Mite Management of Coconut in SAARC Member Countries

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SAARC Agriculture Centre

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Foreword

Coconut farming in South Asia is an important branch of agricultural production. It gives income to the growers continuously and contributes a lot of the total homestead income. It provides livelihood to the farmers through its versatile uses. Prevalence of pests and diseases in majority of the coconut-growing areas has adversely affected the coconut industry to a large extent recently. Coconut palm being a perennial crop, grown mostly under homestead gardens, provides supply of food and shelter for the build-up of various pests which cause extensive damage to the crop during all stages of its growth. Some of them are fatal while others reduce its vigour and finally resulting in economic loss.

Very recently, coconut palms are suffering from reduction in nut size due to immature bud dropping. It has become an epidemic problem. In the recent years, coconut mite invaded coconut plantation as a serious and destructive pests. Feeding damage causes uneven growth of nuts resulting in distorted nuts and in severe damage reduction in nut size leads to almost 25% loss in copra yield. Husk becomes thickened and hard with loss of fibers resulting in poor quality fibers. In severe cases, the nuts are malformed with cracks and hardened husk. Mites are usually found under the bracts of fertilized female flowers and do not infest the unfertilized flowers. This mite is very minute in size.

As the pest is new in the coconut growing country in South Asia, farmers are not aware of the control measures. Few technologies available among the member countries of SAARC can be innovated and sharing them might be useful for controlling mite and to develop techniques for management of coconut mite through IPM method as an ecosystem approach. Sharing the experiences and collecting counsels of expert member of various levels will pave the new way in controlling coconut mite.

Considering the consequence, SAARC Agriculture Centre conducted one study on the **Mite Management of Coconut in SAARC Member Countries** and later arranged a regional consultation meeting in collaboration with BARC, BARI and KGF as well as publishing a book containing a set of recommendations, keynote paper and country status reports to identify effective package of management practices for controlling mite on coconut developed, validated and adapted by the SAARC communities. The publication helps to inquire about the incidence of coconut mite in member countries of SAARC; to understand the practices followed in the member countries to control mite in coconut and to collect counsel on mite management from the scientists with soul coconut knowledge

The beneficiaries will be researchers, policy makers in the Governments of SAARC countries, agriculture and social scientists, extension service providers, NGO and ultimately the farmers.

I acknowledge the sincere efforts to the distinguished contributing authors from SAARC Region and my colleagues for completing this overwhelming job. My good wishes to the members for bringing it in the present form.

The Centre always appreciates for getting comments and suggestions from the users of our products and services to help us enable to improve performance.

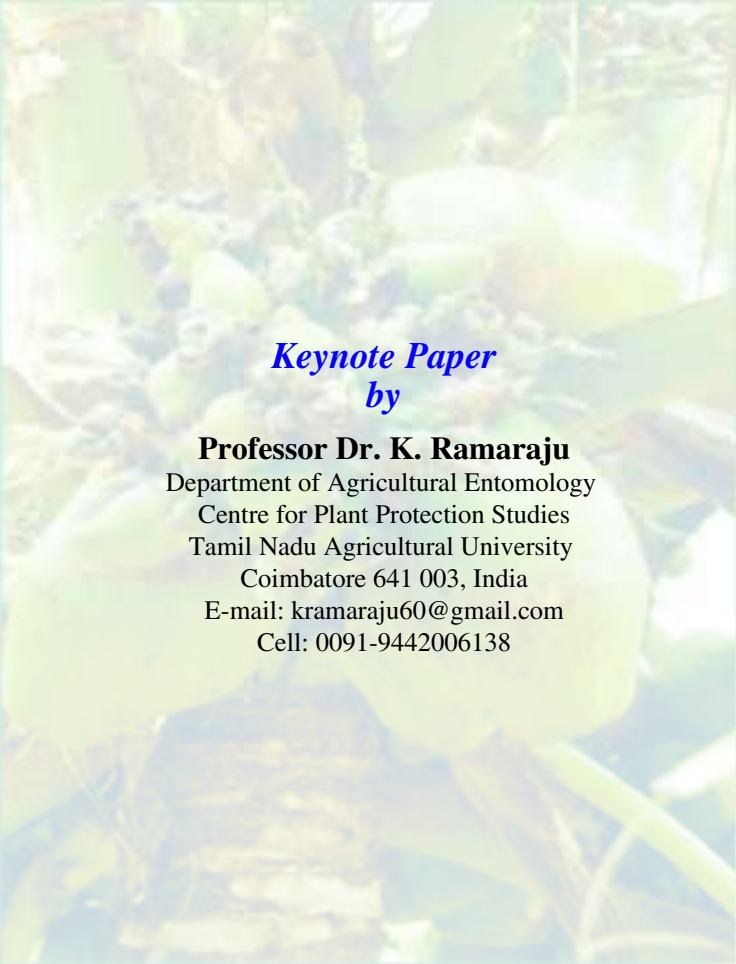
Abul Kalam Azad PhD.
Director, SAARC Agriculture Centre

Contents

Abbreviations and Acronyms

BARC	-	Bangladesh Agricultural Research Council
BARI	-	Bangladesh Agricultural Research Institute
BAU	-	Bangladesh Agricultural University
BSMRAU	-	Bangho Bandhu Sheikh Mujibur Rahman Agricultural University
CC	-	Cochin China
COD	-	Chowghat Orange Dwarf
CPCRI	-	Central Plantation Crops Research Institute
CRI	-	Coconut Research Institute
CRS	-	Coconut Research Station
DAE	-	Department of Agricultural Extension
DG	-	Director General
DoA	-	Department of Agriculture
EC	-	Executive Chairman
ECT	-	East Coast Tall
ED	-	Executive Director
FDD	-	Fruit Development Directorate
HRC	-	Horticulture Research Centre
INM	-	Integrated Nutrient Management
IPM	-	Integrated Pest Management
KGF	-	Krishi Gobeshona Foundation
LCT	-	Laccadive Tall
LO	-	Laccadive Ordinary
MGD	-	Malayan Green Dwarf
MoA	-	Ministry of Agriculture
MoAD	-	Ministry of Agriculture Development
NARC	-	National Agricultural Research Centre
NARC	-	Nepal Agricultural Research Council
NPPO	-	National Plant Protection Organization
PARC	-	Pakistan Agricultural Research Council
PMD	-	Pakistan Meteorological Department
PPD	-	Plant Protection Directorate
RARS	-	Regional Agricultural Research Station
SAARC	-	South Asian Association for Regional Cooperation
SAC	-	SAARC Agriculture Centre
TEPC	-	Trade and Export Promotion Centre
WAT	-	West African Tall
WCT	-	West Cost Tall

Mite Management of Coconut in SAARC Member Countries



Keynote Paper
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An Overview of Coconut Eriophyid Mite, *Aceria guerreronis* K.

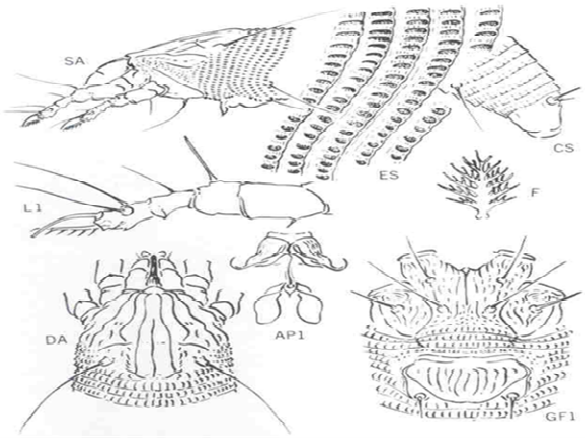
Coconut, commonly referred to as "Tree of Life" as well as "KalpaVriksha" provides livelihood to billions of people across the world. Globally, coconut occupies an area of 12 million hectares with a total production of about 56 billion nuts. India, Indonesia, Philippines and Sri Lanka are major coconut-growing countries, contributing 78 per cent of the total world production. India ranks third in the production and fourth in the productivity of coconut in the world with a production of 14 billion nuts in 2011-12 from 2.1 million hectares, accounting for about 22 per cent of the total world production. Coconut provides food, drink, medicine and altogether health to millions of consumers as well. This crop is attacked by nine species of eriophyid mites. Among them, nut infesting mite, *Aceria guerreronis* Keifer (Eriophyidae: Acari) has become a major problem in many of the coconut-growing countries.

Occurrence and outbreak

The occurrence of eriophyid mite, *A. guerreronis* on coconut was first reported from the Guerrero State in Mexico in the year 1965 as a nut inhabiting mite. Since then it has been reported from many coconut growing areas of the America, West Africa and the Caribbean Islands from Cuba to Trinidad and St.Lucia in the West Indies. In the Asia-Pacific region it was first noticed in Sri Lanka during 1997. In India it was first observed during 1998 in Ernakulam district in Kerala, which later spread to all other coconut growing regions of the country. At present, the mite damage is wide spread in all coconut growing states in India causing moderate to heavy damage. Occurrence of this mite was also noticed in Bangladesh, Nepal, Maldives and other South East Asian countries.

Taxonomic identification of coconut eriophyid mite (Fig. 1)

- Strongly produced median (1/3rd distally from shield anterior), an admedian and one submedian (sinuate); a transverse line across in front of dorsal tubercles.
- Six rayed simple feather claw.
- Oval or elongate microtubercles set between rings.
- Female genitalia away from coxal bases, cover flap bearing about 7-9 ribs.
- Coxae ornamented with lines and lines of granules; anterior coxae somewhat elongate, the sternal line extending to second tubercles.



AP1 - Internal female genitalia
DA - Propodosoma and anterior of hysterosoma (Dorsal view)
F - Feather claw
L1 - Left legl
CS - Hysterosoma, posterior lateral view
ES - Lateral microtubercle
GF1 - Female extermal genitalia and coxae
A - Propodosoma and anterior hysterosoma (Lateral view)

Fig. 1. Taxonomic characters of coconut mite

Ecology / population dynamics

The mite population was observed throughout the year on the young developing buttons. Maximum mite population was recorded during summer months and minimum during the rainy months. Sometimes the population was fairly high even during the high rainfall months. All coconut varieties/germplasm and nut colour were damaged by this mite. Longer periods of drought resulted in greater yield loss due to the infestation of eriophyid mite, because, fruit growth is slower during dry periods. Nuts in coconut palms of all ages were found to be affected by mite. Well maintained trees, with appropriate fertilizer application were found to suffer less from mite attack. Damage of *A. guerreronis* increased with increase in N levels and decreased with increase in K levels. Correlation and regression analysis revealed that there was no significant relationship between live mite population and weather parameters.

Biology

Eriophyid mite is microscopic, slender, vermiform and creamy white (yellowish) in colour. It has an anterior cephalothorax, an annulated tapering abdomen and needle like mouth parts, which are internally placed. Life cycle of this mite constitutes egg, two larval instars and an adult stage. Eggs are shiny white and globular in shape which hatch into larvae (protonymph) in two days. The second instar larva is called nymph which subsequently moult into adults. Adult mite is very minute, measuring 200-250 μ in length and 35-50 μ in width, with two pairs of legs found in the anterior region of the body. Both nymphs and adults cause damage. Each female can lay approximately

30-50 eggs. It takes about 7-8 days to complete one life cycle from egg to adult. The egg, first and second larval instar lasts about 3, 2 and 2 days, respectively. The mites are found under the bracts (tepals) of young buttons (after fertilization) and are not usually found in unfertilized flowers. The distribution of eriophyid mite colony is not uniform inside the perianth. Normally in two or three places the mite colonies are congregated under the tepals. In most of the cases old and fresh colonies are found beneath the fourth tepal. Each colony contains hundreds of eggs, larvae, nymphs and adults (Plate 1). The colonies may vary in size and shape. After causing damage in a particular spot/area the mites tend to move to fresh areas in the meristematic tissue and start colonization.

Mode of Dispersal

Dispersal of mite is mainly through wind. Hence, they can spread very fast to the nearby palms. Honey bees and other insects visiting the inflorescence of coconut presume to act as agents for dispersal of mites. Various stages of mites are seen in the tepals of perianth and tender portion of developing nuts. Two to six months old young green developing buttons harbour maximum number of mites. Maximum activity of mites on the nut surface was seen between 6.00 and 9.00 a.m. and this habit may facilitate easy dispersal of the mites within the tree or through wind to other trees or fields.

Host range

Cocosoid palm, *Lytocarium wedellianum* was reported as an alternate host of coconut eriophyid mite in Brazil. Palmyra, *Borassus flabellifer* was identified as an alternate host of *A. guerreronis* for the first time in Tamil Nadu. In palmyra, the mites were found on the tepals. The feeding damage caused by them results in the development of faint reddish brown or brown coloured patches on the inner side of the tepals. Unlike coconut, no significant feeding marks were seen on the outer surface of the fruit or on the developing tissues. Queen palm, *Sygarus romanzoffiana* was also identified as a third alternate host in Southern California, USA.

Nature of damage

The eriophyid mite, *A. guerreronis* infests the coconut buttons one month after fertilization. Both nymph and adult mite suck the sap from the meristematic tissues of the growing nuts covered by the perianth. In the young damaged buttons, initial symptoms appear in the form of triangular, pale white or yellow patches close to each perianth. Different stages of mites live in the white, tender portion covered by the inner bracts of the perianth and suck the sap continuously. Draining of the sap from young buttons led to yellow discolouration which gradually turned into brown colour resulted

in poor development of nut, which leads to the reduction in nut size and kernel content. Longitudinal fissures and splits occur on the outer surface of the husk. At this stage, husk develops cracks, cuts and gummosis and malformed (Plate1). Feeding damage causes uneven growth of nuts resulting in distorted nuts and in severe damage, reduction in nut size leads to almost 25 per cent loss in copra yield. Husk becomes thickened and hard with loss of fibres resulting in poor quality fibres. As the age of nut advances, the population of mite decreases. Mites occur in large numbers only in young buttons (2 – 6 months old).

A colony of eriophyid mite

Young buttons showing triangular yellow and brown patches

Longitudinal fissures and splits

Eriophyid mite damaged bunckes

Plate 1. Coconut mite colony and damage symptoms

In general, infestation by mite has not resulted in reduction of yield of nuts. In a few cases, the shedding of infested buttons (1 – 4 months old) has been noticed. But the shedding of young buttons due to mite ranged from 5 to 10 per cent only. The mite damage did not reduce the average number of nut yield per tree per year. The damage of husk extends to its hardening and losing of its fibrous characteristics, results in poor coir output, which has affected the coir industry. Reduction in the copra yield ranged from 15-42 per cent in the severely damaged nuts. White fibre of 100.5 and 60.1 kg were obtained from 1,000 un-infested (grade 1) and severely infested (grade 5) nuts, respectively. Further dehusking time increased by 40 per cent due to hardening of nuts.

Impact on germination

Germination was not affected in the mite damaged nuts. Even nuts showing grade 5 (> 50% surface damage) recorded 92% germination and it was on par with grade 1, but the seedling vigour varied in different grades. In grade 1 and 2, the height of the seedlings was higher (118 cm) as against 83 cm in grade 5. Similarly, stem girth also varied considerably in different grades.

Quality Parameters in infested and un-infested coconut

Changes in the biochemical composition of mite infested coconut buttons

The total sugars and reducing sugars were increased in mite affected tissue by 12.4 per cent and 17.4 per cent, respectively. The total sugar content was significant with 4.26 per cent in healthy tissue as against 4.79 per cent in mite affected tissue. The reducing sugars were non- significant with 2.07 per cent in the healthy tissue and 2.43 per cent in mite affected tissue. There was significant increase in total free aminoacids, phenol and crude protein content in mite affected tissue. There was a significant difference in peroxidase and IAA oxidase activity between healthy and mite affected tissue. The peroxidase activity increased in the mite affected tissue by 39.2 per cent and the changes observed in the healthy tissue was 0.217/min/g of the sample as against 0.302/min/g of the mite affected sample. The IAA oxidase activity was 0.105 in healthy tissue and 0.150 in the mite affected tissue with 42.9 per cent increase in IAA oxidase activity in mite infested sample.

The effect of mite on quality aspects *viz.*, reducing sugars, oil content and peroxidase value were compared in infested and un-infested nuts. The amount of reducing sugar in coconut water and kernel was found to be more in healthy nuts. The per cent reduction in oil content in infested nuts compared to healthy ones did not show much variation. Increase in peroxidase value was observed in the infested nuts which indicate that such nuts may quickly become rancid. As the oil becomes rancid, the amount of free fatty acid released from the oil increased which also acts as an indicator of rancidity. The quantity of reducing sugars and the acidity content were very low in the highly damaged nuts. There was drastic reduction in both quality and quantity of coir.

Management

Coconut mite is one of the most difficult pests to control owing to its hidden habitat. Chemical control has not been viewed as a good long-term control method because of potential problems of residues in coconuts, hazards to natural enemies, workers and the environment and the potential development of resistant strains of mite. Emphasis is now being given to other potential alternatives like botanicals, biological control, because of its strengths like eco-friendliness and safety, is one of the options for the sustainable management of coconut mite.

Eco-friendly agents

Application of neem oil 3%, neem oil 2% + garlic extract 2.5%, NSKE 5%, Fish oil rosin soap 40g/lit were found effective in reducing the mite damage. Significant reduction of mite population and damage was also obtained after spraying with commercial formulations of azadirachtin 1% @ 5ml/lit. of water. But repeated application at regular interval is needed to achieve maximum control.

Biological control

Coconut eriophyid mite is not attacked by parasitoids, but a few predators could attack the mite. Naturally, it is very difficult to use the biological agents because the sheltered habitat with a high reproductive rate and rapid development of *A. guerreronis* provide a little chance for the natural enemies to be effective. The major reason attributed for the failure of predatory mites includes the niche or the habitat occupied by eriophyid mite which is too small for the larger size of the predatory mites to occupy. Accessibility of the predatory mites is greatly restricted. Only very small, relatively flat bodied predatory mites like *Neoseiulus* can gain entry into the petals and feed on the eriophyid mites. Even though a large number of predatory insects and mites were found associated with *A. guerreronis*, their predatory potential is very low.

Though mite species belonging to families of Phytoseiidae, Stigmaeidae, Cunaxidae, Bdellidae, Tarsonemidae, Tydeidae, Cheyletidae and insects under the families, Coccinellidae, Cecidomyidae, Chrysopidae, Thripidae and Anthocoridae are known to be predatory on eirophyid mites, only phytoseiids and tarsonemids are more often associated with the coconut mite. Predatory mite species of the family Phytoseiidae *viz*., *Neoseiulus paspalivorus* (Plate 2) and *N. largoensis,* Tarsonemidae *viz*., *Stenotarsonemus* sp. and *Lupotarsonemus* sp. and Bdellidae *viz*., *Bdella distincta* (Plate3) and *B. indicata* are known to bring down the population of coconut mite marginally.

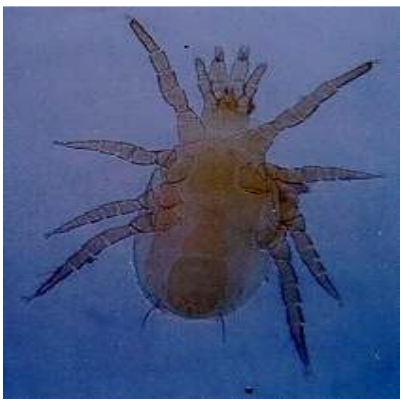


Plate. 2 *Neoseiulus paspalivorus*

Plate. 3. *Bdella* sp.

Among the predatory mites recorded, *N. paspalivorus* was the predominant one in Tamil Nadu. The population of *N. paspalivorus* ranges from 3 – 10 per nut. This lower population could be due to the fact that the predatory mite may be a generalist feeder and are not specifically feeding on *A. guerreronis*. Hence, more emphasis is being given for conservation of *N.papalivorus* in coconut gardens. *N. paspalivorus* have potential as prospective predator for biological control since they do not prefer too much light and their body is too flat to creep underneath the tepals of coconuts.

Biology of *N. Paspalivorus*

The predatory mite, *N. paspalivorus* could complete its life cycle in about 6 to 7 days when fed on *A. guerreronis* with the developmental time of 1.5, 1.5, 2.1 and 1.3 days for various stages *viz*., egg, larval, protonymph and deutonymph, respectively. The females are long lived (26 days) than the males (20 days).

Spatial and temporal distribution

Studies on the distribution pattern of predatory mite indicated that the predatory mite population increased up to 6 months old bunch and declined thereafter. However, the population of predatory mites peak one month later than the coconut mites and the mean number of predatory mites has a positive correlation with the prey density. Release of 500 predators per bunch could bring about 70 per cent reduction in the mite population than the control bunches. Developmental time of *N. paspalivorus* was very short on coconut mite (5.6 days) than on two spotted spider mite, eggs of *Tetranychus urticae* (6.3 days). However, oviposition rate was not high on *T. urticae* when compared to coconut mite.

Pathogens infecting eriophyid mites

Hirsutella thompsonii, H. nodulosa and *Paecilomyces* sp. are found to infect both *Aceria guerreronis* in coconut and *Phyllocoptructa oleivora* in citrus, whereas other pathogens like *Sporothrix fungivorum, Lecanicillium* (*Verticillium) lecanii* are recorded to infect *Aceria guerreronis*. Several fungal pathogens like *Hirsutella thompsonii* and *H. nodulosa* have been isolated from different parts of the world. In India, *H. thompsonii*, *H. thompsonii* var. *synematosa* have been isolated from coconut mites from Kerala, Karnataka and Tamil Nadu. Other fungal pathogens like *L.lecanii*, *V. suchlasporium*, *Entomophthora* sp. *Beauveria* sp. *Paecilomyces lilacinus*, to *Fusarium* sp. have been evaluated for their pathogenicity against the coconut eriophyid mite and none were found to be effective both under laboratory and field conditions. *Sporothrix fungorum* was first isolated from the coconut eriophyid mite. A bio-product named, 'Mycohit' based on *Hirsutella thompsonii* was developed by Project Directorate of Biological Control (PDBC), Bangalore,India. Several multilocation trials were

conducted in the Southern States of India to test the efficacy of Mycohit and the results revealed that the formulation was found to be promising in reducing the eriophyid mite population (Plate 4).

Plate 4. *Hirsutella thompsonii* (Mycohit) -infected mite

Even though several pathogens were tested, none of them resulted in causing a significant reduction of the coconut eriophyid mite population. Several reasons like non-availability of effective fungal pathogens, weather factors, eriophyid mite habitat (tightness of the perianth prevents the entry of spray fluid to the bracts, want of effective spraying systems etc.) may reduce the effectiveness of biological control measure. *Neoseiulus baraki* and *N. paspalivorus* are the most common predatory mites in Sri Lanka. *N. baraki* is found in higher proportions in drier areas, where as *N. paspalivorus* in wet and intermediate areas. Most effective isolate of *Hirsutella thompsonii* persisted for up to 16 weeks on the nuts. But either of the biocontrol operations lacks the ability to suppress the mite for a longer period in Sri Lanka. A single release of *N. baraki* showed a highly significant positive impact on the coconut mite population in the released palms in Sri Lanka.

Chemical control

The mites infest and develop on the meristematic tissues of growing nuts under the perianth by desapping the soft tissues. Spot application of insecticides *viz.*, monocrotophos (5 ml/lit.), triazophos (5 ml/lit.), carbosulfan (5 ml/ lit.), dicofol (6 ml/lit.), ethion (4 ml/lit.), wettable sulphur (6 g/lit.) and methyl demeton (4ml/lit.) were found to be effective in reducing the mite population (60%) and nut damage (55%). Root feeding / stem injection of insecticides *viz.*, monocrotophos 15 ml, carbosulfan 15 ml and triazophos 15 ml with equal quantity of water recorded appreciable reduction in mite population and nut damage. A waiting period of 45 days

is recommended for the harvest of the tender coconut and matured nuts after root feeding with above chemicals.

Effect of triazophos on non-target organisms in coconut palms

Experiments conducted to study the impact of triazophos 40 E.C. (spot application @ 5 ml/lit) sprayed on the coconut crown for the management of coconut eriophyid mite revealed that the predatory mites were highly susceptible to insecticidal sprays. Sixty days after spraying, the predatory mite population was reduced to 2.9/nut from 4.8/nut. The honey bee population was reduced to more than half i.e. from 16.5 to 7.1 bees/tree at 15 DAT and remained unaffected thereafter. The population of spiders was little affected. The activity of ants in the sprayed palm was significantly less (6.8 ants / tree) while compared to unsprayed palms (7.4 ants/tree).

Determination of residues of insecticides in coconut kernel and water

Residue analysis in coconut water and kernel samples was carried out after root feeding coconut trees with monocrotophos, triazophos, profenofos and carbosulfan, and after spot application with monocrotophos, triazophos, carbosulfan , methyldemeton and dicofol for the management of coconut eriophyid mite to fix up the safe waiting period for harvest. Measurable amount of monocrotophos, triazophos and profenofos residues were detected on 15 and 30 days after application as root feeding in coconut water and kernel (Table 1). No detectable amount of residues were found in them up to 60 days after spot application with carbosulfan, monocrotophos, triazophos, methyldemeton and dicofol and root feeding with carbosulfan. Based on the results, it was suggested that a waiting period of 45 days can be fixed for safe harvesting of nuts after root feeding and spot application of insecticides.

