सत्यमेव जयते

AESA BASED IPM PACKAGE

AESA based IPM – Cashewnut

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The AESA based IPM - Cashewnut, was compiled by the NIPHM working group under the Chairmanship of Dr. Satyagopal Korlapati, IAS, DG, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. During last century, IPM relied substantially on economic threshold level and chemical pesticides driven approaches. However, since the late 1990s there is conscious shift to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy.The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

Sincere efforts have been made by resource personnel to incorporate ecologically based principles and field proven technologies for guidance of the extension officers to educate, motivate and guide the farmers to adopt AESA based IPM strategies, which are environmentally sustainable. I hope that the AESA based IPM packages will be relied upon by various stakeholders relating to Central and State government functionaries involved in extension and Scientists of SAUs and ICAR institutions in their endeavour to promote environmentally sustainable agriculture practices.

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(Avinash K. Srivastava)

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FOREWORD

IPM is a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanicals and chemical. Over the years IPM underwent several changes, shifting its focus from damage boundary, economic injury to economic threshold. Currently most stake holders rely upon economic threshold levels (ETL) and tend to apply chemical pesticides at the first instance in the event of a pest attack, though Government of India has advocated need based and judicious application of chemicals. This approach is likely to cause adverse effects on agro-ecosystems and increase the cost of agricultural production due to problems of pest resurgence, insecticide resistance and sustainability.

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Experience in different countries have since shown that AESA, which takes into account ecological principles and relies on the balance that is maintained by biotic factors in an ecosystem has also resulted in reduction in cost of production and increase in yields. AESA based IPM also takes into account the need for active participation of farmers and promotes experiential learning and discovery based decision making by farmers. AESA based IPM in conjunction with ecological engineering for pest management promotes bio-intensive strategies as against current chemical intensive approaches, while retaining the option to apply chemical pesticides judiciously as a measure of last resort.

The resource persons of NIPHM and DPPQ&S have made sincere efforts in revising IPM packages for different crops by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques and other IPM options with the active cooperation of crop based plant protection scientists working in State Agricultural Universities and ICAR institutions. I hope this IPM package will serve as a ready reference for extension functionaries of Central/ State Governments, NGOs and progressive farmers in adopting sustainable plant protection strategies by minimizing the dependence on chemical pesticides.

(Utpal Kumar Singh)

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PREFACE

Need for environmentally sustainable agricultural practices is recognised worldwide in view of the wide spread ecological imbalances caused by highly intensive agricultural systems. In order to address the adverse impacts of chemical pesticides on agro-ecosystems, Integrated Pest Management has evolved further from ETL based approach to Agro-ecosystem Analysis based Integrated Pest Management (IPM).

In AESA based IPM the whole agro-ecosystem, plant health at different stages, built-in-compensation abilities of the plant, pest and defender population dynamics, soil conditions, climatic factors and farmers' past experience are considered. In AESA, informed decisions are taken by farmers after field observation, AESA chart preparation followed by group discussion and decision making. Insect zoo is created to enable the farmer understand predation of pests by Natural Enemies. AESA based PHM also results in reduction of chemical pesticide usage and conserves the agro-ecosystems.

Ecological Engineering for Pest Management, a new paradigm, is gaining acceptance as a strategy for promoting Biointensive Integrated Pest Management. Ecological Engineering for Pest Management relies on cultural practices to effect habitat manipulation and enhance biological control. The strategies focus on pest management both below ground and above ground. There is a growing need to integrate AESA based IPM and principles of ecological engineering for pest management.

There is a rising public concern about the potential adverse effects of chemical pesticides on the human health, environment and biodiversity. The intensity of these negative externalities, though cannot be eliminated altogether, can be minimized through development, dissemination and promotion of sustainable biointensive approaches.

Directorate of Plant Protection Quarantine and Storage (DPPQS), has developed IPM package of practices during 2001 and 2002. These packages are currently providing guidance to the Extension Officers in transferring IPM strategies to farmers. These IPM package of practices, have been revised incorporating the principles of AESA based IPM in detail and also the concept of Ecological Engineering for Pest Management. It is hoped that the suggested practices, which aim at enhancing biodiversity, biointensive strategies for pest management and promotion of plant health, will enable the farmers to take informed decisions based on experiential learning and it will also result in use of chemical pesticides only as a last resort & in a safe and judicious manner.

(K. SATYAGOPAL)

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AESA BASED IPM PACKAGE FOR CASHEWNUT

Cashewnut plant description:

The cashewnut tree (*Anacardium occidentale* L; Family: Anacardiaceae) is a tropical evergreen plant. The cashewnut tree is native to Central and South America. The tree is very attractive, it produces beautiful rose-coloured scented flowers in panicles, followed by the enticing red fruits. It can grow to 15 metres and favours dry tropical conditions especially in coastal regions. It is a fast growing and strong tree that will tolerate dry conditions once it is established. It is best grown in well drained sandy or sandy loam soils. They will not tolerate poorly drained soils and can be prone to damage from strong winds. Plant can grow as high as 14 metres (46 ft), but the dwarf cashew that grows up to 6 metres (20 ft) has proved more profitable with earlier maturity and higher yields. The fruit of the cashew tree is an accessory fruit (sometimes called a pseudocarp or false fruit). What appears to be the fruit is an oval or pear-shaped structure, a hypocarpum, that develops from the pedicel and the receptacle of the cashew flower (called the cashew apple). It ripens into a yellow and/or red structure about 5–11 cm long. It is edible, and has a strong "sweet" smell and a sweet taste. The pulp of the cashew apple is very juicy, but the skin is fragile, making it unsuitable for transport.

The true fruit of the cashew tree is a kidney or boxing-glove shaped drupe that grows at the end of the cashew apple. The drupe develops first on the tree, and then the pedicel expands to become the cashew apple. Within the true fruit is a single seed, the cashew nut. Although a nut in the culinary sense, in the botanical sense the nut of the cashew is a seed. The seed is surrounded by a double shell containing an allergenic phenolic resin, anacardic acid, a potent skin irritant chemically related to the better-known allergenic oil urushiol which is also a toxin found in the related poison ivy.

I. PESTS

A. Pests of National Significance

1. Insect pests

1.1 Mosquito bug: *Helopeltis antonii* Signoret (Hemiptera: Miridae)

1.2 Stem and root borer: *Plocaederus ferrugenius* L. (Coleoptera: Cerambycidae)

1.3 Leaf miner: *Acrocercops syngramma* Meyrick (Lepidoptera: Gracillariidae)

1.4 Leaf and blossom webber: *Lamida moncusalis* Walker (Lepidoptera: Pyraustidae)

1.5 Flower thrips: *Rhynchothrips raoensis* Ramakrishna Ayyar (Thysanoptera: Thripidae)

1.6 Foliage thrips: *Selenothrips rubrocinctus* Giard. (Thysanoptera: Thripidae)

***Rhipiphorothrips cruentatus* Hood (Thysanoptera: Thripidae)**

***Retithrips syriacus* Mayet (Thysanoptera: Thripidae)**

2. Diseases

2.1 Dieback or Pink disease: *Corticium salmonicolor* Berk. & Broome

2.2 Damping off: *Phytophthora palmivora* (Butler)

2.3 Anthracnose: *Colletotrichum gloeosporioidesm* (Penz.) Penz. and Sacc.

2.4 Inflorescence blight: *Colletotrichum mangiferae* Kelker and *Phomopsis anacardii* Early & Punith

2.5 Shoot rot and leaf fall: *Phytophthora nicotianae* var. *nicotianae* Breda de Haan

3. Weeds

Broadleaf

3.1 Pigweed *Amaranthus viridis* Hook. F. Amaranthaceae

3.2 Common purselane *Portulaca oleracea* L. Portualacaceae

3.3 False amaranth *Digera arvensis* Forssk. Amaranthaceae

3.4 *C*arrot grass *Parthenium hysterophorus* L. Asteraceae

3.5 Goat weed *Ageratum conyzoides* L. Asteraceae

3.6 Coat buttons *Tridax procumbens* L. Fabaceae

Grasses

3.7 Barnyard grass *Echinochloa crusgalli* (L.) Beauv. Poaceae

3.8 Bermuda grass *Cynodon dactylon* (L.) Pers. Poaceae

Sedges

3.9 Purple nutsedge *Cyperus rotundus* L. Cyperaceae

3.10 Flat sedge *Cyperus iria* L. Cypraceae

B. Pests of Regional Significance

1. Insect pests

1.1 Apple and nut borer: *Thylocoptila paurosema* Meyrick (Lepidoptera: Pyralidae) (Goa, Tamil Nadu)

1.2 Mealybug: *Ferrisia virgata* (Cockerell) (Hemiptera: Pseudococcidae)

1.3 Hairy caterpillar: *Metanastria hyrtaca* Cramer (Lepidoptera: Lasiocampidae)

1.4 Leaf folder: *Sylepta aurantiacalis* Fisch (Lepidoptera: Pyralidae)

1.5 Red hairy caterpillar: *Amsacta albistriga* (Walker) (Lepidoptera: Arctiidae)

1.6 Aphids: *Aphis odinae* (van der Goot) (Hemiptera: Aphididae)

1.7 Leaf knot weevil: *Apoderus tranquebaricus* Fabricius (Coleoptera: Curculionidae)

1.8 Cashew scale: *Pseudaonidia trilobitiformis* (Green) (Hemiptera: Diaspididae)

II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PEST MANAGEMENT (IPM)

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical

factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of white paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are:

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based IPM:
Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting material
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation

Observe the field regularly (climatic factors, soil and biotic factors):

Farmers should

- Monitor the field situation at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation and Pest: Defender ratio (P: D ratio)
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

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Plant compensation ability:

Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

Understand and conserve defenders:

- Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem
- Avoid the use of chemical pesticides especially with broad-spectrum activity

Insect zoo:

In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the field and brought to a place for study. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of cashew nut pests can be divided into 3 categories; 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situation

Soil conditions	**:**
Weather conditions	**:**
Diseases types and severity	**:**
Weeds types and intensity	**:**
Rodent damage (if any)	**:**
No. of insect pests	**:**
No. of natural enemies	**:**
P: D ratio	**:**

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial

biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making:

Farmers become experts in crop management:

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

- Farmers are capable of improving farming practices by experimentation
- Farmers can share their knowledge with other farmers

AESA methodology:

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:

    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.

- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart

- Keeping records of what has happened help us making an analysis and draw conclusions

Data to be recorded

- **Plant growth (weekly):** Height of plant; number of leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Seeds; fertilizer; pesticides; labour
- **Harvest:** Yield (Kg/acre); price of produce (Rs./Kg)

Some questions that can be used during the discussion

- Summarize the present situation of the field.
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. Farmers cannot base their decisions on just a simple count of pests. They will have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather condition, etc.) and their own economic and social situation before they can make the right crop management decisions. In ETL based IPM, natural enemies, plant compensation ability and abiotic factors are not considered. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P: D ratio.

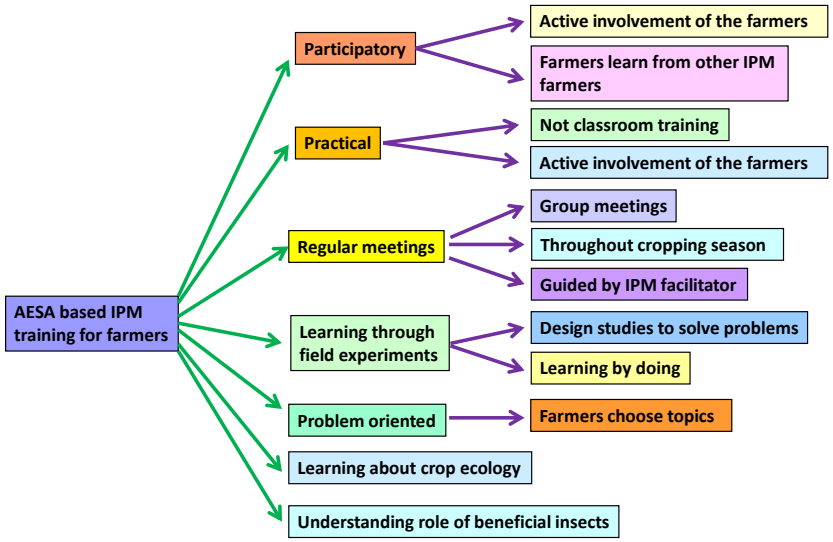
AESA and farmer field school (FFS)

AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach and therefore it has become an integral part of FFS.

Farmers can learn from AESA

- Identification of pests and their nature of damage
- Identification of natural enemies
- Management of pests
- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills



B. Field scouting

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do field scouting in their own fields at regular intervals to monitor the major pest situation.

Surveillance on pest occurrence in the field should commence soon after crop establishment and at weekly intervals thereafter. In each field, select five spots randomly. Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

For insect pests:
Mosquito bug, aphids, mealybugs and scales: Count and record the number of both nymphs and adults on five randomly selected twigs per plant.

For thrips: Count and record the number of nymphs and adults of thrips present on five twigs/ leaves per plant (tapping method also can be used to count thrips).

For leaf miner: Only the number of live mines on five randomly selected twigs/leaves per plant should be counted and recorded.

For *Plocadaerus*, *Lamida*, *Sylepta*, *Metanastria*, *Thylocoptila*, *Amsacta* etc.: Total number of fruits, damaged fruits due to *Plocadaerus*, *Lamida*, *Sylepta*, *Metanastria*, *Thylocoptila*, *Amsacta* and number of larvae on individual plants should be counted and recorded.

For diseases:
Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

Root sampling: Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth or ooze). It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves and/or sheaths of each plant for lesions. Leaf diseases cause most damage during the seedling and flowering stages of plant growth. Observe for the symptoms and signs on the infected plant parts. Determine the percent area of leaf infection by counting the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

Stem, flower and capsule sampling: Carefully examine the stem, flower, and capsule of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, and capsule

should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers and capsules infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone trap catches for *Lamida*, *Sylepta*, *Metanastria*, *Thylocoptila* and *Amsacta*: Pheromone traps for *Lamida*, *Sylepta*, *Metanastria*, *Thylocoptila* and *Amsacta* @ 4-5/acre have to be installed, if available. Install the traps for each species separated by a distance of >75 feet. Fix the traps to the supporting pole at the height of mid canopy. Change of lures should be made at 2-3 week interval (regular interval) or based on loss of lure efficacy. During each week of surveillance, the number of moths/trap/week should be counted and recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Yellow/blue pan water/sticky traps

Set up yellow pan water/sticky traps at height of mid canopy for monitoring aphids and leaf miners and blue sticky traps for flower and leaf thrips @ 4-5 traps/acre. Locally available empty tins can be painted yellow/blue coated with grease/Vaseline/castor oil on outer surface may also be used.

E. Light traps

Set up light traps @ 1 trap/acre at the height of mid canopy for monitoring and mass trapping insects. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm).

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr *et al*. 2004a,b).

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelter such as overwintering sites, moderate microclimate etc.
3. Alternate hosts when primary hosts are not present.

Ecological engineering for pest management – Above ground:

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.

Ecological engineering for pest management – Below ground:

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen, fruits, insects, etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, *Chrysoperla,* earwigs, etc.

