सत्यमेव जयते

AESA BASED PACKAGE

TEA

Directorate of Plant Protection Quarantine and Storage
N. H. IV, Faridabad, Haryana

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telaangana

DEPARTMENT OF AGRICULTURE AND COOPERATION
MINISTRY OF AGRICULTURE
GOVERNMENT OF INDIA

The AESA based IPM - Tea, was compiled by the NIPHM working group under the Chairmanship of **Dr. Satyagopal Korlapati, IAS, DG,** NIPHM, and guidance of Shri. Utpal Kumar Singh 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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Date: 6.3.2014

(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)

CONTENTS

AESA BASED IPM PACKAGE FOR TEA

Tea-Plant description:

Camellia sinensis is native to East commonly called as tea belong to family Theaceae, South and Southeast Asia, but it is today cultivated across the world in tropical and subtropical regions. It is an evergreen shrub or small tree that is usually trimmed to below 2 m (6.6 ft) when cultivated for its leaves. It has a strong taproot. The flowers are yellow-white, 2.5–4 cm (0.98–1.57 in) in diameter, with 7 to 8 petals. The leaves are 4–15 cm (1.6–5.9 in) long and 2–5 cm (0.79–1.97 in) broad. Fresh leaves contain about 4% caffeine. The young, light green leaves are preferably harvested for tea production; they have short white hairs on the underside. Older leaves are deeper green. Different leaf ages produce differing tea qualities, since their chemical compositions are different. Usually, the tip (bud) and the first two to three leaves are harvested for processing. The leaves have been used in traditional Chinese medicine and other medical systems to treat asthma (functioning as a bronchodilator),angina pectoris, peripheral vascular disease, and coronary artery disease. The seeds of *Camellia sinensis* and *Camellia oleifera* can be pressed to yield tea oil, a sweetish seasoning and cooking oil that should not be confused with tea tree oil, an essential oil that is used for medical and cosmetic purposes, and originates from the leaves of a different plant, while both green and black teas may protect against cardiovascular disease.

I. PESTS

A. Pests of National Significance

I. Pests and mites

1.1 Tea mosquito bug: *Helopeltis theivora* Waterhouse (Miridae: Hemiptera)

1.2 Thrips: *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera)

1.3 Jassid: *Empoasca flavescens* Fab. (Cicadellidae: Hemiptera)

1.4 Aphids: *Toxoptera aurantii* Boyer de Fonscolombe (Aphididae: Hemiptera)

1.5 Leaf eating caterpillar: *Spodoptera litura* Fab (Noctuidae: Lepidoptera)

1.6 Bunch caterpillar: *Andraca bipunctata* Walker (Bombycidae: Lepidoptera)

1.7 Red spider mite: *Oligonychus coffeae* Nietner (Tetranychidae: Acari)

1.8 Tea looper complex: *Buzura suppressaria* Guen (Geometridae: Lepidoptera), *Hyposidra talaca* (Walker), *H. infixaria* (Walker) (Geometridae: Lepidoptera)

1.9 Shot hole borer: *Euwallacea fornicates* Eichhoff (Scolytidae: Coleoptera)

1.10 Live wood eating termite: *Microcerotermes* sp. (Isoptera:Termitidae)

1.11 Scavenging termites: *Odontermes* sp. (Isoptera:Termitidae)

2. Diseases

2.1 Brown and Grey blight: *Colletotrichum* sp. & *Pestalotiopsis theae* (Sawada) Steyaert

2.2 Black rot: *Corticium theae, C. invisum*

2.3 Blister blight: *Exobasidium vexans* Massee

2.4 Red rust: *Cephaleuros parasiticus* Scot Nelson, C,mycoides

2.5 Poria branch canker: *Poria hypobrunnea* Petch

2.6 Charcol stump rot*: Ustulina zonata* (Lév.) Sacc.

2.7 Brown root rot disease: *Fomes lamoensis*

3. Weeds

Broad leaf

3.1 Goat weed: *Ageratum conyzoides* L. (Asteraceae)

3.2 Landrina: *Borreria hispida* L. (Rubiaceae)

3.3 Tropical spider wort: *Commelina benghalensis* L. (Commelinaceae)

3.4 Hill glory bower: *Clerodendron infortunatum* L. (Verbinaceae)

3.5 Malabar melastome: *Melastoma malabathricum* L. (Melastomataceae)

3.6 Bitter Vine: *Mikania micrantha* Kunth (Aseteraceae)

3.7 Non tai baihong: *Pouzolzia indica* (L.) G. Benn (Urticaceae)

3.8 Congo jute: *Urena lobata* L. (Malvaceae)

3.9 Wood sorrels: *Oxalis corymbosa* L., *O. acetocella* (Oxalidaceae)

3.10 Kuppaimeni: *Acalypha indica* L. (Euphorbiaceae)

3.11 Common wireweed: *Sida acuta* Burm.f. (Malvaceae)

3.12 Aligator yam: *Ipomea digitata* L. (Convolvulaceae)

3.13 Cichorium: *Cichorium intybus* L. (Astaraceae)

3.14 False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)

3.15 Asthma plant: *Euphorbia* spp. (Euphorbiaceae)

Grasses

3.16 Buffalo grass: *Paspalum conjugatum* L. (Poaceae)

3.17 Torpedo grass: *Pannicum repens* L. (Poaceae)

3.18 Blady grass: *Imperata cylendrica* (L.) P.Beauv. (Poaceae)

3.19 Hairy crabgrass: *Digitaria sanguinalis* (L.) Scop. (Poaceae)

3.20 Indian goosegrass: *Eleusine indica* (L.) Gaertn. (Poaceae)

3.21 Blanket grass: *Axonopus compressus* (Sw.) P.Beauv. (Poaceae)
3.22 Bermuda grass: *Cynadon dactylon* L. (Poaceae)
3.23 Kans grass: *Saccharum spontanium* L. (Poaceae)

Sedges

3.24 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

3.25 Yellow nutsedge: *Cyperus esculentus* L. (Cyperaceae)

4. Nematodes

1. **Root knot nematode: *Meloidogyne* spp (Heteroderidae: Tylenchida)**
2. **Root lesion nematode: *Pratylenchus* spp**

B. Pests of Minor Significance

1. Pests and mites

1.1 Flush worm: *Cydia leucostoma* Meyrick (Tortricidae: Lepidoptera)

1.2 Pink and Purple mite: *Acaphylla theae* Watt and *Calacarus carinatus* Green (Eriophyidae: Acarina)

1.3 Scarlet mite: *Brevipalpus phoenicis* Geijskes (Tenuipalpidae : Acarina)

1.4 Yellow mite: *Polyphagotarsonemus latus* Banks (Tarsonemidae: Acarina)

1.5 Leaf roller: *Caloptilia theivora* Walsingham (Gracillariidae: Lepidoptera)

1.6 Scales: *Saissetia formicarii* Takahashi*, S. coffeae* Walker*, Eriochiton theae* Green*, Coccus viridis* Green (Coccidae: Hemiptera)

1.7 Tea tortrix: *Homona coffearia* Nietner (Tortricide: Lepidoptera)

2. Diseases

2.1 Black root disease: *Rosellinia arcuata* Petch

2.2 Charcoal stump rot: *Ustulina zonata* (Lév.) Sacc.

2.3 Collar canker: *Phomopsis theae* Petch

2.4 Branch Canker: *Poria hypobrunnea* Petch

2.5 Twig die back, stem canker: *Macrophoma theicola* Siemaszko

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 planters. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where planters 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. Planters have 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 paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/planters 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 planters 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
- Planters past experience

Principles of AESA based Integrated Pest Management (IPM):
Grow a healthy crop

- Select a variety relatively tolerant variety to major pests.
- Follow TRA /U proper spacing.
- Soil health improvement (mulching and green manuring).
- 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 planters should apply an adequate 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)

Planters should:

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

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

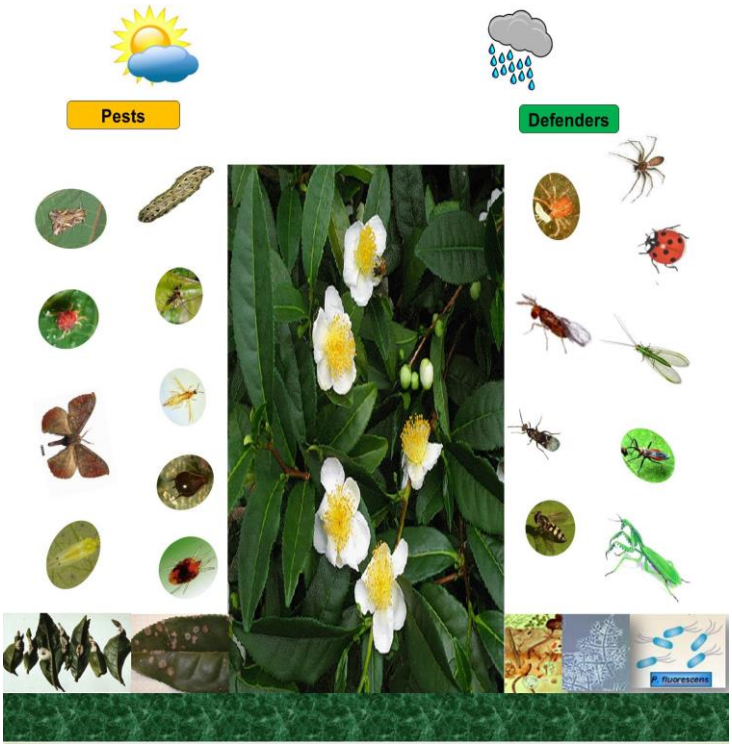
In field various types of insects are present. Some are beneficial and some may be harmful. Generally planters are not aware about it. Predators (friends of the planters) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance planters' skill to identify 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 planters to make appropriate pest management decisions. Sweep net, 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 tea insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Planters:



Decision taken based on the analysis of field situations

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 safe 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 planters 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

Planters become experts in crop management

Planters have to make timely decisions about the management of their crops. AESA planters 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 planters should also be considered for decision making. However, as field conditions continue to change and new technologies become available, planters need to continue improving their skills and knowledge.

- Planters are capable of improving farming practices by experimentation
- Planters can share their knowledge with other planters

AESA methodology

- Go to the field in groups (about 5 planters 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.
    - Insect pests: Observe and count insect 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.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather conditions.

- 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 situations 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

Planters 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 branches
- **Crop situation (e.g. for AESA):** Plant health**;** pests, diseases, weeds**;** natural enemies**;** soil condition**;** irrigation**;** weather conditions
- **Input costs:** Seeds**;** fertilizer**;** pesticides**; l**abour
- **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. Planters 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.

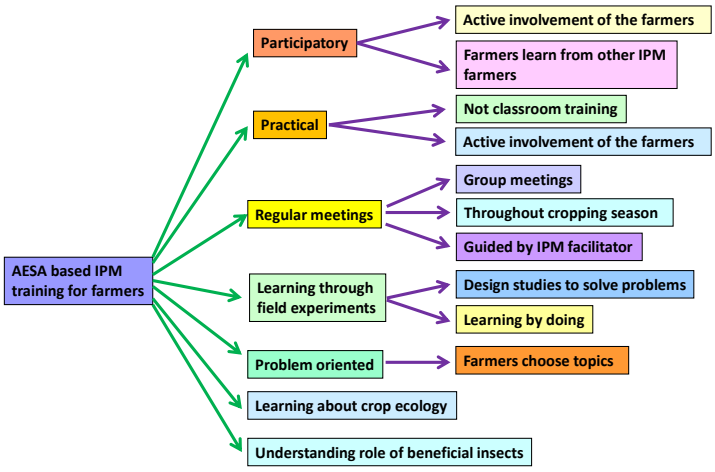
AESA and planter field school (FFS)

AESA is a season-long training activity that takes place in the planter 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.

Planters 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 planters can undertake this exercise. However, other planters also can do field scouting in their own fields at regular intervals to monitor the major pest situation.

Surveillance on pest occurrence in the main field should commence soon after crop establishment and at weekly intervals thereafter. In 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:

Aphids: Count and record the number of both nymphs and adults on three randomly selected leaves (top, middle and bottom) per plant.

Thrips: Thrips population will have to be assessed at periodical interval by collecting 100 shoots at random from each area and counting the number of adult and larval thrips. Attention may be paid to collect the shoots from the plucking table, below the plucking table and also from side branches.

Tea mosquito bug: The percentage of infestation has to be assessed by collecting 100 shoots from pluckers' basket and counting the infested shoots.

Caterpillar pests: Flushworm /leaf roller/tea tortrix population has to be assessed by counting the number of infected shoots from bushes selected at random from that particular area.

Red spider mites: One hundred leaves may be sampled from different areas of the particular field and the number of infested leaves may be counted to find out percentage of infested level.

Eriophyid mites: Pink & purple mite populations have to be assessed at periodical interval by collecting 100 leaves from 100 bushes selected at random from each area. From each leaf, pink & purple mites have to be counted with the help of hand lens.

Shot hole borer: To assess the extent of SBH infestation in individual tea field, the fields has to be divided into 2 ha blocks and from each block one hundred stem cuttings are to be taken at random. Attention may be paid to collect stem of 1-1.5 cm diam. and 20 cm long.

Blister blight: To assess the blister blight disease incidence, one hundred shoots of the same age (three leaves and a bud) and of uniform size have to be collected randomly from the harvest during every plucking interval. The collected shoots have to be examined for various stages of blister lesions. A shoot have to be counted as infected even if a single lesion was noticed. The disease incidence can be quantified on percentage basis.

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 and flowers/fruits sampling: Carefully examine the stem and flowers/fruits of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, and fruits should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems and flowers/fruits infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone trap catches:

Pheromone traps for *Spodoptera litura* and *Caloptilia theivora* @ 4-5 traps/acre have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths/trap should be counted and recorded year round. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water / Blue sticky traps

Set up yellow pan water trap/sticky traps 15 cm above the canopy for monitoring aphids and blue sticky trap for thrips @ 4-5 traps/acre. Locally available empty tins can be painted yellow/blue and coated with grease/vaseline/castor oil on outer surface may also be used.

E. Light traps

Set up light traps @ 1 trap/acre 15 cm above the crop 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).

F. Nematode extraction

Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove small stones, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 60-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which

includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004, a, b).

Ecological Engineering for Pest Management – Below Ground:

There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- 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 of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field 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).

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

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

In order to attract natural enemies following activities should be practiced:

- 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.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfaalfa

Mustard

Cosmos

Anise

Caraway

Dill

***Chrysanthemum* sp.**

Repellent plants

***Ocimum* spp**

Peppermint/Spearmint

Border plants

Maize

Sorghum

Trap plants

Castor

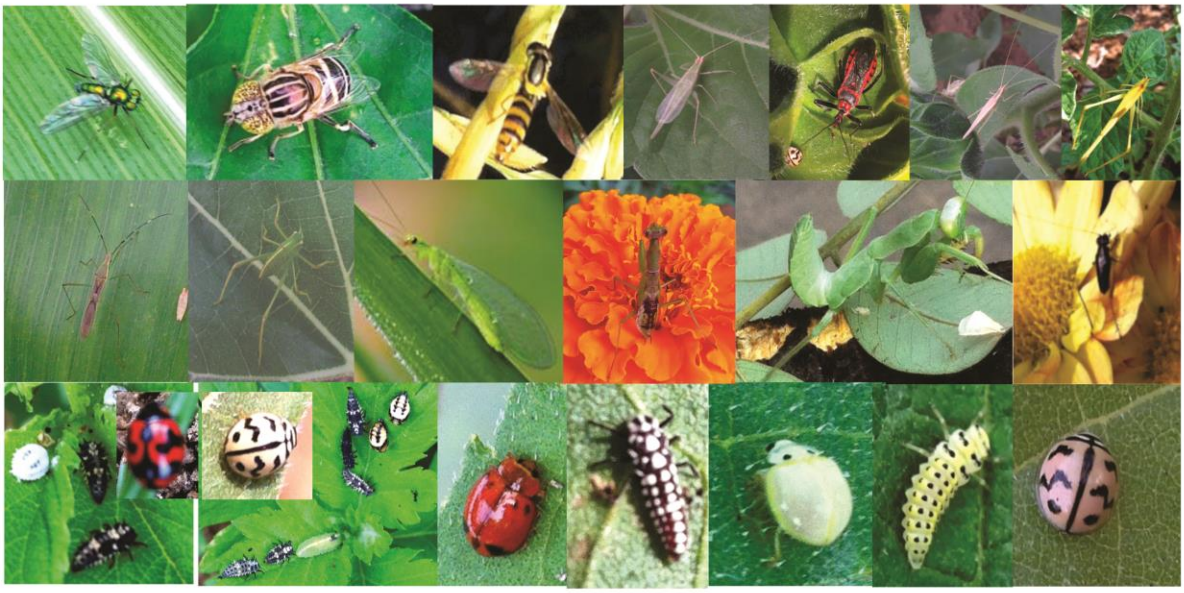
Marigold

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.