Table 1. Residue profile of insecticides applied by root feeding @ 15 ml + 15 ml of water

Insecticide	Maximum residue observed (µg/g)		Waiting period (days)	MRL (µg/g)
	Water	Kernel		
Monocrotophos	0.05	0.28	45	0.01
	0.04	0.03	45	0.01
	0.02	0.28	45	0.01
Triazophos	0.06	0.28	60	0.10
Profenofos	0.03	0.19	60	0.01
	0.04	0.04	60	0.01

Occupational Exposure

Occupational exposure to carbosulfan applied for the management of eriophyid mite in coconut ecosystem revealed that inhalation exposure of applicator and helper to carbosulfan were below detectable level both at the recommended dose (5 ml/lit. of water) and twice the recommended dose irrespective of the spraying system using Baby sprayer and Rocker sprayer when they were operated for a period of one hour. Dermal exposure of applicator and helper were below detectable level at recommended dose of carbosulfan. Whereas, at twice the recommended dose, the estimated total hourly dermal exposure of applicator was 0.03664 mg. The chest region was the highly exposed part of the applicator (27,015.5 ng h^{-1}) followed by head region (2,346.5 ng h^{-1}) when the rocker sprayer was in operation (Table 2).

Table 2. Dermal exposure of applicator and helper to carbosulfan

Part of the body (Surface area of body regions in cm^2)	Baby sprayer Applicator	Rocker Sprayer			
		Applicator (ng h^{-1})		Helper	
	Rec. dose	Rec. dose	Double Dose	Rec. dose	Double dose
Fore head (650)	BDL	BDL	2346.5	BDL	BDL
Neck (130)	BDL	BDL	513.5	BDL	BDL
Chest (3550)	BDL	BDL	27015.5	BDL	BDL
Back (3550)	BDL	BDL	BDL	BDL	BDL
Upper arm (right) (660)	BDL	BDL	1570.8	BDL	BDL
Upper arm (left) (660)	BDL	BDL	1372.8	BDL	BDL
Fore arm (right) (605)	BDL	BDL	BDL	BDL	BDL
Fore arm (left) (605)	BDL	BDL	BDL	BDL	BDL
Thigh (right) (1125)	BDL	BDL	BDL	BDL	BDL
Thigh (left) (1125)	BDL	BDL	3825.0	BDL	BDL
Calf (right) (1190)	BDL	BDL	BDL	BDL	BDL
Calf (left) (1190)	BDL	BDL	BDL	BDL	BDL

However, the residues were below detectable level in all the body parts of the helper. Applicators are misted with the spray while helpers are not misted, as they stay out of the immediate spray area and much of the exposure observed on the chest and head of the applicator was obvious since he looked at the crown while in operation.

Though the application of insecticides are effective in reducing the mite population, repeated application of chemicals at regular intervals may lead to the extermination of natural enemies, environmental pollution, development of resistance to insecticides/ acaricides, residue problems in the produce and a possible secondary outbreak of minor pests. Moreover, spraying of chemical insecticides is not possible in taller trees. In such cases root feeding of chemicals may be resorted to. Further, the efficacy of root feeding may also depend upon the rate of dissipation, age and height of the tree or the quantity of chemical reaching the target site. So, all these factors should be borne in mind before the application of any chemical in coconut ecosystem. Hence, it is concluded that only need based selective (specific) chemicals, preferably, safer chemicals can be used to manage the target pest without disturbing the ecosystem. Therefore, a decision was taken at national level in India not to use insecticides against the management of mite, hence an IM package was developed.

Integrated Management package

A new Integrated Management package comprising nutrients and botanicals was developed for the management of this mite.

Nutrient / Fertilizer application

- Application of recommended doses of Urea and Super phosphate and an increased dose of Muriate of Potash to increase the plant resistance to the mite infestation.

  Urea – 1.3 kg; Super Phosphate – 2.0 kg; Muriate of Potash – 3.5 kg/tree/year

- Application of well decomposed Farm Yard Manure @ 50 kg and neem cake @ 5 kg/tree/year.

- Soil application of micronutrients

  Borax - 50 g/tree/year; Gypsum - 1.0 kg/tree/year; Magnesium sulphate - 0.5 kg/tree/year

- Basin cultivation of green manures like sunnhemp, cowpea, calapagonium etc. and incorporating *in situ*.

- Judicious irrigation and mulching with coconut leaves and husk in the basin.

Application of botanical pesticides

- Spot (topical) application of the following eco-friendly agents on the nuts, preferably, during non-rainy season at least three times a year.

Round	Ecofriendly pesticides	Quantity/tree	Period
1.	Azadirachtin1%	5 ml in one lit. of water	January – February
2.	Neem oil + Teepol	30 ml in one lit. of water	March – April
3.	Azadirachtin 1%	5 ml in one lit. of water	May – June

Note: Besides the above three rounds of spraying two more rounds are required additionally to get maximum control of mites.

- Root feeding can be adopted wherever spraying is difficult (three rounds/year).
- Azadirachtin 1% 10 ml.+10 ml. of water/ tree

Method of application

- Botanicals should be applied in sequence at 45 days interval using a one litre hand sprayer. Rocker sprayer and pedal sprayer can be used for spraying small trees from the ground.
- Spray should be applied at the crown region covering only the top six bunches during non-rainy season.
- Bunches must be covered very well by the spray fluid and approximately one litre of spray fluid may be required per tree for spot application.

Precautions and Safety measures

- Spraying should be avoided during windy season to prevent contamination.
- At the time of spraying, protective mask and clothing should be used.
- Wash face and hands cleanly with soap after spraying.

Demonstration and Evaluation of the Integrated Management Package

Large scale demonstration trials were conducted in forty farmers' fields in Coimbatore and Pollachi blocks of Tamil Nadu, India for the management of coconut eriophyid mite from June 2004 to September 2007. Four representative gardens, two each in Coimbatore and Pollachi blocks were selected to study the impact of integrated mite management (IMM) on population build up of eriophyid and predatory mites, per cent green nut damage and copra content. The results revealed that well maintained trees, with balanced dose of fertilizer application and irrigation suffer less from mite attack. There was a significant reduction in eriophyid mite population and nut damage in IM treated gardens compared to Non IMM gardens. Among the predatory mites, *N. paspalivorus* was the major one found associated with eriophyid mite inside the

perianth. Mean Grade Index damage recorded at the time of harvest was significantly low in Pollachi (1.61) and Coimbatore block (1.85). There was significant increase in nut yield (60 – 78 per cent) with high Benefit Cost Ratio (3.0 – 4.3). Increased copra weight was also recorded in IM treated gardens.

Current status

At present coconut mite problem is prevalent in all coconut growing areas of India, but the population level and damage percentage varied in different places. But in most of the places the intensity is low. Farmers have tried several methods over the years but they could not achieve complete control of the pest due to various reasons. Well maintained gardens or adoption of IMM package with least intervention of pesticides recorded higher nut yield with less mite damage on the surface. It also sustains natural enemy population which plays a key role in suppressing the mite population under check. In general, higher population was noticed during summer months coinciding with high temperature which favour fast multiplication of the mite. Extensive cultivation of coconut in larger scale also provides a favourable niche for survival of the mite. Currently most of the farmers are not adopting any specific management practices for mite management.

Future Thrust

Further studies on the following aspects has to be carried out to sustain the production of coconut

- ✓ understand the origin, mode of entry, dispersal, host-mite relationship
- ✓ identification of tolerant/resistant varieties,
- ✓ effective biocontrol agents and ecofriendly methods
- ✓ increase the persistence level of botanicals and biopesticides

Conclusion

At present IMM is recommended for mite management. The very concept behind this recommendation is to keep the palms healthy and vigorous in order to compensate for the loss caused by the mites. Further, spot application of eco friendly botanicals significantly reduces the mite population and nut damage. Need based application of nutrients along with spot application of botanicals will sustain and enhance the production of nuts, besides minimizing the mite damage significantly without causing any ill effects to coconut ecosystem.

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Mite Management of Coconut in SAARC Member Countries

Synopsis Paper
by

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GOAL

To identify an effective package of management practices for controlling mite of coconut in SAARC Member Countries

Background

- Coconut is an important and popular crop in South Asia and provides livelihood to millions of landless and marginal farmers in South Asian Region
- Coconut farming in SAARC Member Countries is an important branch of agricultural production
- It provides food, drink, medicine to millions of consumers as well as considered as a crop of high economic value due to its diversified uses
- The crop is commonly grown in homesteads areas with efficient utilization of land
- Coconut Mite–a devastating pest of coconut of the most in the SAARC member countries

Background

- Coconut is attacked by various pests and diseases but in recent times incidence of nut infesting mite has become a major problem affecting the yield and quality of nuts
- Very recently, coconut palms are suffering from reduction in nut size due to immature bud dropping
- Severe infestation results in reduced nut size, copra content and malformed nuts with cracks and hardened husk
- Mite attacks coconut when the nut age is two to seven months old

Objectives

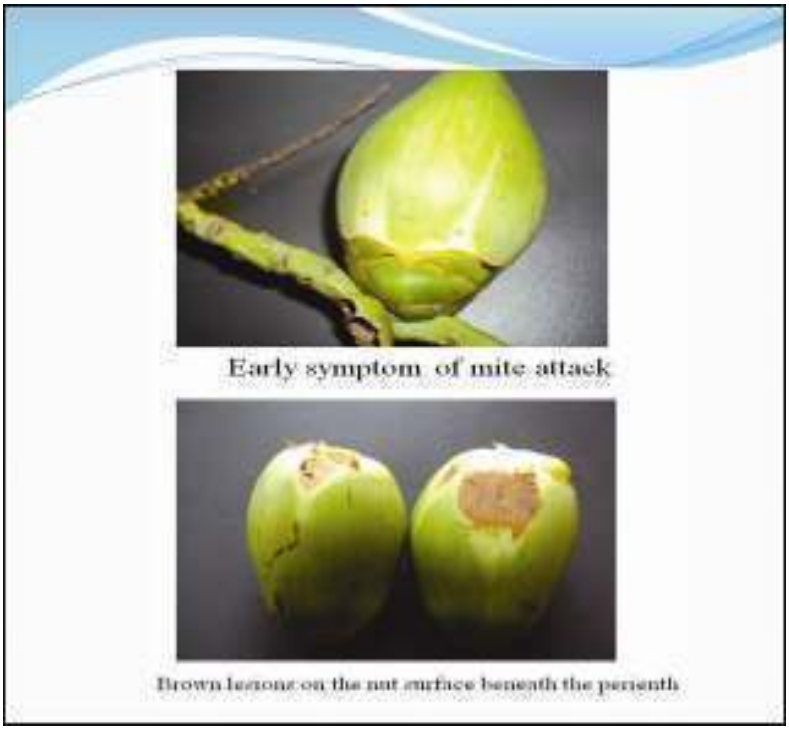
- To inquire about the incidence of coconut mite in member countries of SAARC
- To understand the practices of the member countries to control mite in coconut tree
- To collect council on mite management from the scientists with core coconut knowledge

Benefits/Outcome of the Program

- An effective package of management practices for controlling mite on coconut developed, validated and adapted by the SAARC communities
- Further studies on the following aspects has to be carried out to sustain the production of coconut
- Understand the origin, mode of entry, dispersal, host-mite relationship
- Identification of tolerant/resistant varieties,
- Effective bio-control agents and eco-friendly methods
- Increase the persistence level of botanicals and bio-pesticides

- Need based application of nutrients along with spot application of botanicals will sustain and enhance the production of nuts, besides minimizing the mite damage significantly without causing any ill effects to coconut ecosystem
- A holistic integrated management system should be developed to manage all the pests and diseases
- The technical sessions of this consultation workshop would be helpful to identify an effective package of management practices for controlling mite of coconut by the SAARC community


Mite infected bunch


Early symptom of mite attack
Brown lesions on the nut surface beneath the perianth


Damaged coconut by mite


Mite management by fire


Two months old fertilized female flower of coconut


Mite free coconut tree

Mite Management of Coconut in Bangladesh

By

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Insect Pest Management of Coconut in Bangladesh Especial Emphasis on Eriophyid Mite, *Aceria Guerreronis*

1. Introduction

Bangladesh lies in the northeastern part of South Asia between 20°34′ and 26°38′ north latitude, and 88°01′ and 92°41′ east longitude. The country is bounded by India on the west, the north, and the northeast and Myanmar on the southeast and the Bay of Bengal on the south. The area of the country is 56, 977 sq. miles or 1,47,570 sq. km. The country has a population of 152.5 million and its average population density of 1015 person per sq km is one of the highest in the world. Except the hilly regions in the north-east and the south-east and some highlands in north and north-western part, the country consists of low, flat and alluvial fertile lands.

Bangladesh enjoys generally a sub-tropical monsoon climate. While there are six seasons in a year, three namely, winter, summer and monsoon are prominent. Winter, which is quite pleasant, begins in November and ends in February. In winter, there is not usually much fluctuation in temperature that ranges from minimum of 7-13° Celsius (45-55°F) to maximum of 24-31° Celsius (75-85° F). The average maximum temperature recorded in summer months is 37° Celsius (98° F) although in some places it occasionally rises up to 41° Celsius (105° F) or more. Generally monsoon starts in July and stays up to October. This period accounts for 80% of the total rainfall. The average annual rainfall varies from 1,429 to 4,338 millimetres. The maximum rainfall is recorded in the southern part of the country, coastal areas of Chittagong and eastern part of the country, northern areas of Sylhet district, while the minimum is observed in the western and northern parts of the country.

The economy of Bangladesh is primarily dependent on agriculture. With about 84 percent of the total population living in rural areas and directly or indirectly engaged in a wide range of agricultural activities, the agricultural sector plays a critical role in the national economy, accounting for 18.7 percent of total gross domestic products in 2012-13 (BBS, 2013). The agricultural sector is the single largest contributor to income and employment generation and a vital element in the country's challenge to achieve self-sufficiency in food production, reduce rural poverty and foster sustainable economic development. Agriculture of Bangladesh is now in the process of transformation from subsistence to commercial farming.

Bangladesh grows a variety of crops and rice is the predominate one that accounts for about 78% of the cropped areas. On the other hand at present different fruit crops occupy only 1.2% of the total cultivated land of the country, where about 70 different fruits are grown including coconut (Figure 1). Coconut occupies only 0.65% of total cultivated lands for fruit crops in Bangladesh (Figure 2). However, in Bangladesh

coconut is considered as a crop of high economic value due to its diversified uses. The crop is commonly grown in homesteads with efficient utilization of land. Many smallholders households generally depend on the coconut for their livelihood as it provides regular incomes (Eyzaguirre and Batugal, 1999). The southern part of the country contributes about 80% of total production (BBS, 2011). The national yield of coconut has been estimated at 63 kg/fruit bearing tree/year with a total production of 1,35,000 tonnes/year from 39,000 ha cultivated land (BBS, 2011). It has also been estimated that around 44% of total production of coconut is consumed as tendernut and 40% as mature nut for fresh consumption. Only 9% is processed in industries while 7% is used for seedling purpose (Islam, 2002).

Among the different biotic and abiotic stresses for low productivity of coconut, different types of pest attacks are considered as the most important one. Among the insect pests Rhinoceros Beetle, *Oryctes rhinoceros*, Red Palm Weevil, *Rhynchophorus ferrugineus* and Coconut Eriophyid Mite, *Aceria guerreronis* are considered as the most destructive ones in Bangladesh. However, recently coconut nuts are found to be seriously suffered due to the severe infestation of Coconut Eriophyid Mite. Due to their extensive feeding on young buds resulted in reduction in size followed by immature bud drop. The problem has become epidemic in south and southwestern parts of the country and extensive damage to coconut has been noticed causing high economic losses affecting a large number of farmers.

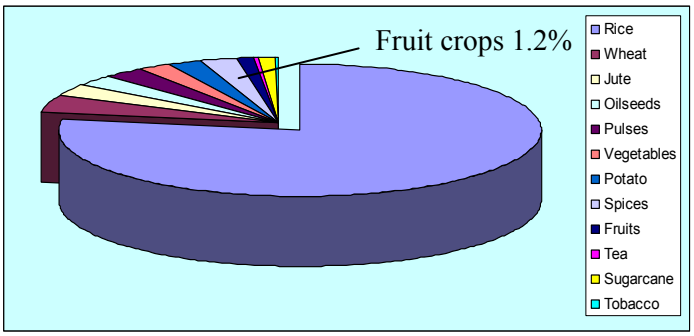

Fig.1: Area occupied by different crops in Bangladesh (BBS, 2011)

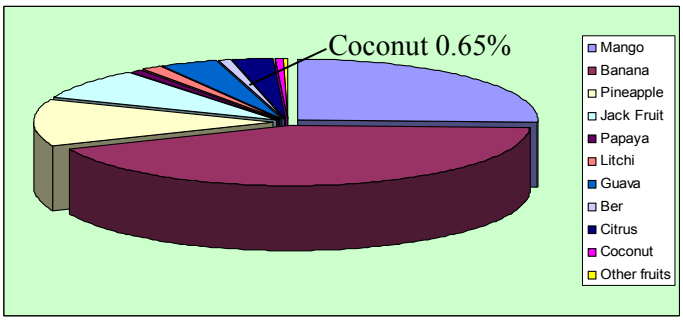

Fig. 2: Area occupied by different fruit crops in Bangladesh (BBS, 2011)

2. Insect pests of coconut in Bangladesh

2.1 Rhinoceros Beetle: *Oryctes rhinoceros*

This is one of the major and destructive pests of coconut in Bangladesh. On an average around 30-40% coconut plantation throughout the country has been infested by this pest. Pest population occurs round the year but maximum population rises during June – September with the onset of monsoon.

The adult beetle bores into the unopened fronds and spathes and the damage by the pest leads to 15 to 20% yield loss. Infestation was visible when frond opened fully and shows characteristic triangular cuts. Fully opened fronds showing characteristic diamond shaped cuttings. Holes with chewed fibre sticking out at the base of central spindle also appeared.

Fig. 3: Adult Rhinoceros Beetle

Fig. 4: Rhinoceros Beetle larvae

Fig. 5: Typical symptom of Rhinoceros Beetle infestation

2.2 Coconut Eriophyid Mite: *Aceria guerreronis*

In the recent years coconut mite invaded coconut plantation as a serious and destructive pests in Bangladesh. Feeding damage causes uneven growth of nuts resulting in distorted nuts and in severe damage reduction in nut size leads to almost 25% loss in copra (dried sliced kernel) yield. Husk becomes thickened and hard with loss of fibers resulting in poor quality fibers.

Mites are usually found under the bracts of fertilized female flowers and do not infest the unfertilized flowers. This mite is very minute in size measuring 200 – 250 micron in length and 36 – 52 micron in width with two pairs of legs. Nymph and Adult is pale in color with elongate body and worm like appearance. The life cycle of this mite, which consists of egg, two larval instars and an adult stage, is completed in 7 -10 days.

At first the symptom is observed on 2-3 month old buttons as pale yellow triangular patches below the perianth. Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk. At severe infestation, oozing of the gummy exudation from the affected surface of the nuts may happen. Eventually uneven growth of nuts occurred that results in distortion and stunting of those nuts leading to reduction in copra yield. In severe cases, the nuts are malformed with cracks and hardened husk.

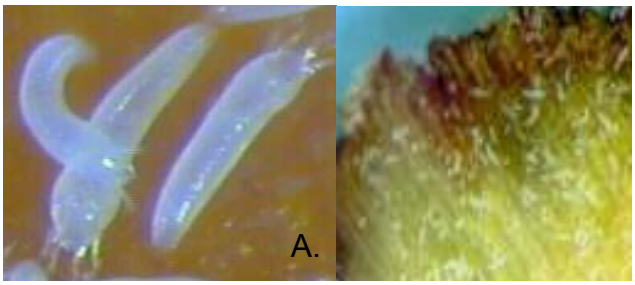

Fig. 6: Mite Colony (A. microscopic view) (Courtesy: K. Ramaraju, 2012)

Fig. 7: Typical symptoms

2.3 Red Palm Weevil: *Rhynchophorus ferrugineus*

Red palm weevil is one of the most destructive pests of coconut, oil palms and ornamental palms throughout Bangladesh. It occurs round the year but becomes severe after monsoon. The infestation rate is around 10-15%. However due to its severe infestation the plant dies within short period of time.

The grubs cause damage inside the stem or crown by feeding on soft tissues and often cause severe damage especially when a large number of them bore into the soft, growing parts. In case of severe infestation the inside portion of trunk is completely

eaten and become full of rotting fibers. In case of young palms the top withers while in older palms the top portion of trunk bends and ultimately breaks at the bend (wilting). In the advanced stage of infestation yellowing of the inner whorl of leaves occur. The crowns falls down or dry up later when palm is dead. The hole can be seen on the stem with chewed up fibers protruding out.

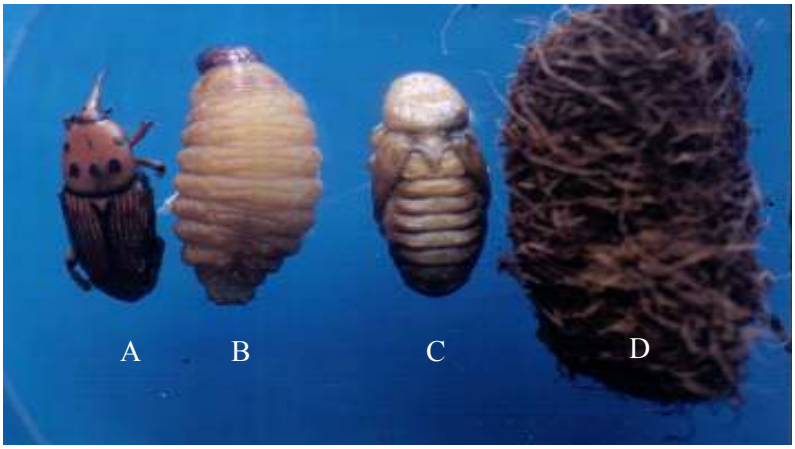

Fig. 8: Different life stages of Red Palm Weevil
(A. Adult, B. Grub, C. Pupa, D. Pupal cocoon)

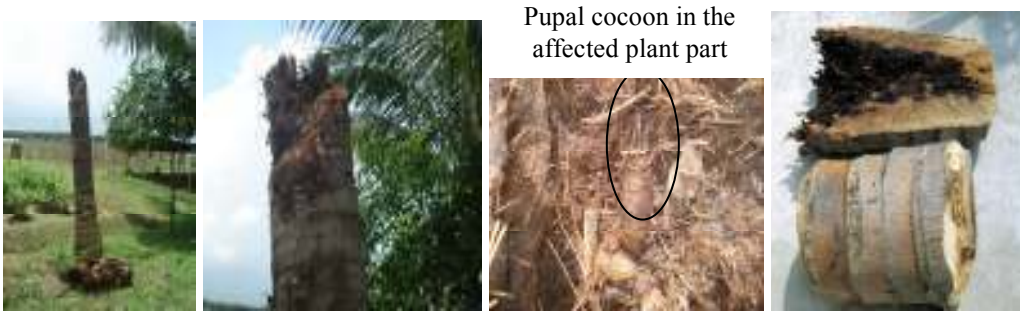

Fig. 9: Typical infestation symptom of red palm weevil in coconut

2.4 Termite: *Odontotermes obesus*

Termite is considered as the minor pest of coconut. However, it's sporadic attack observed throughout the country. The adults are cream colored, tiny insects resembling ants with dark colored head. Termites are likely to cause damage to transplanted seedlings particularly in the earlier stage (wilting of seedlings). Base of trunks plastered with soil and fibers.

Fig. 10: Typical symptoms of termite attack in coconut plant

2.5 Scale Insect: *Aspidiotus destructor*

Scale insect is also considered as the minor pest of coconut. It occurs mainly in summer. Scale insects affects on leaves and nuts of coconut palms. A severe infestation, scale forms a continuous crust over flower spikes, young nuts and lower surface of leaves. Heavy infestation results in stunting of new leaves, reduction of crop yield or complete crop failure

Fig. 11: Infestation of scale insect on coconut leaves & scale insect (close view)

2.6 Mealy Bug: *Pseudococcus longispinus*

Mealy bugs are also considered as a minor pest attacking coconut plants throughout the country. It colonizes on all tender plant parts like bases of spear leaf, spadix and inflorescence and beneath the perianth of the nut. It feed on the plant sup. So, due to its

severe attack leaves are yellowing and dry up. As a result, the leaves become highly stunted, deformed and crinkled appearance occurred.

Fig. 12: Infestation of mite on coconut nut and leaves

3. Coconut mite and their management approaches in Bangladesh

3.1 Occurrence and outbreak

The occurrence of eriophyid mite, *Aceria guerreronis* on coconut was first reported from the Guerrero State in Maxico in 1965 as nut inhabiting mite. In the South Asia it was first observed in Sri Lanka during 1997. In India it was first observed during 1998 in Kerala (Sathiamma *et al*., 1998) and in Bangladesh the incidence of this mite was first noticed during 2004 (Islam *et al.,* 2008). During that period mobile phone networks were expanding throughout the country and mobile phone towers were setting at different regions and the coconut farmers believed that the problem happened due to the effect of mobile phone network expansion. However, later on the real cause of this bud damage was identified by the scientists. Infestation of coconut mite is noticed all over Bangladesh but severe infestation of this pest was recorded from the southern part of the country especially in the coastal districts.

3.2 Bio-ecology and nature of damage

Eriophyid mite is microscopic, slender, vermiform organism and creamy white in color. Initially, the mites are seen under the bracts of young developing buttons around two months after fertilization. They are not usually found in unfertilized flowers. Two to six months old young green developing buttons harbor maximum number of mites. Eriophyid mite lives in a colony form and the distribution of colony is not uniform inside the perianth. Normally in two or three places the mite colonies are congregated under the tapals (Ramaraju & Sunilkowsick, 2012). Each colony contains hundreds of eggs, larvae, nymphs and adults.

