MANAGEMENT STRATEGIES OF PAPAYA MEALYBUG INFESTING MULBERRY

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MANAGEMENT STRATEGIES OF PAPAYA MEALYBUG INFESTING MULBERRY

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PREFACE

Sericulture in Tamil Nadu met out a serious threat during 2008 to 2010 because of outbreak of papaya mealybug on mulberry besides a number of agricultural crops. Extensive damage caused by the pest on mulberry rendered many gardens unfit to use for silkworm rearing which reflected adversely on silk productivity of the state and the farmers faced heavy economic loss. The chemical control measures invariably applied did not yield any impact but the pest posed threat to Indian Sericulture industry after invasion to other major silk producing states *i.e.* Karnataka and Andhra Pradesh.

However, the situation has been managed after the implementation of classical bio-control programme by National Bureau of Agriculturally Important Insects (NBAII), Bangalore by mass multiplication and release of three exotic parasitoids in hot spot areas with the help of Tamil Nadu Agricultural University, Coimbatore as well as research and extension units of Central Silk Board (CSB). The contribution and co-ordination of scientists of extension units in Tamil Nadu under Central Sericultural Research and Training Institute (CSR&TI), CSB, Mysore with us to combat the pest in mulberry is appreciative.

In this line, the technical bulletin "**Management Strategies of Papaya Mealybug Infesting Mulberry**" by Regional Sericultural Research Station, Salem describes the comprehensive information on papaya mealybug and its management with excellent illustrations of practical technologies. The eco-friendly technologies developed by the scientists of Central Silk Board *viz*., water jetting to control papaya mealy bug and other sucking pests and "Field Bio-cage" for mass multiplication of parasitoids of papaya mealybug under field conditions are found effective tools of Integrated Pest Management (IPM).

I am confident that the bulletin will be very useful to the field functionaries in the management of papaya mealy bug. I appreciate the authors for their utmost efforts to bring out the bulletin for the benefit of sericulture industry.

(V. Prabhakaran, I.F.S.)

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FOREWORD

Papaya mealybug (*Paracoccus marginatus*), an introduced polyphagous pest is believed to be native to Mexico or Central America. In India, it was first reported in Tamil Nadu during July 2008 infesting papaya and within a span of 2-3 months, it caused an extensive damage to the sericulture industry by spreading to over 3000 acres of mulberry plantation in Coimbatore, Erode and Salem districts of the state. The sericulturists, due to severe foliar damage, were forced to stop rearing and even started uprooting the mulberry plantations in affected areas. Later, the pest spread to neighbouring states of Kerala during 2009 and to Karnataka during 2010.

Thanks to the swift action taken by CSR&TI, Mysore who in collaboration with Department of Sericulture, Tamil Nadu, Tamil Nadu Agricultural University (TNAU), Coimbatore and National Bureau of Agriculturally important Insects (NBAII), Bangalore by employing physical, mechanical, chemical and biological methods, could bring the pest incidence below the economic injury level. Further, the field level innovations of the scientists of Regional Sericultural Research Station (RSRS), Salem such as introducing water jetting system in mulberry garden, installation of field bio-cage for easy mass multiplication of bio-control agents and use of Seri-torch to maintain field sanitation by burning the weeds and crop residues supported to combat the pest incidence.

In this context, it is a timely and effective step to bring out a technical bulletin documenting essential information about the papaya mealy bug and its management and shall serve as a reference and record to understand the behaviour of this noxious alien pest and help the field officers and also extension officers in its management. The efforts of the authors in this direction deserve all the appreciation. I wish this book to be translated into local languages for better utility.

(Dr. S.M.H. QADRI)

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INTRODUCTION

Like any other agriculture crop, Mulberry (*Morus alba* L.) is also prone to attack by a number of insect pests. The leaf webber, *Diaphania pulverulentalis* Hampson (Lepidoptera: Pyralidae), pink mealybug, *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae), mulberry thrips, *Pseudodendrothrips mori* Niwa (Thysanoptera: Thripidae), spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) and jassid, *Empoasca flavescens* F. (Homoptera: Cicadellidae) are some predominant pests causing severe damage and economic loss to the sericulture farmers. Several minor pests of mulberry which are major in status on other crops often build-up their population under favourable conditions and crosses the economic injury level and emerge as a major pest.

Leaf webber | Pink mealybug | Mulberry thrips | Spiralling whitefly | Jassid

Recently, Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), a polyphagous exotic sucking pest posed a serious threat to Indian sericulture due to its sudden outbreak and extensive damage on mulberry, the food plant of silkworm (*Bombyx mori* L.) especially in southern states. The pest causes heavy economic losses in potential sericulture clusters by reducing the usage of number of mulberry gardens as it make the leaves unfit to feed silkworms which resulted with abrupt reduction in rearing capacity of the silkworms and cocoon productivity. Feeding papaya mealybug infested mulberry leaf has adverse effect on growth and development of silkworm and economic traits of cocoons. Outbreak of this pest and its extensive damage is also observed on a number of agricultural and horticultural crops, ornamental plants and weeds. This necessitates regular observation to take up suitable preventive and control measures to sustain sericulture industry. Towards this a brief account of the life cycle, mode of spread, nature of damage in mulberry and its eco-friendly management strategies are given in this bulletin.