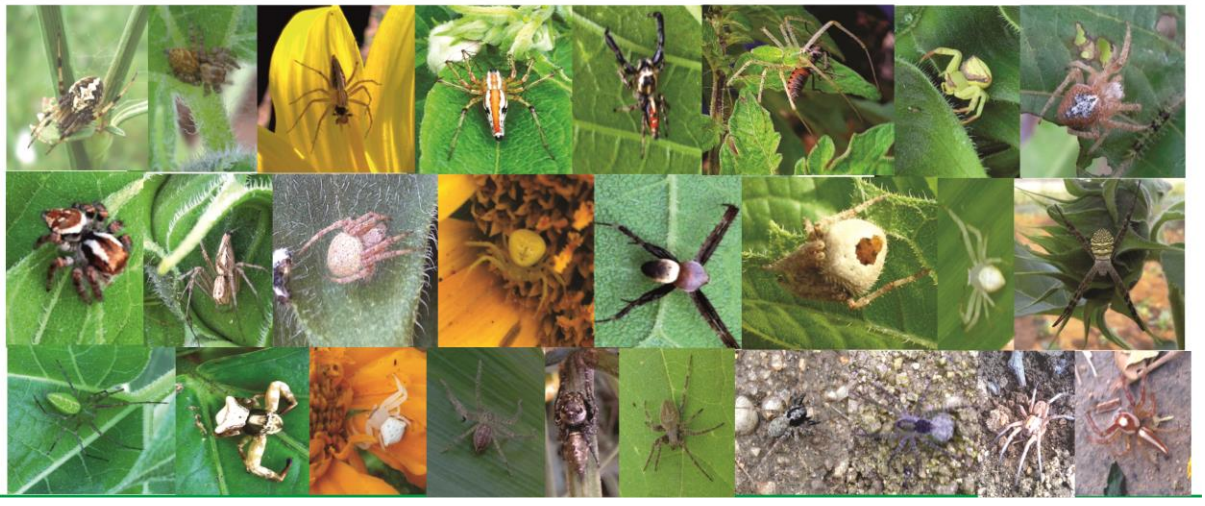
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE WISE IPM

Management	Activity
Pre-planting*	
	<u>Common cultural practices:</u> • Deep ploughing of fields during summer to control nematodes population. • Soil solarization • Field sanitation, rogueing. • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations. • Growing castor, pea or marigold as a trap crop for the management of Leaf miner and *Spodoptera*. • Plant tall border crops like maize, sorghum or millet to reduce pest population. • Adopt ecological engineering by growing the attractant, repellent, and trap crops around the field bunds.
Nutrients	Apply nutrients on the basis of soil test report and recommendation for the agro-climatic zone. • Soils having pH around 5.0 are suitable for tea plantation. • For new plantation pits of 30 x 45 x 60 cm size are dug. • For application in nursery, a nutrient mixture should be prepared with following composition; • **Composition of the nutrient mixture:** Ammonium phosphate (20:20) 35 g, Muriate of Potash,12 g, Magnesium sulphate 15 g, Zinc sulphate 3 g. • This nutrient mixture is applied in nursery @ 30 g dissolved in 10 litres of water over an area of 4 sq.m. This should be done fortnightly.
Weeds	**<u>Cultural control:</u>** • Deep plouging during summer • Stale seed bed technique • Keep boundaries of tea field weed free to prevent dispersal of weed seed into the tea field. • Field should be well prepared by tillage operations and after tillage; the underground reproductive propagules of weeds must be collected and destroyed. • Digging out of tubers and rhizomes of weeds is discouraged to prevent re-infestation from fragmented underground propagules.
Insect pests and soil borne diseases	**<u>Cultural control:</u>** • **Field Sanitation:** Weeds like *Mikania cordata, Bidens biternata, Emillia* sp., *Polygonum Chinese* and *Lantana camara* offer excellent hiding places and serve as alternate host for the tea masquito bug. Growth of weeds and wild host plants near in and around tea field may be controlled and this will help to reduce the

	growth of tea mosquito population. • For other adopt common practices.
Termites	**<u>Cultural control:</u>** • Bushes should be properly cleaned out at the time of pruning by removing the snags, dead and diseased branches. Any earthen materials like earth runs over the trunk and stems, earth depositions on the collar of the bushes should be wiped out/removed at the time of pruning • Pruning cuts should be painted with indopaste or copper fungicide or *Trichoderma* bio-cide. Remains of old shade tree stumps inside the sections should also be cleaned and treated/removed permanently. • Improve drainage condition in the termite prone fields. • Improve shade status of the tea fields. • Destroy termite mounds and queens. Remove earth runs and fork the soil around collar region of the infested tea bushes/ shade trees before application of pesticides. • Weeds like grasses etc. within radius of 30cm from the collar region of the bushes should be cleaned. • In tea sections where live wood eating termite is noticed, the mulching materials should also be sprayed with recommended chemicals. • Keep the soil is in moist condition for effective spraying and control. Slight irrigation before and after spraying improves condition of the (hard and dry) soil for absorption of pesticide.
Nematodes	**<u>Cultural control:</u>** • Soil from the nursery site should be tested for eelworm population and acidity status. If the population of eelworm is found to be 6 or above per10g of soil tested, it is considered to be unsuitable for use. • Preparation of the nursery bed should be done by harrowing and ploughing to expose and dry the un-decomposed weeds and roots of the plants. All sorts of mulching materials should be kept away from the seed nursery to avoid nematode infestation. • Plant parasitic nematodes can be killed by uniform heating (after sieving) of the soil up to 60° – 70°C for 4-5 minutes on plain tin sheets. The soil can be used after heat treatment. • Removal of weed hosts from nursery beds will help in minimizing the population build-up. • Soil sampling in the estates is should be systematic following appropriate procedure to avoid errors in the assessment of eelworm. **<u>Chemical control:</u>** • Carbofuran 3% CG@ 33.10 g/plant

Nursery and seedling*	
Weeds	• Use the certified and weed free seeds or healthy cuttings. • Keep the nursery weed free by hand pulling of the weeds.
Planting*	
Nutrients	• Pits are filled with top soil and organic manure mixed with *Trichoderma*.
Weeds	• Closer spacing of tea plants, inter-planting, and use of quick growing planting materials will help uniform ground coverage and thereby reduce weed growth. • Plant cover crop/green manure between rows to avoid ground exposure. • Use weed free compost and straw mulches. • Mulching with biodegradable materials after planting or pre-emergent herbicides like Oxyflourfen 23.5% EC @ 260 -400 l in 200-300 l of water/acre within 2-3 days after planting may be used if weed flora (*Digiteria, Imperata, Paspalum*) of the field is known based on previous year.
Nematode and soil borne diseases	**Cultural control:** • Select healthy and disease free seeds. • Use resistant tolerant varieties. • Miling with straw/pine needles/eucalyptus leaves.
Mites	**Cultural control:** • Grow nurseries away from infested crops and avoid planting next to infested fields • Grow healthy crops; avoid water and nutrient stress • Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation • Keep perennial hedges such as pigeon peas, they are said to encourage predatory mites
* Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed and nursery treatment and soil application (If Commercial products are used, check for label claim. However, biopesticides produced by planters for own consumption in their fields, registration is not required).	
Vegetative	
	Common cultural practices: • Collect and destroy diseased and insect infected plant parts. • Provide irrigation at critical stages of the crop • Avoid water stress and water stagnation conditions. • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed **Common mechanical practices:** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested shoots may be collected and destroyed • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow sticky traps for aphids and leaf minor and blue sticky trap for thrips @ 4-5 trap/acre.

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Use light trap @ 1/acre and operate between 6 pm and 10 pm
Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks)
Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc.
Set up bonfire during evening hours at 7-8 pm

<u>Common biological practices:</u>

Conserve natural enemies through ecological engineering Augmentative release of natural enemies.