The mite population was observed throughout the year on the young developing buttons. During the summer months maximum mite population was recorded and in the

cooler months population decline. Sometimes the population was fairly high even during the high rainfall periods. Greater yield loss due to the infestation of eriophyid mite happened during the longer periods of drought due to slow growth rate of fruit during dry period. Dispersal of mite is mainly done through wind. However, it may be dispersed by the visiting honey bees and other insects.

Eriophyid mite infest the coconut buttons one month after fertilization. Both nymph and adult mite suck the sap from the meristematic tissues of the growing nuts covered by the perienth. Initial symptoms appear in the form of triangular pale white or yellow patches close to each perianth in the young damaged buttons. Generally different stages of mites live in the white, tender portion covered by the inner bracts of perianth and suck sap continuously. Due to continuous sucking initially yellow discoloration of nut started that gradually turns into brown color and results in warty shrinking of husk. At this stage, cracks, cuts and gummosis develops in the husk. Continuous draining of sap from young buttons results in poor development of nut which leads to the reduction in nut size and kernel content. The nuts appear malformed, kernel under-developed or partially developed. Feeding damage causes uneven growth of nuts resulting in distorted nuts and in severe damage reduction in nut size leads to almost 25% loss in copra yield. Husk becomes thickened and hard with loss of fibers resulting in poor quality fibers. As the age of nut advances, the population of mite decreases.

3.3 Management

Very few works have so far been reported on the management of the coconut mite in Bangladesh. The management of the coconut mite is following the same route of current pest management strategies for other pests. So, before discussion about the coconut mite management brief highlight on the current pest management situation is as follows:

Current pest management Situation: Till today crop protection of Bangladesh is mostly dependent on chemical pesticide. Pesticide use in Bangladesh started from mid fifties and gained momentum in early 1970's with the introduction of green revolution through the use of high yielding rice varieties. Through the import of 3 metric tons (MT) of insecticides in 1956, Bangladesh entered into the era of the synthetic chemical pesticides for pest control and during 2011-12 about 51,560 ton pesticides have been imported, spending about 12 hundred crore taka (BCPC, 2013), where 43.79% is insecticide, 56.07% fungicides and 0.14% miticide. In Bangladesh pesticides used by farmers vary to some extent on location, crop, stock of insecticide to the local dealer. Although 80% of the insecticides are being sprayed in rice but the intensity of insecticide application per unit area is highest in the high valued vegetables and fruits. Among the various vegetables, fruits and spices crops, profitable crops like brinjal,

country bean, cabbage, cauliflower, cucurbits, summer tomatoes, okra, string beans, mango, litchi, chilli etc. receive excessive amounts of pesticides as they suffer serious pest damage (Alam *et al.,* 2004). However, application of pesticides is not high in the coconut plantation in Bangladesh. Due to development of resistance by different insect pests to different chemical pesticides, it was reported that for vegetables in general, an increasing trend was observed in use of pesticides by farmers in combating the pests throughout the country (Sabur and Mollah, 2000). However, in spite of everyday application of toxic pesticides, farmers could harvest 40%-50% fruits free of insect infestations (Alam *et al.,* 2004). Considering this situation care should be taken to set management strategy(ies) against any pest populations.

Registered pesticides in Bangladesh: Till December 2013, 175 different products (2894 trade name products) are being registered for agricultural purposes (insecticide 78, miticide 6, bio-pesticide 3, fungicide 52, stored grain pest 4, rodenticide 2, herbicide 30) (PPW, 2013) (Table 1). However, the government has already banned extremely hazardous (Ia) and highly hazardous pesticides (Ib). Till 2012, government has banned 195 trade name products, that include all "dirty dozens" product along with extremely and highly hazardous pesticides.

Table 1. List of registered pesticides in Bangladesh till December 2013 (Plant Protection Wing, 2013)

Sl. No.	Types of pesticides	Total registered pesticides		Remarks
		Common name	Trade name	
01.	Insecticides	83	1976	Registrations of bio-pesticides have been started from 20 December 2012. Before that several bio-pesticides were registered as insecticides
02.	Miticides	06	153	
03.	Bio-pesticides	07	11	
04.	Fungicides	54	771	
05.	Stored grain pesticides	04	66	
06.	Herbicides	32	377	
07.	Rodenticides	02	13	
Total		188	3367	

Reduction in insecticide use: However, it is a good news that with the increase of the popularity of bio-pesticide based IPM packages, the reduction of synthetic pesticides use has been started in Bangladesh. In 2010-11 for the first time a decline trend of total pesticide use was observed, 3190 mt less used than previous year (PPW, 2011) in the country. Sales reduction of granular, liquid and powder insecticides were 18.7%, 3.34%, and 4.47%, respectively happened in 2012 in comparison to 2011 (Table 2)

(BCPA, 2013). Sales of miticides were also decreased by 25.25%, which is mainly used in tea and vegetables. However, sales of fungicides (general) were increased 5.8% and sulphur 3.83%. Due to intensive research and promotional works on the development and dissemination of bio-pesticide based IPM packages against different insect pests, several cost-effective packages have been developed and became popular among the farmers community. So, use of synthetic pesticides especially in case of insecticides are showing a declining trend, whereas the bio-pesticide market is growing. However, for disease management use of bio-pesticide is still lagging behind.

Table 2. Total ex-depot sales of the member companies of Bangladesh Crop Protection association during 2011 & 2012.

Figures in MT/KL

Name of pesticides		Year 2011		Year 2012		% increase (+) or decrease (-) over 2011	
		FP	AI	FP	AI	FP	AI
Insecticides	Granular	20,335	1,082	16,539	815	(-) 18.7	(-) 24.7
	Liquid	3,574	905	3,455	795	(-) 3.3	(-) 12.1
	Powder	673	360	641	333	(-) 4.8	(-) 7.6
Fungicide	General	3,007	1,704	3,182	1,818	(+) 5.8	(+) 6.7
	Sulphur	12,804	10,228	13,295	10,617	(+) 3.8	(+) 3.8
Miticide		73.8	23.9	55.2	17.2	(+) 25.3	(+) 27.9

3.4 Coconut mite management

Different pesticides (miticides, insecticides, fungicides) having acaricidal properties were used for the management of coconut mite throughout the world. However, mite management with sole synthetic chemical pesticides is not dependable and sustainable because mite population may grow resistance against those pesticides. Not only that environmental pollution and health hazard is the bi-products of indiscriminate use of synthetic chemical pesticides. Therefore, an integrated package should be developed and used for the sustainable mite management of coconut. The integrated management should be bio-rational based where sole dependency on pesticides can be avoided.

In Bangladesh very limited research and development works has so far been reported on the overall insect pest management of coconut including coconut eriophyid mite. Recently scientists of BARI worked on different aspects of coconut mite at Jessore region of Bangladesh with the financial assistance of Krishi Govasona Foundation (KGF). The developed integrated management package against coconut eriophyid mite by KGF project is as follows (Islam, 2014):

a) Nutrient/Fertilizer application:
Application of recommended doses of Urea and Triple Super Phosphate and increased dose of Muriate of Potash to increase the plant resistance to the mite infestation. Application of the well decomposed Farm Yard Manure (@ 50 kg/tree/year). Soil application of micronutrients (Borex 50 g/tree/year, Gypsum 1.0 kg/tree/year, Magnesium sulphate 0.5 kg/tree/year).

b) Sanitation: Removal of mite infested nuts, branches and inflorescences.

c) Application of miticide:
Spot application of miticide, Propergite (Omite 57 EC) @ 1.5 ml/ liter of water

Division of Entomology, BARI has started a research and development work on the bio-rational based integrated management of three devastating insect pests coconut, viz. Rhinoceros Beetle, *Oryctes rhinoceros*, Red Palm Weevil, *Rhynchophorus ferrugineus* and Coconut Eriophyid Mite, *Aceria guerreronis* at the coastal belt of Bangladesh.

4. Conclusion and recommendations

A country like Bangladesh having limited land space, coconuts are rarely grown on large plantation except for few in the coastal areas. They are mainly grown in the homestead in almost all parts of the country. As coconut crop is the means of livelihood of many landless and marginal farmers in our country, so Government of Bangladesh is very much interested to increase the productivity of this crop on a sustainable basis. However, the yield of coconut in Bangladesh is still very low in comparison to other neighboring countries and infestation of different insect pests and diseases is one of the major reasons for that. This crop is attacked by various pests and diseases and among them Rhinoceros Beetle, Red Palm Weevil, Coconut Eriophyid Mite, leaf spot disease etc. are very much destructive. Although in the recent years incidence of nut infesting mite has been outbreak as a major problem in Bangladesh, which affecting both the yield and quality of nuts but the other pests are also need to be addressed. So, development and dissemination of an integrated management strategies addressing the major insect pests and diseases is the crying need at this moment.

However, the pest management tools should be safe, cost-effective and have minimum risk or hazard to human and desirable components of environment. In Bangladesh, till now research efforts have been unexpectedly slow and limited for the development of bio-pesticide based IPM technologies for coconut pests along with other crops. As a result, the availability of bio-pesticide based IPM technologies lagged behind seriously for years, compelling the farmers to have no other option than to rely solely on pesticide use for pest management. So, extensive research work especially in the public sector should be undertaken for the development of effective and cheap bio-pesticide

based IPM technologies against major insect pests & diseases of coconut. Emphasis on biological control, host plant resistance should be given for sustainable management. At the same time extensive promotional works all over the country should be undertaken for the quick dissemination of the developed bio-pesticide based IPM technologies. Private sector should assist in different aspect to develop the commercial venture of the bio-pesticides or microbial, so that those products can be available at the farm level. At the same time strict quality control measures should be undertaken for the commercially available bio-pesticides.

However, it is good to note that some of our neighboring countries of this region have made remarkable progress towards developing and popularizing sustainable management technologies against not only for coconut mite but also for other pests and diseases of coconut. So, a coordinated approach of the scientists of this region can play a vital role to develop a sustainable and environment friendly means to manage those pests. Especially a coordinated project involving the member countries to develop sustainable solution of the pest and disease problems in coconut including mite can be undertaken under the SAARC umbrella to boost up the overall productivity of coconut crop in South Asia.

In that way a holistic and sustainable way of bio-pesticide based integrated management packages of different pests and diseases of coconut should be undertaken to reduce the pest management cost with minimum risk or hazard to human and desirable components of their environment.

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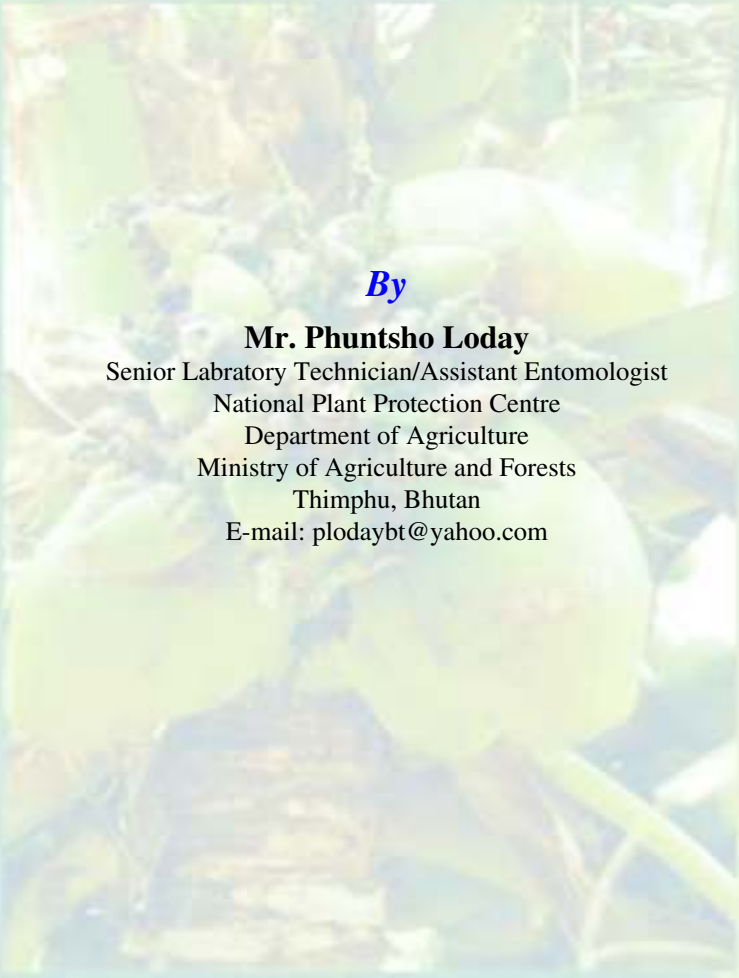
Mite Management of Coconut in Bhutan



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Bhutan:

- Bhutan is located in southern Asia between India and the Tibet Autonomous Region of China.
- The country is broadly categorized into three climatic zones which are sub-tropical in the southern foothills; temperate in the middle valleys and inner hills; and alpine in the northern mountains.
- The country has a total geographical area of 38,394 Square Kilometres with a population of 745,600 people.

Agriculture and Crops:

- Agriculture is the main source of livelihood for 69% of the population.
- Out of total land mass only 2.93% is cultivated area.
- Among Cereals, Rice and Maize are main staple, while Wheat, Barley Buckwheat and millet are also cultivated
- Citrus, Apple, Mango, Ginger and Cardamom are some of the major horticultural crops that are either exported or consumed locally
- Bhutan also grows several vegetables; among them chili is widely cultivated

National Plant Protection Centre:

- Among several National centres under the Department of Agriculture, the National Plant Protection Centre at Semtokha is designated as a national referral and coordinating authority for information, policy and activities related to plant protection services in Bhutan.
- The Centre is also mandated to develop and disseminate Integrated Pest Management practices in Agricultural and Horticultural cropping system
- The Centre also undertakes intensive program of research and development activities that also includes extension & farmers trainings through on-farm research activity;
- The centre also develops and disseminates plant protection extension materials.

- In order to implement the mandates of plant protection services, the Centre has five main technical divisions catering to specific responsibilities.
- These technical divisions are Plant Pathology, Entomology, Weeds and Vertebrate pests, Pesticides and Pest Surveillance

Coconut plantation in Bhutan:

- Although coconut is not commercially grown in Bhutan, but the crop is found in some pockets with few trees either for household consumption or for religious offering
- There is a potential to grow this crop on a larger scale especially in warm and humid sub tropical regions bordering Indian Sub continent.
- In these regions, it has favourable growing conditions with abundant sunlight and regular rainfall; temperatures are high enough for its growth and have a consistently warm and humid throughout the year.
- The other reason why this crop is not promoted is due to lack of technical skills and knowledge.
- From informal discussions with farmers and extension workers it has been found that there is a growing interest and requirement for technical assistance to grow this crop

Pest problems with special reference to mites:

- No proper surveys or research information is available concerning mites problem in coconut in Bhutan
- However, if the crop is cultivated on larger scale requirement for such information is crucial to sustain the productivity of the crop
- Besides mites, it is expected that other pests or diseases may be found if proper survey is done
- Therefore, I would like to request the gathering here to provided assistance to Bhutan to:
- Conduct feasibility studies in terms of varieties, agronomy practices and pest management of coconut to be grown on a commercial scale in Bhutan

- To conduct detail survey on mites and other pests problems in Bhutan
- To train interested Bhutanese farmers on agronomy and pest management of coconut

Mite Management of Coconut in India

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Introduction

Coconut palm (*Cocos nucifera* Linn.) occupies a dominant role among the cultivated palm species in India as it provides livelihood securities to more than 10 million people in 18 States and 3 Union Territories of the country. In India, this palm is aptly called a "*Kalpavriksha"* since each and every part of the plant can be used for the welfare of the mankind. The crop is cultivated in an area of 2.07 million ha with a total production of 23,351 million nuts (CDB, 2014). The four Southern States *viz*., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh contribute the major share of the area (90%) and production (92%) of the crop in the country. Although production and productivity of coconut in India has grown up considerably in the past few decades, prevalence of pests and diseases in majority of the coconut-growing areas in the country has adversely affected the coconut industry to a large extent. Coconut palm being a perennial crop, grown mostly under homestead gardens in Kerala, provides continuous supply of food and shelter for the build-up of various pests which cause extensive damage to the crop during all stages of its growth. Some of them are fatal while others reduce its vigour and finally resulting in economic loss. In India, palm health management strategies in coconut were initially developed with more orientation towards the use of insecticides and fungicides. But increased awareness on the ill-effects caused by indiscriminate use of plant protection chemicals had made Integrated Pest Management (IPM) the most accepted strategy to combat pests which not only integrates available components in a compatible way as possible but also leaves behind a pest residue for the sustained survival of natural enemies.

Coconut eriophyid mite, *Aceria guerreronis* Keifer (Eriophyidae: Acarina) is a potential and invasive pest of coconut causing heavy economic loss to be coconut Industry. In India, coconut eriophyid mite was first reported from Amballur Panchayat in Ernakulam district of Kerala during 1998 (Sathiamma *et al*., 1998). Within a short span of time the mite had spread rapidly to all major coconut growing regions of the country and currently its incidence is reported from the entire coconut growing states of West and East Coast and North-East part of India including Lakshadweep and Andaman and Nicobar Islands (Nair, 2002; Ramaraju *et al*., 2000; Mallik *et al*., 2003; Khan *et al*., 2003; Mullakoya, 2003; Singh and Rethinam, 2004; Sujatha and Rao, 2004; Nair *et al*., 2005; Rabha *et al*., 2013)

Hosts

The host range of *A. guerreronis* is very narrow. Apart from coconut, A. *guerreronis* was also recorded from palmyrah palm (*Borassus flabellifer*) in India (Ramaraju and Rabindra, 2001).

Biology

Coconut eriophyid mite is a microscopic creamy-white, vermiform organism measuring 200-250 microns in length and 36-52 microns in breadth. The body is elongated, cylindrical, finely ringed and bears two pairs of legs at the anterior end. Mites attain sexual maturity within a week's time and start laying eggs. An adult mite lays about 100-150 eggs. The eggs hatch into protonymphs, deutronymphs and finally to adults. The total life-cycle is completed in a period of 7-10 days (Mohanasundaram *et al.*, 1999; Haq, 2001)

Nature of damage and symptoms

In coconut, mites infest the developing young buttons after pollination and form active colonies containing various stages of development *viz.,* eggs, nymphs and adults inside the floral bracts (tepals) and feed on the soft meristematic portions beneath the perianth. High reproductive potential and shorter life cycle of the mite result in the enormous multiplication of the colonies. When colony size becomes substantially increased, mite emerges out of the interspaces between the tepals of the developing nut for dispersal. Dispersal of the pest takes place mainly through wind. Honeybees and other insects visiting inflorescence of coconut also act as agents for dispersal. The faster spread of the pest within a short period of time in a particular geographic area is mainly due to the aerial dispersal and high biotic potential. Mallik *et al.* (2003) reported enhanced migration of mites during the cooler hours of the day. Infestation symptoms of mite are primarily observed approximately one-month after the initial colonization of the mite inside the fertilized buttons. Appearance of elongated white streaks below the perianth is the first external visual symptom on young buttons. In many cases, an yellow halo develops around the perianth. Within a few days, this halo develops into yellow triangular patch pointing towards the distal-end of the button. This can be clearly seen in two-three month old buttons. In a short time the yellow patch turns brown and show necrotic patches on the periphery of the perianth. As the nut grows, the injuries transform into warting and longitudinal fissures on the nut surface. In severe infestation the husk develops cracks, cuts and gummosis. Shedding of buttons and young nuts as well as malformation of nuts due to retarded growth are the other indications associated with severe attack of the pest. The distribution of eriophyid mite colony is not uniform inside the perianth. Normally in two or three places the mite colonies are congregated under the tepals varying in size and shape.

Population dynamics

The coconut palm puts forth on an average one inflorescence a month. Thus, throughout the year the mite could locate nuts of suitable age for initiating infestation and population build-up. Peak population was observed during the summer months and

a sharp decline in subsequent rainy months indicating a negative relationship between mite population and rainfall (Mathew *et al*., 2000; Nair, 2002; Nampoothiri *et al.,* 2002; Mallik *et al*., 2004). Studies undertaken in Kerala coast revealed that a period of high temperature with intermittent rains causing high humidity favoured higher multiplication and rapid spread of the mite (Nair *et al*., 2003). Observations on the population of the mite within various age groups of the nuts showed that third and fourth bunches harbour maximum mite population.

Sampling techniques

A reliable technique used for the estimation of mite population on the nuts was the washing method. The perianth of the nut is removed and the bracts are arranged in a funnel. The nut surface and the bracts are washed with 30 ml detergent solution and the wash is shaken for few seconds. Soon after shaking, the number of mites in 1 ml of the solution is counted and the total population is estimated. This method gives a uniform distribution of mites in the solution. The disadvantage of this method is that live and dead mites cannot be distinguished in the solution.

A cellotape embedding technique was developed for evaluation of *A. guerreronis* population from the colonies (Girija *et al*., 2001). Transparent cellotape was pressed gently over the mite colony to embed the whole population, including eggs, nymphs and adults, on to the cellotape. Populations were counted using calibrated microscope.

Another method for population estimation is by direct counting. In this method mite colonies are scooped out as thin peels along with the nut surface. The number of mite stages and predators in 16sq mm (4mmx 4 mm) are counted manually under a stereo-microscope and usually expressed as number of mite/mm^2. For population estimation, sample of two nuts /palm one each from 3rd and 4th youngest bunch is taken. For recording damage, the nuts were classified according to visible injuries on nut surface. A score of 0-4 scale was developed for recording the extent of mite damage on coconuts. Nuts without mite infestation (healthy-score 0), nuts with less than 25% surface damage (low infestation-score 1), 25-50% nut surface damage (medium infestation-score 2) and 51-75% nut surface damage (high- score -3) and >75% surface damage, malformed and puny nuts (severe-score 4).

Crop loss

Yield loss to various levels has been reported world wide as a result of infestation by the pest. In general, pest incidence and extent of loss are comparatively high during the initial few years of pest occurrence in a particular locality due to the invasive nature of the pest. Yield loss depends on the cultivar, health and general maintenance of the crop as well as intensity of infestation. Increased difficulty in dehusking (leading to greater

labour requirements for this job) also contributes to economic loss. Feeding by few mites causes only cosmetic damage to the husk without affecting the quality and quantity of copra and coconut water.

During 1998, when the pest outbreak was reported in India, almost 70% of nuts were affected showing malformation and reduction of nut size (Nair, 2002). In Kerala though pest damage has been reported initially ranging from 50-70%, later surveys carried out in Alappuzha district during 2000 has shown significant reduction in crop loss indicating an average loss of 30.94% in terms of copra and 41.74% in husk production (Muralidharan *et al*., 2001). Similar studies undertaken in the neighbouring state, Tamil Nadu during 2000 revealed an average loss of copra yield to the tune of 27.5% (Ramaraju *et al*., 2000) and 18-42% in Karnataka when severe infestation symptoms were seen on more than 50% of surface area of infested nuts (Mallik *et al*., 2003). Mite damage caused significant reduction in quality of fibres in terms of fibre length and tensile strength. Studies undertaken at Kerala Agricultural University during 2003 revealed that fibres from moderately to severely infested nuts suffered 26-53% reduction in length (Naseema Beevi *et al*., 2003). Observations recorded during subsequent years revealed overall reduction in incidence and intensity of pest in areas of its initial occurrence with loss in terms of copra ranging from 8-12% (Nair *et al*., 2004; Rajan *et al*., 2007). In India, estimates indicated an annual loss of 2000-2500 million rupees (INR) in Kerala alone due to this mite (Singh and Rethinam, 2004). Yield loss in terms of infestation severity was also worked out. Reduction of kernel (59.4%) and copra (57.6%) was observed in infested nuts of category 4 (>75% nut surface damaged distorted nuts) whereas there was no significant difference in nut parameters *viz*., weight of nut, weight of husk, weight of kernel and shell between healthy nuts and nuts showing category 1,2, and 3 (up to 75% nut surface symptoms).

Thomas *et al.,* (2004) reported that different grades of mite infested seed nuts could not significantly influence on the growth and vigour of the coconut seedlings in terms of number of leaves, collar girth, seedlings with split leaves as well as on the number of thick roots. They have also recommended that the mite infested seed nuts should be sorted into different lots according to severity of infestation and nursery should be raised separately.

A snap survey on the incidence of coconut eriophyid mite was undertaken during 2009 at Coimbatore and Thanjavur districts (Tamil Nadu), Hassan and Tumkur districts (Karnataka), Retnagiri (Maharastra), Trivandrum and Kasaragod districts (Kerala) selecting six panchayats in each district. The average mite incidence ranged from 4.06 - 46.11% in different regions surveyed. Survey undertaken during April 2010 for assessing mite incidence in Lakshadweep Islands indicated a high infestation of 57.5% in Kavaratti, a moderate incidence of 23.2% in Kalpeni and a low infestation of 17.9%

in Minicoy Island (CPCRI, 2010). Mite incidence in Andhra Pradesh showed 28.9% (West Godavari) to 39.6% (East Godavari) (Rajan *et al*., 2012)

Varietal susceptibility

A coconut variety exhibiting resistance to eriophyid mite is not reported from any country. The tepal traits, colour, shape and size of the nut influence the degree of damage. Among these, shape of the nut (round shape) and tepal traits (tight perianth) are important attributes for mite tolerance. Varieties like Malayan Yellow Dwarf (MYD), Malayan Red Dwarf, Rennal Tall, Cameroon Red Dwarf, Equatorial Green Dwarf and Hybrid [MYD x West African Tall (WAT)] were reported to show different degrees of tolerance to mite attack in different countries of the world (Rethinam, 2003). In India, observations from CPCRI revealed that Kalpa Haritha, a superior high yielding tall selection (Kulasekharam Green), showed lesser incidence of eriophyid mite infestation (<10%). Varieties viz., COD (Chowghat Orange Dwarf), Malayan Green Dwarf (MGD), Laccadive ordinary (LO), Cochin China (CC), Andaman Ordinary (AO), Gangabondum (GB), Spicata and Kenthali showed maximum tolerance to mite infestation in the field. Varieties like West Coast Tall (WCT), Laccadive Tall (LCT), East Coast Tall (ECT), Tiptur Tall and Chowghat Green Dwarf (CGD) recorded maximum incidence in the field in various locations (35-80%). However, field incidence may vary depending on season and nutritional status of palm.