Ecological Engineering Plants

Attractant plants

Dill

Anise

Caraway

Spearmint

Buckwheat

Yellow clover

White clover

Tansy

Cowpea

Fennel

Cosmos

Parsley

Mustard

Sunflower

Buckwheat

Carrot

French bean

Marigold

Cornflower

Coriander

Sesame

Border plants

Sorghum

Maize

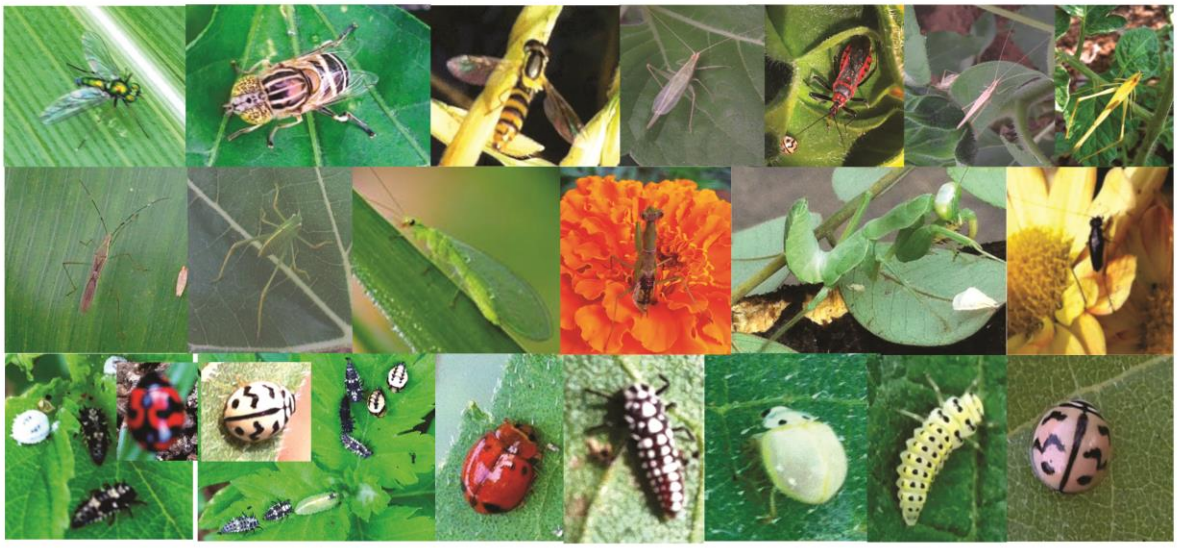
Pearl millet

The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types

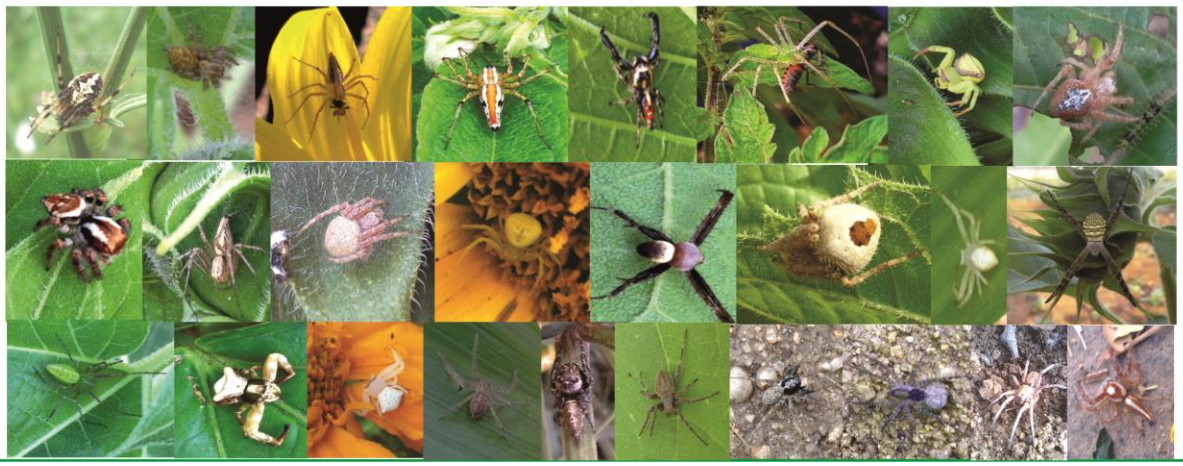
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Destroy the alternate host plants • Sow the ecological engineering plants • Sow sorghum/maize/ pearl millet in 4 rows all around the main crop as guard/barrier crop • Plough the field before planting to destroy existing weeds in the field. • Plough deep after harvest to bury the pupae. • Seed nuts must be collected during peak period of harvest and sun dried for two to three days. • Medium size nuts (7-9 gm) may be selected to get vigorously growing seedlings. • Seed nuts should be soaked over night in water before sowing. • Sow the soaked nuts in the polythene bags filled with potting mixture. • Seedlings will be ready for grafting 40-50 days after germination.
Selection of root stock:	
	Cultural control: • Select 40-50 days old healthy seedlings having unbranched main stock
Selection of scions:	
	Cultural control: • Select a high yielding variety cashew as a mother plant to collect adequate number of scions. • The graft should be prepared on the root stock with appropriately selected scions and will be ready for planting after 5-6 months.
Nursery*	
	Common mechanical practices: • Remove new sprouts emerging from root stock at frequent intervals. • Shift the grafts frequently from one place to another to prevent them from striking roots into the ground.
Leaf spot	• Follow the common cultural, mechanical and biological practices
Planting stage*	
	Common cultural practices: • Collect and destroy plant parts infested with insect pest and diseases • Use weed free, healthy suckers for planting. • Remove and destroy crop residues. • Avoid planting during wet weather condition • Take up planting in shade free area
Nutrients	• Cashew responds well to manuring which is essential to get early and high yields in new plantations and to get regular high yields in mature plantations. • Since cashew is grown under neglected conditions, application of

	nutrients is not usually done. Cashew responds well to fertilizer application. • Application of organic manure at 30 kg/tree along with inorganic fertilizers i.e., NPK at 500 g + 125 g + 125 g /tree in two splits during June-July and September- October based on soil nutrient status increases the yield. • In red soils recommended dose can be applied in single split**.** • In addition, neem cake and SSP @ 100 g per pit should be applied. • Improving the soil fertility through application of organic manures and raising of green manure crops. • Being a deciduous tree cashew provides approximately 5.0 tons of cashew biomass in the form of fallen leaf, twigs, flowers and apples. Use of earth worms for the production of vermicompost from cashew biomass is a low cost technology. • About 3.5 tons of vermicompost can be produced from an area of 1 ha of grown up cashew orchard.
Weeds	• Until tree canopies shade out the weeds, weeding is essential around the tree trunks up to a radius of about 2 m. • The rest of the orchard requires slashing of under growth at least twice a year. • The weeding cycles are generally confined to the pre-monsoon and post-monsoon periods to coincide with the fertilizer application. Therefore, fertilizers should be applied after weeding.
***** Apply *Trichoderma viride/ harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage:	
	<u>Common cultural practices:</u> • Collect and destroy crop debris • Collect and destroy disease infected and insect damaged plant parts • Provide irrigation at critical stages of the crop • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed • Remove weed plants **<u>Common mechanical practices:</u>** • Handpick the older larvae during early stages • Collect and destroy plant parts infested with insect pest and diseases • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Set up bonfire during evening hours at 7-8 pm **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering

<table>
<tr><td></td><td>

- Augmentative release of natural enemies

</td></tr>
<tr><td>Nutrients</td><td>

<table>
<tr><th>Age of tree (years)</th><th colspan="3">June-July 1st Dose</th><th colspan="3">September-October 2nd Dose</th></tr>
<tr><td></td><td>N (g/tree)</td><td>P (g/tree)</td><td>K (g/tree)</td><td>N (g/tree)</td><td>P (g/tree)</td><td>K (g/tree)</td></tr>
<tr><td>1st</td><td colspan="6">FYM, Neem cake, SSP in pits</td></tr>
<tr><td>2nd</td><td>85</td><td>20</td><td>20</td><td>85</td><td>20</td><td>20</td></tr>
<tr><td>3rd</td><td>170</td><td>40</td><td>40</td><td>170</td><td>40</td><td>40</td></tr>
<tr><td>4th onwards</td><td>250</td><td>60</td><td>60</td><td>250</td><td>60</td><td>60</td></tr>
</table>

- Fertilizer is applied annually at the end of the rainy season into a shallow trench at the drip line of trees.
- It is also recommended that fertilizer be applied in split doses during pre-monsoon (May-June) and post-monsoon (September-October) periods to assure better uptake of nutrients.
- If a single application is done, the post-monsoon period is more suitable when ground moisture is adequate.
- One third the recommended dose is applied in the first year, two third the dose in the second year and the full dose thereafter.
- Fertilizers are applied in trenches (10-15 cm deep) dug about 100-150 cm away from the trunk.

</td></tr>
<tr><td>Weeds</td><td>

- Timely hoeing & hand weeding should be done manually / mechanically during initial years.

</td></tr>
<tr><td>Leaf miner, leaf and blossom webber</td><td>

- Follow the common cultural, mechanical and biological practices

</td></tr>
<tr><td>Thrips: Flower thrips and Foliage thrips</td><td>

- Follow the common cultural, mechanical and biological practices

<u>Cultural control:</u>

- Inter crop with *Sesbania grandiflora*, to provide barrier which regulate the thrips population.
- Do not follow chilli or onion intercrop crop – both the crops attacked by thrips
- Sprinkle water over the seedlings to check the multiplication of thrips

</td></tr>
<tr><td>Mealybugs</td><td>

- Follow the common cultural, mechanical and biological practices

<u>Cultural control:</u>

- Regular monitoring and early detection of infestation are essential to combat this menace
- The plantation and neighbouring areas should be free from weeds and alternate hosts
- The infested portion of the plant with mealy bug colonies may be pruned and destroyed
- Fallen leaves under the tree canopy should be collected and burnt to

</td></tr>
</table>

	avoid further spread of the pest.
Scales, leaf folder, aphids	• Follow common biological practices
Flushing stage (in Sept. & Oct.):	
Mosquito bug	**<u>Cultural control:</u>** • Remove alternate hosts such as neem, guava, cocoa, mahogany, cinchona, cotton, apples, grapes, drumstick, black pepper, jamun etc. • Remove the volunteer (self-sown) neem plants in and around cashew plantations. • At the out-break situation, the management programme against this pest should be launched on large scale community basis as the efforts made by an individual farmer may not be of much use. • Monitor crop regularly for signs of damage • Avoid interplanting cashew with other crops which are hosts for *Helopeltis* bugs such as and cotton **<u>Mechanical control:</u>** • Remove the volunteer (self-sown) neem plants and other weeds in and around cashew plantations. **<u>Biological control:</u>** • Follow common biological practices
Flushing and flowering stage (in Nov. & Dec.):	
Stem and root borer	**<u>Cultural control:</u>** • Removal of dead trees and trees with advanced stages of infestation at least once in 6 months. • Avoid injuring the plants by sickle and other garden tools, which otherwise will attract the adult for egg laying. • The affected bark should be removed along with the grubs **<u>Mechanical control:</u>** • Mechanical removal of the immature stages (grubs) of the pest during initial stages of infestation. • Identify the borer hole (alive) and extract mechanically by chiseling out the damaged area of the tree and swab neem oil (50 ml neem oil + 1 liter water + 0.5 ml teepol/5 gm of soap) on the trunk up to a height of 1 meter **<u>Biological control:</u>** • Follow common biological practices
Flowering-fruiting stage (~~Jan.-Feb~~.):	
	<u>Cultural control:</u> • Plant may require irrigation, about 200 litre of water per adult tree may be applied an interval of 15 days.
Mosquito bug	• Same as in flushing stage
Stem and root	• Same as in flushing and flowering stage

borer	
Fruiting – harvesting stage ~~(march- April- May~~):	
	<u>Common cultural practices:</u> • Deep irrigation is effective • About 2000 liter of water per adult tree may be applied at a interval of 15 days. • Mature nuts that fall on the ground may be collect as it may result production of pooor quality kernels.
Fruit and nut borer	**<u>Biological control:</u>** • Follow common biological practices **<u>Chemical control:</u>** • Spray dichlorvos 76% EC @ 376-501 ml in 600-800 l of water/acre
Stem and root borer, Leaf and blossom webber, Mealybug, Thrips, Mosquito bug	• Same as in above
Nutrients	• Apply deficient micronutrient if any.
Weeds	• Keep the orchard weed free.