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

Manuring of young tea commences two months after planting. The ratio and source of nutrients vary according to soil reaction (pH).
Rates of fertilizer are kept slightly higher in soils with pH above 5.
Apply phosphorus at 36 Kg/acre every year in one application.
Application of fertilizers should be done before the onset of monsoon. Fertilizers should be broadcast around the drip circle avoiding contact with the collar.

<table>
<tr><th rowspan="2">Year of application</th><th colspan="2">Total weight Kg/acre /annum</th><th rowspan="2">No. of applications</th></tr>
<tr><th>N</th><th>K</th></tr>
<tr><td>I year</td><td>72</td><td>110</td><td>5</td></tr>
<tr><td>II year</td><td>112</td><td>150</td><td>6</td></tr>
<tr><td>III year</td><td>120</td><td>180</td><td>6</td></tr>
<tr><td>IV year onwards</td><td>120</td><td>120</td><td>6</td></tr>
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</td></tr>
<tr><td>Weeds</td><td>

Remove the major weeds and creepers like Mikania micrantha by hand weeding or slashing.

Use “Cheel hoe” with a half-moon shaped blade in freshly planted areas for scraping the aboveground parts of the weeds and leveling the local depressions in the ground.
Cut the top growth of weeds in young tea areas with sickles. But perennial grasses like Imperata, Saccharum etc. should be removed.
Since mulching cannot be done near to the collar of the plant, removal of sporadic weed growth is necessary.
Weeds removed from the field should be taken outside the cropped area and heaped. Regrowth of rhizomatous and tuberous weeds inside the heap should be removed periodically. Before using in compost-pits, proper decomposition of all vegetative propagules must be ensured.
While practicing strip weeding in slopes the uncontrolled strip should be subjected to manual slashing
In mature tea areas, where pruning is due in the later months, one time winter application of any one of the below listed herbicide may be adopted as per weed infestation in the field as post emergence

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	application, when weeds are young and at active vegetative growth stage. Rotation of available herbicides will take care of plant succession and herbicidal resistance. **<u>Chemical control:</u>** • Glufosinate ammonium 13.5% SL (15% w/v) @ 1.0-1.32 l in 150-200 l of water/acre for the management of *Panicum repens, Borreria hispida, Imperata cylindrical, Digitaria sanguinalis,Commelina benghalensis, Ageratum conyzoides, Eleusine indica, Paspalum conjugatum* weeds. • Glyphosate 41% SL IPA Salt @ 0.8- 1.2 l in 180 l of water/acre for the management of *Axonopus compressus, Cynodon dactylon, Imperata cylindrical, Polygonum perfoliatum, Paspalum scrobiculatum, Arundinella, bengalensis*, *Kalm grass.* • Glyphosate ammonium Salt 5% SL @ 12 l in 200 l of water/acre for the management of *Cynodon dactylon, Digitaria sanguinalis, Paspalum conjugatum, Ageratum conyzoides, Biden pilosa , Cyperus rotundus, Boreria latifolia, Euphorbia spp., Imperata cylendrica*. • Glyphosate 71% SG (Ammonium Salt) @ 1.2 Kg in 200 l of water/acre for the management of *Acalypha indica, Sida aculata, Ipomea digitarea, Cychorium intybus, Digera arvensis, Digitaria sanguinalis , Paspalum conjugatum, Ageratum conyzoides, Cynondon dactylon, Cyperus rotunedus* • Paraquat dichloride 24% SL @ 0.32-1.7 l in 80-160 l of water/acre for the management of *Imperata, Commelina benghalensis, Boerraria hispida, Paspalum conjugatum.*
Aphids	**<u>Cultural control:</u>** • Reflective mulches such as silver colored plastic can deter aphids from feeding on plants. • Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves. **<u>Biological control:</u>** • Insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use. **<u>Chemical control:</u>** • Phosalone 35% EC @ 411.2 ml in 200-400 l of water/acre.
Flush Worm, Tea tortrix**, Shot hole borer**,**	• See common control practices.
Cutworm	• See common control practices.
Leaf roller**	• See common control practices. **<u>Chemical control:</u>** • Deltamethrin 2.8% EC @ 160 ml in 160-240 l of water/acre

Red, brown and black rot disease	**Cultural control:** • Uproot the infected bushes and burnt it. • Insulation of diseases patches by making trenches of 120 cm (4 feet) deep and 45 cm (1.5 feet) width surrounding the diseased plants help in the preventing the spread of primary root disease. **Chemical control:** • Copper oxy chloride 50% WP @ 0.24 Kg in 50 l of water/acre
Blister blight	**Cultural control:** • Use spore trap/regular field assessment. • Maintain the plucking interval. • Pruning during November/December is effective to reduce the disease incidence for new clearing. • Avoid broad leaved Assam jats. • Prohibit the entry of workers of the infested section into the healthy sections. **Biological control:** • Spray 2-3 rounds of 5-10% aqueous extracts of *Cassia alata/Polygonum hamiltoni/ Acorus calamus/ Adhatoda vasica/ Equisetum arvense/ Polygonum hydropiper/ Tagetis petula* at 15 days interval. **Chemical control:** • Bitertanol 25% WP @ 80 g in 30 l of water/acre or Copper oxy chloride 50% WP@ 0.168 g in 70 l of water/acre or Copper Hydroxide 77% WP @ 140 g in 300 l of water/acre or Hexaconazole 5% EC @ 10 g in 200 ml, 70-90 with power sprayers 175-200 with knap sack sprayer or Propiconazole 25% EC @ 50-100 g in 70-100 l of watwer/acre or Streptomycin Sulphate 9% + Tetracylin Hydrocloride 1% SP @ It is fungal disease and can be controlled by spraying 40 gms with 350 to 420 gms copper oxychloride (50% Wettable power) in 67 liters of water per hectarewith air blast sprayer, covering two rows on either side.
Red rust	**Cultural control:** • If vigour of plant is maintained by balanced nutrients, the disease is less. • As the disease starts on the onset of rain, it is desired to spray fungicide twice during the month of July/ August at 15 days intervals. • Avoid plant stress. Avoid poorly drained sites. Promote good air circulation in the plant canopy to reduce humidity and duration of leaf wetness. • Identify and correct predisposing factors such as- poor drainage, low soil fertility, particularly potash, improper soil acidity, inadequate shade and continuous use of green crops like *Tephrosia candida*, *T. vogelli* etc. in addition to pruning of severely

	affected sections. **<u>Biological control:</u>** • Spray 4-6 rounds of 5% aqueous extracts of *Argimone maxicana/ Polygonum hemiltonii* at 15 days interval. **<u>Chemical control:</u>** • Copper oxy chloride 50% WP @ 0.24 Kg in 50 l of water/acre
Black rot	**<u>Cultural control:</u>** • Prune or skiff the severely affected sections. Improve aeration by lopping side branches and 'matidals'. Thin out dense shade and improve drainage. • Give alkaline wash after pruning. • Shorter pruning cycle helps in minimizing infestation.
Charcoal stump rot, Collar and branch canker**, Grey blight,** Die back****	**<u>Cultural control:</u>** • Remove the affected portion during rejuvenation. • Avoid intensive harvesting using flat shears. • Maintain a proper balance of nitrogen and potassium fertilizers. • Avoidance of predisposing factors. • Avoid mulching and fertilizer application close to the stem collar and planting in gravelly soil. • Avoid plant stress. Grow tea bushes with adequate spacing to permit air to circulate and reduce humidity and the duration of leaf wetness. • Prohibit the entry of workers of the infested section into the healthy sections. **<u>Biological control:</u>** • Spray 2-4 rounds of 5% aqueous extracts of *Amphineuron opulentum/ Cassia alata/ Polygonum sinensis* at 15 days interval.
Maturity/Flowering	
Nutrients	As per table above. • The rate of fertilizer application for mature tea varies with yield and soil test values while the N: K_2O ratio varies with the stage of pruning. • Apply the recommended quantity of mixtures along the drip circle of plants. In the semi-circular furrow taken above the plant on the slope. • Apply the fertilizers when there is adequate soil moisture and when the fields are free from weeds. • Punch holes of 15-22 cm depth in the soil on either side of the plants and place the rock phosphate.
Weeds	• Remove the weeds before shedding of their seeds to reduce the weed infestation in the subsequent season. • Hand weeding around collar region of young tea bushes is always safe and it should be done. • Care should be taken so that the weeds do not flower and seeds infest the new areas, drains and estate boundaries.
Tea mosquito bug	**<u>Cultural control:</u>** • When an attack by *Helopeltis* becomes unmanageable the affected bushes may be skiffed to reduced the damage. Medium prune (60-70 cm) is best suited for shot-hole borer infested fields