Pest Management

Nearly sixty systemic and contact insecticides have been evaluated world over and recommended from time to time for management of coconut mite. In India also, a wide spectrum of pesticides have been evaluated by various research agencies including both Central Institutes and State Agricultural Universities (Nair *et al*., 2002; Ramaraju *et al*., 2000; Saradamma *et al*., 2000; Kannaiyan *et al.,* 2002; Mallik *et al.,* 2003). Though these pesticides *viz*., triazophos, chlorpyriphos, phosalone, fenpropathrin, imidacloprid *etc* were effective in the field when given as spray/ root feeding / stem injection, none of the chemicals has been used for area-wide adoption in India due to environmental reasons. Only botanicals have been recommended. But the search for safer compounds is continued to facilitate treating large areas. Even wettable sulphur recommended for mite management in the initial years was withdrawn due to its deleterious effects on the natural enemies of mite particularly on the entomopathogenic fungi. The massive crown of the palm, large area to be covered in a short spell of time, need for repeated application, residual toxicity of pesticides, labour intensive mode of application *etc* were other factors which were unfavourable for the wider use of chemical pesticides.

Currently neem based botanical formulations are recommended for mite management in the field. Spraying of neem oil-garlic soap mixture at 2% or commercial neem

formulation containing azadirachtin 10,000 ppm @ 0.004% or root feeding with neem formulations containing azadirachtin 50,000 ppm (7.5 ml) or azadirachtin 10,000 ppm (10 ml) mixed with equal volume of water is recommended for mite management (Saradamma *et al*., 2000; Nair *et al.,* 2000, 2003; Mallik *et al*., 2003; Rajan *et al*., 2009)

Method of spraying

As the mite colonies are lodged inside the soft tissues of the developing nuts covered by the perianth, botanical formulation should be applied as fine droplets on the perianth region from top so as to provide its penetration into the perianth lobes through surface tension. Pesticide solution should cover 2 to 6 month old nuts since these bunches harbour maximum number of mites. There is no need to spray the unpollinated and mature nuts in the palm. If the pesticide is applied on the bunches using pneumatic hand sprayer 250 to 500ml spray fluid is required per palm. The neem-based formulation can be applied through roots also for getting effective control of the pest.

Root feeding method

An active semi-hard, pencil thick and brownish coloured root without damage was traced from about one metre away from the bole region. A slanting cut of 45° at the tip portion was made with a sharp knife. About 7.5 ml of Azadirachtin 5% formulation or 10 ml Azadirachtin 1% formulation was mixed with equal volume of water in a polythene pouch. The cut end of the root was immersed in the pesticide solution up to the bottom of the pouch and the mouth of the pouch was tied with a twine. Care should be taken to avoid any injury or spillage of the pesticide solution and cover the root gently with leaf mulch or loose soil. Root feeding of insecticides, though preferred by the farmers due to ease of operation and suitability for tall trees, is disadvantageous from the point of view of contamination of copra and coconut water with the insecticides.

Root feeding of carbosulfan 15 ml + 15 ml of water left residue below permissible level after 60 days in both coconut water and kernel samples (Kuttalam *et al.,* 2000). Root feeding with triazophos @ 10, 15 and 20 ml (1 : 1 v/v with water) observed after 45 days of application was well below the tolerance level (Kuttalam *et al*., 2000; Narasimha Rao, 2000).

Biocontrol agents

Due to the limitations of pesticidal applications and the labour intensive nature of the application techniques for pesticides, biological control programmes gain major importance in the management of coconut eriophyid mite. Biocontrol is most desirable

as it is safe and eco-friendly. Hence, it is more vital in sustainable management of the pest. Among the biocontrol agents, predators and pathogens constitute the major groups of natural enemies. So far, no parasitoid has been reported parasitizing on *A. guerreronis*.

Predators

The sheltered habitat and biology of *A. guerreronis* provide few opportunities for other natural enemies to be effective, but some have been observed occupying the meristematic zone of coconut fruits. Predatory mites belonging to Phytoseiidae, Bdellidae and Tarsonemidae are encountered in various collections. *Amblyseius paspalivorus, Bdella* sp. and a tarsonemid attacking mite colonies were reported from Tamil Nadu (Marimuthu *et al.,* 2003), *Amblyseius* sp. and *Phytoseilus* sp. from Kerala (Naseema Beevi *et al.,* 2003) and *A. paspalivorus* and the tarsonemid, *Lupotarsonemus* sp. were reported from Karnataka (Mallik *et al*., 2003). *Neoseiulus baraki* Athias-Henriot, *N. paspalivorus* De Leon, *Typhlodromus* sp., *Chelacaropsis moorei* Baker, *Cheletogenes ornatus* (Canestrini & Fanzago), and *Bdella* sp. are the major mite predators encountered and *N. baraki* found as the most predominant predator observed in samples collected from various geographical zones of the country (Chandrika *et al.,* 2010). Seasonal incidence of *N. baraki* showed persistence throughout the year with peak during April. The average percentage of nuts lodging predators showed a steady increase in the total nuts collected from various locations during different years and recorded a steady increase in population over the years (2000-2013) from 37.09% to 82.70%. The insect predators observed in the studies include a thrips, syrphid and coccinellid which are of very low occurrence. The predatory mites are larger in size compared to the coconut mite and hence they gain entry only later into the nuts and hence compared to the young developing nuts below three months, more predators are encountered in 4-6 months old nuts. This is one of the limiting factors for the wider use of the predators. However, conservation of the predatory fauna in the ecosystem is beneficial to regulate the coconut mite in nature (Nair *et al*., 2005; Rajan *et al*., 2009).

Pathogens

Among microbial acaro-pathogens, fungi contribute the predominant pathogens of coconut eriophyid mite. Fungal species associated with eriophyid mite include species of *Sporothrix, Poecilomyces, Beauveria, Metarhizium, Verticillium, Acremonium, Aspergillus, Pencillium, Fusarium and Hirsutella thompsonii* (Kumar *et al*., 2001) and *Scopulariopsis brevicaulis* (Gopal *et al*., 2002). Pathogenicity trials with *Fusarium moniliformae,* Actinomycetes, bacteria and *H. thompsonii* resulted in 34.3%, 10%, 4.5% and 76% mortality, respectively of the mite in treated nuts. *Lecanium* spp. and

Penicillium sp. were not pathogenic. Owing to the phyto-infective property of many *Fusarium* species including *F. moniliformae* no detailed studies were attempted (Chandrika *et al.,* 2010).

The fungal pathogen, *H. thompsonii* has received considerable attention throughout the world as the most effective natural enemy of eriophyid mite of coconut. This fungus has three varieties of which *synnemetosa* has been more often invading *A. guerreronis*. In India the incidence of *H. thompsonii* was recorded from Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Pondicherry, Odisha and Lakshadweep Islands (Beevi *et al.,* 1999; Kumar, 2002; Chandrika *et al.,* 2010). CPCRI could collect virulent native isolates of this fungus from different locations of India. A total of 42 isolates of *H. thompsonii* were collected and maintained. Pathogenicity tests were carried out with all the 42 isolates of *H. thompsonii*. Pathogenicity was proved positive by establishing Koch's postulates with 9 isolates when carried out in detached nuts harboring mite colonies. Talc-based preparation of *H. thompsonii* (isolate CPCRI 51-II) @ 20g/litre/palm containing 1.6 x 10^8 cfu with a frequency of three sprayings per year resulted in 63-81% reduction in mite population in the field (CPCRI, 2011). Mutilocation trials conducted through All India Coordinated Research Project on Palms at Ambajipeta (Andhra Pradesh), Aliyarnagar (Tamil Nadu) and Ratnagiri (Maharashtra) evinced encouraging results.

Nutrient management as a component of IPM

Soil test based balanced nutrition play a key role in improving the palm health status thereby imparting tolerance to the mite attack. The nutrient management package consists of balanced application of NPK fertilizers at recommended doses in two splits (NPK @500g, 300g, 1200g/palm/year), recycling of organic biomass in coconut ecosystem using *in situ* vermi-composting or growing of green manure crops like cow pea or sunn hemp at a seed rate of 100g/palm and its incorporation in coconut basin and conservation of soil moisture by appropriate mulching methods. Well maintained trees, with appropriate fertilizer application, were found to suffer less from mite attack. Inter cropping of sunnhemp with coconut reduced the mite incidence upto 13.6 per cent and reduced the damage grade. The least damage of 29% was seen in palms treated with neem cake 2 kg + bone meal 0.5 kg + mill ash 4 kg (per tree/ year) (Muthiah and Bhaskaran, 2000). Low incidence of coconut eriophyid mite was observed in coconut gardens with intercrops *viz*., flowering plants, banana *etc* than the garden raised as monocrop in Andhra Pradesh. They also recorded that well maintained coconut plantations with proper irrigation and nutritional care exhibited a marked reduction in mite incidence when compared to neglected plantations (Rajan *et al*., 2012).

Palm and farm hygiene

Modification of agronomic management practices through irrigation and optimum utilisation of chemical fertilisers have also been suggested to regulate the mite population in the field. Long periods of drought resulted in greater yield loss due to the mite attack, because fruit growth is slower during dry periods. Tender nuts (containing eggs, larvae, nymphs, adults) harbour mite colonies under the perianth. Phytosanitary measures including restrictions on movement of mites and infested parts to non-affected areas reduce the spread of the pest. Removal of dried spathes, inflorescence parts, fallen nuts *etc* and burrying them in the soil or burning them reduces the pest inoculum and subsequent infestation. Crown cleaning should be taken up as and when necessary.

IPM of coconut eriophyid mite

In India, adoption of integrated mite management approach with need-based application of botanical pesticides either by spraying or root feeding and adequate nutrient management of the affected palm has given encouraging results in the field. An integrated strategy blending plant protection and nutrient management is currently recommended for management of the pest.

Plant protection includes spraying on the terminal five pollinated coconut bunches thrice a year during December-January, April-May and September-October coinciding with population build up of the pest

- 2% neem oil-garlic soap mixture/neem formulation containing azadirachtin 10000 ppm (0.004%)/palm oil (200 ml) and sulphur (5g) emulsion/talc based preparation of *Hirsutella thompsonii* @ 20 g/litre/ palm containing 1.6 x 10^8 cfu

  Or-

- Root feeding of neem formulations containing azadirachtin 50000 ppm @ 7.5 ml / azadirachtin 10000 ppm @ 10 ml mixed with equal volume of water.

The nutrient management package consists of:

- Balanced application of NPK fertilizers at recommended doses in two splits (Urea 1.0 kg, super phosphate 1.5 kg, muriate of potash 2.5 kg)
- Application of well-decomposed Farm Yard Manure @ 50 kg and neem cake @ 5 kg per palm per year
- *Insitu* growing of green manure crops like cow pea, , *Calapagonium* sp. or sunn hemp (seed rate of 100g/palm basin) in the garden and its incorporation in coconut basin.
- Judicious irrigation and mulching with coconut leaves and husk in the basin.

- Soil application of micronutrients: Borax -50 g/palm/year; Magnesium sulphate – 500g /palm/year especially in Onattukara region of Kerala .

In South India, State Agricultural Universities, ICAR Institutions and private institutions have recommended an integrated and holistic approach for managing the mite population based on the findings of individual tactics tested against the pest. Removal of dried spathes, inflorescence parts, and fallen nuts etc. and burying in the soil or by burning minimizes the pest inoculum. Crown cleaning is to be taken up periodically. The movement of mite infested nuts from place to place is to be restricted to minimize the spread of mite. If locally acceptable, raise genotypes like Kalpa Haritha, Lakshadweep ordinary, Cochin China, Andaman ordinary and Gangabondam (which recorded minimum nut damage) in areas of severe mite infestation.

IPM package was demonstrated in farmer's fields at Krishnapuram village, Kerala covering 25 ha area of coconut gardens in 208 farmer holdings. Here the integrated nutrient management technology was implemented along with recommended practice of azadirachtin spraying thrice a year and the mite incidence could be brought down to 15.3% from 68% in period of three years (Rajagopal *et al*., 2003).

Future thrust

- Collective efforts of scientists working in different countries for exchange of technical expertise on the innovative mite management strategies.
- Mite-host relationship, influence of abiotic and biotic factors on the mite population and developing forecasting models.
- Collection and cataloguing of natural enemies from various agro-ecological zones to identify promising biocontrol agents sustaining the prevailing abiotic stress.
- Improving the performance of natural enemies through genetic manipulation, after addressing their safety to environment and other organisms.
- Synergistic interaction studies of bioagents with botanicals for mite management.
- The predators of coconut eriophyid mite identified in different countries may be catalogued, mass multiplied and made available with a view of exploring possible use of suitable candidates.
- Influence of organic amendments and macro/micronutrients needs to be studied/standardized and strengthened.

- Crop habitat diversification for mite regression through emergence of bouquet of volatiles.
- Identification of resistant/tolerant cultivar and evolving a variety with tight perianth through breeding/genetic manipulation and use of molecular markers for identifying eriophyid mite resistance as well as identifying seedlings with superior traits before transplantation.
- Generating data on application of organic wastes and recycling of organic matter on management of eriophyid mite.
- Field trials in various agroclimatic zones for developing location specific low cost management technology.
- Area-wide farmer participatory demonstrations and Farmer Field School approach for effective dissemination of mite management strategies.
- International cooperation through networking of research carried out in different parts of the world which would enable exchange of natural enemies, technologies, *etc*. need to be encouraged by all funding and donor agencies.

Epilogue

Coconut eriophyid mite, *A. guerreronis* is one of the potential invasive pests of coconut in India. In a period of 12 years from its initial occurrence, the pest has spread to all major coconut growing regions of India including Lakshadweep Islands causing heavy economic loss to coconut industry. Detailed and thorough studies on various aspects of bioecology and management have been carried out by various research agencies in the country. An IPM package consisting of two components *viz*., plant protection and nutritional care was developed and field validated. A natural decline in the mite incidence could be observed especially in most of the pest infested tracts in the West Coast. Both biotic and abiotic factors can be attributed as probable reasons for the reduction in mite incidence. The slow and steady increase in the population of predatory fauna, natural infection of mite population by pathogenic fungi particularly *H. thompsonii* and uniform distribution of rainfall in the major coconut growing areas of West Coast of the country are considered to be the major factors for natural regulation of the pest. However, in depth studies on biocontrol agents with tolerance to abiotic stress, role of plant nutrition including PGPRs, breeding for mite resistance are highly essential to chalk out a cost effective, eco-friendly and sustainable management of the pest. Adoption/cultivation of mite tolerant coconut varieties like Kalpa Haritha in endemic zones would be encouraged.

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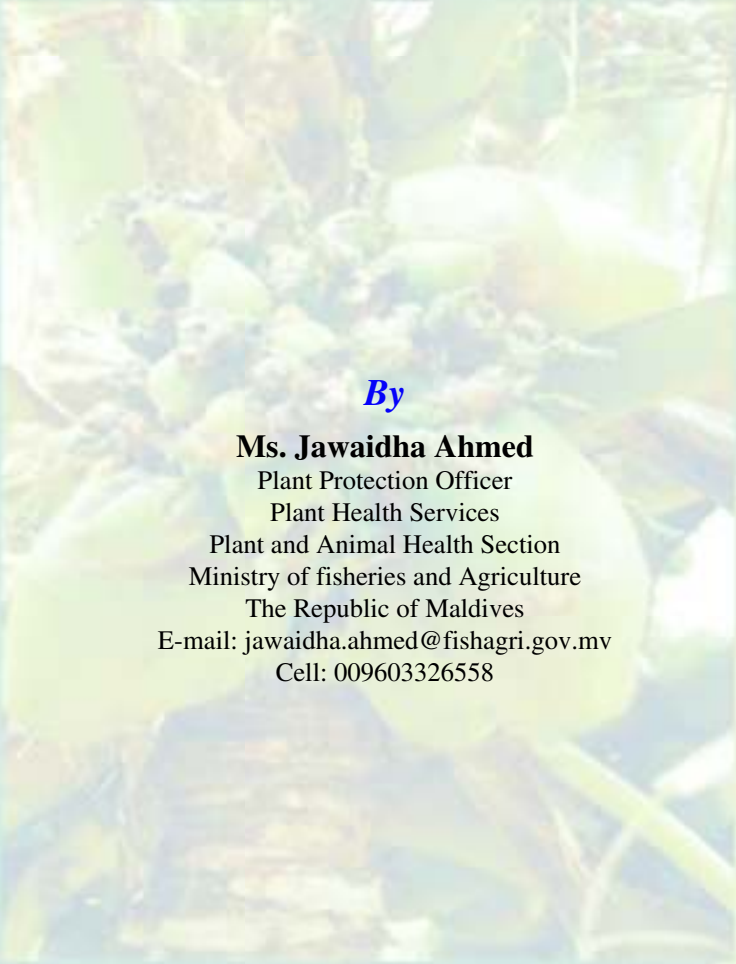
Mite Management of Coconut in Maldives



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The Maldives

- The Maldives is a coral archipelago consisting of 1190 islands, forming a chain of 820 km at its length and 130km at its width.

- These islands are grouped into 26 coral atoll sets in an area of 90,000sq.km in the Indian Ocean.
- At least 90% of this area consists of seas

- The islands are small, few with a land area in excess of one kilometre.
- They are low-laying with an average elevation of 1.6m above sea level
- The natural vegetation of the island consists of a variety of plants growing in profusion.

- The vegetation is relatively uniform and follows a common pattern: salt-tolerant bushes in the island edges then large trees and coconut palms further inland.

- All islands are dominated by large stands of coconut palms locally known as '*Dhivehi ruh*' (scientifically *Cocosnucifera*)

Coconut palms are declared as the national tree of the Republic of Maldives due to its abundance

Coconut Mites in the Maldives

- Coconut plays a major role in the economy of the Maldives directly by providing food and income from coconut products.

- Coconut mite *Aceria (Eriophyes) guerreronis* (Keifer) of the family Eriophylidae has been posing serious problems to the production of coconut in many countries.

- However, quantitative knowledge about its distribution, damage and abundance in Maldives is lacking.

Islands which has been reported

- Only very few islands have been reported coconut mite case ;
- Baa.Goidhoo
- L.Gan
- Kendhikulhedhoo

Symptoms seen in Coconuts of Maldives

- Young and developing coconuts display superficial bands of varying widths of longitudinally-striated necrotic tissue about the circumference of the nuts.
- Nuts may also be reduced in size and may have circumferential constrictions and other malformations. These mites do not cause any damage to leaf tissue.

Control Measures

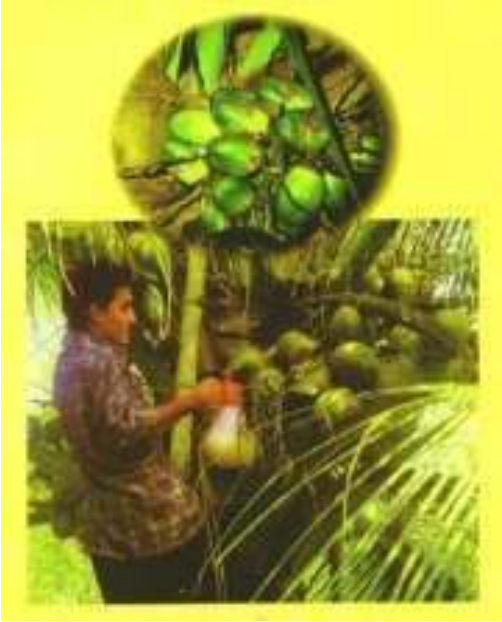
- In Maldives the coconut mite case is very rare .
- Awareness programs were conducted by the technical staffs.
- Methods recently use to control coconut mite

Neem-garlic-soap emulsion

- Ingredients to prepare ten litres:
- Neem oil 200 ml
- Garlic 200 g
- Washing soap 50 g

Procedure

- The garlic must be well ground either manually or using a grinder, adding sufficient water.
- The garlic paste is then sieved through a cloth to get the extract. The specified quantity of soap is cut into small pieces and then dissolved in hot water. This solution also should be siemake a good emulsion.
- This is further mixed well with the garlic extract and then made upto 10 litres by adding water and stirring well to make the neem-garlic-soap emulsion for spraying. It is found to control the mite effectively.



2. Palm oil or vegetable oil and sulphur mixture

- It has been proved that mite can be reduced effectively.

Ingredients to prepare one litre:

- Palm oil 200 ml (1 cup)
- Water 800 ml (4 cups)
- Soap powder 12g (2 tablespoons)
- Wettablesulphur 80% 5 g (1 tablespoon)

Procedure

- Mix water, soap powder and sulphur. Add palm oil into the above mixture and mix thoroughly. Usually one liter of the above solution is enough to spray on to one palm.

Some invasive species found commonly in Maldives

Hispid beetle

- The Hispid beetle a parasite that infests coconut palms is spreading rapidly in the Maldives.
- So far the hispid beetle has infested palms in several islands of South Ari Atoll including Dhiddhoo, Dhigurah, Fenfushi, Malignly, Tholhifushi, Ariyadhoo, Sun Island, Holiday Island, Vakarufalhi, and Rangali (Hilton Maldives).

Symptoms seen in Maldives coconut Palm trees;

- The infected fronds turn brown, decay, and die. The dead fronds then allow other organisms such as fungus and bacteria to thrive and decompose the tender parts of the palm, which ultimately dies.

Methods adopted in Maldives to prevent hispid beetle;

- Earwigs(Biocontrol agent) , Diaphos 10 gm (chemical packet), Actara 25WG(insecticide)

Rhinocerous Beetle

- The coconut black beetle (*Oryctes rhinoceros)* is a major pest occurring in coconut cultivations in almost all islands in Maldives.

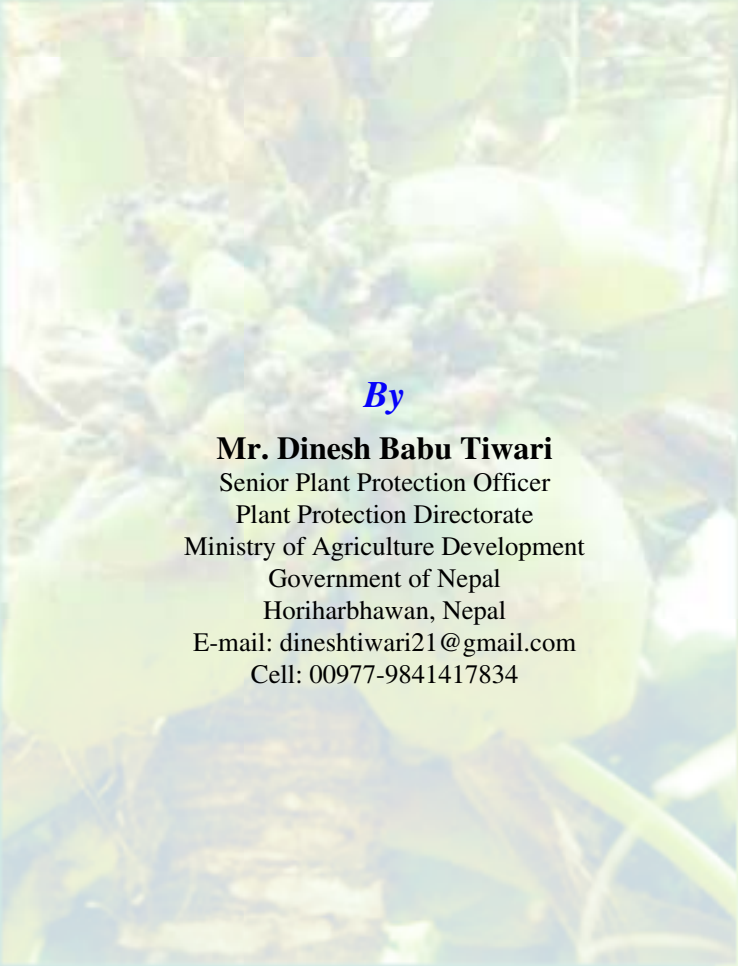
Symptoms seen in Maldives;

- Seen considerable retardation of growth in young palms and seedlings and occasional death of seedlings.

Control methods in Maldives;

- For controlling purpose orycta virus has been used .

Mite Management of Coconut in Nepal



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Status of Coconut pests and its Management in Nepal

Background

Nepal is an agricultural country. About 66 percent of the active population is engaged in agriculture and 36% of the GDP is contributed by agriculture. However, agriculture is still largely of subsistence nature. The country is landlocked which covers the land area of 147,181 square km. Geographically, it is located between $26^0$22' to 30^0 27' North latitude and 80^0 4' to $88^0$12' East longitude. The east-west length of Nepal is 885 Km and North to South width is not uniform the mean width is 193 Km. World's highest mountain peak (8848 meter), the Mount Everest, is belongs to Nepal.