Healthy and papaya mealybug infested mulberry garden

TAXONOMIC POSITION

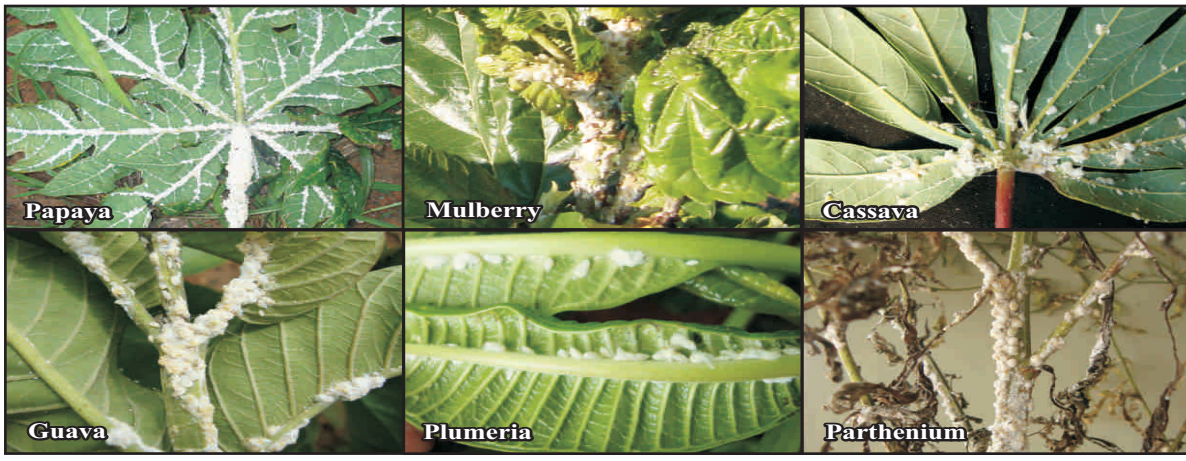
Authority : Williams & Granara de Willink, (1992)
Kingdom : Animalia
Phylum : Arthropoda
Class : Hexapoda (Insecta)
Order : Hemiptera
Super family : Coccoidea
Family : Pseudococcidae
Genus : *Paracoccus*
Species : *marginatus*

DISTRIBUTION

Papaya mealybug is an invasive exotic pest believed to be native of Mexico and / or Central America. The pest was first described in 1992 from the Neotropical Region in Belize, Costa Rica, Guatemala and Mexico and its consequent spread was reported over many countries in Caribbean and pacific regions during 1994 and then to South and South-East Asia in last decade. In India occurrence of the papaya mealybug was first recorded during 2008 in Coimbatore region of Tamil Nadu and became a major pest of various agricultural and horticultural crops including mulberry and number of weed species in Erode, Tiruppur, Salem and Namakkal districts. Subsequently, invasion of the pest has been reported in neighbouring states *viz*. Kerala, Karnataka, Andhra Pradesh and other tropical regions of the country.

HOST PLANTS

The pest is polyphagous in nature having wider host range and reported to infest more than 60 host plants of about 25 genera including economically important crops *viz.* papaya, tapioca, jatropha, hibiscus, avocado, citrus, cotton, tomato, eggplant, pepper, beans, peas, sweet potato, mango, cherry, pomegranate *etc* in Caribbean countries. In India the pest was recorded over 80 plant species of which heavy population build-up and severe damage was noticed in several species including economically important crops.