	(except when other factors demand a different height of pruning). Longer pruning cycles will tend to increase the intensity of borer damage, especially in mid and low elevation areas. • The tea mosquito bug lay large number of eggs on the broken ends of plucked shoots. Intensive manual removal of stalks during plucking will help to reduce the incidence of the tea mosquito bug. • Removal of the alternate host of *H. theivora* such as Guava (*Psidium guajava*), Oak (*Quercus* spp.), Melastoma (*Melastoma* sp.), Thoroughwort (*Eupatorium* sp.), Fragrant thoroughwort (*Eupatorium odoratum*), Dayflower (*Commelina* spp.), Sesbania (*Sesbania cannibina*), Jackfruit (*Artocarpus heterophylla*), Bortengeshi (*Oxalis acetocello*), Ornamental jasmine (*Gardenia jesminoid*), Mulberry (*Morus alba*), Kadam (*Enthocephalus cadamba*), Jamun (*Eugenia jambolana*), Boal (*Ehretia acuminata*), Mikania (*Mikania micrantha*), *Acacia moniliformis*, *Duranta repens*, *Piper hemiltonii*, *Phlogacanthus thirsyfiorus*, *Ficus benjamina*, *Sida cordifolia*, *Cannabium sativam*, *Ixora* sp, *Persea bomycina*, *Pteridium aquilium*, *Murraya koenigii* and *Premna latifolia* from in and around plantations would give a good control. Wild plants (noneconomic) nearby the fields having feeding spots of *H. theivora* have to be eradicated, as far as possible. • The ecotone (border) between forest line and tea plantation need to be kept clear of weed and noneconomic plants. • *H. theivora* prefers moist conditions and mild temperatures. For that reason, populations of this pest are often higher under heavy shade. Regulate the shade in densely shaded area areas lopping of the lower branches of shade trees. Moderate shade of 60% is preferable. **<u>Biological control:</u>** • See common practices. • Applying native plant crude aquaus extracts viz. *Clerodendrum viscosum* (Dhopat tita/ Ghato)*, Polygonum hydropiper* (Pothorua bihlonganii)*, Cassia alata* (Khor pat), *Xanthium strumarium, Vitex negundo* and *Amphineuron* Sp (Bitter fern) @ 5% concentration may also be done in case of low and moderate infestation of the pest. • Entomopathogen, *Beauveria bassiana* @ 1.2 Kg/acre minimized infestation of *H. theivora* in field condition. **<u>Chemical control:</u>** • Clothianidin 50% WDG @ 48 g in 200 l of water/acre or Profenofos 50% EC @ 320-400 ml in 160 l of water/acre or Thiacloprid 21.7% SC@ 150 ml in 160 l of water/acre or Thiamethoxam 25% WG @ 40 g in 160-200 ml of water/acre
Thrips	**<u>Cultural control:</u>** • The recommendation on shade management, if adopted, will help to prevent the excessive built up of thrips and mites • For other see common practices.

	• Caustic washing of the trunk of the bushes after cleaning the mosses and lichens and stirring of soil around the collar region will kill the pupae. **Biological control:** • See common practices. **Chemical control:** • Azadirachtin 1% MIN. E.C. Neem Based.@ 1600-2000 ml in 180 l of water/acre or Azadirachtin 5% W/W MIN. Neem Extract Concentrate Containing M/s EID Perry @ 80 g in 160 l of water/acre or Deltamethrin 2.8% EC@ 48- 60 ml in 160 -240 l of water/acre or Ethion 50% EC @ 200 ml in 200-400 l of water or Profenofos 50% EC@ 320-400 ml in 160 l of water/acre or Quinalphos 25% EC @ 304 ml in 200-400 l of water/acre
Looper caterpillar**	• See common cultural and biological practices of vegetative stage. **Chemical control:** • Azadirachtin 5% W/W MIN. Neem Extract Concentrate Containing@ 80 g in 160 l of water/acre or Deltamethrin 2.8% EC@ 48- 60 ml in 160 -240 l of water/acre or Profenofos 50% EC @ 320-400 ml in 160 l of water/acre or Deltamethrin 2.8% EC@ 40-60 ml in 160-240 l of water/acre or Quinalphos 20% AF @ 400 g in 160 l of water/acre
Bunch caterpillar	• See common cultural and biological practices of vegetative stage. **Chemical control:** • Azadirachtin 5% W/W MIN. Neem Extract Concentrate Containing@ 80 g in 160 l of water/acre or Deltamethrin 2.8% EC@ 48- 60 ml in 160 -240 l of water/acre
Mites (red, pink, yellow** scarlet**, and purple**)**	**Cultural control:** • The recommendation on shade management, if adopted, will help to prevent the excessive built up of mites. • Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation • Uproot and burn infested plants. This can be successful during the early stages of infestation when the mites concentrate on a few plants • Keep the field free of weeds • Remove and burn infested crop residues immediately after harvest • The bushes along the motorable roads, which remain covered with dust are very often found to be severely attacked by red spider mite. Protect the roadside bushes from dust by growing hedge plants like *Phlogacenthus thrysiflorus* (titaphool) or applying water on such dusty roads at regular intervals is a good practice for management of red spider mite. • To prevent migration of red spider mites by restricting the pluckers from entering into un-infested areas from infested areas and cattle trespass inside the tea sections should be stopped. • Removal of alternate hosts (*Borreria hispida*, *Scoparia dulcis*,

	Melochia corchorifolia and *Fussiala suffruticosa*) in and around plantations would give a good control • The bushes in ill drained or waterlogged areas are subject to increased red spider damage, than those in well drained areas. Therefore, inadequate drainage is not only harmful to the tea plants but also creates conditions conducive to the buildup of *O. coffeae.* • Red spider mite incidence is high on the bushes receiving heavier doses of nitrogen but potash and phosphorus application decreased the amount of red spider in tea. Therefore, appropriate fertilization practice is necessary. • Red spider mite affected fields should get a new tier of maintenance foliage since the infested bushes are very week due to defoliation of maintenance leaves. • Measures should be taken (Two rounds of spray at 15 days interval) during December and January in Young and Un-prune Tea; Skiffed tea – February; Pruned tea – Early March. • After severe attacks of mite two rounds of applications must be followed at an interval of 7 – 10 days (April – October- 7 days and Nov – March-10 days). • Coverage of both surfaces and foliage is necessary. During full cropping seasons control measures should be undertaken as spot treatment only. • For pruned tea monitoring is necessary soon after tipping. • Avoid spraying during middle hours of the day in sunny weather. • Thorough drenching of top, middle and bottom hamper of bushes with spray fluid is necessary to kill the residual population. • The crude water extracts of native plants viz. *Clerodendrum viscosum, Melia azadirach, Vitex negundo, Gliricidia maculata*, *Wedelia chinensis*, *Morinda tinctoria*, *Pongamia glabra*, neem kernel, pongam kernel, garlic, *Swietenia mahagoni* seeds, *Pongamia pinnata* seeds, *Sophora flavescens*, *Acorus calamus* rhizomes, *Xanthium strumarium*, *Clerodendron infortunatum*, *Aegle marmelos*, *Clerodendron inerme, Phlogocanthus tubiflorus*, *Achanthus aspera*, *Artemisia nilagirica*, *Phyllanthus amarus* and *Lantana camara* showed great promise in controlling red spider mite population at field level. **Biological control:** • See common biological practices. **Chemical control:** **For Red Spider mites** • Azadirachtin 1% MIN. E.C. Neem Based.@ 1600-2000 ml in 180 l of water/acre. or Azadirachtin 5% W/W MIN. Neem Extract Concentrate Containing@ 80 g in 160 l of water/acre or Bifenthrin 8%SC @ 200 ml in 160 l of water/acre or Dicofol 18.5% EC @ 500 ml in 100 l of water/acre or Ethion 50% EC @ 200 in 200-400 l of water/acre or Fenazaquin 10% EC @ 400 ml in 160-320 l of water/acre or Fenpropathrin 30% EC @ 66-80 ml in 160-200 l of water/acre or