Population and Demography

Its population is 26.3 million (Nepal Popualation census, 2012). There is increasing trend of population and its concentration is increasing in urban areas. Around 86 percent of the people live in rural areas. Despite the past various efforts, 31percent of the people are still under poverty- majority of the poor living in rural areas and engaged in agriculture. Therefore, increasing agricultural production and productivity deserves greater importance in poverty reduction.

Figure : Map of Nepal

Agro-ecosystem and Bio-diversity of Nepal

The country has great variety of topography, which is reflected in the diversity of weather and climate. Ecologically, Nepal is divided into three geophysical region – the mountain region, hill region and terai (plain) region. Thus, the country is of geophysical, biological and cultural diversity. The temperature, rainfall and the overall

climate in Nepal vary from tropical to arctic with altitude ranging from 60 m to 8848 m from MSL. Four great rivers flow transversely from north to south. Mountains, hills, valleys and Terai posses different agro-ecosystems. Mountains belongs 35% of total area. (4800 msl and above). Hills Covers about 42% area (300 to 4800 msl). Agro-based livestock industries and horticultural production in the region are the main source of income of the people. Likewise terai Covers about 23% of the total area (<300 msl). This region serves as a main source of food supply to other region of the country. Coconut cultivation is mainly limited to eastern terai of Nepal.

Distrubution of Cultivated Land in Nepal

Physical region	Area in sq.Km	
	Total	Cultivated
Himalayan/Mountain	51817	1436
Hills	61345	9337
Terai	34019	25138
Total	**147181**	**35912**

Source: Agriculture Diary, 2014. Agriculture Information and Communication Centre, Hariharbhawan, Nepal.

Agricultural Production and Plant Protection Porgramme in Nepal

In the agricultural sector there are two major wings under the Ministry of Agricultural Development. Agricultural development activities are carried out by the Department of Agriculture (DOA) and research activities are performed by the Nepal Agricultural Research Council (NARC). Under the Department of Agriculture, twelve technical Directorates are functioning in their respective field. Among them Plant Protection Directorate (PPD) has the mandate for crop pest management. Government of Nepal has adopted the integrated Pest Management (IPM) programme as national pest management strategy. Plant Protection Directorate is designated as National Plant Protection Organization (NPPO) of Nepal. Pest survey and surveillance is one of the major task under PPD. It has National Reporting obligation for plant pests. Plant qurantine programme is one of the major component of PPD. Plant quarantine services are provided by National plant quarantine programme, Regional plant quarantine offices and Plant quarntine checkposts which are established at different land frontiers and International Airport.

Major crops

- Rice, Wheat, Maize, vegetables, potatoes, fruits, lentil.
- Cash crop – Cardamom, Tea, Coffee, Sugarcane, Jute

Coconut cultivation in Nepal

Coconut deserves significant importance in Nepalese culture. However, its cultivation is limited to eastern Terai of Nepal. Coconut cultivation is mainly in homestead gardening. Likewise, very few works have been performed under the coconut cultivation, pest management and its promotion. Separate institutute and programme under research and extension is not established for coconut development. Fruit Development Directorate (FDD) under the Department of Agriculture is working for area extension of the fruit. Pest survey is initiated by Plant protection directorate through its network. It is estimated about 555 ha area is under coconut cultivation. Out of which total productive area is about 395 ha. Local production of coconut is 2537 ton and productivity is 6.43 ton (Fruit Development Directorate, 2013). About 2607 ton of coconut was imported in the year 2012/13 (Trade promotion centre, 2013). Therefore, internal demand of coconut is fulfilled by importation.

Status of coconut Import and export in Nepal

Countries	2008/09		2009/10		2010/11		2011/12		2012/13	
	Import (ton)	Export	Import (ton)	Export	Import (ton)	Export (ton)	Import (ton)	Export	Import (ton)	Export (ton)
India	2338		2094		2320		2469		2599	3.5
China			17		0.2	22.4		0.5		0.07
Malaysia									7.7	
Sri Lanka			10.96							
Thailand	0.96				0.31		1.06			

Source: Trade and export promotion centre 2012/13 Report

Coconut pests and its Management

Coconut is one of the minor crop grown in Nepal. Which is reflected in crop management and pest identification technology generation as well. Neither the demand for crop promotion and pest management is raised from private sector (including farmers level) in a specific way, nor the attempt from research and extension is performed extensively in those field. In demand of the fruit saplings locally produced saplings are supplied by the District Agriculture Development Offices (DADO). Whenever the pest problem is noticed, the plant protection officers are mobilized for pest management. As known from the Eastern Regional Plant Protection Laboratory, few pathological problems- rotting, drying and dropping of leaves and fruits, infestaiton of borer, scales and mites problems are noticed in the coconut tree. However, the species of mite is not verified. In connection to the information collection for paper preparation, when an interaction was made with stakeholders in eastern region of Nepal, the problem of reduction in nut size and imature bud dropping is known from the stakeholders. Which is very much resembling with mite infestation. However pest verification is to be made. In cases of pest infestation field sanitation and pesticides used is advised for pest management. In case of mite infestation Acaricide - Dicofol is recommended and its used is found effective for pest management as known from the stakeholders. Crop protection compendium (CPC) 2007 has listed certain coconut pest of Nepal. However, documentation, reporting and expertise development for the coconut pest is yet to be initiated in a more formal way.

Coconut pest list of Nepal (Crop Protection Compendium - 2007) :

Aleurocanthus woglumi - Citrus blackfly
Aonidiella orientalis - Oriental yellow scale
Aphis gossypii - Cotton aphid
Aspidiotus destructor - Coconut scale
Atherigona orientalis - Pepper fruit fly
Chromolaena odorata - Siam weed
Cnaphalocrosis medinalis - Rice leaffolder
Ephestia elutella - Chocolate moth
Euphorbia hirta - Garden spurge
Fusarium oxysporum - Basal rot
Ganoderma lucidum - Basal stem rot
Heliothrips haemorrhoidalis - Black tea thrips
Imperata cylindrical - Satintail
Lasiodiplodia theorbromae - Diplodia pod rot

Macrophomina phaseolina - Charcoal rot of bean
Mimossa pudica - Sensitive plant
Momordica charantia - Bitter gourd
Panicum repens - Torpedo grass
Parasa lepida - Nettle caterpillar
Parasaissetia nigra - Pomogranate scale
Parthenium hysterophorus - Parthenium weed
Pseudaulacaspis cockerel - Magnolia white scale
Pseudaulcaspis pentagona - Mulberry scale
Pulvinaria psidii - Green shield scale
Saissetia coffeae - Hemispherical scale
Senna obtusifolia - Sicklepod
Stephanitis typical - Banana lacewing bug
Tyrophagus putrescentiae - Cereal mite - Haines, 1974.
Xyleborus perforans - Island pinhole borer

Conclusion

Its an organized initiative for Nepal to develop the work for noxious pest - coconut mite management. Pathway for pest dispersion and risk reduction will be discussed. Recent technology on crop husbendry and pest management will be shared. Plant quarantine system should be strengthened and mobilized adequately. Since India, Bangladesh, Sri Lanka, Maldives, Pakistan including APCC countries (Thailand, Indonesia, Vietnam and Philippines) are the reservoir of expertise of coconut pests including mite, Nepal is expecting to get advantage of this plateform in developing National capacity for coconut pest management. SAC would coordinate to achieve the objectives. Pest management itself is a complex process so the integrated approach should be followed in a collective way.

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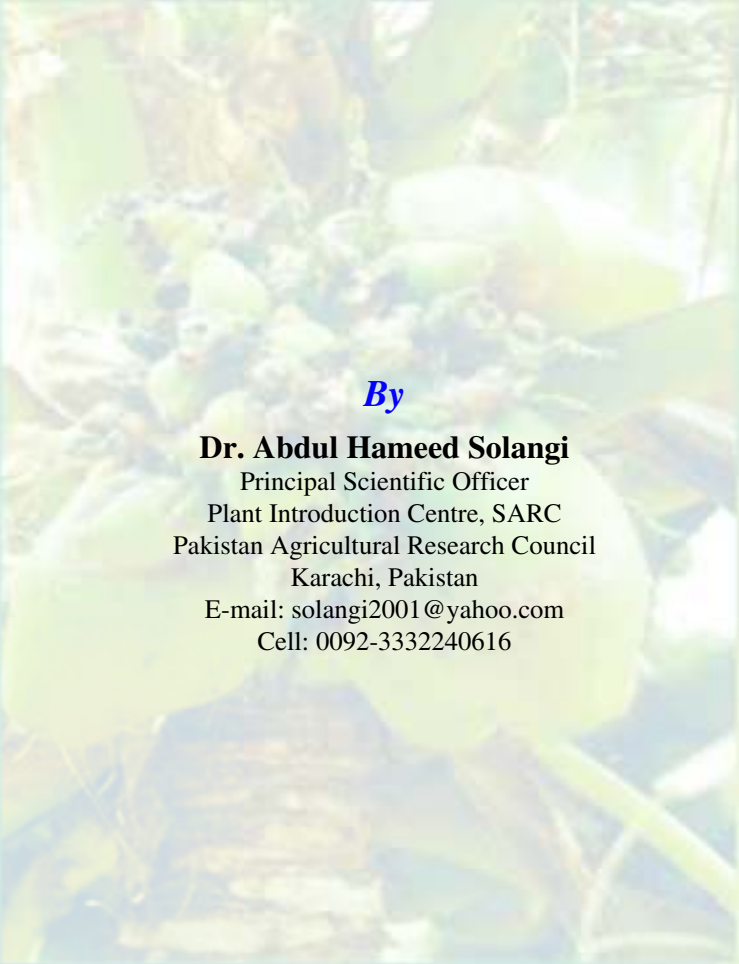
Mite Management of Coconut in Pakistan



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Status of coconut mite (*Aceria species*) and its management in coastal area of Pakistan

Introduction

- The Islamic Republic of Pakistan is place of ancient civilization. Pakistan lies between the longitudes of 23º 30' and 36º 45' North and between the longitudes of 61º and 75º 31' East. This territory is a region of diversified relief, with mountains to the north and west and arid and stem-arid expanses to the south and east.
- Pakistan, located in the north of the tropic of cancer, possesses a great range of diversity; from some of the hottest in the world Jacobabad has even recorded absolute maximum temperature of 53°C.
- By the grace of Almighty Allah and the efforts of our farmers, the performance of the agricultural sector deposited many constraints as been quite impressive. This performance however is much below the real potential of Pakistan's agriculture.
- In Pakistan Coconut (*cocos nucifera* L.) is grown in coastal areas of two provinces, Sindh and Balochistan (Fig.1). The major contributing districts are Karachi, Thatta and Badin in Sindh and Lasbella in Balochistan.
- The coconut plantations have been in existence in Karachi for a long time, most of these are scattered and there is no organized plantation with known varieties.
- In the early I950s to 1970s, the coconut was hardly grown on a commercial scale in Pakistan.
- Now a day's coconut palm is grown on an area of about 60 thousand hectares with a production of 1500 tones, but due to more consumption imported thousand of tones are imported every year.
- Geographically, Pakistan has a diverse climate ranging from subtropical to temperate and alpine forests. Climatically, it is arid and semi-arid region. Plant genetic resources make a positive impact on different components of national economies including those relating to food, agriculture, forestry, medicine, industry, transport, shelter, energy and environmental protection etc.
- In Pakistan, the coastal belt is characterized by sandy as well as saline soils. The climatically information regarding temperature, relative humidity, rain fall and wind velocity of the past six years (2005 to 2010) of main districts (Karachi, Thatta and Lasbella) is shown in Fig. 2-6 **(PMD, 2011).**

Fig.1 Coconut Plantation in Costal Area of Pakistan

- The coconut palm prefers certain climatic conditions and for its commercial viability climatic factors such as rainfall distribution, altitude, period of drought has to be given serious considerations, whereas the ecological factors are strongly interrelated and one finds it difficult to classify their influence on the performance of coconuts according to their importance

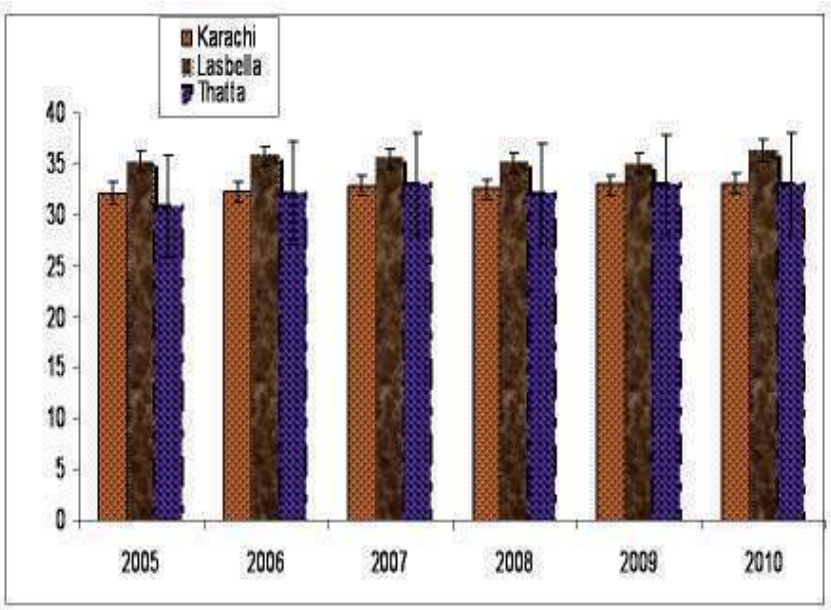


Fig. 2. Yearly mean maximum temperature in different districts of Sindh (Karachi and Thatta) and Balochistan (Lasbella).

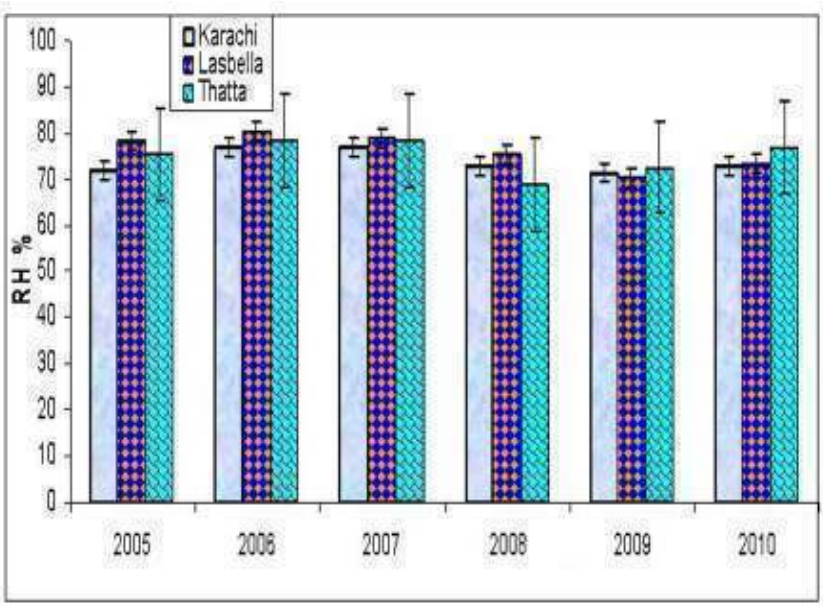


Fig. 3. Yearly mean relative humidity in different districts of Sindh (Karachi and Thatta) and Balochistan (Lasbella).

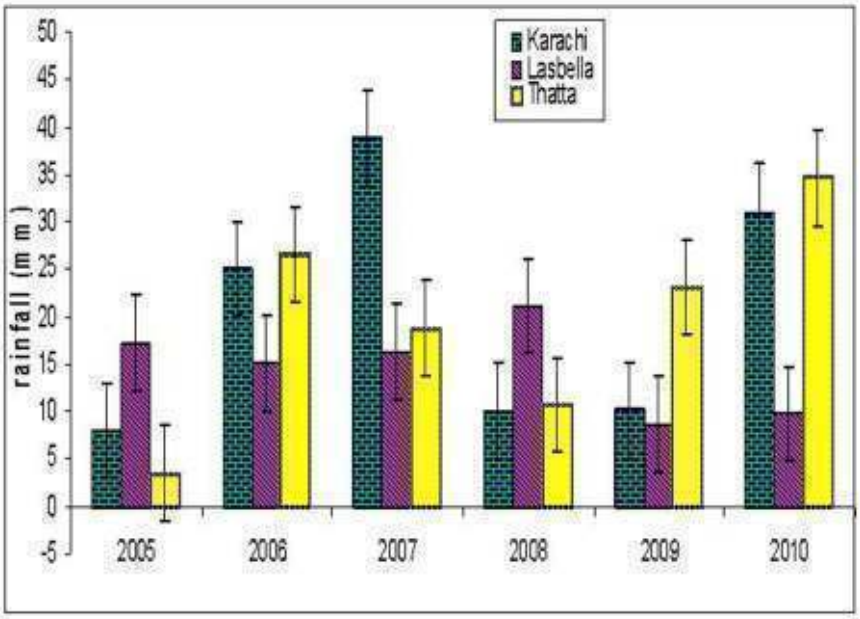


Fig. 4. Yearly mean rain fall in different districts of Sindh (Karachi and Thatta) and Balochistan (Lasbella).

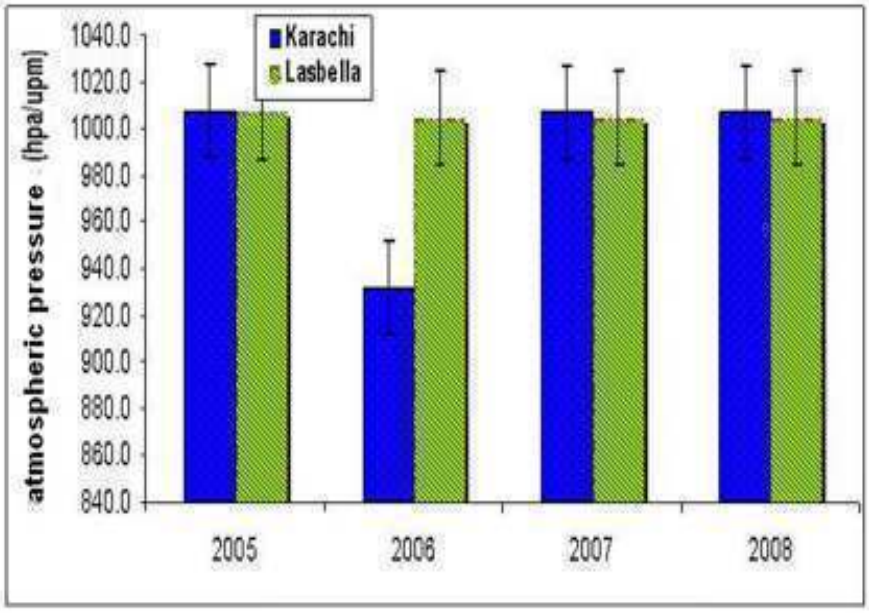


Fig.5. Yearly mean of atmospheric pressure at 1200 UTC (GMT) in different districts of Sindh (Karachi and Thatta) and Balochistan (Lasbella).

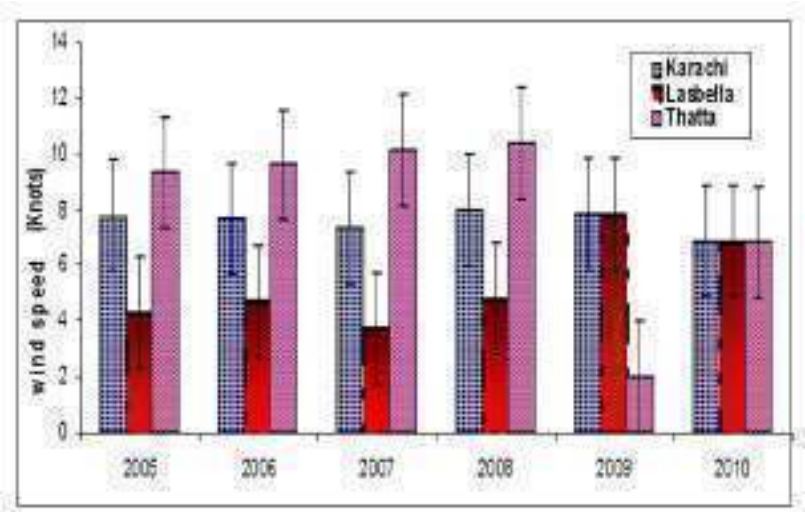


Fig. 6. Yearly mean wind speed at 1200 UTC (GMT) in different districts of Sindh (Karachi and Thatta) and Balochistan (Lasbella).

- The coconut is not indigenous to Pakistan. The seedlings produced in nurseries came from nuts imported from other countries; most of which have no or very little information on variety or specific characters (Fig.7to11).
- In addition, varieties grown in the country are facing pest and disease problems. There are a number of insect pests infesting the different parts such as roots, leaves, trunk / stem and fruit of the coconut, but some beetles, weevil, moths, flies, termites, scales and mites are very common in all coastal areas.
- The coconut mite is also very serious and devastating disease of the coconut. The tiny microscopic mites feed on the tissue of the nut surface. They damage, distort and reduce size of the fruits. The fruits eventually turn brown and finally drop. Incidence of coconut mite has spread to most coconut production areas and it has been considered one of the most notorious and important pests of coconut fruits in coastal area.

Fig. 7. Coconut Plantation and Propagated Seedling at IPI, PARC Karachi.

Fig. 8. Coconut Harvesting Nut for observation at IPI, PARC Karachi.

Fig. 9. Coconut mites infection surface beneath the perianth and infected nuts.

Fig. 10. Coconut mites effected bunches of coconut

Fig.11. Coconut inflorescence characteristic

- Button and immature nut shedding before and after fertilization is common problem in coconut. Immature nut fall in coconut has been attributed to various factors i.e microbial infections, insect pest damages and Physiological reasons were also identified as predominant causes for nut shedding (Fig.12).

Fig.12. Immuture nut fall due to Coconut mites

- Immature nut fall was common all over the farms of Karachi, Thatta and Lasbella.

- The survey concluded that mites have become major pest of the coconut plantation as their infestation was found more in button stage as compared to mature fruit. It was observed that the mite attack was 30% higher in Lasbella as compared to Karachi and Thatta districts.
- The physiological factors lead to the destruction of the root system and consequently, abstract absorption of water and nutrients. The nut fall is very often usually observed at the end of drought weather.
- The coconut plantation in the coastal area is facing lot of insects, pests and diseases including mites. The plants are either loosing yield or completely dieing due to above various insect pests that are needed to be identified and recorded to device control strategies. The present study is a preliminary step to estimate the incidence of mites on coconut in various localities in coastal area of Pakistan.

Quantitative assessment of losses caused by the coconut mite

- An extensive survey of coconut crop was carried out at 15 coconut forms in Karachi, Thatta and Lasbella. The insect data recorded on average incidence percentage. It was observed that the mites attack was 30% higher in Lasbella as compared to Karachi and Thatta districts.
- The loss of nutrient through surface erosion and runoff has resulted in the use of fertilizer (organic + inorganic) in supplementing poor indigenous soil nutrient supply in coconut palm cultivation.
- Initially, these pests were controlled by the use of appropriate insecticides. Pakistan farmers have been relatively slow in adopting plant protection measures but rapid progress has been observed in recent years with the use of increasing pesticides.

Management of the coconut mite

- The initial survey of the coconut farms were conducted in coastal areas viz, Karamat farm Gadap, Farahat farm Malir, Darululoom Karachi plantation, Institute of Plant Introduction farm, Gharko research farm, Qureshi farm, Brohi farm of Thatta, Adil baloch farm, Mir Hazar Khan and Kalmati farm Lasbella in 2013. Coconut parts viz, mature fruit, immature fruit, female button and inflorescence were collected from different farms as described in (COGENT/Bioversity, 2008). Though this pest was noticed only in a limited area during 1999-2000 but now it has become a major pest of coconut plantation in Pakistan.
- The mites are very minute in size and are not visible by naked eye. Through the mites are microscopic their damage is enormous and hundreds of mites

could be seen in each infested button and tender nut. The visible systems are brown discoloration noticed in patches of the huck.

- In case of sever attack the button sheds, resulting in very poor setting percentage. In other cases the nuts are deformed and undersized with poor development of kernel and huck. Generally the mites spread trough wind and its multiplication is at high rate.
- Neem is a key ingredient in Non-Pesticidal Management (NPM), providing a natural alternative to synthetic pesticides. Neem seeds are ground in to a powder that is soaked overnight in water and sprayed on to the crop. To be effective, it is necessary to apply repeatedly, at least every ten days.
- Neem cake is widely used to fertilize cash crops. Ploughed in to the soil, it protects plant roots from nematodes and white ant. The mixture of neem oil + Castor oil + soap powder + Wet able Sulphur 80% (100ml+100ml+12g+5g)/liter/palm/year was sprayed on the crown of affected palms with a modified Knapsack sprayer to control the coconut mite.

Organic Manures and Inorganic Amendments

- The dry neem (***Azadirachta indica*** A.juss.) fruits were collected under the neem trees from Institue of Plant Introduction. After collection, the seeds were crushed for use as test material.
- The leaves of *Gliricidia* trees (***Gliricidia sepium***) were also collected from the Institute Plant Introduction as test material.
- The inorganic fertilizers additives like Urea for nitrogen, Di-ammonium phosphate for phosphorus and Murait of potash for potassium having NPK fertilizer doses were applied in the ratio of 1.0:0.5:1.0 kg/palm in two annual (July and December) split applications for four years. There were three replications of eight treatments.