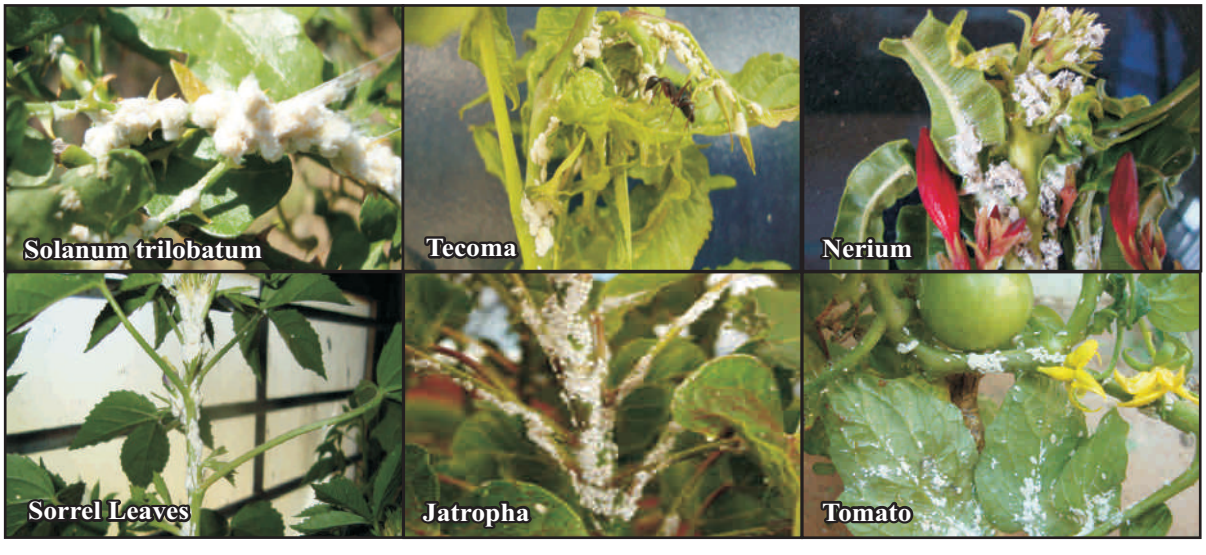


List of plant species affected severely by infestation of papaya mealybug, *Paracoccus marginatus* in Tamil Nadu, India

Botanical Name	Common Name	Family
Abelmoschus esculentus L.	Okra*	Malvaceae
Abutilon indicum (Link) Sweet	Indian Mallow	Malvaceae
Acalypha indica L.	Indian Acalypha	Euphorbiaceae
Adiantum incisum Forssk.	Walking maiden hair	Adiantaceae
Albizia saman F.Muell	Rain Tree	Fabaceae
Alternanthera sessilis (L.) R.Br.	Sessile joy- weed	Amaranthaceae
Amaranthus spinosus L.	Spiny amaranth	Amaranthaceae
Annona squamosa L.	Custard -apple*	Annonaceae
Boerhavia diffusa L.	Hog weed	Nyctaginaceae
Cajanus cajan (L.) Milsp.	Pigeon Pea*	Fabaceae
Carica papaya L.	Papaya*	Caricaceae
Ceiba pentandra (L.) Gaertn.	Kapok tree*	Malvaceae
Celosia argentea L.	Plumed cockscomb	Amaranthaceae
Codiaeum variegatum (L.).A.J.	Garden croton	Euphorbiaceae
Crotalaria retusa L.	Rattle weed	Fabaceae
Erythrina Variegata L.	Coral tree*	Fabaceae
Euphorbia neriifolia L.	Indian Spurge tree	Euphorbiaceae
Gossypium hirsutum L.	Cotton*	Malvaceae
Hibiscus cannabinus L.	Sorrel leaves*	Malvaceae
Hibiscus mutabilis L.	Cotton rose mallow	Malvaceae
Hibiscus rosasinensis L.	Chinese rose	Malvaceae
Ipomea carnea Jace	Bush Morning Glory	Convolvulaceae
Jatropha curcas L.*	Physic nut*	Euphorbiaceae
Jatropha gossypiifolia L.	Bellyache bush	Euphorbiaceae
Jatropha multifida L.	Coral plant	Euphorbiaceae
Lycopersicon esculentum Mill.	Tomato*	Solanaceae
Manihot esculenta Crantz	Cassava #*	Euphorbiaceae

Morus alba L.	Mulberry##*	Moraceae
Nerium oleander L.	Common oleander*	Apocynaceae
Parthenium hysterophorus L.	Congress weed	Asteraceae
Pedalium murex L.	Large Caltrops	Pedaliaceae
Plumeria obtusa L.	Frangipani (white)*	Apocynaceae
Plumeria rubra L.	Frangipani (Red)*	Apocynaceae
Psidium guajava L.	Guava*	Myrtaceae
Pulmonaria longifolia Boreau	Lungwort	Boraginaceae
Punica granatum L.	Pomegranate*	Lythraceae
Phyllanthus fraternus Webster	Gulf leaf flower	Euphorbiaceae
Ricinus communis L.	Castor*	Euphorbiaceae
Solanum melongena L.	Eggplant*	Solanaceae
Solanum nigrum L.	Black nightshade*	Solanaceae
Solanum torvum Sw.	Turkey Berry*	Solanaceae
Solanum trilobatum L.	Horse nettle*	Solanaceae
Solanum tuberosum L.	Potato*	Solanaceae
Solanum xanthocarpum L.	Yellow - berried night shade	Solanaceae
Tecoma stans (L.) Juss.	Yellow bells	Bignoniaceae
Tectona grandis L.	Teak*	Lamiaceae
Tephrosia purpurea Pers	Wild Indigo	Fabaceae
Trianthema portulacastrum L.	Pigweed	Aizoaceae
Tribulus terrestris L.	Puncture vine	Zygophyllaceae
Tridax procumbens L.	Coat buttons	Asteraceae
Vigna mungo (L.) Hepper	Black gram*	Fabaceae
Vigna radiata (L.) R. Wilczek	Green gram*	Fabaceae
Catharanthus roseus (L.)	Periwinkle	Apocynaceae

 # = Food plant of eri silkworm, ## = Food plant of mulberry silkworm
*** Economically Important Crops.**



DESCRIPTION

Eggs

Eggs are greenish yellow and are laid in an egg sac that is three to four times the body length and entirely covered with white wax. The ovisac is developed ventrally on the adult females and contains around 600-900 eggs.