	Fenpyroximate 5% EC @ 120-240 ml in 160-200 l of water/acre or Flumite 20% SC / Flufenzine 20%SC @ 200-240 ml in 200-400 l of water/acre or Hexythiazox 5.45% W/W EC @ 120-200 ml in 160 l of water/acre or Profenofos 50% EC @ 320-400 ml in 160 l of water/acre or Propargite 57% EC @ 300-500 ml in 160 l of water/acre or Spiromesifen 22.9% SC @ 160 ml in 160 l of water/acre or Sulphur 52% SC @ 800 ml in 160 l of water/acre or Sulphur 80% WP@ 400 g in 80 l of water/acre **For Pink mite:** • Azadirachtin 5% W/W MIN. Neem Extract Concentrate Containing@ 80 g in 160 l of water/acre or Dicofol 18.5% EC @ 500 ml in 100 l of water/acre or Fenazaquin 10% EC @ 400 ml in 160-320 l of water/acre or Fenpropathrin 30% EC @ 66-80 ml in 160-200 l of water/acre or Fenpyroximate 5% EC @ 120-240 ml in 160-200 l of water/acre or Flumite 20% SC / Flufenzine 20%SC @ 160-200 ml in 200-400 l of water/acre or Phosalone 35% EC@ 411.2 ml in 200-400 l of water/acre or Profenofos 50% EC @ 320-400 ml in 160 l of water/acre or Propargite 57% EC @ 300-500 ml in 160 l of water/acre or Sulphur 40% WP @ 1000-2000 g in 300-400 l of water/acre or Sulphur 80% WP@ 400 g in 80 l of water/acre **For Scarlet mite:** • Dicofol 18.5% EC @ 500 ml in 100 l of water/acre or Hexythiazox 5.45% W/W EC @ 120-200 ml in 160 l of water/acre or Propargite 57% EC @ 300-500 ml in 160 l of water/acre or Fenpropathrin 30% EC @ 66-80 ml in 160-200 l of water/acre **For Purple mite:** • Dicofol 18.5% EC @ 500 ml in 100 l of water/acre or Ethion 50% EC @ 200 in 200-400 l of water/acre or Fenazaquin 10% EC @ 400 ml in 160-320 l of water/acre or Fenpropathrin 30% EC @ 66-80 ml in 160-200 l of water/acre or Fenpyroximate 5% EC @ 120-240 ml in 160-200 l of water/acre or Flumite 20% SC / FLUFENZINE 20%SC @ 160-200 ml in 200-400 l of water/acre or Phosalone 35% EC@ 411.2 ml in 200-400 l of water/acre or Propargite 57% EC @ 300-500 ml in 160 l of water/acre or Sulphur 40% WP @ 1000-2000 g in 300-400 l of water/acre or Sulphur 80% WP@ 400 g in 80 l of water/acre **For Yellow mite:** • Dicofol 18.5% EC @ 500 ml in 100 l of water/acre or Ethion 50% EC @ 200 in 200-400 l of water/acre or Fenpropathrin 30% EC @ 66-80 ml in 160-200 l of water/acre
Jassids	**Cultural control:** • Regular field assessment. • For others see common practices. • Caustic washing of the trunk of the bushes after cleaning the mosses and lichens and stirring of soil around the collar region will

	kill the pupae. **Chemical control:** • Profenofos 50% EC @ 320-400 ml in 160 l of water/acre
Scale insects**	**Cultural control:** • Prune heavily infested plant parts to open the tree canopy and destroy' them immediately. • Prune infested parts (branches and twigs) preferably during summer. • These should be placed in a pit constructed on one corner of the orchard. Allow branches and twigs to dry until the parasites escape. • Burn the remaining debris. • Removal of attendant ants may permit natural enemies to control the insect. **Chemical control:** • 'Ethion 50% EC @ 200 in 200-400 l of water/acre
Flushworm**	• Same as vegetative stage
Aphids	• Same as vegetative stage.
Blight, Rust, Rots, Canker**	• Same as vegetative stage.

***The dosage of pesticide is based on high volume sprayer.**
****Regional pests**

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. NUTRIENT DEFICIENCY SYMPTOMS

Nutrient	Symptoms
Nitrogen: Older leaves become yellow in color; size of the leaf will be affected. **Correction Measure:** Foliar spray of urea@1%	
Phosphorus: Stunted plant growth and pigmentation seen in older leaves. **Correction Measure** Foliar spray of DAP@1%.	

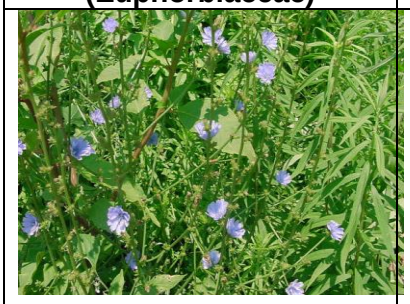
Magnesium: Yellowing symptom seen in older leaves. **Correction Measure:** Foliar spray of $MgSO_4$@1.0%.	
Sulphur: Yellowing of young leaves; elongation of leaf growth will be affected. **Correction Measure:** Foliar spray of $CaSO_4$@1-2%.	
Boron: Plant tip and flower bud is affected; leaf size becomes small and malformed. **Correction Measure:** Foliar spray of borax@0.5%	
Copper: Young leaves become pale yellow. **Correction Measure:** Foliar spray of $CuSO_4$@1-2%.	
Iron: Young leaves become yellow in color; Occurrence of interveinal chlorosis. **Correction Measure:** Foliar spray of $FeSO_4$@0.5%	
Manganese: Young leaves become yellow; veins remain green in color. **Correction Measure** Foliar spray of $MnSO_4$@1.0%	

Zinc: Symptoms seen in young leaves; leaves become small and necrotic. **Correction Measure:** Foliar spray of $ZnSO_4$@ 0.5%.	

Source: http://kau.edu/pop/beverages&stimulants.htm
http://www.agritech.tnau.ac.in/agriculture/agri_index.html
http://www.ihbt.res.in/TIM/fert1.jpg
Naidu (2012).

VII. COMMON WEEDS

		
1. Goat weed *Ageratum conyzoides* L. (Asteraceae)	**2.Landrina: *Borreria hispida* L. (Rubiaceae)**	**3. Hill glory bower: *Clerodendron infortunatum* L. (Verbinaceae)**
		
4. Malabar melastome: *Melastoma malabathricum* L. (Melastomataceae)	**5. Bitter Vine: *Mikania micrantha* Kunth (Aseteraceae)**	**6. Non tai baihong: *Pouzolzia indica* (L.) G. Benn (Urticaceae)**

		
7. Congo jute: *Urena lobata* L. (Malvaceae)	**8. Wood sorrels: *Oxalis corymbosa* L. (Oxalidaceae)**	**9. *O. acetocella* L. (Oxalidaceae)**
		
10. Kuppaimeni: *Acalypha indica* L. (Euphorbiaceae)	**11. Common wireweed: *Sida acuta* Burm.f. (Malvaceae)**	**12. Aligator yam: *Ipomea digitata* L. (Convolvulaceae)**
		
13. Cichorium: *Cichorium intybus* L. (Astaraceae)	**14. False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)**	**15. Asthma plant: *Euphorbia* spp. (Euphorbiaceae)**
		
16. Tropical Spiderwort: *Commelina benghalensis*	**17. Buffalo grass: *Paspalum conjugatum* L. (Poaceae)**	**18. Torpedo grass: *Pannicum repens* L. (Poaceae)**

L. (Commelinaceae)		
 **19. Blady grass: *Imperata cylendrica* (L.) P.Beauv. (Poaceae)**	 **20. Hairy crabgrass: *Digitaria sanguinalis* (L.) Scop. (Poaceae)**	 **21. Indian goosegrass: *Eleusine indica* (L.) Gaertn. (Poaceae)**
 **22. Blanket grass: *Axonopus compressus* (Sw.) P.Beauv. (Poaceae)**	 **23. Bermuda grass: *Cynadon dactylon* L. (Poaceae)**	 **24. Kans grass: *Saccharum spontanium* L. (Poaceae)**
 **25 Yellow nutsedge: *Cyperus esculentus* L. (Cyperaceae)**	 **26. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)**	

VIII. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1. Tea mosquito bug:

Biology:

Egg: The eggs are elongated and sausage shaped. Each egg bears two C filamentous processes which project out from the tissues in which the eggs have been inserted Hatching occurs within 5 to 7 days in summer and 20 to 27 days m winter.

Nymph: The nymph bears delicate, elongated legs. The dirty-yellow nymphs suck the sap of the host plant and undergo five moults to attain maturity. The larval period lasts for 9-10 days in

summer and 25-29 days in winter.