Fig. 16. Neem tree (*Azadirachta indica* A. Juss.) (For Neem seed collection) (A) and *Gliricidia sepium* (Jacq.) Stued. (Leaves collection) (B) Plantation at experimental site, Institute Plant Introduction (IPI), Karachi.

- The pesticides posed a threat to human health, especially where jelly or water coconuts are heavily consumed. Spray neem oil + Castor oil + surf (20ml +10ml+ 05g)/Liter against mite. The results of neem seed powder/cake 200g + equal solution of Sand on Leaf axil filling with 12gm of naphthalene balls covered with sand at 45 days interval is also effective.
- It was observed that the mites attack was 30% higher in Lasbella as compared to Karachi and Thatta. The control measures were given to the farmers after diagnosis of the insect. The mites were controlled with the regular spray of Monocrotophse + Neem oil and Castor oil @ 1+2+5ml/liter of water / palm tree was effective against the mites. The spray has to be done 3 times a year January, May and September. While spray ensures that the spray fluid falls over the perianth region especially on button and tender nuts.

Orchard management

- Orchard management activities focused on finding the most effective and efficient fertilizer rates for economic production. Addition of Farm yard manure and green manure also proved beneficial, particularly for soil improvement in slightly saline soils.
- It is proved that applications of organic and inorganic fertilizers {NPK (1.0:0.5:1.0kg) + NSP (10.0kg) + GSL(20.0kg)} palm/year improved the health of palms, and decreased flower and fruit drop resulting in higher nut yield with better quality.
- The results also indicated that the organic amendments with inorganic fertilizer in coconut plantation reduced the level of inorganic fertilizer which therefore, minimize the expenditure of the farm land, improve fertility status of soils, save the environment and living organisms from any hazards **(Solangi, 2013)**.
- Besides this ingredient nutrient management (INM) for mite affected coconut palm with 30kg FYM,1.3kg Urea, 2kg Super phosphate, 3.5kg Murate of potash, 1kg Gypsum and 30gm of Borax was also proved beneficial.

Irrigation

- Irrigation was another important aspect under orchard management as areas planted to coconut receive very low rainfall and frequently face drought. Furthermore, many of these areas have sandy soils. To address this situation, it was recommended that crops be irrigated weekly during summer and fortnightly during winter.
- **Mariau (1986)** also found copra loss to decline with irrigation. He suggested that during periods of moisture stress, nut growth is slower and so the meristematic tissue is subjected to extensive damage by the coconut mite.

Intercroping

- It is concluded that vegetables Luffa/Banana as intercropped in coconut garden not affected on the growth and yield (30-40% nut production increased) of the coconut palm and also due to different cultural methods enhance the growth and yield of vegetables in coconut garden under the agro-climatic conditions of coastal area of Pakistan (Fig. 16).
- This practice improves the soil fertility by recycling organic wastes, enhance the yield of palms and generates additional income and employment potential for the farmers families (Solangi,2009)

Fig. 16. Intercropping of Banana and Vegetable under coconut plantation .

Production and Marketing

- Very little or no work has been carried out on the production and marketing of alternative and high-value coconut products as overall yield was relatively small and farmers did not have problems for marketing the nuts. The fruits are mainly used to extract coconut water and immature albumen. The coconut

leaves are used as roofing materials while, the stem has no known uses other than as firewood.

Environmental control

- Adoption of phytosanitory measures in coconut gardens as cleaning the crown of the palm, keeping the plantation clean and burning of all immature nuts fallen due to mite infection. The soil moisture conservation through mulching the basin with coconut leaves/green manure/green leaf manure.
- It was suggested that field sanitation, such as the removal of mite infested nuts and dry leaves and thinning of nut population in high fruiting trees could reduce coconut mite populations.
- Proper drainage, weed control, adequate fertilization and replacement or rehabilitation of old plants for controlling the coconut mite have also been advocated.
- While, some of these cultural practices, including increasing soil water retention, might not directly impact coconut mite populations, they improve the health of the trees and ultimately, their tolerance to damage by the coconut mite.

Varietals resistance

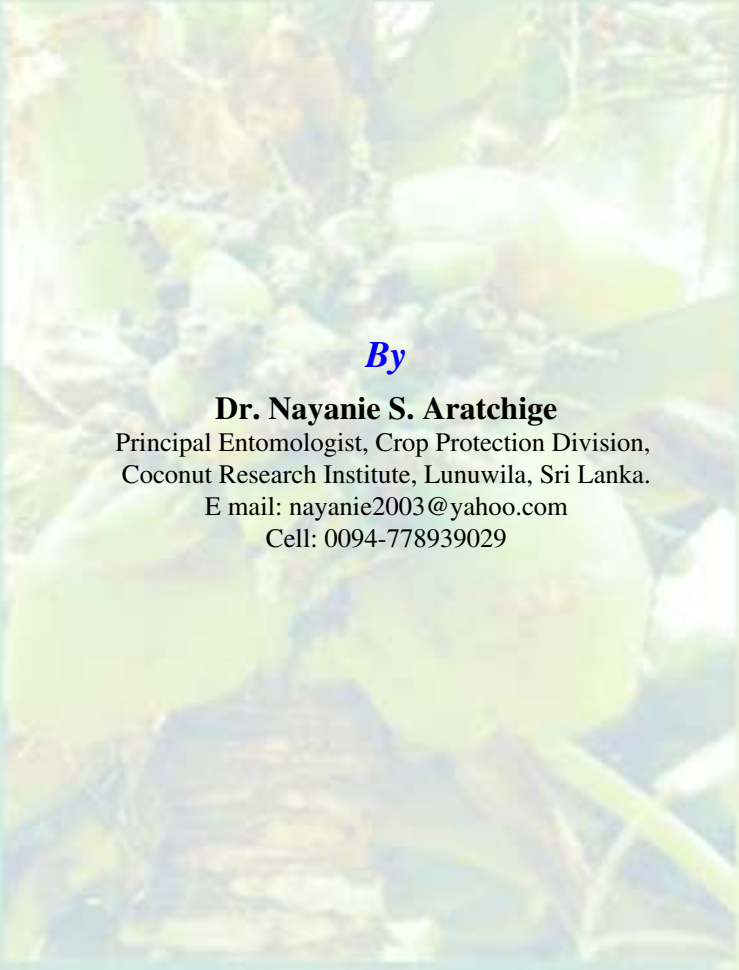
- The characterization of locally-adapted germplasm resources. To date monitoring of coconut germplasm resources in farmer's fields has established the location and prevalence of some Tall and Dwarf varieties.
- Results of the evaluation carried out that Tall variety were found more tolerant to biotic and abiotic stresses and produced bigger nuts with better copra quality. The farmers of the area preferred Dwarf and Hybrid varieties but could not cultivate on larger areas because of abiotic stresses.
- Varietals differences in the susceptibility of coconut plants to infestation by the coconut mite have been reported. The shape and color of coconuts are the two main characteristics that determine the susceptibility.

Conclusion and Recommendations

- The application of organic amendments with inorganic fertilizers enhanced the growth and nut production in nutrient deficient soils. It is therefore, recommended that treatment {NPK (1.0:0.5:1.0kg) + NSP(10.0kg) + GSL(20.0kg)} palm/year was enough to improve the morphological diversity, high nut production, better income to coconut farmers, economical and beneficial for conservation of coconut genetic resources in coastal area of Pakistan.

- The use of organic manures such as farmyard manure, compost green manure and bio-fertilizers along with chemical fertilizers are essential to suppress any possible negative impact of fertilizers on the soil and to sustain soil productivity.
- It was concluded that essential oils (Neem oil + Castor oil) and their constituents have varying degree of pest controlling activities. The study shows the possibilities of encouraging the use of botanical biocides as future pest management strategies of coconut mite.
- The results of neem seed powder 200g + equal solution of Sand on Leaf axil filling at 45 days interval is also effective. This study suggests that a minimum of 40% yield increase.
- It is further recommended that the palm should be frequently examined for insect attack and the necessary remedial measures should be adopted promptly.
- The research institute should collaborate with other coconut R&D organization in other countries to investigate the epidemiology, etiology and control measure of coconut mite.
- In the present study, it was noted that attack of mites was more in button stage as compare to mature fruit; there is still an urgent need to evolve effective protection measures, based on research to save the economy of the coconut community and specially coastal area of Pakistan.

Mite Management of Coconut in Sri Lanka



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Abstract

Coconut mite, *Aceriaguerreronis* is one of the most important major pests of coconut in Sri Lanka. After its invasion in late 1990s, is has widely spread to all main coconut growing areas in the country posing a great threat to the industry. From the outset of the pest, biological and ecological aspects of the pest have been studied and several control methods based on chemicals, biological control agents (entomopathogenic fungus and local and exotic predaceous mites) and varietal tolerance have been evaluated. Four chemical recommendations and one recommendation using predaceous mite, *Neoseiulusbaraki* have been made based on the results of the experiments.

Two methods, chemical control using low toxic chemicals (use of 20% palm oil and 0.5% sulphur mixture) and biological control using*N. baraki*have found to be the most effective methods to reduce the damage due to coconut mite. These methods were proven to be successful and cost effective methods in managing the pest. A national level project is in place to mass produce *N. baraki* to issue to the growers.

This paper reviews research and development activities carried out during the past fifteen years on coconut mite management in Sri Lanka.

Introduction

Agriculture contributes 11% to the Gross Domestic Production (GDP) of Sri Lanka. The plantation crop sector, tea, rubber and coconut, accounts for 0.9, 0.2 and 1% of the GDP respectively at current prices (Annual Report of the Central Bank of Sri Lanka, 2012). Out of the three main plantation crops, coconut is grown in 394,836 ha mainly in the North-western and Western provinces (coconut triangle) and the Southern province (mini coconut triangle) of Sri Lanka (National Coconut Development Plan "Kapruka Navodawa" of the Ministry of Coconut Development and Janatha Estate Development, http://www.cdjedmin.gov.lk/. Accessed on 30-07-2014).The total coconut production in 2012 was 2,940 million nuts (Annual Report of the Central Bank of Sri Lanka, 2012). Coconut is a major livelihood crop supporting nearly 4 million people in Sri Lanka, either directly or indirectly. It is also an important industry-related export earning crop which contributes 1% to GDP from fresh mature nuts and value-added products (Annual Report of the Central Bank of Sri Lanka, 2012). Per capita consumption of coconut in Sri Lanka is about 116 nuts.

Over the past few decades, the coconut production in Sri Lanka has marginally increased but not sufficient to meet the increasingdomestic and export demand. In addition, pests and diseases are also posing a great threat to the coconut industry. Among the major pests, coconut mite (*Aceriaguerreronis*Keifer) is wide spread in the country and responsible for significant crop losses especially in the dry- and intermediate-zones (annual mean rainfall: <1000 mm and 1000-2000 mm respectively).

Coconut mite is considered the most invasive and notorious major pest of coconut in Sri Lanka.

Invasive history and the current distribution of coconut mite in Sri Lanka

Coconut mite was first reported in 1998 from the Kalpitiya Peninsula (North Western Province, dry-zone) (Fernando *et al*., 2002). Within two years, it was spread to almost all coconut growing areas in the dry- and intermediate-zones of the country and few coconut growing areas in the wet-zone. At present, the coconut mite has invaded all districts except NuwaraEliya which is mainly a hilly area where coconut is not as extensively grown as in other districts (Plate 1). However, the incidence of coconut mite varies from district to district with higher incidences in dry- and intermediate-zones than in the wet-zone (Plate 1).

In addition to coconut, the mite has been observed on *Borassusflabellifer* (Asian Palmyrah) fruits in Sri Lanka (G.J. de Moraes, Personal communication). But unlike in coconut, the pest does not seem to cause any economic loss in Asian Palmyrah fruits in Sri Lanka.

Plate 1: Incidence of coconut mite in different districts in Sri Lanka

Yield loss:

Coconut mite damage is initially visible as cream or white triangular patches from the perianth of coconut. Later the patches become necroticand corklike(Plate 2) and in severe infestations deep fissures and gummy exudates can be observed on coconuts. In a severe infestation, feeding of coconut mite beneath the perianth of immature nuts of coconut result in scarring of the nut surface which may cause button and immature nut fall, reduced size and deformation.

Plate 2: Coconut mite infested nuts on a palm

In Sri Lanka, the percentage of palms that are infested by the coconut mite in plantations varies between 2-100% (Fernando and Aratchige, 2010). In a survey conducted in Sri Lanka, the incidence of mite damage in harvested nuts has been as high as 86% of the total nuts sampled, ranging from 69.8 – 94.5% (Wickramananda*et al*., 2007). It has also been observed that the percentage of small sized nuts and deformed nuts are considerably higher in infested palms (0.72-25.5% and 0.33-6.9% respectively) compared touninfestedpalms (<1%) (K P Waidyarathne, personal communication). An estimated loss of 15.8% of total crop loss was observed when the losses due to button and immature nut fall, size reduction in the harvested nuts and nut deformation were combined (Wickramananda*et al*., 2007). Furthermore, the same authors revealed 13.4% reduction in the fresh, unhusked weight of nutsin infestednuts suggesting that the coconut mite infestation could reduce the husk production.

Population dynamics

A study conducted to determine the population dynamics of the coconut mite and its relation with the local rainfall data in two areas namely, Kalpitiya and Madurankuliya in the north-western part of Sri Lanka revealed that the coconut mite densities varied significantly among years and months in each year (Aratchige*et al*., 2012). Although the amount and the frequency of rainfall of the same month and the previous month did not significantly affect the coconut mite densities, the drought length (i.e. the number of days without rainfall of >5 mm) affected the coconut mite densities; longer the dry period, higher was the coconut mite densities. Generally peak densities of coconut mite were observed during February-March and June-September i.e. during the period of either decreasing or low rainfall and the populations of coconut mite remained low during rainy seasons (Fig. 1)(Aratchige*et al*., 2012).

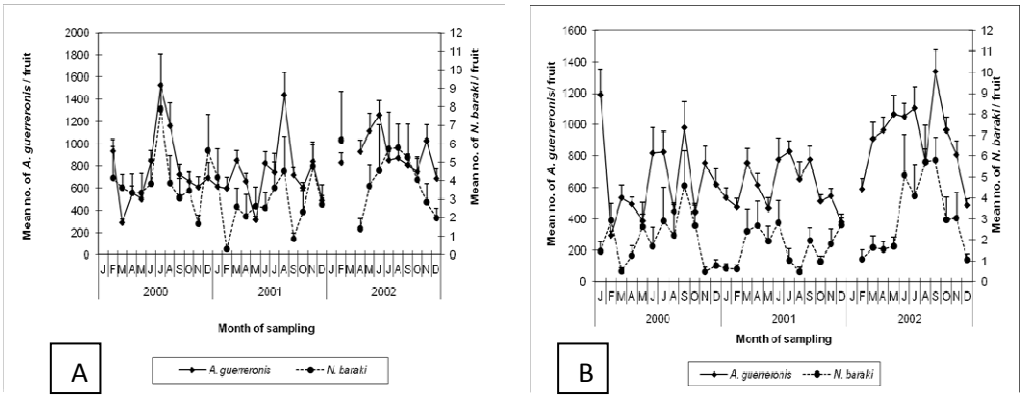

Fig. 1: Population fluctuations of coconut mite and the predaceous mite, *Neoseiulusbaraki* in Kalpitiya (A) and Madurankuliya(B) from January 2000 through December 2002.

Source: Aratchige*et al*., 2012.

The distribution pattern of the coconut mite varies among palms and also among bunches of different ages within a single palm. Unfertilized flowers are free from coconut mites (Fernando *et al*.,. 2003) and the colonization starts just after fertilization of the female flowers (Moore and Alexander, 1987; Howard *et al*., 1990; Fernando *et al*., 2003; Neglo*et al*., 2010). In Sri Lanka,starting from the nuts after fertilization, mean number of coconut mites is increased up to the bunch of 5 month old (i.e. 5 months after fertilization of the female flower) and declined thereafter (Fernando *et al*., 2003). In general, peak densities of coconut mite are observed on 3-7 month old bunches (Fernando *et al*., 2003; Moore and Alexander 1987; Varadarajan and David 2002; Mallik*et al*., 2003; ThirumalaiThevan*et al*., 2004; Galvão*et al*., 2011; Neglo*et al*., 2011).

Dispersal

Understanding the dispersal of coconut mite is important to determine the infestation process on new bunches within or between palmsto develop management strategies. In Sri Lanka, it has been determined that the majority of the migrating coconut mites was females and that the peak migration occurs early in the morning (Annual Reports of the Coconut Research Institute of Sri Lanka in 2002 and 2003). However, in-depth studies on the dispersal of the coconut mite have not so far being done.

Rearing of coconut mite

Proper method of laboratory culturing of the coconut mite is a pre-requisite of laboratory studies such as screening of chemicals and evaluation of predaceous mites/ entomopathogenic fungi. Though the pest had been reported in the world in mid-1960,

a method for laboratory rearing had not been developed until 2004 (Wickramananda*et al*., 2004). Four different culture media i.e. extract of meristematic tissues in agar medium, cotyledon extracts in agar medium, wax coated perianths and tender leaf tissues had been evaluated for the suitability of rearing coconut mites. At the end of ten days after introduction of inseminated females, significantly higher number of mites have been observedon the tender leaf tissues (4.18, 4.25, 13.85 and 300.57 mean numbers of mites on agar-meristematic tissues, agar-cotyledon extract, wax coated perianths and tender leaf tissues respectively) (Wickramananda*et al*., 2004).

Another method to rear coconut mites and *Neoseiulusbaraki*Athias-Henriot, the predaceous mite was developed using embryo-cultured seedlings (de Silva and Fernando, 2008). Coconut mites can be reared on embryo-cultured seedlings grown on culture media in glass vials sealed with polyethylene. 4-6 month old embryo-cultured seedlings were proven to be the best for rearing the coconut mites where more than 20,000 mites can be obtained 5 weeks after introducing 75 coconut mites collected from the field (de Silva and Fernando, 2008). However, this method is quite laborious and expensive.

Sampling techniques

Correct sampling is an important aspect in ecological and other studies on control measures of coconut mite. This is one of the most difficult aspects in experimental works with the coconut mite because of its small size and the secluded habitat it occupies. Damage symptoms are not reliable method of sampling for the assessment of infestation levels due to the fact that, in the very early phase of coconut mite colonization, a considerable percentage of infested nutsdoes not show symptoms (Fernando *et al*., 2003) and the decline in coconut mite population starts shortly before the maximum level of damage symptoms is expressed, progressing very quickly afterwards, without a proportional reduction in damage symptom (Navia*et al*., 2013). Therefore, actual count of mites is necessary for proper population assessments.

Several methods have been used for population assessment of the coconut mite in different studies. The method that includes washing the bracts of the perianth of coconut mite-infested nuts in a 30 ml detergent solution followed by counting the number of mites in 1 ml aliquot of this solution and estimating the total number of mites by extrapolation (multiplying by 30.1) was found to be very accurate (R^2=0.99, $P<0.0001$) to predict the total population of coconut mites (Siriwardena*et al*., 2005).

It has also been noted that the variations of the coconut mite populations are lower on 6-month old bunch (i.e. 6 months after fertilization of the female flower), suggesting that the sample from this bunch would be more reliable than that from other bunches in population assessment of the coconut mite (Fernando *et al*., 2003).A considerable variability in the natural population of the coconut mite is also observed in the field and

therefore, pre-treatment assessment of the densities in different plots are taken and treated as covariates in data analysis (Fernando *et al*., 2010; Aratchige*et al*., 2012).

Defensive mechanisms in coconuts in response to coconut mite damage

In managing pests, plant defense is one of the important considerations, especially in selecting tolerant/resistant varieties and inducing defense traits in the plants. In a study done using Sri Lanka Tall (SLT), Sri Lanka Green Dwarf (SLGD) and their hybrids, the microscopic gap between the perianth and the nut surface was compared and it was related with the coconut mite and *N. baraki* densities. It was shown that SLGD, with its smaller and more elongated nuts, had a larger perianth-nutgap in uninfestednuts and this gap was large enough for the coconut mites to creep under the perianth. Yet, this gap was not sufficient for *N. baraki* to creep through, unless nuts are infested. However, when the nuts are infested, this gap widened to such an extent that even *N. baraki* can also enter through it (Aratchige*et al*., 2007). The highest mean number of coconut mites was also found in SLGD. Authors suggested that the morphological changes apparently induced by the herbivoreor a by-product of necrosis and suberization of the nutare part of the induced plant defense against the coconut mite damage. However, this concept has not been further studied though perianth-nut gap has been used as a parameter in evaluating resistant coconut varieties (Perera*et al*., 2013; Aratchige, unpublished data).

Control strategies

As with all eriophyoid mites, coconut mite has perfectly evolved as a pest. Its small size, hidden habitat, high reproduction rate, ability to build in to permanent infestations and tall nature of the host plant make the control of this pest, always a challenge. However, from the outset of the pest in 1960s, a large number of chemicals have been tested worldwide with varying efficacies (Mariau and Julia, 1970; Mariau and Tchibozo, 1973; Moore and Alexander, 1987; Moore *et al*., 1989; Nair, 2002; Nair *et al*., 2002; Sujatha*et al*., 2003; Mohanasundaram*et al.,* 1999; Ramaraju*et al*., 2002; Rethinam*et al*., 2003; Muthiah*et al*., 2001; Pushpa and Nandihalli, 2010; Fernando *et al*., 2002; see also review by Navia*et al*., 2013).

Chemical control

So far, more than 30 insecticides have been tested in Sri Lanka, nevertheless only a handful of chemicals have been reported to be at least partially effective. When the pest was first reported in Sri Lanka, a large-scale control campaign was carried out with the assistance of the Coconut Cultivation Board and other government organizations to manage the pest. Out of nearly 500,000 palms infested by the coconut mite, about 450,000 palms were injected with 20 ml of Monocrotophos (60% EC) while the others

were sprayed with sulphur and bunches were pruned (Annual Report of the Coconut Research Institute of Sri Lanka, 1999). Although control seemed quite effectiveinitially, it was soon abandoned as the effectiveness lasted only for about 2 months and repeated applications were needed (Fernando *et al.*, 2002). Later, two neem-based insecticides (2% neem oil and garlic mixture and Neem Azal T/S i.e. 1% Azadirachtin) were recommended (Annual Report of the Coconut Research Institute of Sri Lanka, 2003).These were also not sufficiently effective in controlling the pest and the effects were not long lasting, requiring frequent applications which were not practical but expensive. The application of 30% used engine oil in water, soap powder and wheat flour on the immature nut surface was effective in controlling pest and decreasing the damage incidence in treated bunches as well as in newly developed bunches (Chandrasiri and Fernando, 2004). However, this treatment reduced the predaceous mite, *N.baraki* numbers in treated nuts. Though these chemicals were effective in controlling the pest under experimental conditions, growers' acceptance was low due to marked ineffectiveness and difficulty in application of the chemical.

An emulsion of 20% vegetable oil and 0.5% sulphur WP was found to be effective in controlling the coconut mite (Fernando and Chandrasiri, 2010). Spraying of this emulsion resulted in mean mortality of 87% and 98% reduction in the coconut mite population, compared to the control palmswithin first 20 days after spraying. The spraying of this emulsion at 6-month intervals significantly increased the undamaged nuts and decreased the damaged-small sized nuts in the harvest. Results of a cost-benefit analysis has shown that benefit:cost ratio varies between 0.56-4.15 suggesting that the spraying of the emulsion is profitable to the growers. Application of this emulsion was less effective on *N.baraki* (Fernando and Chandrasiri, 2010).

Based on these results, spraying of 20% palm oil and 0.5% sulphur in an aqueous emulsion with soap powder has been recommended to control coconut mite.This is by far the most effective chemical control recommendation against the coconut mite.

Biological control:

Relatively little efforts had been dedicated in the world to evaluate natural enemies of coconut mite (Moore and Howard 1996; Moraes and Zacarias, 2002)until its detection in Sri Lanka and India in late 1990s. Later countries such as Brazil, Benin, Tanzania and Oman also have intensified their research in this direction. In Sri Lanka, efforts have been directed towards evaluating local and exotic predaceous mites and entomopathogenic fungus as biological control agents.

1. Use of entomopathogenic fungus

Hirsutellathompsonii, an entomopathogenic fungus has been evaluated in a series of experiments in Sri Lanka where a survey carried out in the coconut mite-infested areas

showed a low incidence of the fungus naturally on coconut mite (Edgington*et al*., 2008). *H. thompsonii* isolates have been collected from different geographical regions of Sri Lanka but, only four isolates, namely IMI 390486, IMI 391722, IMI 391942 and IMI 390486, were better than the other isolates when the growth characteristics and sporulation in culture were compared. Isolate IMI 391722 showed the highest vegetative growth rate between 20-35^{0}C and the second highest spore production at 15-35^{0}C (Edgington*et al*., 2008). Therefore, this isolate was used later in field evaluations (Fernando *et al*., 2007).

Two applications of spore suspensions ofisolate IMI 391722, two weeks apart, on the five youngest bunches resulted in the highest efficacy against the coconut mite populations. Less than 10% of the fruits receiving isolate IMI 391722 had high levels of coconut mites (4100 live mites per fruit) at 4 weeks after the second application in one site (Fernando *et al*., 2007). Percentage infested nuts with mycosis due to *H. thompsonii* was also higher in the palms sprayed with the isolate IMI 391722 (Fernando *et al*., 2007). However, asthe effect of application of *H. thompsonii*was relatively short in duration and the results were not consistent (Fernando *et al*., 2007), the use of *H. thompsonii*for the control of coconut mitewas discontinued in Sri Lanka.

