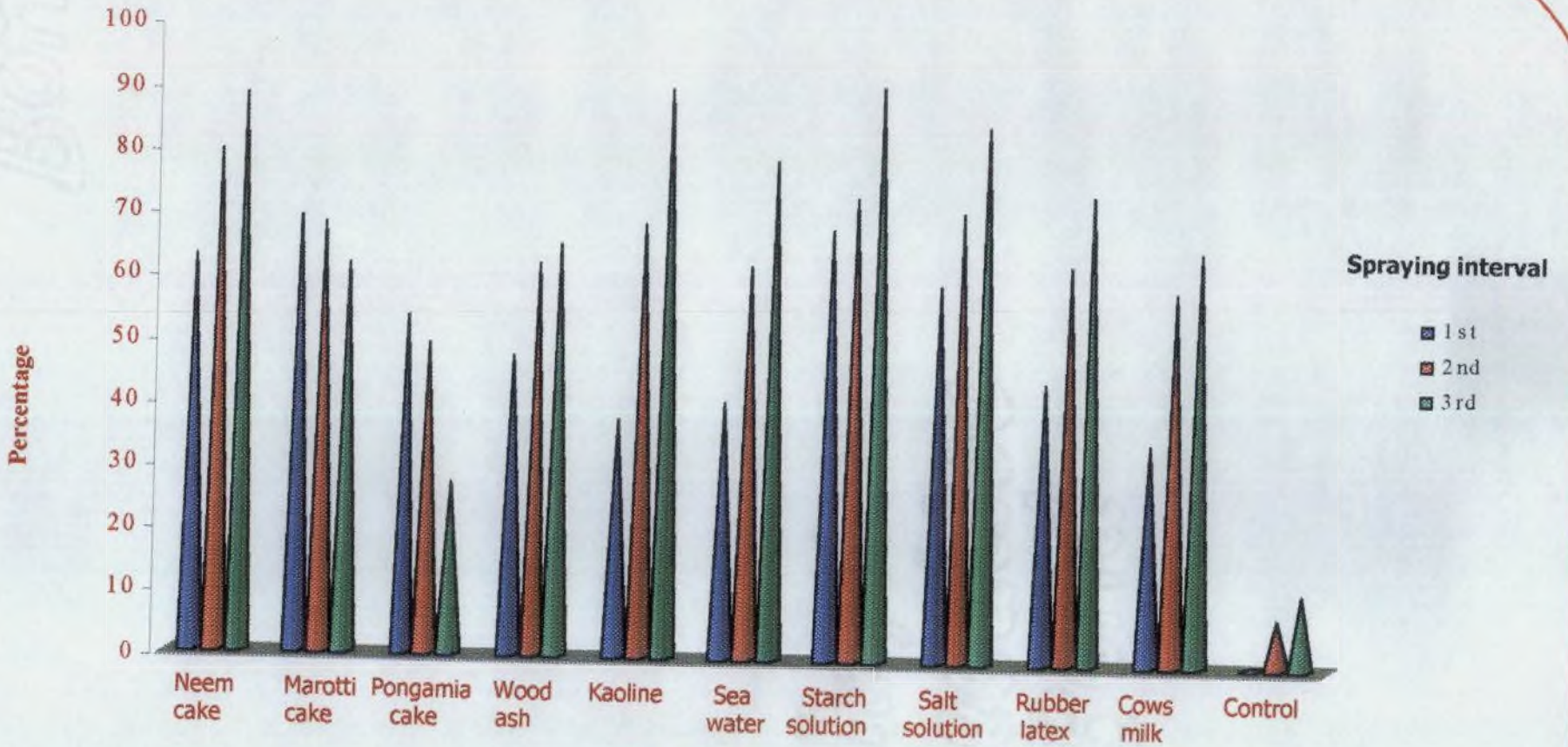

Fig. 6. Percentage reduction of CEM population treated with natural products and innovative farmer practices at three intervals of spraying