Nymphs

First instar nymphs called crawlers are quite active and moves freely to settle on the soft portion of the stems and leaves and starts feeding by sucking the sap with its piercing and sucking mouth parts. Normally, once settled, they do not move except when disturbed. The nymphs secrete and embed themselves in white waxy coating.

(Credits: Dale Meyerdirk, National Biological Control Institute)
website:http://entnemdept.ufl.edu/creatures/fruit/mealybugs/papaya_mealybug.htm

Adult Females

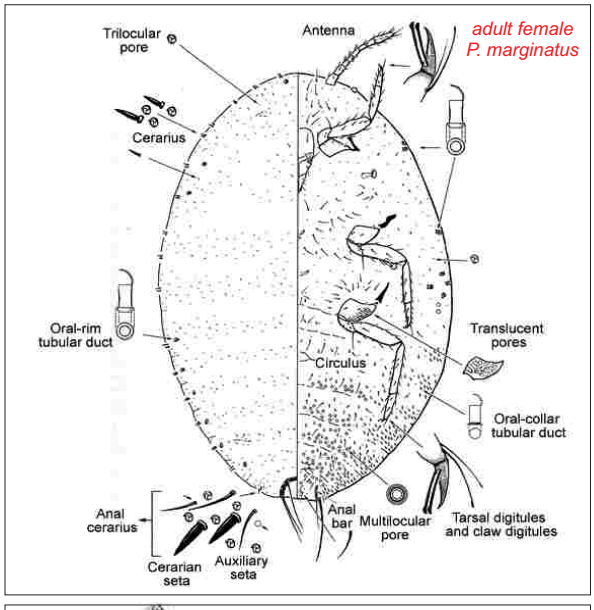
The adult females are yellowish green in colour and measuring approximately 2.2 mm length and 1.4 mm width. The body is covered with a white mealy wax coating. A series of short waxy caudal filaments less than ¼ the lengths of the body exist around the margin. They have no wings and move by crawling short distances. Two characteristics that are important in distinguishing *P. marginatus* adult females from all other species of *Paracoccus* are the presence of oral-rim tubular ducts dorsally restricted to marginal areas of the body and the absence of pores on the hind tibiae. The female of tukra mealybug *M. hirsutus* is distinguished by the presence of nine antennal segments whereas it is eight in papaya mealy bug.

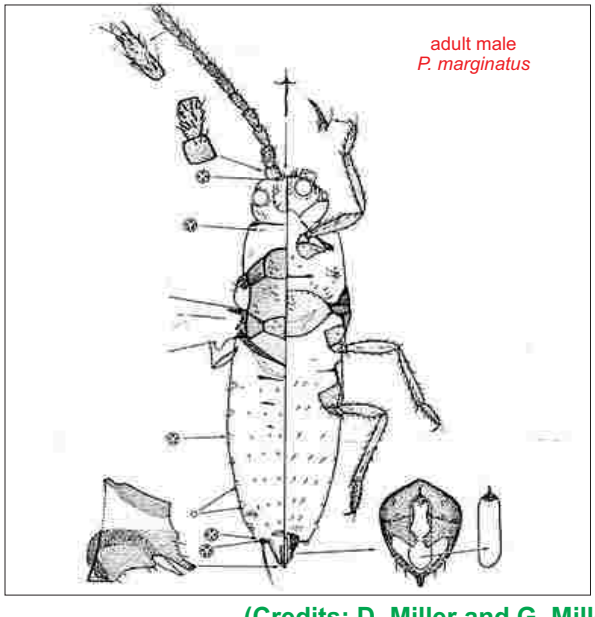
Adult males

Adult males tend to be coloured pink, especially during the pre-pupal and pupal stages, but appear yellow in the first and second instar. Adult males are approximately 1.0 mm length with an elongate oval body that is widest at the thorax (0.3 mm). Adult males have ten segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotised thorax and head, and well developed wings. Adult males may be distinguished from other related species by the presence of stout fleshy setae on the antennae and the absence of fleshy setae on the legs.

LIFE CYCLE

Egg-laying usually occurs over the period of one to two weeks and hatch in about 10 days. The neonate nymphs or crawlers begin to actively search for feeding sites and settle. Female crawlers have four instars whereas males have five and fourth one is produced in a cocoon and referred to as the pupa. The fifth instar of the male is the only winged form of the species capable of flight. Adult females attract the males with sex pheromones. Under greenhouse conditions, reproduction occurs throughout the year. A generation takes approximately one month to complete depending upon the temperature.