Management of regional importance insect pests

Leaf knot weevil/cachew weevil:

- Remove bark from infested areas and destroy any larvae or pupae found, this process should be repeated every month for up to six months
- Severely infested trees should be removed and destroyed
- Remove all adult weevils from tree prior to destruction and also remove bark and kill all larvae and pupae

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

Insecticide resistance: Resistance to insecticides may be defined as 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species' (IRAC). Cross-resistance occurs when resistance to one insecticide confers resistance to another insecticide, even where the insect has not been exposed to the latter product.

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including the initial frequency of resistance alleles present in the population, how rapidly the insects reproduce, the insects' level of resistance, the

migration and host range of the insects, the insecticide's persistence and specificity, and the rate, timing and number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

General strategy for insecticide resistance management: The best strategy to avoid insecticide resistance is prevention and including insecticide resistance management tactics as part of a larger integrated pest management (IPM) approach.

1) Monitor pests: Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.

2) Focus on AESA. Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

3) Ecological engineering for pest management: Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.

4) Take an integrated approach to managing pests. Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.

5) Mix and apply carefully. While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.

6) Alternate different insecticide classes. Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

7) Preserve susceptible genes. Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VI. NUTRITIONAL DEFICIENCIES

Potassium: Chlorosis occur first on leaf margins and proceed to entire leaf. Under severe deficiency, older leaves seem to complete pale yellow and dry.
Correction Measure: Foliar spray of KCl@1%

Iron: Chlorosis occur first in young leaves; young leaves seem to complete pale yellow in color.
Correction Measure: Foliar spray of FeSO4@0.5%

Zinc: necrotic spots occur on leaves, younger leaves become small.
Correction Measure: Foliar spray of ZnSO4@0.5%

VII. COMMON WEEDS

1. Pigweed: *Amaranthus viridis* Hook. F. Amaranthaceae

2. Common purselane: *Portulaca oleracea* L. Portualacaceae

3. False amaranth: *Digera arvensis* Forssk. Amaranthaceae

4. *C*arrot grass: *Parthenium hysterophorus* L. Asteraceae

5. Goat weed: *Ageratum conyzoides* L. Asteraceae

6. Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. Poaceae

7. Bermuda grass: *Cynodon dactylon* (L.) Pers. Poaceae

8. Purple nutsedge: *Cyperus rotundus* L. Cyperaceae

9. Flat sedge: *Cyperus iria* L. Cyperaceae

10. Coat buttons: *Tridax*

***procumbens* L. Fabaceae**

VIII. DESCRIPTION OF INSECT PESTS

1) Mosquito bug:

The mosquito bug is considered to be the most serious pest of cashew in India, and causes more economic loss to the crop than any other pest. It is estimated that this pest alone is responsible for damage of nearly 25% of shoots, 30% of inflorescence and 15% of tender nuts. It causes more than 30% economic loss by inflorescence blight and immature nut fall.

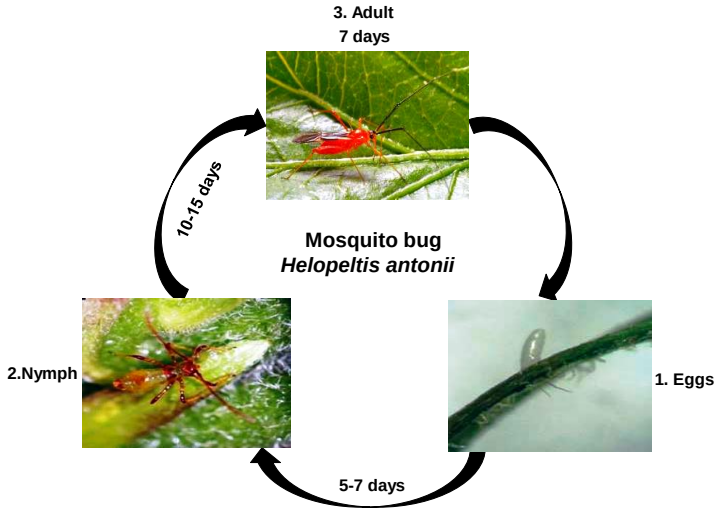
Biology:

Egg: Female bug lays reniform and creamy white eggs singly by deeply inserting them into the tender tissues of new shoots, leaf petioles and veins. The presence of chorionic threads projecting outside the tissues is indicative of the presence of eggs inside. Each female bug lays, on an average, 50 eggs. The incubation period of the egg is on an average 5-7 days, at a temperature range of 24-32 ^{o}C and relative humidity of 50-100 per cent. About 60% of the eggs normally hatch out as nymphs.

Nymph: The nymphs go through 5 instars in 10-15 days. The first instar is completed in 1.9 days, second instar in 2.2 days, third in 2.8 days, fourth instar in 2.8 days and fifth instar in 3.2 days and thus nymphal period completes within 13-15 days. Nearly 60 per cent nymphs survive and moult as adults. The nymphs are wingless and smaller, but otherwise resemble the adults. The young nymphs are orange coloured and ant-like.

Adult: The female bug lives for about 7 days, while the longevity of male is 9-10 days. The adult bug is reddish-brown, about 6-8 mm long with a black head, red thorax, black and white abdomen. The pest can easily be recognized by its peculiar pin-like, knobbed process projecting on the dorsal side of its mid thorax. The adult usually feeds during early hours (6-10 am) and makes about 150 feeding punctures per day. The adults are poor flyers, generally fly below the bush and mating takes place mostly on the undersurface of cashew leaves.
The life-cycle is completed in 25-32 days. The bug resembles mosquito in sitting position and hence this pest is known as ‘mosquito bug’.

Life cycle:



1,2 http://www.scielo.cl/scielo.php?pid=S0718-58392013000300015&script=sci_arttext
3. http://www.infonet-biovision.org/default/ct/204/crops

Damage symptoms:

- Nymphs and adults of this mirid bug suck sap from the leaves, young shoots, inflorescence, developing young nuts and apples.
- The injury made by the suctorial mouth parts of the insect results in exudation of a resinous gummy substance from the feeding punctures.
- The tissues around the point of entry of stylets become necrotised and black scab formed, due to the action of the phytotoxin present in the saliva of the bug, infesting the tender shoots / inflorescences at the time of feeding. These lesions turn pinkish brown in 24 hours and become black in 2-3 days.
- Feeding on tender leaves causes crinkling.
- Affected shoots show long black lesions and may cause die-back in severe cases.
- Infested inflorescence usually turns black and die, immature nuts may drop off.
- Heavily infested trees show scorched appearance, leading to the death of shoots and growing tips.



1. Damage on cashew nuts. 2. Young shoot damage 3. Leaf damage

1,2,3. http://www.infonet-biovision.org/default/ct/204/crops

Natural enemies of mosquito bug:

Parasitoids: *Trichogramma* spp., *Telenomus* spp., *Chaetostricha* sp, *Erythmelus helopeltidis*

Predators: Red ant, dragon fly, ladybird beetle, spider, praying mantis, black ant, anthocorid bug

2) Stem and root borer:

The stem and root borer is the most serious pest of cashew as its damage results in death of trees. It is an internal tissue borer and hidden dreaded enemy of cashew tree as it is capable of killing the tree outright. The infestation by the pest is more severe in neglected plantations.

Biology:

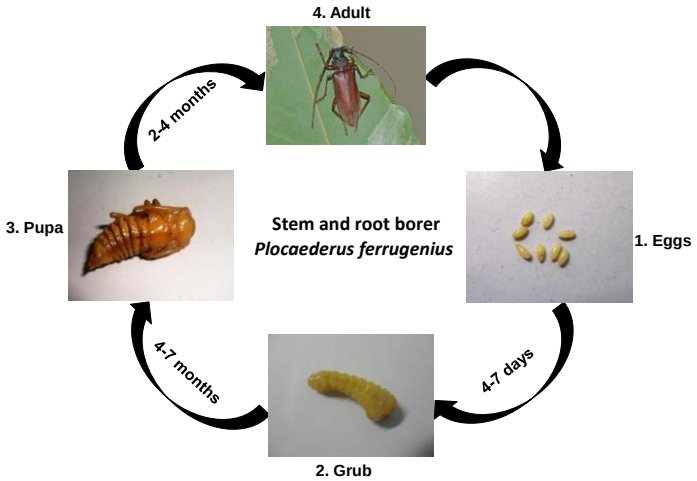
Egg: The female beetle lays 60-90 eggs. The eggs are whitish, ovoid in shape measuring about 3 mm in length (looks like rice grain) and these eggs are inserted into the live tissues in the crevices of the bark at the collar region and exposed roots above the soil. The egg period varies from 4-7 days.

Grub: The eggs hatch out as tiny grubs, which bore into the fresh tissues of the bark, feed on the sapwood tissues and make tunnels in broad and in irregular directions. The tunnels are deepest in the middle and shallow at the sides. The grubs feed inside the tissues for 4-7 months. The grown up grubs are off-white in colour measuring about 7-10 cm in length. The fully fed grubs descends to root zone through tunnels, bores into the heartwood and forms an oval shaped chamber with a circular exit hole for the emergence of adult beetles. The chamber is tightly packed with fibrous tissues and frass, providing protection to the calcarious cocoon within which the grub undergoes pupation.