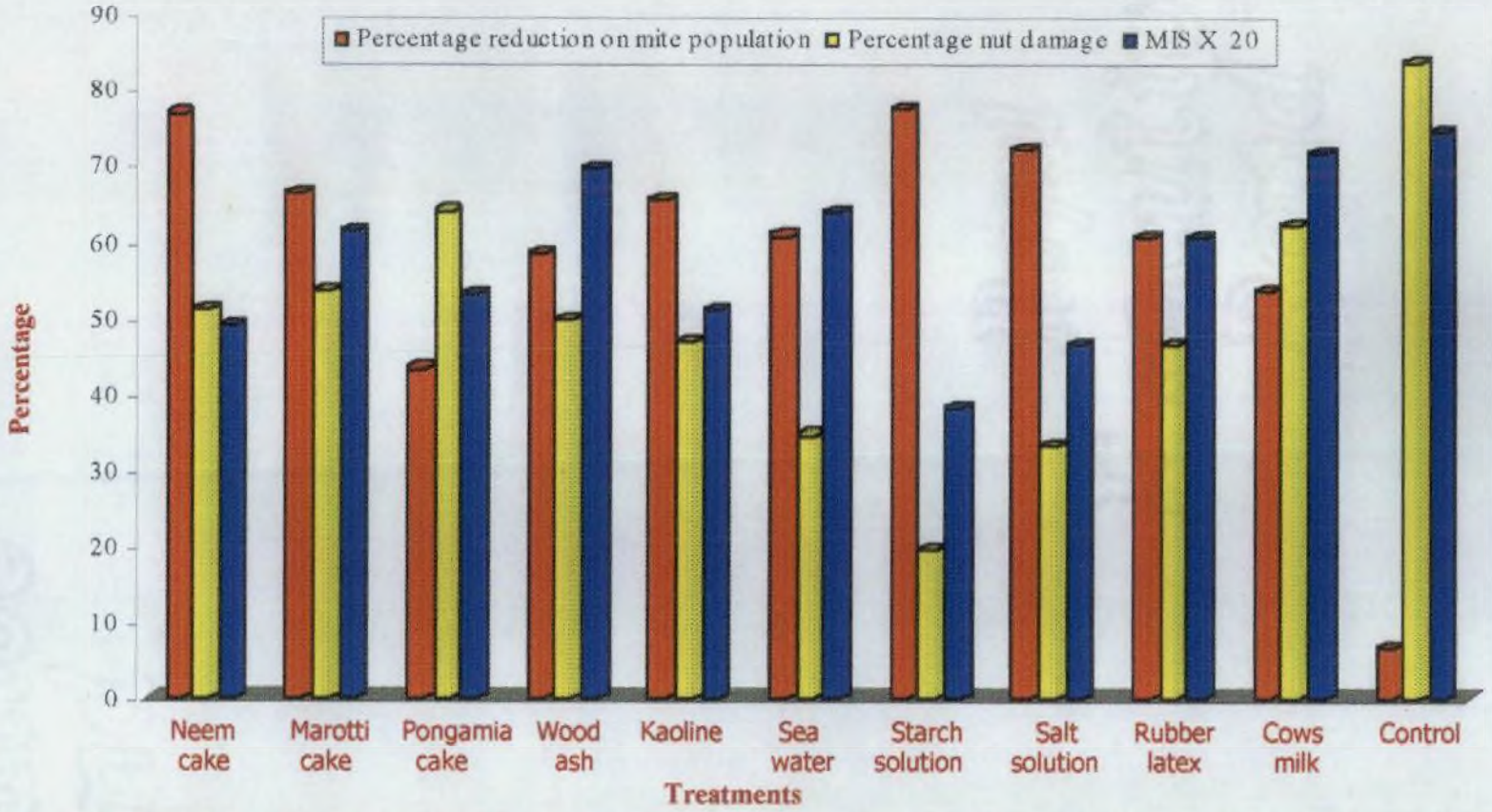

Fig. 7. Effect of natural products and innovative farmer practices on the percentage reduction on mite population, percentage nut damage and intensity of damage on nuts

reported earlier that monthly treatment of bunches with sea water reduces the mite damage probably by half.

Among powdered cakes applied, neem cake was found to be efficient in protecting the young button against mite attack. Based on the MIS, there was less than ten per cent damage in 1 to 4 bunches. The cakes applied mostly remained between the spathes than on nut surface, so the repellent action of cakes were not of much use. The same drawback was also noticed in the case of wood ash, hence found to be very ineffective. Marotti cake and pongamia cake were found to be comparatively less effective. Efficacy of various oil cakes were reported by Muthiah and Bhaskaran (2000) against CEM. Application of kaoline one kg palm^{-1} on the crown was promising in combating the mite menace with significant reduction in population and percent damaged nuts with low mean intensity score (Tables 7 to 9). As in the case of starch and salt solution, this may be acting as a physical poison. The minute sized dust particle of kaoline adhered to the nut surface for a long period. However considering the cost and availability, the use of Kaoline cannot be suggested.

Rubber latex, which was reported to be effective by farmers, was also evaluated in the field. Ganesh sprayer of two litres capacity was used for its application. It was found too difficult for application because of its immense sticky and solidifying nature and consequent clogging of sprayer. Similar spraying difficulties were reported by Moore *et al.* (1989) while testing the efficacy of polybutene (Hyvis) a sticker against CEM. No

significant effect leading to yield increase by application of sticker was observed by them.