(Credits: D. Miller and G. Miller, USDA & NBAII, Bangalore)
website:http://entnemdept.ufl.edu/creatures/fruit/mealybugs/papaya_mealybug.htm

MODE OF SPREAD

Papaya mealy bug is highly invasive and spreads like wild fire. Its invasion over 50 countries was reported during the last decade. Local infestation occurs by crawling of nymphs and gravid females from infested plants to healthy one. However, the spread occurs by all the possible ways *i.e.* by wind, human beings, animals, birds, ants, rain, irrigation water, farm equipments, transport of infested planting materials, fruits, vegetables *etc.* The gravid females and crawlers are dispersing to vast area mainly by wind as they are blown easily to longer distance.

SYMPTOMS

The pest infests almost all parts of the plants above the ground portion. Papaya mealy bug infestations are typically observed as clusters of cotton-like masses on whole length of green / tender stem and veins of mulberry leaves as the pest secrete a thick waxy coat over the body. It can easily be distinguished from that of pink mealybug, *M. hirsutus* infesting mulberry which affects only apical portion and cause bunchy top called tukra.

Papaya mealybug has piercing-sucking mouth parts and feeding on phloem sap of mulberry both from stem and leaf resulting in loss of moisture and decline in nutritional values. The pest also injects a toxic substance into the plants while feeding. The symptoms appear on the leaves as chlorosis (yellowing), deformation (curling), pre mature drop, stunted growth followed by death of plants. Growth of dense black sooty mould on leaves over the honey dew excreted by the pest reduces the photosynthetic efficiency of the plants as well as pollutes entire mulberry garden in case of severe infestation.

Cluster of cotton-like masses, stunted growth, leaves deformation, chlorosis and black sooty mould

A simple test can be taken up to confirm the papaya mealy bug as it is difficult to distinguish visually from the pink mealybug, *M. hirsutus* causing tukra on mulberry. When papaya mealybug is pressed in a white paper it turns yellow whereas pink in case of tukra mealybug. Further when specimens of papaya mealybugs are placed in alcohol the body colour changes to bluish-black.

IMPACT ON SERICULTURE

Silkworm rearing

Feeding silkworms with papaya mealybug infested mulberry leaves adversely affects its growth and development and economic parameters *viz.,* cocoon yield and silk ratio in addition the leaf yield loss in mulberry garden reduces the silkworm rearing capacity. Many farmers in the hotspot area skipped the silkworm rearing as the mulberry leaves turned totally unfit for feeding silkworms and in few places mulberry was uprooted which led to drastic reduction in cocoon productivity. Invasion of the pest and extensive damage on mulberry in major silk producing states *viz.,* Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra is highly alarming to sericulture industry.

WHY FLARE UP?

There are few aspects, which are likely to have helped in sudden outbreak of this devastating pest. Since it is an introduced pest in India these factors attained a specific importance and hence the points given below need attention of all concerned to overcome the menace.

- Papaya mealybug prefers tropical climate.
- Failure of monsoon followed by dry weather and increase in atmospheric temperature.
- Shorter developmental period, higher reproductive potential and multiple source of dispersal.
- Wider host range (alternate hosts) and greater adaptability and survivability on them.
- High use of nitrogenous fertilizers in mulberry garden and luxuriant growth of plants
- Presence of thick wax coat around the body and ovisac of pest, which protect it from adverse climatic conditions, pesticides and natural enemies.

- Symbiotic association of ants helps the mealybugs to spread as well as safe guard them from the natural enemies.

Symbiosis with red & black ants

- Multiple crop stages in same field or in vicinity facilitate the mealy bugs to migrate from infested mulberry garden to sprouted one after pruning, alternatively.
- Indiscriminate use of insecticides induces resistance in the pest and at the same time destroys the natural enemy complex in the mulberry ecosystem which helps the pest to resurge easily.

MANAGEMENT STRATEGIES

Since the incidence of papaya mealybug was reported for first time in India, detailed studies are being undertaken by various workers to draw a package of practices to combat the pest to protect agricultural / horticultural crops as well as mulberry. The following management practices have been found to be useful and can be adopted to overcome the menace successfully.

CULTURAL AND MECHANICAL METHODS

- Multiple batch mulberry plantations maintenance should be avoided as they help the pest shifting from one plot to another.

- Planting of highly susceptible host plants such as papaya, cassava, hibiscus, jatropha *etc* in the vicinity of mulberry garden should be avoided. The alternate host plants in and around the garden should be removed.
- Clipping off the infested twigs and leaves and burning during early stage of infestation is the best method of eradication of the pest. All crop residues in the infested garden harbouring mealybug populations should be removed and burnt.

Collection and burning of infested shoots

Pruned stems harbouring papaya mealybug

- Pruned stems / shoots of infested mulberry garden should not be stored. The crop residues harbouring the pest should be removed from the mulberry garden and burnt.
- The stems meant for propagation should be dipped in 0.2% DDVP solution (dichlorvos 76 EC @ 2.6 ml per litre of water) for 15 minutes before transportation / planting.