Pupa: The pupal period lasts for 2-4 months. Adult emergence occurs from November – June coinciding with monsoon rains. The adult beetle lives for 1-3 months. Pest infestation has been found to be heavier in summer than in the rainy season.

Adult: The adult is a medium sized (25-40 mm long), reddish-brown longicorn beetle. In the male, antennae are twice as long as the body, but in the female, they do not surpass the body length. The adult makes an indignant squeaking sound by rubbing the prothorax and mesothorax together.

Life cycle:



1,2,3. file:///C:/Users/COMPAQ/Desktop/ICAR%20Research%20Complex%20for%20Goa.htm

4. http://www.nbaii.res.in/insectpests/images/Plocaederus-ferrugineus10.jpg

Damage symptoms:

- Stem borer infestation could be identified by the presence of small holes at the collar region, gummosis, extrusion of frass through the holes at the collar region, yellowing and shedding of leaves, drying up of twigs and gradual death of the tree.
- Adult beetles lay eggs in the crevices of bark on the trunk. The grubs that hatch out, bore into the bark and feed on the sub-epidermal and vascular tissues and the tissues are tunneled in irregular fashion. As a result of the injury to the bark tissues, gum oozes out and gets hardened subsequently resulting in gummosis.
- When the vascular tissues are damaged the ascent of plant sap is arrested and the leaves become yellow and start shedding. In the advanced stages of infestation twigs dry up and the tree dies.
- Cashew trees more than two years of age are prone to be attacked by this pest. However, the infestation is severe in older and neglected plantations. Even though the infestation is noticed throughout the year, the peak period of infestation was observed during summer months.


http://www.icargoa.res.in/dss/images/cashew/cashew
http://creationwiki.org/pool/images/thumb/9/97/Cashewtree.jpg/250px-Cashewtree.jpg

3) Leaf miner:

The leaf miner is a major pest causing serious damage to the tender foliage of post-monsoon flushes.

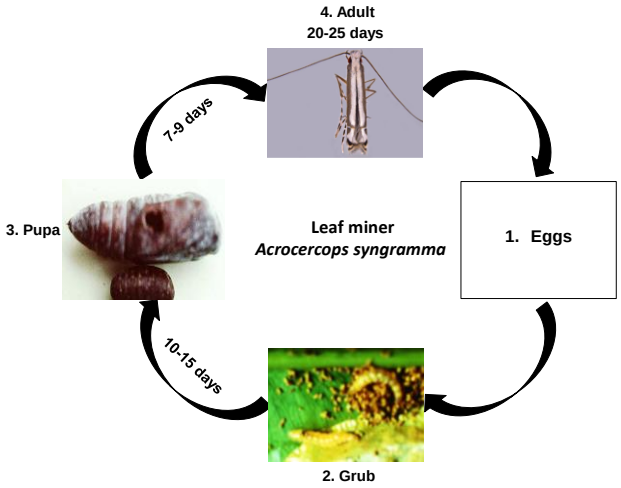
Biology:

Larva: Freshly hatched larvae are pale white in colour and the head is brownish yellow. At maturity, it changes into cherry red colour. The larvae are almost cylindrical, tapering posteriorly. The larvae remain active most of the time under 'blister'. The caterpillars make their own way out of the mined areas and fall to the ground for pupation. The length of fully grown larvae is 5-9 mm. The total larval period ranged between 10 to 15 days.

Pupa: Pupation takes place mostly in the soil and in some cases in the leaf-folds in a thin membranous cocoon. While pupating, they secrete a membranous protective covering. The pupal period lasts 7 to 9 days.

Adult: The adult is a silver grey moth which lays eggs on tender leaves. The life cycle of this pest is 20 to 25 days.

Life cycle:



2. http://pikul.lib.ku.ac.th/insect/007-013%20INSECTS%20of%20Thailand/009%20Systematics/30LEPIDOPTERA/
3,4.http://agritech.tnau.ac.in/horticulture/horti_plantation%20crops_cashewnut.html

Damage symptoms:

- Young caterpillars soon after hatching, start mining the epidermal layer on the upper surface of the tender cashew leaves, leaving tortuous markings. Later on, the thin epidermal mined areas swell up. As a result, the affected areas form blistered patches of greyish white colour.
- When the infested tender leaves mature, big holes are manifested in the damaged areas. The results of injury is the permanent damage to the young leaves which are shrivelled, dried and shed prematurely.
- Nursery seedlings and young plantations are more prone to the infestation of this pest than the older ones.
- Normally 3 to 8 blisters and as many as eight caterpillars are observed on a single leaf.

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2.

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4.

1.http://agritech.tnau.ac.in/horticulture/horti_plantation%20crops_cashewnut.html

2,3,4. http://pikul.lib.ku.ac.th/insect/007-013%20INSECTS%20of%20Thailand/009%20Systematics/30LEPIDOPTERA/

Natural enemies of leaf miner:

Parasitoids: *Chelonus* spp., *Sympiesis* sp

Predators: Lacewings, robber fly, Coccinellids, spiders, red ants, drogon fly, praying mantis etc.,

4) Leaf and blossom webber:

Leaf and blossom webber is reported to be a major pest in East-Coast, particularly in Tamil Nadu, Andhra Pradesh and Orissa. Another species, *Orthaga exvinacea* Hamps (Noctuidae) has also been recorded as pest on cashew, but it is of minor importance.

Biology:

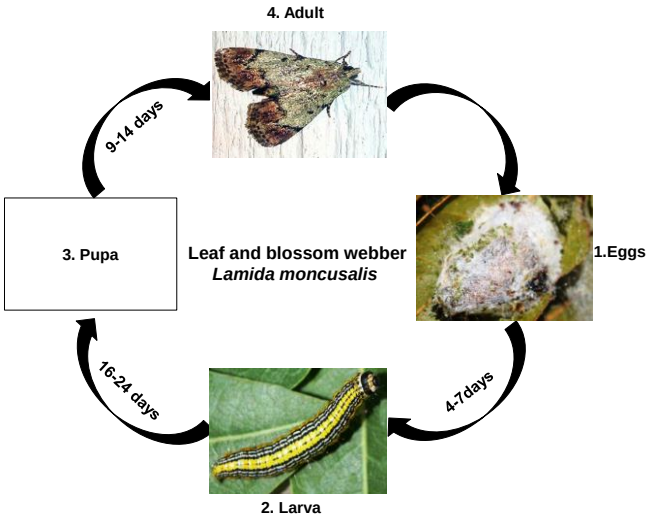
Egg: The eggs are laid singly or in small groups of 3-5 on the leaves during night, more usually on the ventral surface and occasionally on the tender shoots, finely glued on to the surface. Freshly laid eggs are yellowish green in colour, ovoid, some what flat on the surface, but three broad pink bands appear across the surface a day later. The eggs are very small in size (0.85 x 0.59 mm). The total number of eggs laid by a female varies from 18 to 83. The incubation period lasts 4 to 7 days.

Larva: The caterpillar is dark green in colour with yellow longitudinal bands and pinkish dorsal lines. Full grown larva measures 24.0 to 27.0 mm in length and the larval period is 16 to 24 days with 5 larval instar.

Pupa: Pupation takes place in cocoons in the leaf webs. The pre-pupal period lasts 1-4 days and the pupal period 9-14 days. Freshly formed pupa is light yellow with greyish tinge at the thoracic region. The pupa is 13 mm long and 4.1 mm breadth.

Adult: Adult emerges by making a rupture in the pupa. Males have peculiar habit of resting on the dorsal side of the leaves with the tip of the abdomen raised and bent upwards. Males of are dark, while the females are olive green. Pairing takes place after sunset and mating continues for about 30-50 minutes. Females are found to mate only once during their life time. Females kept without mating, lay unfertilized eggs from third day onwards, while gravid females lay eggs within 2 days after mating. Life cycle is completed in 37 - 41 days.

Life cycle:



1,2.. http://entnemdept.ufl.edu/creatures/orn/trees/mahogany_webworm.htm
4. http://mothphotographersgroup.msstate.edu/contrib_living_plate.php?plate=03&init=TM&page=2&sort=h

Damage symptoms:

- Leaf and blossom webbers attack new flushes and inflorescences. The caterpillars of this pest web the shoots and inflorescences together, reamain inside and feed on them.
- Subsequently the webbed portion of the shoots and blossom dry up. Hence, it is called shoot and blossom webbing caterpillar.
- The galleries of silken webs reinforced with castings and scraps of plant parts are indicative of the presence of caterpillars inside the webbed portion. The incidence is found severe mostly on young trees.

1.

1. file:///C:/Users/COMPAQ/Desktop/ICAR%20Research%20Complex%20for%20Goa.htm

Natural enemies of leaf and blossom webber:

Parasitoids: *Tetrastichus* sp, *Trichogramma* sp, *Bracon* spp., *Goniozus* sp, *Trichospilus pupivora*

Predators: King crow, common mynah, wasp, reduviid bug, big eyed bugs, pentatomid bug, earwigs, ground beetle, rove beetle, lacewing, ladybird beetle, spiders, praying mantis, dragon fly, robber fly, red ants etc.,

5) Flower thrips:

Thrips is attack cashew inflorescence. The rasping and feeding injury made by these thrips results in scab on floral branches, apples and nuts, forms corky layers on the affected parts and subsequent shedding of flowers, improper filling of kernel, malformation of nuts and even

immature fruit drop. It is reported that the infestation of flower thrips alone accounts for 16 % fruit drop (2% in mustard stage, 12 % in peanut stage and 2 % in later stages) in cashew.