Adult: The adult *H. theivora* is small bug measuring 6-8 mm in length. The body is slender and elongated with yellowish-brown or olive green head, dark red thorax and yellow and greenish-black abdomen. Appendages are long, dark and delicate. The thorax bears a characteristic dorsal knobbed process. Life cycle is completed in about 15 20 days in summer and 45-60 days in winter in North-East Indian conditions. There may be several generations in a year.

Life cycle:

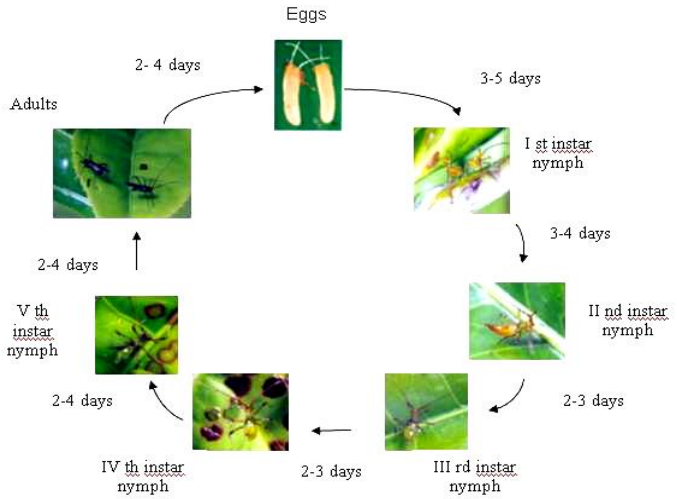


Photo courtesy: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Damage symptoms:

- The nymphs and adults suck the sap of the young leaves, buds and tender stems and while doing so, they injects toxic saliva which causes the breakdown of tissues around the site of feeding.
- Within 2-3 hours of sucking a circular spot is formed around the feeding point and in 24 hours it becomes translucent, light browning. Within a few days the spots appear as dark brown sunken spots which subsequently dry up. The badly affected leaves become deformed and even curl-up.
- In addition, due to oviposition, the tender stems develop cracks and over-callusing which lead to blockage of vascular bundle thereby affecting the physiology causing stunted growth and sometimes die-back of the stems.

Circular spots in leaf due to feeding

Die-back symptom

Photo courtesy: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Natural enemies of tea mosquito bug:

Parasitoids: Mymarid, *Erythmelus helopeltidis.*
Predators: *Chrysoperla zastrowii sillemi, Mallada* sp, *Oxyopes* sp. (Spider), Reduviid bug Praying Mantids.
Pathogens: Nematodes (*Hexamermis sp*.) *Beauveria bassiana.*
*For the management refer page number……

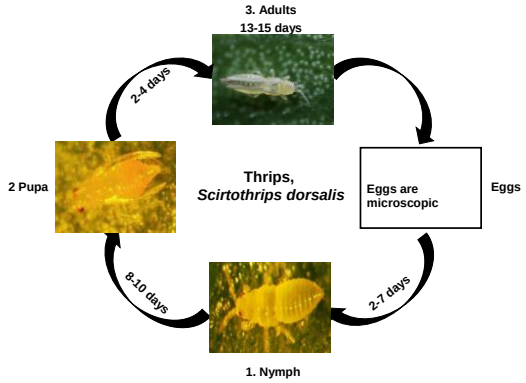
2. Thrips:

Biology:

Egg: The egg is bean-shaped, slightly narrower at one end and is almost colourless when freshly laid.

Nymph: The newly hatched nymph is almost white but soon after sucking of plant sap, the colour gradually changes to pale yellow. The second instar nymph is orange yellow .
Pre-pupa: The pre-pupa can be recognized by the free antennae directed forward while in the pupa; the antennae are reflected over the head to reach the middle of the pro-thorax.

Adult: The adult insect is pale yellow in colour, the abdomen being paler. The female measures 1.05 mm long and 0.19 mm width. The male measures 0.71 mm in length and 0.14 mm in width.



Damage symptoms:

- Feeds on tender above ground parts, creating feeding scars, distortion of leaves and discoloration of buds
- The infested leaves curl upward, crumble and shed
- Infested buds become brittle and drop down.
- The sucking marks are made one after one, forming thin pale lines on the underside of leaves parallel to the main vein


Photo courtesy: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Host-range and favourable conditions:

- *S. dorsalis* is found in almost all chilly growing areas. It is a polyphagus pest. Besides chilli, it also infests brinjal, cotton, groundnut, castor, bottlegourd, guava, tea and grapevine. It is more common on un-irrigated chilli crop than irrigated one.

Natural enemies of thrips:

Predators: *Anthocoris* and Orius spp., predatory thrips (*Aeolothrips intermedius*, *Mymarothrips garuda*), *Chrysoperla carnea, Mallada* sp, praying mantids, ladybird beetles, syrphid flies, spiders etc.

Pathogens: *Steinernema* sp., *Verticillium lecanii, Beauveria bassiana, Metarhizium anisopliae, Paecilomyces fumerosus*

*For the management refer page number……

3. Leaf eating caterpillar:

Biology:

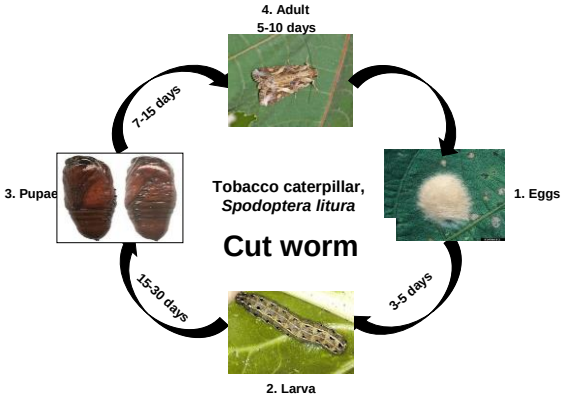
Egg: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.

Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. Larval stage lasts 15-30 days

Pupa: Pupation takes place inside the soil, pupal stage lasts 7-15 days.

Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing. Pest breeds throughout the year. Moths are active at night. Adults live for 7-10 days. Total life cycle takes 32-60 days. There are eight generations in a year.

Life cycle:



1.http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3 http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf

4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.
- Irregular holes on leaves initially and later skeletonisation leaving only veins and petioles
- Heavy defoliation.

Damage symptoms

http://www.missouribotanicalgarden.org/Portals/0/Gardening/Gardening%20Help/images/Pests/Caterpillars_Surface701.jpg

Parasitoids: *Trichogramma chilonis, Tetrastichus* spp., *Telenomus* spp., *Ichneumon promissorius, Carcelia spp*, *Campoletis chlorideae, Lissopimpla excels, Ichneumon promissorius* etc.

Predators: *Chrysoperla zastrowi sillemi*, coccinellids, King crow, braconid wasps, dragonfly, spider, robber fly, reduviid bug, praying mantis, and red ants etc.

*For management refer to page number----

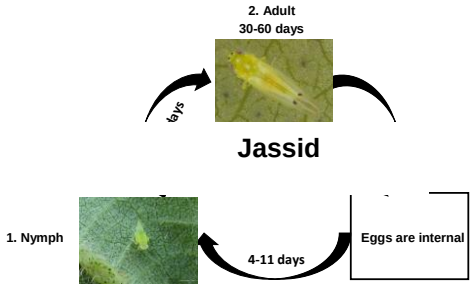
4. Jassid:

Biology:

Egg: Adult females lay eggs along the midrib and lateral veins of the leaves. The egg period is 4 to 11 days.

Nymph: The nymphs resemble the adults, but lack wings. Instead, they have slightly extended wing pads. They are pale green in color. They tend to move sideways when disturbed. The nymphal period varies from 1-4 weeks depending on the temperature.

Adult: The adults are wedge-shaped, pale green insects. They have fully developed wings with a prominent black spot on each forewing. The adults may live for one to two months.



Jassid

1. http://www.flickr.com/photos/dalalsure/3726494086/

2. http://www.nbaii.res.in/insectpests/Amrasca-biguttula.php

Damage symptoms:

- Both nymphs and adults suck the sap from the lower leaf surfaces through their piercing and sucking mouthparts. While sucking the plant sap, they also inject toxic saliva into the plant tissues, which leads to yellowing. When several insects suck the sap from the same leaf, yellow spots appear on the leaves, followed by crinkling, curling, bronzing, and drying, or "hopper burn". Leafhoppers also cause damage in okra, cotton, and potato seriously.