2. Use of predaceous mites

Predaceous mites have been reported worldwide in association with the coconut mite and are considered one of the most important biotic agents that regulate the coconut mite populations (Moraes and Zacarias, 2002). So far more thantwenty apparently predaceous mites have been reported in association with the coconut mite (see review by Navia*et al*., 2013).

a. Diversity of predaceous mites in Sri Lanka

In Sri Lanka, fivephytoseiid species have been reported on coconut, twoof which, *N. baraki* and*N. paspalivorus*(De Leon)were found on fruits, in association with the coconut mite and *Indoseiulusliturivorus* (Ehara)*,Amblyseiuslargoensis*(Muma)and *A. duplicesetus* (Moraes and McMurtry)were found on coconut leaves (Moraes*et al*., 2004). It has been suggested that *N.* aff. *paspalivorus*reported by Fernando *et al*., (2002, 2003) and Fernando and Aratchige (2003) to most probably be *N. baraki*, which is more abundant than *N. paspalivorus* in Sri Lanka (Moraes*et al*., 2004).

b. Use of local predaceous mites

Out of the predaceous mites reported in association with the coconut mite in Sri Lanka, only *N. baraki*has been extensively evaluated as a prospective biological control agent.Its flat and elongated idiosomawith short distal setae and short legs (Moraes and Zacarias, 2002; Moraes*et al*., 2004) enabling it to creep under the perianth, close

association with the coconut mite (Fernando *et al*., 2003; Aratchige*et al*., 2012) and ability to feed and develop on coconut mites(Annual Report of the Coconut Research Institute of Sri Lanka, 2003) were the key factors for selecting it as a potential predaceous mite against the coconut mites.

i. Biology and ecology of *N. baraki*

In Sri Lanka, *N.baraki* is by far the most dominant predaceous mite in association with the coconut mites. It is reported in all coconut mite-infested areas especially in dry- and intermediate-zones of the country and in the dry areas in the wet-zone (Moraes*et al*., 2004; Fernando and Aratchige, 2010). Another Phytoseiid mite, *N. paspalivorus* which is morphologically very similar to *N. baraki* is commonly found in the wet-zone and the wet areas (closer to rivers and stagnating water bodies) in the dry-zone of Sri Lanka (Moraes*et al*., 2004; Fernando and Aratchige, 2010).

A close association between populations of *N. baraki* and the coconut mite has been shown in Sri Lanka (Fernando *et al*., 2003; Aratchige, 2007; Aratchige*et al*., 2012).The distribution of *N. baraki* on bunches of different age on a palm has strongly been influenced by the distribution of coconut mites on the palm, suggesting that the predators would be effective in regulating coconut mite populations which peaks on 5 month old bunches while the former shows peak population on bunches one month older (Fernando *et al*., 2003).

Population fluctuation pattern of *N. baraki* differs spatially and temporally (Plate 03) and population densities of *N. baraki*are not significantly regulated by the amount of rainfall but by the frequency of rainfall of the same month and drought length(Aratchige*et al*., 2012). The density of the coconut mite one month prior to that of *N. baraki* significantly affects the density of latter (Aratchige*et al*., 2012).Compared to that of its prey, *N. baraki* populations are more influenced by external abiotic factors probably due to more active movement of the predaceous mites than the coconut mites in search of food and shelter.

ii. Mass rearing of *N. baraki*

As a prerequisite for the mass production of *N. baraki*, several food sources were tested with varying suitability (Fernando *et al*., 2004; Annual Reports of the Coconut Research Institute of Sri Lanka in2001, 2002 and 2003). *Tyrophagusputrescentiae*, a cosmopolitan storage mite was more promising than the other food sources tested except coconut mite and was used in subsequent studies to develop mass rearing methods (Aratchige*et al*., 2010; Kumara *et al*., 2014) and in field releases (Fernando *et al*., 2010; Aratchige*et al*., 2012). *N. baraki*, when fed on *T. putrescentiae*developed from egg to adult in 11.1 days and deposited 26.4 eggs in 70.0 days (Fernando *et al*., 2004).

Plate 3: Tray-type arena for the mass production of *N. baraki*

Two methods can successfully be used to mass produce *N. baraki*, when *T. putrescentiae* is used as the alternative food source. *N. baraki* is mass produced in tray-type rearing arenas which consists of a plastic tray on which a black polyvinyl sheet is pasted (Plate 03). An insect glue layer is applied along the periphery of the polyvinyl sheet to avoid the escape of the mites from the arena and external contaminants. On the polyvinyl sheet, a glass sheet is placed on a small piece of synthetic net and a piece of foam wrapped in a piece of wet tissue is placed on the glass sheet. Rice bran and flour mixture (1:1) is sprinkled on the polyvinyl sheet and *T. putrescentia* and *N. baraki* are mass produced on the arena.A 240-fold increase of *N. baraki* could be obtained from this method in 5 weeks (Aratchige*et al*., 2010).

Due to the clumsiness of removing the insect glue layer from the polyvinyl sheets before releasing *N. baraki* in to the field, a sachet-type rearing method was developed to mass produce *N. baraki* (Plate 04). A two-ply polypropylene sachet of gauge 150 and 24 x 36 cm is used in this method. A partially separated chamber accommodates a wet tissue to provide high humidity inside the sachet and drinking water for the mites (Plate 04). A 260-fold increase of the original population could be obtained from this method in 6 weeks (Kumara *et al*., 2014).An insectary room of 4 x 3.5 m^2 (air-conditioned, 25^0C) which has 6 racks with 3 shelves of 2 x 0.5 x 1.5 m^3each (Plate 05) can accommodate approximately 2,000 sachets at a time.

Plate 04: Sachet-type rearing method of *N. baraki*

Plate 05: Mass rearing insectary room of *N. baraki*

iii. Effect of single release of *N. baraki* in controlling the coconut mite

A single inundative release of 10,000*N. baraki* could significantly increase its population resulting in significant decrease in the coconut mite population (Fernando *et al*., 2010). During the post release period of 6 months, significant increase of *N. baraki* with a mean number of 8.99 mites per nut was observed in the released palms compared to the unreleased palms (6.19 mites per fruit). The mean numbers of coconut mites per nut during the sampling period were 1264.77 and 1815.0 in released and unreleased palms respectively (Fernando *et al*., 2010). This is the first demonstration of the effect of releasing *N. baraki* in reducing the coconut mite population. However, the release of *N. baraki*was not correlated with the reduction of the damage due to coconut mites, though a marked reduction in the pest was observed. Further, due to the continuous infestation of coconut mites in its several generations over a long period of 2-6 months on nuts of coconut, multiple releases of *N. baraki* were suggested for better effects (Fernando *et al*., 2010).

iv. Effect of multiple releases of *N. baraki* to control the coconut mite

Compared to single releases, multiple releases of *N. baraki* were assumed to be more profitable in decreasing the coconut mite populations in the long-run, decreasing the crop loss due to the coconut mite damage and thereby increase the remunerative financial benefit to the growers. Release of 5000 mites per palm at 2- or 4-month intervals on to 1/4th of the plantation (25% palms of the plantation) resulted in a higher percentage of normal-sized nuts in the harvest (85.6 and 88.4% in two released blocks compared to 79.1 and 80.1% in unreleased blocks) and a lower percentage of small-sized nuts (13.3 and 10.1% in two released blocks compared to 20.0 and 17.2% in unreleased blocks). Release of *N. baraki* in this manner for 2 years resulted in benefit:cost ratio of 1.76-3.11 confirming that the releases are cost effective (Aratchige*et al*., 2012).

Results of experiments on single and multiple releases of *N. baraki*has led to a recommendation of releasing 5000 *N. baraki* at 3-4 month intervals (depending on the rains) on to quarter of the coconut plantation at least for 2 years. This is the first ever and so far,the only recommendation of using predaceous mites for the control of coconut mite in the world.

v. National project to mass produce and release of *N. baraki* in growers field

In view of supplying *N. baraki* sufficiently to the growers, Ministry of Coconut Development and Janatha Estate Development (MCDJED) in Sri Lanka undertakes a national level project with the technical guidance of the Coconut Research Institute and in collaboration with the Coconut Cultivation Board and 2 state-owned private companies, Chilaw Plantation PLC. andKurunegala Plantation PLC. Thirteen mass

producing laboratories of *N. baraki* are now in operation and 7 more are expected to be established in different coconut mite-infested districts (National Coconut Development Plan "KaprukaNavodawa" of the MCDJED,http://www.cdjedmin.gov.lk/.Accessed on 30-7-2014). Under this project, since 2012, more than 350,000 sachets of *N. baraki* have been issued to the growers.

c. Use of exotic predaceous mites

Three exotic predaceous mite species, namely *Amblyseiuscucumeris* (Oudemans), *A. californicus*(McGregor) and *Proctolaelapsbickleyi*(Bram)have been tested as biological control agents against the coconut mite in Sri Lanka. Both*A. cucumeris* and *A. californicus*were ineffective as their dispersal, survival and reproduction were low under local conditions (Annual Report of the Coconut Research Institute of Sri Lanka, 1999). *P. bickleyi*is a voracious mite and has been reported in association with the coconut mite in other countries (Lawson-Balagbo*et al.*,2008; Silva *et al.*, 2010). However, this mite could not be tested in the field in Sri Lanka because it feeds on the local predaceous mites(Annual Report of the Coconut Research Institute of Sri Lanka, 2005). Therefore, research on biological control using predaceous mites in Sri Lanka focused only on the local predaceous mites.

Varietal tolerance

Use of differences in the varieties in responses to the coconut mite damage has been less profoundly considered in Sri Lanka and in other countries. Results of a preliminary study to investigate the differences between levels of tolerance in the varieties in terms of symptoms initiation, subsequent expression of symptoms, coconut mite population levels, distance between nut surface and the perianth of the nut, and the crop loss due to mite damage revealed that the said parameters were least in Yellow Dwarf x Sri Lanka Tall hybrid(DYT) suggesting DYT as the most promising putative tolerant coconut variety for coconut mite damage in Sri Lanka (Perera*et al.*, 2013). Further evaluations in this direction are being done in Sri Lanka.

Summary

Four recommendations using chemicals and one biological control method using predaceous mites, have been made from the studies on coconut mite in Sri Lanka. Mass rearing methods of the coconut mite and *N. baraki* have been perfected and several other information of paramount importance in coconut mite management has been generated.

In future, more attention will be given on identification of resistant varieties and understanding of the mechanisms behind the varietal resistance in order to include the traits in the coconut breeding programmes.

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Mite Management of Coconut in Bangladesh

Special Papers

Control and Management of Coconut Mite in Bangladesh

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Introduction

Coconut is an important homestead crop of Bangladesh. It contributes to the livelihood of farmers through its versatile uses. It has a high utilizing potential for shelter, cosmetics, pharmaceuticals energy and environmental protection. In a country with limited land space, orchard plantation rarely found with an exception in southern part of the country. Approximately 100 million nuts are produced in the country in an area about 35 thousand hectares. South and southwestern parts of the country contributes 80% of total production (BBS, 2009). The yield of coconut is about 21 nuts per year which is very low, compared to those of other coconut-growing countries. This poor yield is due to lack of high-yielding varieties, inadequate nourishment, insect pest and diseases as well as management practices.

Recently, coconut palms are found to suffer from mite attacks. The mite injures the tender portion of young nuts and suck sap from the nut. The injury ultimately leads to warting and longitudinal fissures on the nut surface. Coconut orchards are at the verge of extinction now due to this pest (Keifer,1965). The literature pertaining to coconut mite in Bangladesh is scanty as it is a recent pest. Considering the importance of coconut and the potentiality of this mite to cause damage and to mange pest many pesticides and bio-pesticides have been used in Bangladesh without any successful result.

Coconut Research and development at BARI

In spite of the importance of coconut in the national economy, due importance has not been paid to the improvement of this crop. In the early 1960s' a Coconut Research Station (CRS) was established at Rahmatpur in Barisal, a costal district aiming to establish a systematic collection, evaluation and conservation of coconut germplasm. After establishing of Bangladesh Agricultural Research Institute (BARI), the CRS was converted to BARI regional station and research on coconut became stagnant. The station has a large collection of Malaysia Dwarf and Sri lanka Typica varieties, King Coconut and Nana coconut besides local ecotypes. However, in 1996, CRS, BARI released and recommended two coconut varieties, the BARI Narikel-1 and BARI Narikel-2 for planting throughout the country. In early 80s' a 100-ha isolated coconut garden was established at Ramu, Cox's Bazar, a costal district to produce hybrid nuts and sapling for distributing to the growers. It was established under DAE. The garden has large stand of CRI 60 and Malayan Dwarf coconut. There is a lack of progress in achieving its goal due to the lack of fund and trained manpower (Islam and Hossain,

2000). Bangladesh joined COGENT as a member country in 1998 with a view to sharing the coconut genetic resources with other member countries of the network. Research program on the production and processing of the coconut and its bio-products for both food and non-food item at household levels were taken involving women to increase the income of the smalholders (Bhuiyan et al., 2005). Under the COGENT program, a systematic survey was conducted following coarse grid sampling method for characterization and *in situ* evaluation of existing coconut germplasm in Bangladesh. No report on mite was noticed by this time. Mite infestation was first reported in Jessore district in 2004 and later it was spread to adjacent districts (Islam et al., 2008). But it was unknown to the people until 2008 when it was first reported from Regional Agricultural Research Station (RARS).

Initial research on coconut mite at BARI

The literature pertaining to coconut mite in Bangladesh is scanty as it is a recent pest. Considering the importance of coconut and the potential of the mite pest to cause damage and many pesticides and bio-pesticides have been used in Bangladesh which did not produce any successful result. At the early time of mite infestation farmers thought it to be the cause of insect or diseases or nutritional deficiencies. Accordingly, people treated the infected nuts either by insecticides or fungicide or adopted nutritional management without knowing the real cause of the problem. Therefore, all kinds of endeavor became futile and which led the farmers to believe that radiation of the mobile tower might cause their nut splitting. The superstition generated many ritual, magical and spiritual treatments without knowing scientific region. However, systematic research on mite in Bangladesh was first initiated from the Regional Agricultural Research Station (RARS), of Bangladesh Agricultural Research Institute (BARI), Jessore in 2006 (Islam *et al.*). Two experiments were designed to control distortion and warting of coconut at early growth stage. Foliar application of omite (miticide) and soil application of boron (in the form of boric acid) at different doses were used in the first experiment. Based on the result of 1st experiment omite in second experiment at the rate of 1.5 to 2% was sprayed followed by removing of infected nuts and inflorescences. Soil application of boron could not cure the dryness appearance of nut. Spraying the coconut crown by omite adjacent to the bunch region produced healthy nuts without any spot on the pericarp. Reduction of extent of damage by foliar application of omite hypothetically suggested that mite was the cause of the pericarp damage of coconut. Further large scale investigation in the farmers' field was suggested for conformation of result (Islam et al., 2008).

Up scaling on coconut mite control

During 2011 to 2013 a study was conducted to control the incidence of suspected mite attack in coconut through chemical. Trichoderma based compost and mechanical control. The study was carried out in an ecosystem unit involving farmers under financial support of Krishi Gobeshona Foundation (KGF). Laboratory study was adopted to diagnose the causal organism associated with the physical injury on the

pericarp. The study was conducted on 4429 palms in an area around 696 hectare, representing an ecosystem involving 551 households of 8 villages. There were six treatments in the study:

T_1 : Removing of flowers and foliar application of Omite @ 0.2%

T_2 : Removing of flowers and foliar application of Neem oil @ 0.3%

T_3 : T_1 & soil incorporation of Neem cake at the root zone @ 250g/tree

T_4 : T_1 & soil incorporation of tricho-compost in root zone@ 1kg/tree

T_5 : T_2 & soil incorporation of Neem cake at the root zone @ 250g/tree

T_6 : T_2 & incorporation of tricho-compost at the root zone 1kg/tree

All the six treatments were equally effective in controlling mite in coconut. Treatment which included soil incorporated Neem cake at the root zone at the rate of 250g/tree produced maximum edible portion. However, nuts per palm (coconut tree) were counted 72 to 85 at 9th month of intervention which was significantly different from 12 to 17 nuts per palm counted before the intervention. The results were consistent in three consecutive years.

Infested nuts of different age groups were collected and examined under stereo zoom microscope to trace out the pest on nut surface. Infested nuts of 2-6 month old were found to be infested with colonies of tiny mites beneath the perianth (Plate 1). No mite infestation was traced out in unfertilized flowers (Plate 2). Mites moved to another nut when infested nut reached the age of 7 months and above (Plates 4). Mite colonization was found maximum in younger nuts of 2-3 month old. It was found to congregate in two or three places beneath the 3rd or 4th tepals. Adult, nymph and egg were found in each colony (Plate 6). Distribution of colonies was not found uniform inside the perianth. Triangular yellowish brown patches extending distally on the fruit surface from beneath the perianth of young developing button indicated the typical symptoms of mite attack (Plate-7). When the perianths of infected nuts were removed, brown lesions were noticed around the stalk (Plate 8). The causal organism was identified as mite *Aceria guerreronis* of eriophyid family (Keifer, 1965). Eriophyid mite is microscopic, slender, vermiform and whitish to creamy white in color (Plate 9). Treating palms with Omite or Neem oil followed by removing of infected nuts, bunches and inflorescences stopped mite attack. As a result, the harvested nuts were spotless with attractive smooth pericarp.

Stepwise approaches in controlling mite in coconut:

Steps and time	
Step	1
Time	Mid Oct to mid Nov
Activity to be done	Cleaning of infected, nuts and bunches and burning near the tree

Steps and time	
Step	2
Time	Mid Oct to mid Nov
Activity to be done	Spray on crown djacent to the bunch region by miticide (e.g., omite 57 EC) @1.5 mi/liter of water including nearby juvenile palms which seldom produce flowers/fruits.
Step	3
Time	Mid February to mid March
Activity to be done	Do the second spray on newly born fruits when the fruit age at least 2 months. Use the same dose of miticide
Step	4
Time	Mid April to mid May
Activity to be done	Spray miticide on fruits after harvesting (if necessary) the tender nut/mature nut
Step	5
Time	Mid June to Mid July
Activity to be done	Spray miticide as indicated before

Conclusion

Coconut mite thrives in a favorable condition on nut surface near the stalk under the bract which is tightly attached to the nut. Present investigation is the beginning of research on mite and sustainable recommendation will need continuation of investigation. Since, coconut is a tall tree, manipulation of this ecosystem is extremely difficult by few researchers. The present technology may be recommended until a sustainable control measure and management practices against mite are developed. Study also needed to select genotypes which are resistant or tolerant to mite attack. Hybridization in coconut is not very difficult and suitable hybrid may be developed with desirable characters against mite attack.

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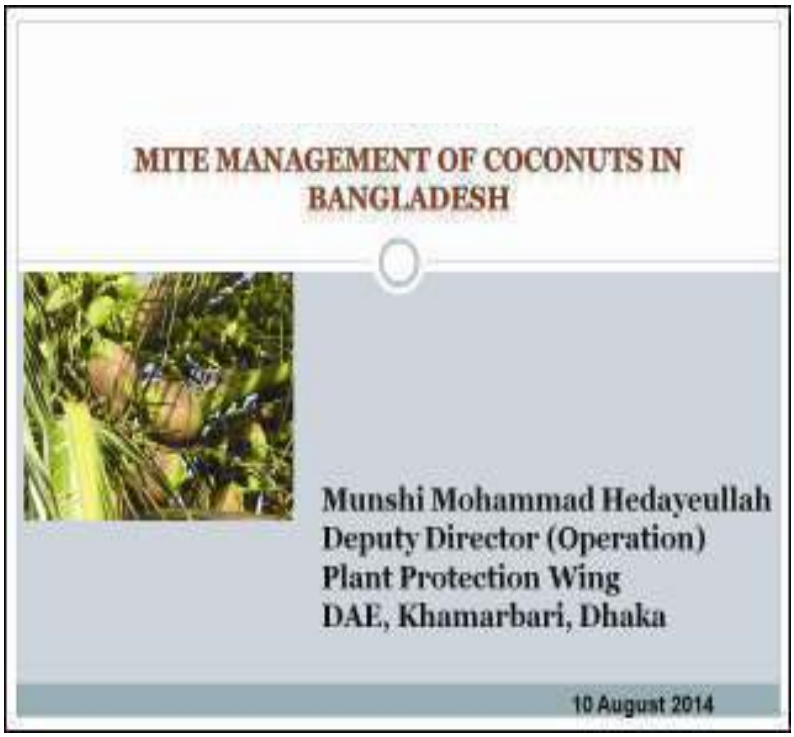
MITE MANAGEMENT OF COCONUTS IN BANGLADESH
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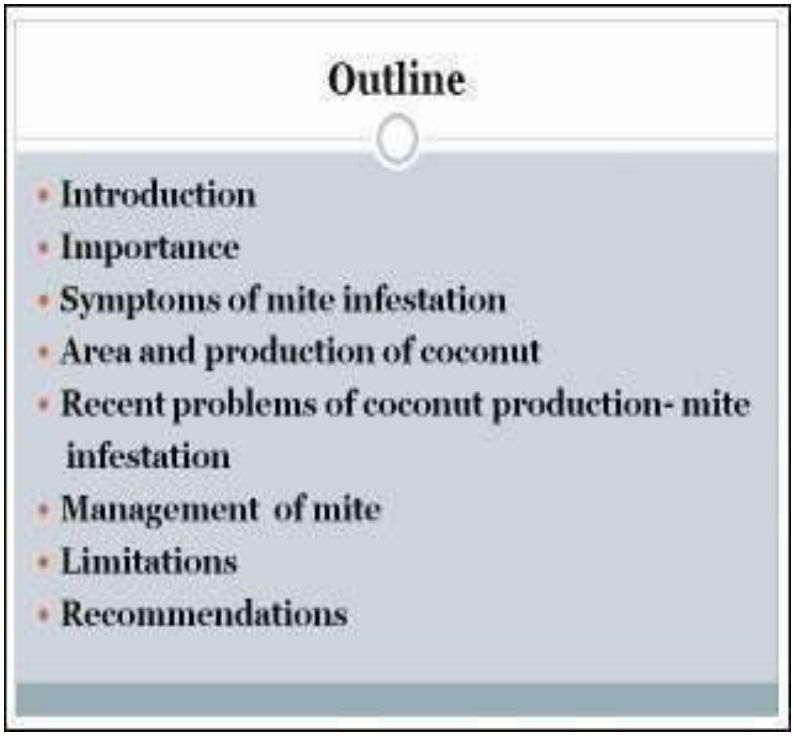
10 August 2014


Outline
• Introduction
• Importance
• Symptoms of mite infestation
• Area and production of coconut
• Recent problems of coconut production- mite infestation
• Management of mite
• Limitations
• Recommendations

Introduction

- Coconut is considered a subsistence crop in Bangladesh.
- Coconut is an important cash crop in Bangladesh.
- It grows mainly in the homesteads throughout the country and is concentrated mainly in southern districts.
- However, the production of coconut is rapidly declining and during the last six years, production decreased from 90,000 tons to 33000 tons (BBS, 2011).

Area and Production of coconut in different regions in Bangladesh

Sl	Region	Cultivated area (ha) : 2013-2014			t/ha	Total
		Orchard	Homestead	Total		
1	Dhaka	225	5019	5244	9	47196
2	Mymensingh	120	3155	3775	9	33975
3	Comilla	51	1209	1260	8	10080
4	Sylhet	23	1375	1398	7	9786
5	Chittagong	1228	7466	8494	13	110422
6	CHT	6	1464	1470	10	14700
7	Rajshahi	224	1924	2148	8	17184
8	Barishal	1531	9572	11103	10	111030
9	Rangpur	86	1090	1176	9	10584
10	Jessore	2531	15064	17595	11	193545
	Total					558502

Mostly cultivated varieties are

- Local
- Malayasian King/Dwarf
- BARI-1,2
- Kanchanpuri
- Colombo & Colombo Tall
- Sreelankan

Uses of Coconut

- Hair Oil
- Kernel (raw, sweet, curry, cake etc
- Edible oil
- Coir & shell (Mattress, Rope, handicrafts etc)
- Green Belt

Bio fertilizer from coir dust

- Recently, coconut palms are found to suffer from mite attacks. This problem has taken an epidemic turn in south and southwestern region of the country.
- The mite injures the tender portion of young nuts and suck sap and initially the damage appears as a triangular yellowish brown patch extending distally on the fruit surface from beneath the perianth. The injury ultimately leads to warting and longitudinal fissures on the nut surface.

- Mite has become a major pest in coconut during the recent years. The exact data on the extent and severity of coconut damage due to mite attack has not been recorded.
- The growth of nut is prevented and ultimately the usual size of the nut, shell, and kernel are reduced.

- It seems probable that a great proportion of decrease in coconut production is accounted for mite attack.
- Severity of mite incidence is high in Khulna, Jessore, Jhalokati, Gopalgonj and Bagerhat districts.

- Mite in recent years has become a major pest of coconut.
- Severity of mite incidence and fruit damage is high in Khulna, Jessore, Jhalokati, Gopalgonj and Bagerhat districts.
- The mite is microscopic and attacks coconut at the early growth stage resulting in deformed and small size.

- Most of the infected nuts cannot survive to maturity due to mite attack. Being a very small pest, mite remains unnoticed until the injured surface of nut becomes dried up.
- This type of havoc in coconut is quite new to the farmer although, the problem is not new in other coconut growing countries of the world.