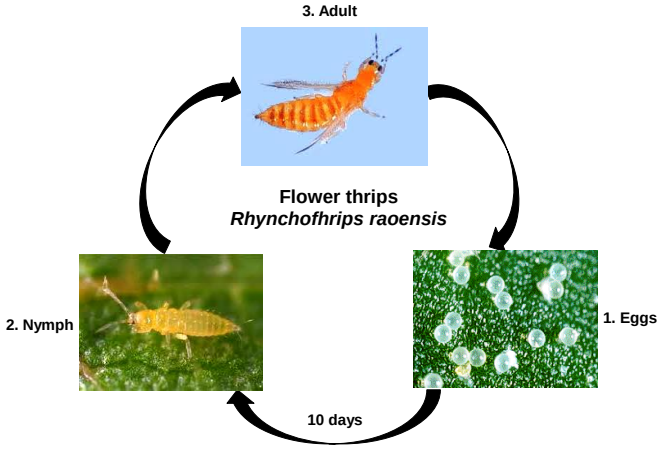
Biology:

Eggs: The eggs are inserted singly in the epidermis of the leaf. The nymphs emerge in about 10 days.

Nymph: The nymphs of red-banded thrips *S. rubrocinctus* can be distinguished by their greenish yellow colour and red bands across the first and last abdominal segments.

Adult: They are minute, slender, fragile, soft bodied, fast moving insects and adults have fringed wings.

Life cycle:



1. http://www.daylilies.org/ahs_dictionary/thrips.html
2. http://www.agf.gov.bc.ca/cropprot/grapeipm/thrips.htm
3. http://www.ces.ncsu.edu/depts/ent/notes/O&T/flowers/note21/note21.html

Damage symptoms:

- Adults and nymphs are seen in colonies on the lower surface of leaves and suck the sap from leaves, inflorescence and apples and nuts.
- As a result of their rasping and sucking activity the leaves become pale brown, scab on floral branches, apples and nuts, forms corky layers on the affected parts.
- In severe cases there will be shedding of leaves and stunting of growth of trees.

Natural enemies of flower thrips:

Predators: Predatory mite (*Amblyseius swirskii*), predatory thrips (*Aeolothirps* spp.), insidious flower bugs (*Orius insidiosus*), ant lion, lygaeids, ladybird beetle, anthocorids etc.,

6) Foliage thrips:

Three species of thrips have been reported as foliage pests of cashew of which *S. rubrocinctus* is of economic importance. This thrip is widespread throughout the tropics, however, it is not considerd to be a major pest because its infestation is restricted to a small area.

Biology:

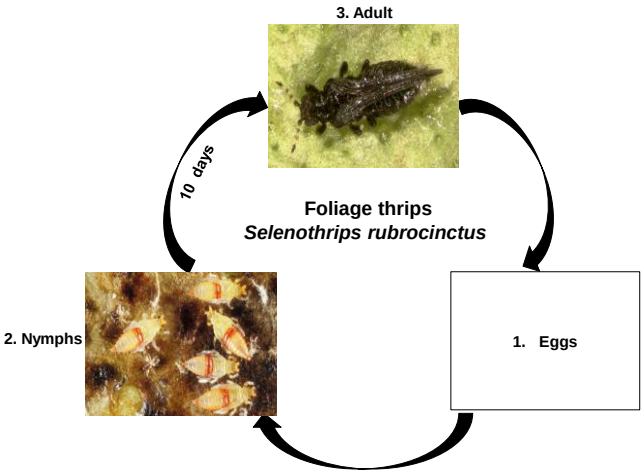
Egg: The eggs are inserted singly in the epidermis of the leaf and each is covered with a drop of excremental fluid which dries to form a black disc like pellicle.

Nymph: The nymphs emerge in about 10 days, wander freely and carry a drop of excremental fluid at the apex of the abdomen which is carried upraised and is lowered at intervals to deposit the droplet which gives a small brown stain when it dries up. The nymphs commonly known as red-banded thrips are distinguished by their greenish yellow colour and recognized by bright red bands across the first and last abdominal segments, while the adults possess a highly polygonally reticulate body with needle-like terminal antennal joints and broad wings with dark strong stiff setae. The nymphs feed for 10 days, involving a mono-feeding.

Pupa: Pre-pupal instar lasting for a day and non-feeding pupal instar for further 2-3 days.

Adult: Winged dark-brown adults emerge which have mandibular and maxillary stylets similar to those of nymphs. The female can oviposit soon after emergence and may produce up to 50 eggs during her life of about a month.

Life cycle:



2,3 http://entnemdept.ufl.edu/creatures/orn/thrips/redbanded_thrips.htm

Damage symptoms:

- Adult and young thrips are seen in colonies on the lower (abaxial) surface of leaves and suck the sap. As a result of rasping and sucking activities, the leaves of infested young trees become pale-brown and crinkled with roughening of upper surface. In severe cases, there will be shedding of leaves and even stunting of growth.
- The population of thrips varies from tree to tree in the same area and the insects do not feed indiscriminately, some trees even remain uninfested while others are heavily infested. The trees which produce leaves after the onset of monsoon, are found free from attack because leaves become old during summer months and hence are not normally infested.
- The leaves of post-monsoon flushes about full size but not mature, are mostly invaded by thrips, but as the leaves become old, a number of newly hatched nymphs decline to accept the old leaf tissue and finally the remaining population disperse.
- In most of the young plants, thrips are found to appear on the foliage and cause heavy

damage, particularly in summer months. The population increases during the dry season from December to January to a peak in April-May and then rapidly declines during wet season.

1. 2.

1. file:///C:/Users/COMPAQ/Desktop/ICAR%20Research%20Complex%20for%20Goa.htm
2. http://entnemdept.ufl.edu/creatures/orn/thrips/redbanded_thrips.htm

Natural enemies of foliage thrips:

Predators: Predatory mite, predatory thrips, insidious flower bugs, ant lion, lygaeids, ladybird beetle, anthocorid bugs etc.,

7) Fruit and nut borer:

The apple and nut borer causes 10% yield loss during years of severe infestation in certain tracts.

Biology:

Egg: The female adult lays single eggs on apple fruits and inflorescence.
Larva: There are 5 larval instars which are completed in 15-23 days.
Pupa: The fully grown larvae drop to the ground and pupate in earthen cocoons. The pupal period lasts about 8-10 days.
Adult: The adult is a medium sized moth with dirty black fore-wings and pale dark hind wings, with a wing span of about 15-20 mm in length.

Damage symptoms:

- The young larva of *T. panrosema* move to the joints of nut and apple, scrape the epidermis and then bore into them.
- In later stages, they bore into tender apples and nuts and feed on them.
- The borer affected nuts do not develop, become shrivelled and dried up resulting in pre mature fall of nuts and apples.
- Usually, the borers tunnel near the junction of apples and nuts, and the entry holes are plugged with excreta.

Natural enemies of fruit and nut borer:

Parasitoids: *Trichogramma* spp., *Bracon* spp**.**

Predators: *Chrysoperla carnea*, ladybird beetle, King crow, common mynah, wasp, dragonfly, spiders, robber fly, reduviid bug, praying mantis, red ants, big eyed bugs (*Geocoris* sp), pentatomid bug (Eocanthecona furcellata), earwigs, ground beetles, rove beetles, shield bug, anthocorids etc.,

8) Mealybug:

The mealy bug is a serious pest of cashew in all cashew growing areas. Two other species of mealybugs infesting cashew includes *Planococcus lilacinus and Planococcus citri.* They are called *chappathi poochi*, *maavupoochi*, *kallipoochi* in different localities in Tamil Nadu.

Biology:

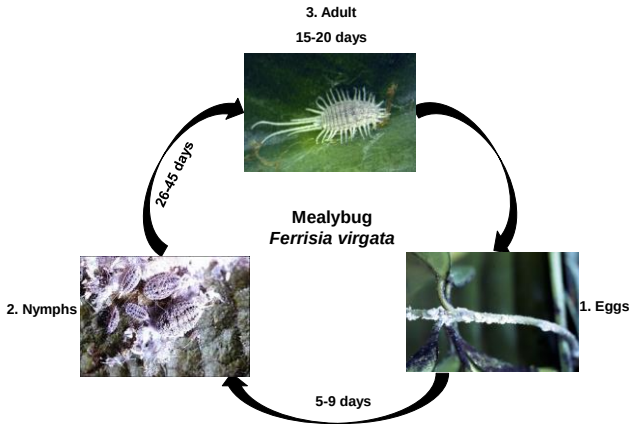
Egg: The eggs are amber in colour and within a day they hatch into crawlers.

Nymph: Nymphal period lasts for 26-45 days.

Adult: Adult lives for 15-20 days. The tailed mealy bugs have reproductive potential of laying 100-300 eggs in masses covered with cottony white mealy filaments.

The total life period is 45-65 days.