- Number of weed species in mulberry garden serves as alternate host. From these weeds the pest easily migrates to the new sprouts after each pruning and build up its population heavily on plant maturity. Hence maintenance of mulberry garden free from weeds is essential and the infested weeds should be burnt immediately. Thermal weeding using "Seritorch" was found to be effective as it burns the weeds along with the mealybugs. Thermal weeding also burns the crop residues harbouring the pest populations and helps field sanitation in the infested garden.

Seritorch

Thermal weeding in mulberry gardens

- Symbiotic association of the ants with the mealybugs greatly helps in spread of mealy bugs. Prevention of movement of ants by destruction of its colonies help to slowdown the population build up of papaya mealybugs in the mulberry garden.
- Farm equipments used in the infested mulberry garden should be sanitized before moving to uninfested field.
- Flood irrigation in the infested garden helps the bugs to spread to healthy plants easily. Using sprinklers or rain guns (power sprinklers) for irrigation found effective to keep the pest population below economic injury level in hotspot area where water source is adequate.

Irrigation through sprinkler reduces the intensity of papaya mealybug in mulberry garden

PHYSICAL METHOD

Water Jetting

Sucking pests are naturally controlled in rainy season. When it rains heavily, many younger stages of the insects get dislodged from plant surfaces by the combined effect of wetness and the kinetic energy of the rain drops as well as strong wind. This observation suggests that by directing a powerful jet of water at infested plant parts, the pests could be controlled successfully. However, this practice could not become popular because fetching bulk quantity of water for jetting is cumbersome, time consuming and expensive. The scientists of Central Silk Board (Sakthivel *et al*. 2011 a,b & c) have developed an effective and user friendly water jetting system for control of papaya mealybug and other sucking pests in mulberry garden in which a portion of irrigation water from main pipeline is diverted through a garden hose for jetting by fitting suitable adopter to facilitate to connect the hose.

Arrangements for diversion of irrigation water for jetting in mulberry garden to manage papaya mealybug and other sucking pests

Water jetting involves physical force which hits on the infested plant parts to dislodge and washout the pests so that the crop is kept free from the population of the pests. The sucking pests including papaya mealybug are soft bodied slender insects and the force of water when jetted with a reasonably high pressure lethally injures most of them as well as fallen ones will be available to ground predators and this will also make their return to the host difficult. Water jetting not only eliminates the pest population but also removes the black sooty mould and dirt particles from the leaf surface and hence it enhances the photosynthetic activities resulted with increase in leaf quality and yield. The jetted water simultaneously irrigates the garden.

Water Jetting in papaya mealybug infested mulberry garden

Spray of insecticides is not recommended as the exotic parasitoids released under classical bio control programme are very much sensitive to the insecticide. Moreover, the chemical applications also destroy the native natural enemy complex. Spray of strong jet of water and release of natural enemies are found ideal under this condition to combat the pest successfully. Therefore, this water jetting technology is found effective, economic and eco-friendly, helps to avoid use of noxious chemical insecticides and to contain the incidence of pests even at the time of silkworm rearing, conserves natural enemy complex and also compatible with bio-control measures.

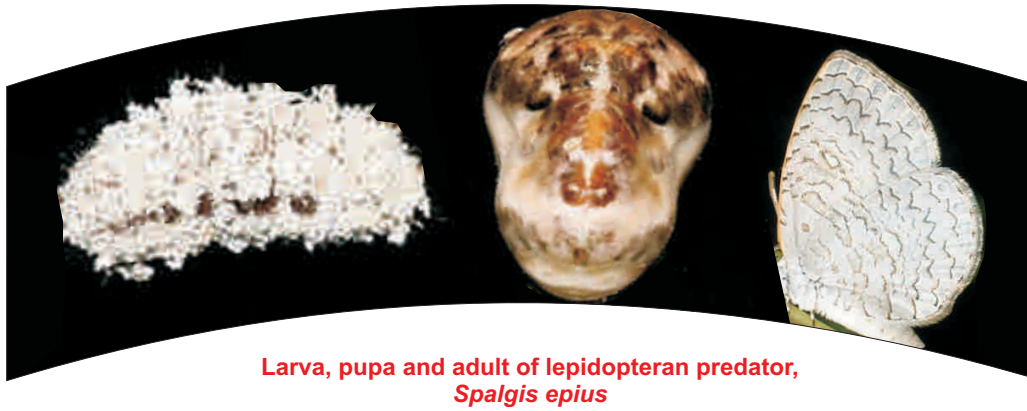
Water Jetting : An user friendly technology

Routine water jetting helps to maintain pest free mulberry garden

BIOLOGICAL METHODS

Papaya mealy bug has never gained the status as a serious pest in several countries, probably due to the presence of an endemic natural enemy complex. Hence bio-control was identified as a key component of the management strategy for the papaya mealybug.

The natural enemies feeding on the papaya mealybug such as several coccinellids, lacewings, wasps, spiders *etc* and parasitoids are abundantly available in mulberry ecosystem. Lepidopteran predator, *Spalgis epius* (Lycaenidae) is a well known representative of carnivorous butterfly feeding dominantly on the ovisacs, nymphs and adults of papaya mealybug. They may be provided with non-toxic environment for proliferation and conservation of the native natural enemy complex is essential to reduce the mealybug population.