Field evaluation of natural products and innovative farmer practices revealed that neem cake one Kg per palm was found to be the best among the treatments in containing nutfall (Fig.8). The mean nutfall in neem cake applied palms was only 1.63 as against 18.52 in control. All the other treatments were also significantly superior in reducing the nutfall compared to control.

The studies have clearly indicated the effectiveness of botanicals and safer synthetic acaricides for the management of coconut eriophyid mite. Application of botanical *viz.*, neem oil three per cent, castor oil three per cent and neemazal 0.4 per cent and synthetic acaricide *viz.*, fenazaquin 0.05 per cent and sulphur W.P 0.4 per cent at monthly intervals could protect the young buttons at critical stages of mite infestation. Fenazaquin was also found to be safe to natural enemies of the mite. Some of the innovative farmer practices like use of starch solution and salt solution were also found to be promising.

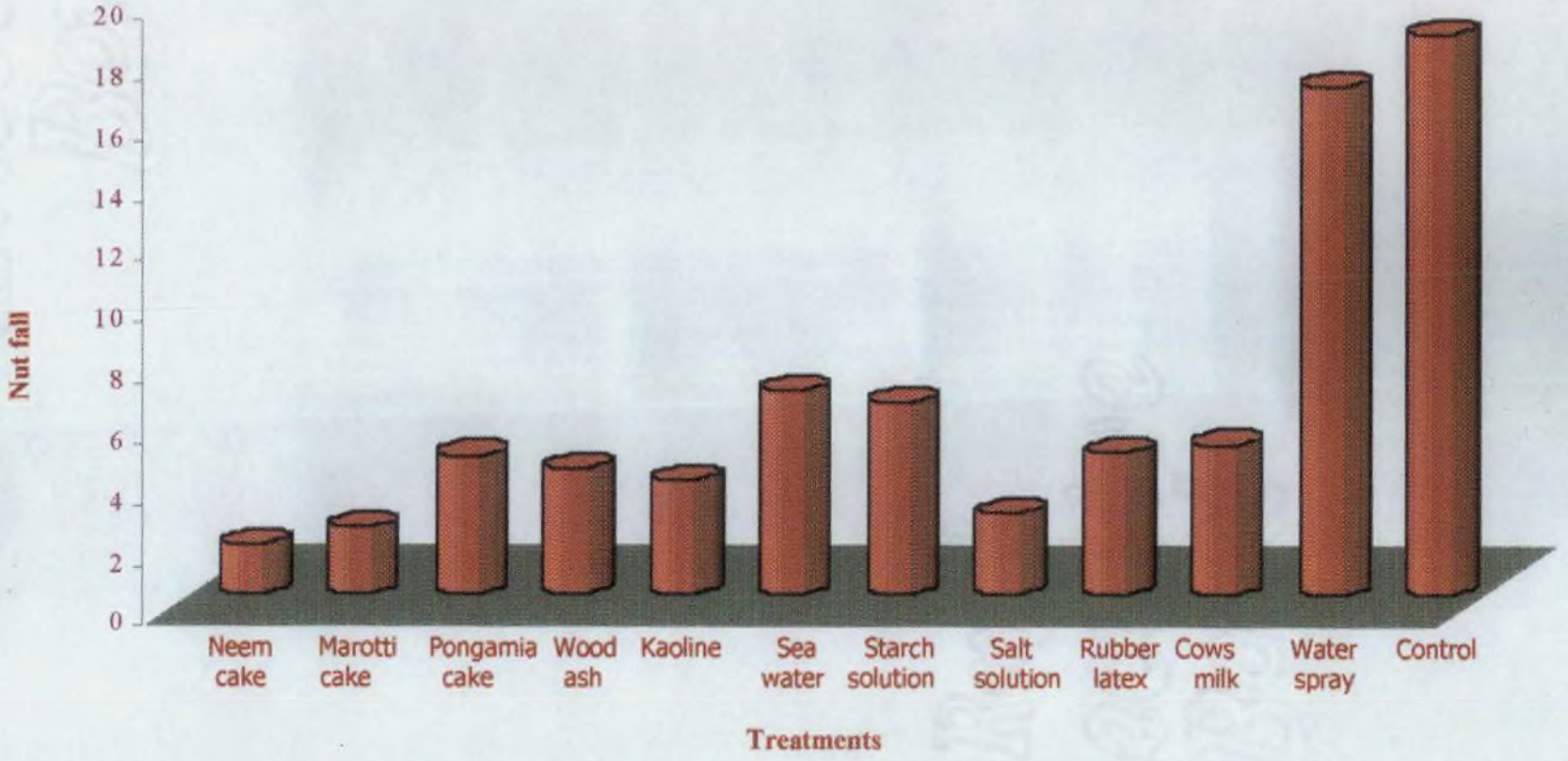

Fig. 8. Extent of nutfall on CEM affected coconut palms treated with natural products and innovative farmer practices

SUMMARY

SUMMARY

The study entitled 'Management of coconut eriophyid mite *Aceria guerreronis* Keifer using eco-friendly methods has been carried out in the Department of Agricultural Entomology and Instructional Farm, attached to the College of Agriculture, Vellayani, Thiruvananthapuram during 2000-2001. The main objective of the study was to generate eco-friendly components including non-chemical methods and safer synthetic acaricides, which can be integrated in developing a sustainable long-term strategy in Integrated Pest Management.