Life cycle:



2. http://www.sel.barc.usda.gov/scalekeys/mealybugs/key/mealybugs/media/html/Species/Ferrisia_virgata/Ferrisia_virgata.html
1, 3 http://mrec.ifas.ufl.edu/lso/mealybug/longtail3.jpg.

Damage symptoms:

- The nymphs and adults colonise on the lower surfaces of tender leaves, twigs, inflorescence panicles and fruit peduncles and suck the sap. The insects being sessile remain stationary while feeding on plant parts. The terminal leaves turn pale yellow and curl downwards due to continuous drainage of sap by large mealy bug populations.
- Besides causing direct damage, the bugs excrete a sweet and sticky substance.
- It falls on the upper surface of lower leaves, twigs and fruiting parts.
- This clogs stomata and makes the plant surface shiny on which black sooty mould fungus develops. This black coating, covering the upper surface of leaves and twigs impedes the photosynthetic activities. Nut qualities also suffer. Ants are attracted to the sweet excreta and aid in spreading the bugs. Nut yield is lost heavily in affected trees.

1. 2.


1,2 http://www.cd3wd.com/cd3wd_40/Biovision/export/printct204$crops.html

Natural enemies of mealybug:

Parasitoids: *Aenasius advena, Blepyrus insularis, Anagyrus* spp.

Predators: Mirid bug, dragonfly, spiders, robber fly, praying mantis, red ants, lacewings, big-eyed bugs (*Geocoris* sp)., Coccinelids such as *Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Rodolia fumida, Scymnus coccivora, Nephus regularis*

9) Hairy caterpillar:

Of the several species of defoliating hairy caterpillars recorded as cashew pests, *M.hyrtaca* assumes serious proportions occasionally. Other species include: *Circula trifenestrata* Helfer; *Bombotelia jacosatrix* Guen, *Lymantria* sp., *Thalassodes quadraris* Guen, etc. which cause damage by defoliation on isolated trees in certain localities.

Biology:

Egg: Eggs are spherical in shape and ash grey to black in colour with an average diameter of 1.83 mm. They adhere to each other closely. The surface is smooth with 3 deep brown, circular spots, arranged in a triangular pattern. The eggs hatch in 9 days.

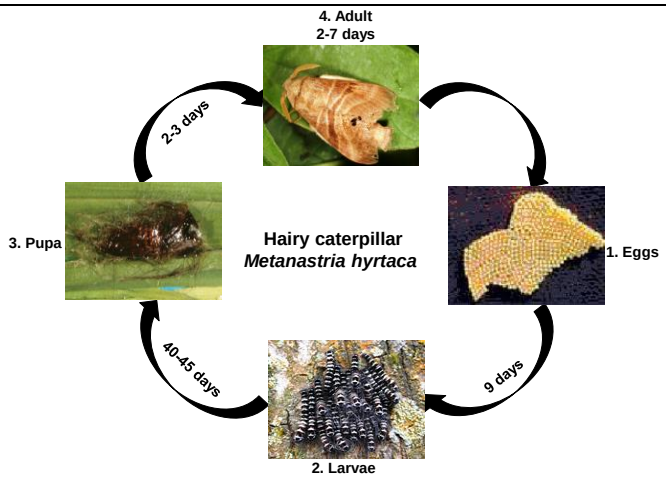
Larva: The larval period is 40 to 45 days. The larvae start spinning a silicon cocoon on leaves with brown silk and larval hairs and then the larvae pupate inside.

Pupa: Pre-pupal period takes 2-3 days and the pupal period ranges from 12-18 days.

Adult: The adult is a stout moth exhibiting sexual dimorphism. The female moth is fairly bigger (body length 29-31 mm) than adult male (body length 25 mm). Male moths have a black patch with a small white spot in the centre of fore-wing and two angulated transverse lines on either side of the patch, but there are no black patches present in the fore-wings of the females, except short wavy lines running across. The abdomen of the male is long and slender; whereas it is stout with tuft of anal hairs in female. The antennae of both male and female are pectinate. Mating generally takes place after sunset. The longevity of the adult ranges from 2-7 days. Egg laying commences within 24 - 36 hours after mating. The moth lays eggs in clusters on the lower surface of cashew foliage or on tender twigs, and the oviposition continues for about 48 hours. It's fecundity ranges from 180-300 with an average of 250 eggs.

The total life-cycle would be 55-75 days with an average of 66 days from eggs to adult.

Life cycle:



1,2,3, 4. http://tnau.ac.in/eagri/eagri50/ENTO331/lecture26/Moringa/004.html

Damage symptoms:

- The caterpillars are nocturnal feeding. They are gregarious and congregate on the lower surface of leaves. Initially, they feed on fresh leaves starting from petiole and continue half way on a leaf, leaving the midrib intact. In later stages, the caterpillars feed voraciously on mature leaves and tender twigs leading to complete defoliation leaving only the bare branches.
- After feeding, they hide at the base of the tree trunk, shaded branches and on the ground under dry leaves during day time. Dark green, pea size faecal pellets littered in mass, on the soil under tree canopy reveals the presence of the pest in the orchard.
- *M.hyrtaca* is a polyphagous pest known to infest drumstick, jamun, sapota, cocoa and garden plants. The pest appears during early monsoon and continues up to December.

Natural enemies of hairy caterpillar:

Predators: Coccinellid, spiders, praying mantis, dragonfly etc.,

10) Leaf folder:

Nearly six species of leaf folders attack cashew. Of these, the pyralid leaf folder *Sylepta aurantiacalis* Fisch is a major pest. Its activity is seen from September to January synchronising with flushing and flowering seasons of cashew.

Biology:

Larva: They hatch in 3-4 days. The neonate larvae are pale green and full grown larvae are a glistening green with brownish head and measure 30.0 to 35.0 mm in length. The total larval period lasts for 18 to 30 days.

Pupa: Pupation occurrs in the leaf fold itself and the pupal period ranges from 8 to 12 days

Adult: The adult is a yellowish, medium size moth with brownish wavy lines running across both the wings. Female moths lay several eggs singly on emerging flush leaves.

Damage symptoms:

- The caterpillars, after emerging from eggs, roll up the tender leaves from tip downwards or longitudinally towards dorsal side throughout the breadth or length to form a tubular niche. The leaves are tightly fastened with silken thread of salivary secretion of the caterpillars.
- Normally one caterpillar is present in each roll. The caterpillar remains inside the leaf roll and feeds on the green tissues by scraping. The fed green matter of the leaf is visible through the transparent integument and the caterpillar appears green in colour.
- As a result of the damage, the terminal and tender leaves dry up. This affects the terminal growth in root stock and young grafts. On regular flushes, the panicle emergence is arrested.
-

Natural enemies of leaf folder:

Parasitoid: *Cotesia flavipes*

Predators: *Chrysoperla carnea,* Coccinellids, King crow, common mynah, wasp, dragonfly, spiders, robber fly, reduviid bug, praying mantis, red ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.

Natural Enemies of Pineapple Insect Pests

Parasitoids

Egg parasitoids

1. *Trichogramma* spp.

2. *Telenomus* spp.

3. *Chaetostricha* sp

4. *Erythmelus helopeltidis*

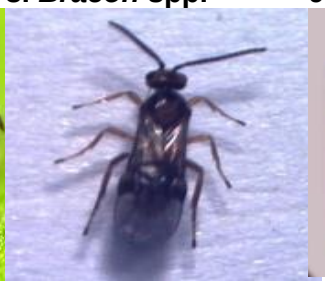
5. *Tetrastichus* sp

Egg-larval parasitoid

6. *Chelonus* spp.

Larval parasitoid

7. *Sympiesis* sp **8. *Bracon* spp.** **9. *Cotesia flavipes*** **10. *Goniozus* sp**

Pupal parasitoid

11. *Trichospilus pupivora*

Nymphal and adult parasitoid

12. *Aenasius advena* **13. *Blepyrus insularis*** **14. *Anagyrus* spp.**



2. https://c1.staticflickr.com/5/4090/5207450835_d4231c111a.jpg
3. http://www.raipon.jp/hachi/wp-content/uploads/2012/05/Chaetostricha-2.jpg
4. http://www.nbaii.res.in/IndianMymaridae/Mymaridae/html/Mymaridae/images/Erythmelus4.jpg
5. http://www.pbase.com/image/135529248
6. http://commons.wikimedia.org/wiki/File:Chelonus.basalis.-.lindsey.jpg

7. http://baba-insects.blogspot.in/2012/12/zuiko-auto-macro-lens-38mm-f28.html
9. http://www.uky.edu/~mjshar0/genera/Cotesia/cotesia.html
10. http://nature.berkeley.edu/millslab/lbam.html
11. http://www.nbaii.res.in/Featured_insects/Trichospilus-pupivorus.php
12. http://www.nbaii.res.in/Featured_insects/Aenasius-advena.php
13. http://www.nbaii.res.in/Featured_insects/Blepyrus-insularis.php
14. http://www.biodiversidadvirtual.org/insectarium/Anagyrus-sp.-1d5.-img528601.html