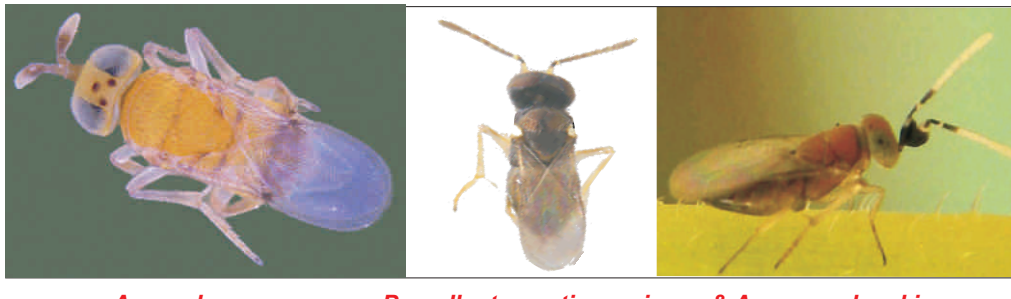


Larva, pupa and adult of lepidopteran predator, *Spalgis epius*

***Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Spalgis epius* and spider *(Oxyopes* sp.*)* feeding on papaya mealybug**

List of natural enemy complex of Papaya mealybug recorded in Tamil Nadu, India

Natural Enemies	Family	Relative abundance
A. Predators		
Coleoptera		
Anegleis cardoni (Weise)	Coccinellidae	*
Axinoscymnus puttarudriahi Kapur & Munshi	Coccinellidae	*
Brumus suturalis (Fabricius)	Coccinellidae	*
Cheilomenes sexmaculata (Fabricius)	Coccinellidae	**
Coccinella septempunctata (Linnaeus)	Coccinellidae	**
Cryptolaemus montrouzieri Mulsant	Coccinellidae	***
Micraspis discolor (Fabricius)	Coccinellidae	***
Nephus regularis (Sicard)	Coccinellidae	*
Scymnus coccivora Ayyar	Coccinellidae	**
Neuroptera		
Chrysoperla zastrowi sillemi (Esben-Petersen)	Chrysopidae	**
Dichochrysa astur (Banks)	Chrysopidae	*
Lepidoptera		
Spalgis epius (Westwood)	Lycaenidae	***
Spiders (Arachnida)		
Oxyopes birmanicus Thorell	Oxyopidae	*
Oxyopes javanus Thorell	Oxyopidae	***
Oxytate virens Thorell	Thomisidae	**
Plexippus paykulli Audouin	Salticidae	*
B. Parasitoids (Exotic)		
Hymenoptera		
Acerophagus papayae Noyes & Schauff	Encyrtidae	Imported and introduced in India
Anagyrus loecki Noyes & Menezes	Encyrtidae	
Pseudleptomastix mexicana Noyes & Schauff	Encyrtidae	



Acerophagus papayae, Pseudleptomastix mexicana & Anagyrus loecki

(Courtesy: Dale E. Meyerdirk, USDA APHIS PPQ United States & NBAII, Bangalore)

In general, biological control is regarded as most effective long-term solution to mealybug infestation because, the parasitoids and predators are self perpetuating, persists even when the mealybug is at low population densities. In classical biological control, the natural enemies of the exotic introduced pest are imported, mass multiplied and inoculative releases made in the affected areas/infested garden. The parasitoids thus released will perpetuate and multiply in large number under field condition and start spreading wherever pest has disseminated.

Three species of encyrtid parasitoids *A. papayae, P. mexicana* and *A. loecki* which are host specific to papaya mealy bug have effectively controlled the pest when introduced into countries such as Guam, Palau islands and Sri Lanka. Surprising, in Sri Lanka, *A. papayae* alone could control the pest within six months of its release.

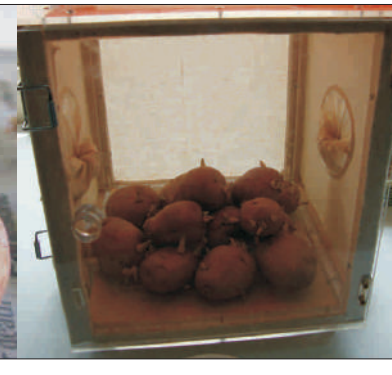
In Tamil Nadu the recent outbreak of papaya mealybug was brought under control successfully in hot spot areas after mass multiplication and release of all three parasitoids by NBAII Bangalore, Tamil Nadu Agricultural University, Central Silk Board nested units and Department of Sericulture, Government of Tamil Nadu.