The following experiments were carried out:

1. Screening of four plant oils, New FOIS (G), three formulations of neem and screening of five synthetic acaricides along with an untreated control against coconut eriophyid mite in the laboratory.

2. Evaluation of the promising natural products and acaricides along with water spray and untreated control against coconut eriophyid mite in the field.

3. Field experiment to assess the efficacy of the products like cakes, wood ash, kaoline and innovative farmer practices against coconut eriophyid mite.

In the screening trial of plant oils in the laboratory, based on the mean per cent corrected mortality, castor oil three per cent was found to be

effective against coconut eriophyid mite closely followed by neem oil three per cent, after 24 hours of spraying, while 48 hours after spraying New FOIS (G) ten per cent and Neemazal 0.4 per cent were ranking top. Seventy-two hours after spraying, neem oil three per cent was found to be promising followed by Neemazal 0.4 per cent and castor oil three per cent. Soluneem two per cent was inferior to all the treatments at three intervals.

Among the five synthetic acaricides screened in the laboratory, fenazaquin 0.05 per cent closely followed by sulphur W.P 0.4 per cent were found to be effective at all the three intervals after spraying. Lower dose of diafenthiuron 0.025 per cent was inferior to all the other treatments.

In the field experiment of the promising oils, botanicals and synthetic acaricides, fenazaquin 0.05 per cent followed by sulphur W.P 0.4 per cent suppressed the mite population effectively. Third round of spraying provided maximum protection. The mean percentage of infestation and intensity of damage over the seven bunches revealed that fenazaquin 0.05 percent was the promising one followed by sulphur W.P 0.4 per cent. The bunches which were first, second and third at the time of initial spraying obtained maximum protection. Palms treated with fenazaquin 0.05 per cent had least nut fall. Eventhough sulphur W.P 0.4 per cent were not much efficient all the treatments were statistically at par with fenazaquin 0.05 per cent and also significantly superior to the control.

Evaluation of oil cakes, wood ash, kaoline and innovative farmer practices in the field showed that maximum mite population suppression was obtained with starch solution five per cent closely followed by neem cake one kg palm^{-1} and salt solution five per cent. They were significantly superior to all the other treatments. Maximum reduction was obtained at the third round of spraying. Starch solution five per cent was found to be effective in reducing the percentage of infestation and intensity of damage, while neem cake recorded minimum nut fall.

Regarding the oils, botanicals and synthetic acaricides, fenazaquin 0.05 per cent and sulphur W.P 0.4 per cent gave promising results. While among the innovative farmer practices, starch solution five per cent was found suitable for being incorporated in the management of coconut eriophyid mite. The results in the present pest management trials indicated the possibility of reducing the use of chemical pesticides by including botanicals and natural products.

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* Original not seen.

MANAGEMENT OF COCONUT ERIOPHYID MITE *Aceria guerreronis* Keifer USING ECOFRIENDLY METHODS

BY

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ABSTRACT OF THE THESIS
Submitted in partial fulfilment of the requirement for the degree
MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
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Vellayani
Thiruvananthapuram

2001

ABSTRACT

Experiments were conducted in the Department of Agricultural Entomology and in the Instructional Farm, College of Agriculture, Vellayani during 2000-2001, to generate eco-friendly components in developing a sustainable long term strategy of pest management against coconut eriophyid mite.

The treatments included the laboratory screening of various oils, botanicals and synthetic acaricides. The promising treatments and innovative farmer practices were evaluated in a field experiment.

The results of laboratory screening revealed that Neem oil three per cent followed by Neemazal 0.4 per cent and castor oil three per cent were promising among the botanicals while fenazaquin 0.05 per cent followed by sulphur W.P 0.4 per cent were found to be effective among the synthetic acaricides.

The field evaluation using promising natural products and synthetic acaricides, showed that fenazaquin 0.05 per cent was effective followed by sulphur W.P 0.4 per cent. Maximum protection was observed after the third round of spraying. Sprays applied at the critical stage of infestation afforded maximum protection to the bunches.

Results of the field evaluation experiment using natural products and innovative farmer practices revealed that starch solution five per cent was the most effective among the various treatments.