Courtesy :Photographs from Dr.M.Nazirul Islam, PSO, BARI

Grading of damage pattern (Islam et al., 2008)

Infected nut on tree

Mite Infected nuts on palm

Healthy new born nut after treatment

Mode of damage of nut by mite

Recent problems of Coconut Production-
Mite infestation

- Mite infestation is a new problem to the farmers
- Reduction in size, deformation followed by immature bud dropping
- Reduced volume of water in green coconut
- Decreased market value & consumers' satisfaction
- Sometimes epidemic turn in specific areas
- Yield loses up to 80% in case of severity

Farmers Training in Kachua, Bagerhat

Farmers Training in Mongla, Bagerhat

Mite management

Good farming practices

- Use quality seedling
- Cleaning
- Debris burning
- Balanced fertilizer

Chemical control

- Propergite 57 EC - 2ml/L of water
- Abamectin 1.8 EC -1.25ml/L of water
- Sulphur 80 WP -910gm/acre
- Chlorfenapyr 10 SC-2ml/L of water


Soil application of fertilizers
Spading deeply will cut feeding root
Hoeing is recommended
Tree spraying by climbing is not practicle
Burning/roasting of debris will kill adult and destroy eggs of mite

Pruning of inflorescence and nut up to age 6-7 month old to reduce mite population

Limitations

- Mostly homestead farming
- Farmers are confused to identify the problem properly
- Control measures taken as scattered
- Lack of quality seedling


Recommendations
▪Developed farmers friendly & effective technology to control mite infestation
▪Farmers training on mite management
▪Availability of quality seedling at farmers level
▪Awareness building
▪Strengthening Research –Extension linkage

Concept Note

Regional Consultation Workshop on Mite Management of Coconut in SAARC member countries

Theme: Coconut for sustainable ecosystem

Coconut farming in South Asia is an important branch of agricultural production. It gives income to the growers continuously and contributes more than 32% of the total homestead income. Very recently, coconut palms are suffering from reduction in nut size followed by immature bud dropping (Fig1). It has become an epidemic problem in South and South-western parts of the country which contribute 80% of total national production. The associated crop loss due to mite infestation was recorded 80-90% and homestead income reduced from 32% to 40%. This problem was first reported in Jamaica in 1991 and in Sri Lanka in late 1997 in the Kalpitiya peninsula of the Puttlam District. Sri Lanka estimated the yield loss of coconut due to the problem was 14% which was equivalent to 55-56 million nuts.

In the Indo-sub-continent the incidence was reported first in Kerala province in 1997-8 and the estimated loss was around 25% (Gopal and Gupta 2001). It has been perceived from the review of literatures, a tiny mite is responsible for the problem (Fig 2) (Keifer, 1965; Griffith, 1984; Ramarenthinum et al., 2000; Islam et al., 2008). In Bangladesh mite was reported first in 2004, although it was not recognized as mite until 2008. Unappealing appearance of mite-damaged coconuts has been shown to adversely affect sales.

This interferes with the livelihood of many individuals. As the pest is new in the country, farmers are not aware of control measure. Farmers believe that the waves of mobile phone towers or interaction of planets are causing malformation of coconut. These types of superstition generated many magical and spiritual treatments without knowing scientific reasons and thus farmers were cheated. Like many other coconut growing countries in the world, however, the problem is not new in India, Sri Lanka and Maldives which are the leading coconut growing countries in the world.

Mode of attack

Mite attacks coconut when the nut age is two to seven months old (Fig 3). Just after fertilization when the nut starts to grow mite attack it for sucking cell sap from the growing tissues of perienth. When nut reaches seven months or above mite moves to new nuts of another bunches. The mite injures the tender portion of young nuts and suck sap and initially the damage appears as a triangular yellowish brown patch extending distally on the fruit surface from beneath the perianth (Fig 4). The injury ultimately leads to warting and longitudinal fissures on the nut surface (Fig 5). The growth of nut is prevented and ultimately the usual size of the nut, shell, and kernel are reduced. The affected nuts make de-husking operation difficult and reduce fibre quality of the husks. Coconut mites probably disperse from one palm to the other on air currents, or by horsy (e.g., carried on insects or birds that visit palm flowers). Inappropriate application of quarantine laws during importing/exporting of live plants (palm seedlings) and nuts helps mite to disperse from one country to another country. Countries in the SAARC are representing around 50% of global production. Technologies available among the member countries of SARC can be innovated and sharing them might be useful for controlling mite. Agricultural research organizations and agricultural universities of India Sri Lanka (CRI) have been involved in various research activities to control the pest, including development of biological control methods. Bangladesh Agricultural Research Institute (BARI) in collaboration with BARC and Krishi Gobeshona Foundation (KGF) conducting research to develop techniques for management of coconut mite through IPM method. According to BARI (2008) an ecosystem approach (area of about 1000 ha), palms treating with Omite @ 2% followed by removing of infected nuts, bunches and inflorescences and burning under the tree (Fig 6) stop mite attack (Fig 7) and communities harvested spot free nuts with attractive smooth pericarp (Fig 8). However, due to mode of infestation of mite along with the morpho-physiology of coconut which provides shelter and food of mite it is difficult to develop a sustainable method for controlling coconut mite. Mite of an infected palm easily can attack the nearby palms even mite of infecting palms of a country can attack coconut of neighboring countries. Consciousness about mite attack and its dispersion are essential to prevent attack of new palms. It should be noted that mite is a sexual problem of coconut and seedlings and young nuts disperse it from one place to other palaces.

The successful stories of member countries of SAARC sought an integrated and concerted effort to resist coconut from mite attack. India, Bangladesh, Sri Lanka, Mal Div, Pakistan including APCC countries (Thailand, Indonesia, Vietnam and Philippines) are the reservoir of expertise of coconut pests including mite. Sharing the experiences and collecting counsels of expert member of various levels will pave the new way in controlling coconut mite.

Figure-2:

Figure-3: Two months old fertilizer female flower of coconut

Figure-4: (a) Early symptom of mite attack (b) Brown lesions on the nut surface beneath the perie

Figure-5:

Figure-6

Objective(s) of the regional consultation workshop

- To inquire about the incidence of coconut mite in member countries of SAARC
- To understand the practices following the member countries to control mite in coconut
- To collect counsel on mite management from the scientists with soul coconut knowledge

Outputs/results:

An effective package of management practices for controlling mite on coconut developed, validated and adapted by the SAARC communities.

Recommendations

Regional Experts Consultation Workshop on Mite Management of Coconut in SAARC Member Countries

A two-days long Regional Expert Consultation Workshop on **"Mite Management of Coconut in SAARC Member Countries"** was held at Bangladesh Agricultural Research Council (BARC), Dhaka and Bangladesh Agricultural Research Institute (BARI), Gazipur during 10-11 August 2014. The program is jointly organized by SAARC Agriculture Centre (SAC), Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI) and Krishi Gobeshona Foundation (KGF)

Goal

To identify effective integrated management package for controlling mite pest of coconut in SAARC Member Countries

Objectives of this initiative includes as follows:

- To inquire about the incidence of coconut mite in member countries of SAARC
- To understand the practices of the member countries to control mite in coconut
- To collect council on mite management from the scientists with core coconut knowledge

Justification of the program

- Coconut contributes to the livelihood of the farmers through its diversified uses.
- It has a high utilization potential for food, shelter, cosmetics, pharmaceuticals, energy and environmental protection.
- Coconut crop is the means of livelihood of many landless and marginal farmers in SAARC countries.
- Among different factors for low productivity of coconut, pest attacks are considered as the most important one.

- Around 30-40% yield loss to as much as total mortality of coconut plant may happened due to pest attack

- In recent times incidence of nut infesting mite has become a major problem in Bangladesh.
- Extensive feeding on young buds by coconut mite resulted in reduction in bud size followed by its immature dropping.
- The problem has become epidemic in south and southwestern parts of the Bangladesh and extensive damage to coconut has been noticed causing high economic losses in all the coconut growing countries of this region.

Coconut Eriophyid Mite: ***Aceria guerreronis***

- This mite is microscopic (200 – 250 micron in length and 36 – 52 micron in width), slender, vermiform organism and creamy white in color

- It build up large and dense population under the perienth and near the stalk.
- Two to six months old young green developing buttons harbor maximum number of mites.
- Mite population observed throughout the year. During summer months maximum population recorded and in the cooler months it decline.



- Due to continuous sucking initially yellow discoloration of nut started turns into brown and results in warty shrinking of husk.
- Continuous draining of sap results in poor development of nut leads to the reduction in size and kernel content. Later nut malformed, kernel under or partially developed.




- In severe damage reduction in nut size leads to almost 25% loss in copra yield.

- Husk becomes thickened and hard with loss of fibers resulting in poor quality fibers
- Different stages of mites live in the tender portion covered by the inner bracts of perianth and suck sap continuously

Possible Benefits/Outcome of the program

- An effective package of management practices for controlling mite on coconut will be developed, validated and adapted by the SAARC communities.
- Further study areas especially on the following aspects has to be carried out to sustain the production of coconut:
  - ❖ Understand the origin, mode of entry, dispersal, host-mite relationship.
  - ❖ Identification of tolerant/resistant varieties.
  - ❖ Effective bio-control agents and eco-friendly methods.
  - ❖ Increase the persistence level of botanicals and bio-pesticides.
  - ❖ Need based application of nutrients along with spot application of botanicals will sustain and enhance the production of nuts, besides minimizing the mite damage significantly without causing any ill effects to coconut ecosystem.
- A holistic integrated management system should be developed to manage all the pests and diseases.

Inaugural and Concluding Sessionn

Dr. SM Nazmul Islam, Secretary, Ministry of Agriculture, Government of Bangladesh was present as Chief Guest in the inaugural occasion and delivered inaugural speech. Dr. Md. Rafiqul Islam Mondal, Director-General, BARI and Dr. Md. Nurul Alam, Executive Director, KGF were also present as Special Guest and Guest of Honour, respectively. The consultation workshop was blessed by the presence of Diplomats from Embassy/High commission, focal points experts from from Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, Keynote Speaker Professor Dr. K. Ramaraju from Tamil Nadu Agricultural University, India.

High officials from Ministry of Agriculture, Government of Bangladesh, Experts from Department of Agriculture, Agricultural University professors from Bangladesh, and honourable Governing Board member of SAC from Bangladesh etc. attended the inaugural session. Dr. Abul Kalam Azad, Director, SAC welcomed all the participants. Around 45 experts from the National Agricultural Research, Education and Extension Systems from member of SAARC countries participated in the consultation including the regional resource focal point experts.

The inaugural session of the consultation workshop was presided by Dr. Md. Kamal Uddin, Executive Chaiman, BARC. During inaugural session, Ms. Nasrin Akter, Senior Program Specialist (Horticulture), SAC presented brief introduction about the program on coconut mite management. Professor Dr. K. Ramaraju, Tamil Nadi Agricultural University presented the key note presentation on this topic.

Mr. Abdul Motaleb Sarker, Director-General (SAARC & BIMSTEC), Ministry of Foreign Affairs, Government of Bangladesh was present as Guest of Honour in the concluding and delivered concluding speech. Dr. Md. Rafiqul Islam Mondal, Director-General, BARI was also present as Chief Guest in the concluding occasion. The concluding session of the consultation workshop was presided by Dr. Abul Kalam Azad, Director, SAARC Agriculture Centre. During concluding session, Dr. Syed Nurul Alam, CSO & Head, Entomology Division, BARI presented draft recommendations of the workshop in the concluding session.

Technical Sessions

During two days consultation meeting, ten (10) technical papers were presented. All the resource persons from SAARC member countries and others participants of the consultation discussed in the three groups on the following issues:

- About the incidences by coconut mite in SAARC member countries
- Present practices in the South Asian Region to control mite in coconut and
- To collect guidance on mite management from the scientists with core coconut knowledge in South Asia

Recommendations

At the end of the Consultative workshop, following recommendations were adopted considering the above issues as follows:

Policy issues

- Some of our neighboring countries of this region have made remarkable progress towards developing and popularizing sustainable management technologies against not only for coconut mite but also for other pests and diseases of coconut. So, a coordinated approach of the scientists of this region can play a vital role to develop a sustainable and environment friendly means to manage those pests.
- A coordinated project to develop sustainable solution of the pest and disease problems in coconut including mite can be undertaken under the SAARC umbrella involving the member countries to boost up the overall productivity

of coconut crop in South Asia. SAC will take initiative for formulating this project.

- Separate Coconut Development Board or similar organisation may be established in those countries where coconut production is not up to the mark. The Board will take the necessary steps for the overall development of coconut industries.
- Separate Coconut Research Institute /Center/unit may be established in the countries where it has not yet done.
- Incentives, viz. bank loan, technical training, supply of high yielding propagation materials etc. for the small holder coconut growers and also bank loan and other related facilities for the SME on coconut products may be given for sustainable growth of coconut industries.
- Strengthening Research – Academic -Extension – Input supply agencies linkage nationally and regionally (among the SAARC countries).
- Web-based net work on coconut production and protection technologies developed by the SAARC member countries and among the coconut researchers, growers may be established.
- Need international exchange of technical expertise through research networking and program for capacity building of coconut researchers, extension worker and academicians may be undertaken.
- Private sector may assist in different aspect to develop the commercial venture of the bio-pesticides or microbial, so that those products can be available at the farm level.
- Steps may be taken to give legal permission to the authorities and solve related issues for easy availability of different bio-pesticides and strict quality control measures should be undertaken for the commercially available bio-pesticides.
- Motivation work for the use of different product including coconut oil among the consumers may strengthen

Research Related Issues

- Survey and mapping of extent of damage and population dynamics of coconut mite along with other devastating pests and diseases may be undertaken.
- Development of bio-pesticide based technologies for coconut mite along with other devastating pests and diseases may be undertaken.
- Collection and cataloging of native natural enemies of mite.

- Identification/development of varieties resistant to coconut mite by utilizing molecular tools or conventional breeding program and genetic manipulation for intermediate variety(no long or no dwarf)
- Holistic approach for integrated packages development for all major insect pests and diseases including coconut mite along with crop management aspect may be undertaken.
- Study on the bio-ecology, mite-host relationship and transboundary pests and disease of coconut may be done.
- Introduction/exchange of effective bio-control agents among the member countries.
- Extensive research work especially in the public sector should be undertaken for the development of effective and cheap bio-pesticide based IPM technologies against major insect pests & diseases of coconut.
- Emphasis on biological control, host plant resistance should be given for sustainable management.
- Research institutes should collaborate with other coconut R&D organization in other member countries to investigate the epidemiology, etiology and control measure of coconut mite. Specially improve early detection methods and search for natural control agents

Extension issues

- Exchange of effective technology (ies) among member countries
- Training for Trainers (TOT)
- Technology transfer through farmers training
- Demonstration
- Farmers Field School
- Motivational /Study tour
- Dissemination of encouraging results through mass media, electronic media, print media
- Conduct adaptive research
- Seminars and workshop
- Visit members country
- Need area-wide farmer participatory demonstrations.

Program

Regional Experts Consultation Workshop on Mite Management of Coconut in SAARC Member Countries

Date: 10-11 August 2014 (Sunday-Monday)

Venue: Inaugural and Technical Sessions at the Conference Room-1 of BARC, Farmgate, Dhaka

Concluding session at the Dr. AKM Amzad Hossain Conference Room, HRC, BARI, Gazipur

Jointly organized by
SAARC Agriculture Centre (SAC)
Bangladesh Agricultural Research Institute (BARI)
Bangladesh Agricultural Research Council (BARC)
Krishi Gobeshona Foundation (KGF)

Objectives of the workshop: To inquire about the incidence of coconut mite in member countries of SAARC; to understand the practices in the South Asian Region to control mite in coconut and to collect guidance on mite management from the scientists with core coconut knowledge in South Asia

Participating Countries: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka

Day 1: 10th August, 2014 (Sunday)

Inaugural Session (BARC Conference Room-1)	
09:00 am	Arrival of all participants
09:00-09:15 am	Registration
09:15-09:30 am	Arrival of Guests
09:30-09:35 am	Recitation from the Holy Quran
09:35-09:50 am	Welcome address and brief introduction about SAC- **Dr. Abul Kalam Azad,** Director, SAC, Dhaka

09:50-10:05 am	Introduction of the Program- **Ms. Nasrin Akter,** Senior Program Specialist (Horticulture), SAC
10:05-10:25 am	Keynote paper presentation- **Professor Dr. K. Ramaraju,** Department of Entomology, Tamil Nadu Agricultural University, India
10:25-10:35 am	Address by Guest of Honour- **Dr. Md. Nurul Alam,** Executive Director, KGF
10:35-10:45 am	Address by Special Guest- **Dr. Md. Rafiqul Islam Mondal,** Director-General, BARI
10:45-11:00 am	Inaugural speech by Chief Guest- **Dr. S M Nazmul Islam,** Secretary, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh
11:00-11:15 am	Address by Chairperson- **Dr. Md. Kamal Uddin,** Executive Chairman, BARC
11:15-11:30 am	**Photo Session and Refreshment**

Technical Session-I (BARC Conference Room-1) Country Paper Presentation	
Chairperson : **Rapporteur :**	**Dr. Md. Nurul Alam, Executive Director, KGF and Former Executive Chairman, BARC, Dhaka** Mr. Nirmal Kumar Dutta, Senior Scientific Officer , Entomology Division, BARI
11:30-11:35 am	Opening Remarks by Session Chairperson
11:35-11:55 pm	**Bangladesh** by Dr. Md. Syed Nurul Alam, CSO and Head, Entomology Division Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
11:55-12:15 pm	**Bhutan** by Mr. Phuntsho Loday, Assistant Entomologist, Bhutan
12:15-12:35 pm	**India by** Dr. Chandrika Mohan, Principal Scientist (Entomology) Central Plantation Crops Research Institute (CPCRI), India
12:35-12:55 pm	**Maldives by** Ms. Jawaidha Ahmed, Plant Protection Officer, Ministry of Fisheries and Agriculture, The Republic of Maldives
12:55-01:15 pm	Open Discussion
01:15-02:00 pm	**Lunch**

Technical Session-II (BARC Conference Room-1) Country paper presentation	
Chairperson : **Rapporteur :**	**Dr. Md. Rafiqul Islam Mondal, Director-General, BARI** Dr. A.K.M. Ziaur Rahman, Senior Scientific Officer, Entomology Division, BARI
02:00-02:05 pm	Opening Remarks by Session Chairperson
02:05-02.25 pm	**Nepal** by Mr. Dinesh Babu Tiwari, Senior Plant Protection Officer Ministry of Agriculture Development, Nepal

02:25-02.45 pm	**Pakistan** by Dr. Abdul Hameed Solangi, PSO (Plant Introduction Centre), SARC, PARC, Karachi, Pakistan.
02:45-03:05 pm	**Sri Lanka** by Dr Nayanie S Aratchige, Principal Entomologist, Crop Protection Division, Coconut Research Institute, Sri Lanka
03:05-03:20 pm	**Local paper** by Dr. Md. Nazirul Islam, Principal Scientific Officer, HRC, BARI
03:20-03:35 pm	**Local paper** by Mr. Munshi Mohammad Hedayet Ullah, Deputy Director (Operation), Plant Protection Wing, DAE Bangladesh
03:35-03.50 pm	Open Discussion
03:50-04.00 pm	**Tea**

Technical Session-III (BARC Conference Room-1) Discussion for Recommendations	
Chairperson	**: Dr. Abul Kalam Azad, Director, SAARC Agriculture Centre, Dhaka**
Facilitators	Dr. Md. Nazirul Islam, Principal Scientific Officer, HRC, BARI and Ms. Nasrin Akter, Senior Program Specialist (Horticulture), SAC
04:00-04:45 pm	Discussion about the incidence of coconut mite in member countries of SAARC; to understand the practices in the region to control mite in coconut and to collect guidance on mite management from the scientists with core coconut knowledge
04:45-06.00 pm	**Formulation of draft Recommendations**
07:00-09:00 pm	**Dinner (Baton Rouge Banquet Hall, Banani, Dhaka)**

Day 2: 11 August 2014 (Monday)

Start from Dhaka at 7:00 am from BARC Campus for BARI, Gazipur, Bangladesh

Time	**Program**	**Location**
09:00 am	Arrival at Bangladesh Agricultural Research Institute (BARI), Gazipur	Entomology Division
09:15 am	Visit IPM Laboratory and Pesticide Analytical Laboratory	Entomology Division
09:45 am	Visit Fruit Research Farm, Pomology Division	Fruit farm, HRC
10:15 am	Arrival at A.K.M. Amzad Hossain Conference Room,	Horticulture Research Center (HRC)
10:20 am	Refreshment	AKMMH Cofrence Room, HRC, BARI

Concluding Session **(AKMMH Conference Room, HRC, BARI at 10:45 am)**	
Chief Guest	Dr. Md. Rafiqul Islam Mondal, Director General, BARI
Guest of Honour	Mr. Abdul Motaleb Sarker, Director General (SAARC & BIMSTEC), MoFA, Bangladesh
Special Guest	Dr. Md. Kabir Ikramul Haque, Member, Governing Board of SAC from Bangladesh and Member-Director (Fisheries), BARC, Dhaka
Chairperson	Dr. Abul Kalam Azad, Director, SAC
10:45 – 11:15 am	Presentation of the draft Recommendation by Dr. Syed Nurul Alam, CSO & Head, Entomology Division, BARI
11:15 - 11:30 am	Remarks by Special Guest
11:30 – 11:45 am	Remarks by Guest of Honour
11:45 – 12:00 pm	Concluding comments by Chief Guest
12:00 – 12:15 pm	Remarks by Chairperson
12:15 – 12:30 pm	Distribution of Mementoes by Chief Guest and Director, SAC
12:30 – 12:45 pm	Vote of Thanks on behalf of SAC, BARC, KGF and BARI by Dr. Tayan Raj Gurung, Senior Program Specialist (NRM), SAC
12:45 – 01:30 pm	Lunch (VIP Cafeteria, BARI)
01:30 – 05:00 pm	Visit National Monument at Savar, Dhaka

Coordinator : Ms. Nasrin Akter
Senior Program Specialist (Horticulture)
SAARC Agriculture Centre

List of participants for Regional Consultation Workshop on Mite Management of Coconut in SAARC member countries during 10-11 August 2014

1. **Mr. Phuntsho Loday**
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   Technician/Assistant Entomologist
   National Plant Protection Centre,
   Department of Agriculture
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2. **Dr. (Mrs.) Chandrika Mohan**
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   Kerala, India – 690 533

3. **Ms. Jawaidha Ahmed**
   Plant protection Officer
   Plant Health Services
   Plant and Animal Health Section
   Ministry of Fisheries and Agriculture
   The Republic of Maldives

4. **Mr. Dinesh Babu Tiwari**
   Senior Plant Protection Officer
   Plant Protection Directorate
   Ministry of Agriculture Development
   Government of Nepal
   Hariharbhawan, Nepal

5. **Dr. Abdul Hameed Solangi**
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   Pakistan

6. **Dr. Nayanie S Aratchige**
   Principal Entomologist
   Crop Protection Division
   Coconut Research Institute
   Lunuwila, Sri Lanka

7. **Professor Dr. K. Ramaraju**
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   Tamil Nadu Agricultural University
   Coimbatore-641003, India

8. **Dr. Md. Nazirul Islam**
   Principal Scientific Officer
   Regional Horticulture Research
   Station, BARI, Norsingdi

9. **Dr. Syed Nurul Alam**
   Chief Scientific Officer & Head
   Entomology Division
   BARI, Joydebpur, Gazipur
   Bangladesh

10. **Mr. Md. Azim Uddin**
    Chief Seed Technologist (Seed Wing)
    Ministry of Agriculture
    Government of the People's
    Republic of Bangladesh
    Bangladesh Secretariat, Dhaka – 1000

11. **Dr. Md. Aziz Zilani Chowdhury**
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    Farmgate, Dhaka – 1215, Bangladesh

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14. **Dr. Rahim Uddin Ahmed**
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26. **Mr. Shah Alam**
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27. **Mr. Sheikh Md. Iftekhar Hossain**
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28. **Mr. Munshi Mohammad Hedayet Ullah**
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29. **Mr. Md. Shahidul Islam**
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30. **Mr. S. M. Borhan Uddin**
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35. **Professor Dr. Abdul Mannan**
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36. **Professor Dr. Md. Mohasin Hussain**
Chairman, Entomology Division
Patuakhali Science and Technology
University, Dumki, Patuakhali

37. **Dr. Md. Nurul Alam**
Senior Program Specialist (PSPD)
SAARC Agriculture Centre (SAC)

38. **Nasrin Akter**
Senior Program Specialist
(Horticulture)
SAARC Agriculture Centre (SAC)

39. **Dr. Muhammad Musa**
Senior Program Specialist (Crops)
SAARC Agriculture Centre (SAC)

40. **Dr. Tayan Raj Gurung**
Senior Program Specialist (NRM)
SAARC Agriculture
Centre (SAC)

Mite Management of Coconut in SAARC Member Countries

Photo Album

Participants of the Consultation Workshop with Guest

Director, SAC is welcoming to all participants

Coordinator of the workshop is presenting Synopsis Paper

Keynote Speaker is presenting paper

Chief Guest is inaugurating the workshop

Crest is giving to the Chief Guest

Executive Director, KGF is giving speech

Director General, BARI is giving speech

Executive Chairman, BARC is delivering speech

Indian Expert is presenting paper

Pakistan Expert is presenting paper

Expert from Sri Lanka is presenting paper

Visit of BARI Entomology Laboratory

Dr. Syed Nurul Alam is presenting recommendations

Expert from Bhutan is receiving certificate

Expert from Maldives is receiving certificate

Expert from Nepal is receiving certificate

Expert from Bangladesh is receiving certificate

DG, BARI is giving Crest to DG, SAARC