Mass multiplication techniques of parasitoids

In laboratory

The parasitoids are mass multiplied in laboratories by culturing the papaya mealybugs on potato sprouts adopting the following procedures :

- Seed potatoes are washed with water, disinfected using 5% sodium hypochlorite solution and treated with 100 ppm gibberellic acid for half an hour.
- Then the potatoes are kept in trays containing wet sand, covered with black cloth and allowed for germination.
- After a week period the potatoes with good sprouts have been selected and provided with egg masses and crawler stage of papaya mealybug for establishment of population.
- The infested potatoes are then shifted to transparent cages and adult parasitoids are released for parasitization and covered with black cloth after keeping 1-2 paper strips streaked with 10% honey solution inside the cage as feed.
- From 15th day onwards emergence of parasitoids will start and they will be collected using aspirators and released in affected area @ 100-200 parasitoids per village.

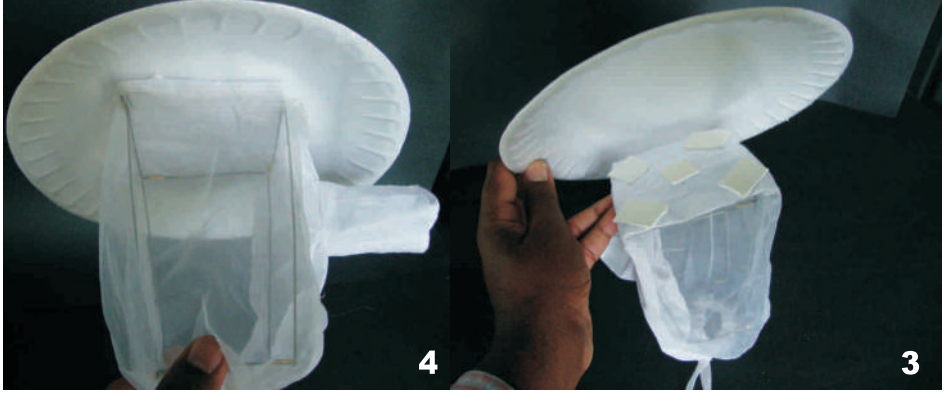




Mass Multiplication of parasitoids in laboratory

Under field condition

In order to facilitate easy multiplication of parasitoids by farmers themselves in their own field, an innovative cage named “Field Bio-Cage” has been developed. In this technology the parasitoids are multiplied in the affected mulberry garden itself (in situ multiplication) utilizing the natural infestation by fixing the mini “Field Bio-Cages” on the shoots bearing heavy population of papaya mealybug. The cages are prepared by making iron frames using 18 gauges of GI rods which is provided with a suitable cloth cover by stitching very fine transparent nylon mesh in three sides and cotton cloth for 4th side as well as top side of the frame. The bottom side of the cloth cover is kept open which should be 2-3 inches longer than the bottom end of the frame and attached with a tape to tie the cage with the shoot. A cloth tube is attached to the cage for release of gravid parasitoids into the cage and collection of emerged parasitoids. A thermo-cool plate is fixed on the top of the cage to protect from sunlight and rain.

Steps for Preparation of Field Bio-Cage



Fixing "Field Bio-cage" on papaya mealybug infested mulberry shoot

Release of parasitoids into the cages for multiplication

The quantity of gravid females released in to the "Field Bio-Cages" should be based on the counts of 2nd instar nymphs. However, crawlers can also be taken for consideration to release the parasitoids consequently in to the same cage 2-3 days after first release. Approximately, 100-250 parasitoids could be produced per cage depending upon the availability of nymph's population.

Watch the emergence of parasitoids inside the cage through the transparent nylon mesh and collect them in test tubes through cloth tube hole using an aspirator and release in the affected area. It is best to remove the cages 8-10 days after release of gravid parasitoids, clip off the treated shoots bearing parasitized (mummified) nymphs and tie and hang them in shady portion preferably bottom side of the mulberry plants in the affected area. The shoots may also be kept in perforated plastic jars in room temperature till emergence of parasitoids and released.

Further, for easy perpetuation of parasitoids under field conditions the infested mulberry shoots can be collected from the gardens after 10 days of inoculation, the infested shoots of these gardens can be used for transfer of parasitoids to other papaya mealybug infested gardens, where parasitoids has not been released. Field Bio-cages also facilitate easy in situ multiplication of other natural enemies *i.e.* the predatory coccinellids and the parasitoids of other pests under field condition without culturing the pests artificially under laboratory condition.

Field release of parasitoids

PRECAUTIONS

Spraying insecticides is often experienced with resurgence of this pest because it resists many of the chemicals. Concurrently, the natural enemy complex is destructed totally as they are highly sensitive. Therefore, it is essential to keep toxic free environment for proliferation of the introduced exotic parasitoids as well as other native natural enemies. Emphasis should also be given to effective eco-friendly methods viz. water jetting, biological control, botanicals etc. to avoid spray of chemical insecticides for management of other pests infesting mulberry.

Indiscriminate use of insecticides in mulberry garden develops resistance in pests but destroys the natural enemy complex, causes toxic effect to silkworm which resulted with crop failure and economic loss besides health hazards to the users.

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Field Bio-Cage: An innovation for mass multiplication of parasitoids of papaya mealybug and other natural enemies under field condition

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