Predators

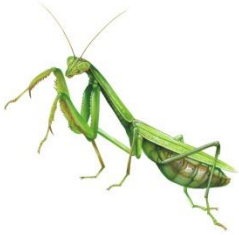
1. Red ant

2. Dragonfly

3. Ladybird beetle

4. Spider

5. Praying mantis



6. Black ant

7. Anthocorid bug

8. Lacewing

9. Robber fly

10. King crow

11. Common mynah

12. Lygaeid bug

13. Reduviid bug

14. Big eyed bug

15. Pentatomid bug

16. Earwig

17. Ground beetle

18. Rove beetle

19. Predatory mite (*Amblyseius swirskii*)

20. Predatory thrips (*Aeolothrips* spp.)

21. Insidious flower bugs (*Orius insidiosus*)

22. Ant lion

1. http://www.ants-kalytta.com/Oecophylla-smaragdina.fr.html
2. http://littlegreenblog.com/green-home/gardening-and-pest-control/save-the-dragonflies/
5. http://www.kimthompsonartist.com/SingleImages/PrayingMantis.html
6. http://www.antwiki.org/wiki/Category:Dolichoderinae
7. http://lpm.uga.edu/beneficials/truebugs.html
9. http://www.visitingnature.com/promachusrufipes.htm
10. http://en.wikipedia.org/wiki/Black_Drongo
11. http://www.epnrm.sa.gov.au/AnimalPlantControl/DeclaredPestAnimals/ TheIndianMynaBird.aspx
12. http://commons.wikimedia.org/wiki/File:Lygaeidae_-_Tropidothorax_leucopterus.JPG
14. http://insectsgalore.blogspot.in/2010/08/big-eyed-bug-geocoris-ugilinosus.html
15. http://www.malaeng.com/blog/?p=9646
16. http://www.johnsonpestcontrol.com/pest-identification/earwigs/
17. http://www.fcps.edu/islandcreekes/ecology/common_black_ground_beetle.htm
18. http://www.ozanimals.com/Insect/Rove-Beetle/Staphylinidae%20family/.html
19. https://greenmethods.com/swirskii/
20. http://www.insectimages.org/browse/detail.cfm?imgnum=5445035
21. http://en.wikipedia.org/wiki/Orius_insidiosus
22 http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm

IX. DESCRIPTION OF DISEASES

1) Die–back or pink disease:

Disease symptoms:

- It is a very common disease of cashew, often assuming great importance during the south-west monsoon period
- Whitish or pinkish growth of the fungus can be seen on the affected branches.
- The fungus penetrates into the deeper tissues and causes the death of the shoots from the tip downwards and hence the name dieback.
- After heavy rains a film of silky thread of the fungus is seen on the branches.
- In advanced stages, the bark splits and peels off. Some times only one branch is affected, but often many branches turn yellow and shed giving a barren appearance to a portion of the tree.

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_plantation_cashew.html

2) Damping off:

Disease symptoms:

- The Disease occurs in nurseries where drainage conditions are poor.
- The organisms attack the roots or collar region of "seedlings or both the regions and cause their death. when seedlings are infected by *Phytophthora palmivora,* they become pale.
- Water-soaked lesions can be observed at the collar region which turn dark and girdles the stem.
- The seedlings droop and ultimately the plants die.
- On leaves, water-soaked lesions can be observed in severe cases. These lesions enlarge and coalesce, often covering the entire leaf lamina.
- All the organisms in combination or alone may cause the disease.

3) Anthracnose:

Disease symptoms:

- The disease has been reported in an epidemic form from Tamil Nadu. It is known to cause severe loss in Brazil.
- The fungus infests the tender leaves, twigs and forms redddish brown, water-soaked lesions. On the affected region exudation of resin can be seen.
- The lesions enlarge and kill the shoots. The tender leaves are crinkled and fruits shrivelled.
- The infected inflorescences turn black. Repeated Infection of the terminal shoots leads to the death of the tree in course of time.

Anthracnose

http://agritech.tnau.ac.in/horticulture/horti_plantation%20crops_cashewnut.html

4. Inflorescence blight :

Disease symptoms:

- This is also a common disease in Kerala especially during the monsoon period.
- The characteristic symptom is the drying of floral branches. The symptoms appear as minute water soaked lesions on the main rachis and secondary rachis.
- The lesions are pinkish brown, enlarge and soon turn scabby. Gummy exudates can be seen at the affected regions.
- The lesions develop into bigger patches and result in drying up of the inflorescences. The incidence is very severe when cloudy weather prevails.

5. Shoot rot and leaf fall :

Disease symptoms:

- During the south west monsoon months of June - August extensive leaf fall and shoot rot symptoms are observed.
- Black elongate lesions are first developed on the stem with exudation of gum. Later, infection spreads up and down, causing the tender stem to collapse and tender leaves to shrivel up.
- The lower mature leaves are also infected with black elongated lesions on mid rib, which later spread to the main lateral veins and the leaf blade.
- The infected leaves are soon shed.

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_plantation_cashew.html

X. SAFETY MEASURES

A) At the time of harvest

Fully mature nuts are to be harvested. Cashew nuts when fully mature look greyish brown. It is better to pick the fallen nuts because there is a possibility of harvesting immature nuts which leads to poor quality kernel during processing. However if one wants to use cashew apple for preparation of cashew apple products one has to pluck the fruits from the tree. One can know the maturity of nuts by just tapping the fruits. If it is fully mature the fruit just drops.

B) During post-harvest storage

Raw nuts immediately after harvest are to be separated from cashew apple and sun dried for 2 to 3 days. If the raw nuts are not dried properly, during subsequent storage, they get spoiled due to microbial infestation. Nuts after drying can be stored in gunny bags well protected from rodents and stacked on a platform above the ground level leaving space on all the sides of the room. Well dried raw nuts (moisture content 8 to 9%) could be stored up to one year without any quality deterioration.

XI. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid monocropping.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seedling without treatment with biopesticides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seedling beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition.	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
12	Release parasitoids only after noticing adult moth as per field observation	Do not apply chemical pesticides with in seven days of release of parasitoids.
13	In case of pests which are active during night spray recommended biopesticides/ chemicals at the time of their appearance in the evening.	Do not spray pesticides at midday since, most of the insects are not active during this period.
14	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for aphids, scales, mealybugs, thrips, tea mosquito bugs etc.	Do not spray pesticides only on the upper surface of leaves.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of	Do not apply long persistent on trap crop,

	trap crop technology.	otherwise it may not attract the pests and natural enemies.

XIII. BASIC PRECAUTIONS IN PESTICIDE USAGE

A. Purchase

1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
2. **Do not** purchase leaking containers, loose, unsealed or torn bags; **Do not** purchase pesticides without proper/approved labels.
3. While purchasing insist for invoice/bill/cash memo

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** expose to sunlight or rain water; **Do not** store weedicides along with other pesticides.
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

1. Never carry/ transport pesticides along with food materials.
2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement
7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution
8. Concentrated pesticides must not fall on hands etc. while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipment

1. Select right kind of equipment.
2. **Do not** use leaky and defective equipment
3. Select right kind of nozzles
4. **Do not** blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. **Do not** use same sprayer for weedicide and insecticide.

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution

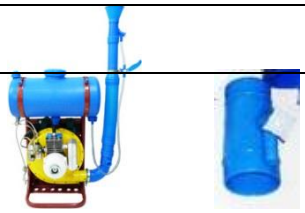
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc. with soap water after spraying
5. Containers buckets etc. used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

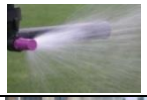
G. Disposal

1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XIV. PESTICIDE APPLICATION TECHNIQUES

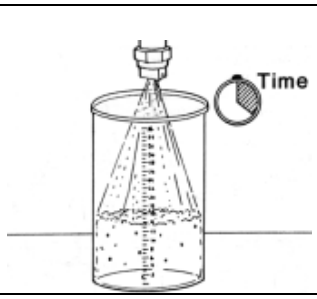
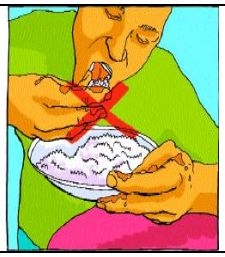
<table>
<tr><th colspan="4">Equipment</th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td>Vegetative stage
i) for crawling and soil borne pests

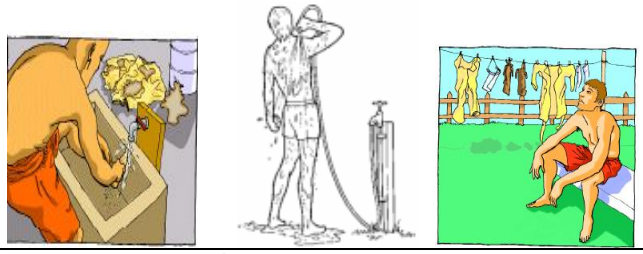
ii) for small sucking leaf borne pests</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min
or
• Motorized knapsack sprayer or mist blower (droplets of small size)
• Airblast nozzle
• Operating speed: 2/3rd throttle</td><td> 
  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
<tr><td colspan="4">Category B: Field flying pest/airborne pest</td></tr>
<tr><td>Vegetative stage</td><td>Insecticides and</td><td>• Motorized knapsack</td><td>  </td></tr>
</table>

Reproductive stage *(Field Pests)*	fungicides	sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (droplets of small size) Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) • Hot tube nozzle	 
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size)	  

XV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	

		 
3.	Clean and wash the machines and nozzles and store in dry place after use.	  
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	 
5.	Do not apply in hot or windy conditions.	 
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	 

8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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