Natural enemies of jassid:

Parasitoids: *Anagrus flaveolus, Stethynium triclavatum*
Predators: Ladybird beetle, ants *Distina albino*, *Chrysoperla* spp., mired bug (*Dicyphus hesperus*), big-eyed bug, (*Geocoris* sp) Praying mantids.

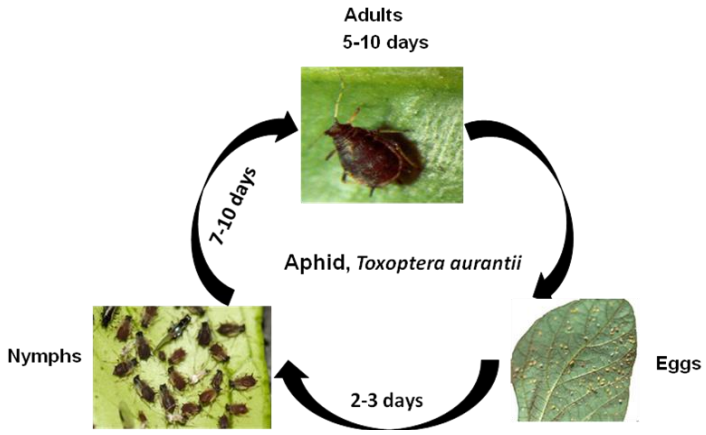
*For the management refer page no

5. Aphids:

Biology:

Egg: are very tiny, shiny-black, and are found in the crevices of bud, stems, and barks of the plant. Aphids usually do not lay eggs in warm parts of the world.
Nymph: (immature stages) are young aphids; they look like the wingless adults but are smaller. They become adults within 7 to 10 days.
Adult: are small, black to dark brownish colour, 1 to 4 mm long, soft-bodied insects with two long antennae that resemble horns. Most aphids have two short cornicles (horns) towards the rear of the body.

Life cycle:



http://gipcitricos.ivia.es/area/plagas-principales/pulgones/toxoptera-aurantii

Damage symptoms:

- Nymphs and adults suck cell sap from the plant foliage.
- In addition, plants may become contaminated by honeydew produced by aphids and

sooty mould growing on honeydew.

- Aphids are also vectors of diseases, including the bean common mosaic virus.

http://www.infojardin.com/foro/showthread.php?t=89572&page=12

Natural enemies of aphid:

Parasitoids: *Aphidius colemani, Aphelinus* sp and *Diaeretiella* sp.
Predators: Fire ant, Robber fly, Big-eyed bug (*Geocoris* sp), Earwig, Ground beetle, Cecidomyiid fly, Lacewing, Ladybird beetle, Spider, Praying Mantis, Reduviid, Dragon fly, hoverfly.

*For management refer to page number----------

6. Bunch caterpillar:

Biology:

Egg: The eggs are yellowish and are arranged in linear order by the female moth. A single female laid about 500 eggs.

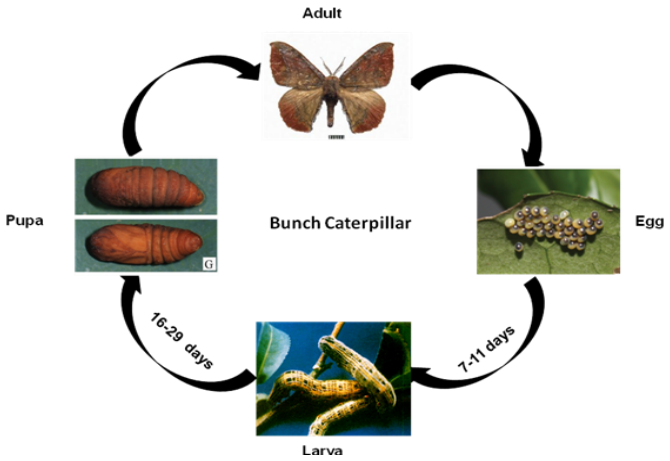
Larva: Within 7 to 11 days (in summer) caterpillars hatches out from the eggs. After emergence the caterpillars, first of all, feeds upon their egg shell, then they lacerate the leaf surface tissues and finally consume the whole leaf blade. The caterpillars remain clustered in characteristic bunches and hence are called “bunch caterpillars”. The gregarious nature of caterpillars continues throughout the larval life. During 3 to 4 weeks of larval life the larvae undergoes five instars. The fully grown and well fed matured larva measures about 65 mm in length. The larva is tawny-yellow with reddish tinge and broad blackish-brown transverse strips.

Pupa: For pupation the larvae descend down from the host plant and pupate on the ground among dried leaves. The pupal period varies in different season. In summer it is 16 to 29 days, in rainy season it is about 46 days and in winter it is 68-120 days. The pupa is reddish-brown in colour and about 25 mm in size. There are four overlapping generations in a year in north-eastern region of India.

Adult: The adult moth is brown in colour. The wing span of male moth ranges from 33 to 45 mm, whereas in female it is 45-58 mm. Dark wavy lines are present on the wings. Fore wings have two white spots near the outer margin. The hind wings are brown posteriorly and pale in

anterior region. The antennae are bipectinate but as compared to females the males have more developed and highly bipectinate antennae.

Life cycle:



http://www.yourarticlelibrary.com/zoology/bunch-caterpillar-andraca-bipunctata-distribution-life-cycle-and-control/24077/

Damage symptoms:

- The damage is caused to the host plant by the caterpillars. The caterpillars eat the foliage of the host plant. Initially, they feed upon the surface tissues only but later on the whole blade is consumed.

- The caterpillars move in groups and before going down for pupation a bunch of caterpillars may destroy several bushes of tea plantation.

1. **2.**

1: http://www.pensoft.net/journals/zookeys/article/928/the-genus-andraca-lepidoptera-endromidae-in-china-with-descriptions-of-a-new-species

2.: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Natural enemies of bunch caterpillar:

Larval Parasitoids: Tachinid fly, *Cylindromyia* sp., *Cotesia ruficrus.*

*For management refer to page number----------

7. Red spider mite:

Biology:

Egg: Eggs reddish, spherical, provided with a small filament. Incubation period is 4-6 days, before hatching becomes light orange colour.
Nymph: Upon hatching, it will pass through a larval stage and two nymphal stages before becoming adult. Developmental stages include six legged larva, protonymph and deutonymph.
Adult: Adult female elliptical in shape, bright crimson anteriorly and dark pruplish brown posteriorlym. Mites spin a web of silken threads on the leaf. Each developmental stage is followed by a quiescent stage and life cycle completed in 10-14 days.

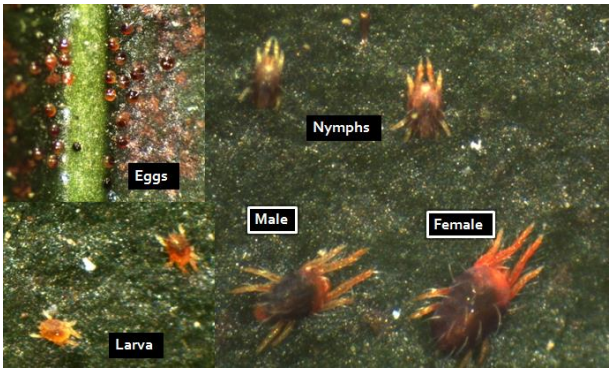


Photo courtesy: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Damage symptoms:

- Spider mites usually extract the cell contents from the leaves using their long, needle-like mouthparts. This results in reduced chlorophyll content in the leaves, leading to the formation of white or yellow speckles on the leaves.
- In severe infestations, leaves will completely desiccate and drop off. The mites also produce webbing on the leaf surfaces in severe conditions. Under high population densities, the mites move to using strands of silk to form a ball-like mass, which will be blown by winds to new leaves or plants, in a process known as “ballooning.”

Photo courtesy: Entomology Department, Tocklai Tea Research Institute, Jorhat, Assam

Natural enemies of red spider mite:

Predators: Predatory mite, Predatory thrips, *Oligota* spp., *Orius* sp (pirate bug), Hover flies, Mirid bug.

*For management refer to page number----------

8. Purple mite:

Biology:

- **Egg:** Eggs hatches in 2-3 days.
- **Nymph:** There are two nymphal stages and they are white in colour, young ones moult three times.
- **Adult:** Adults are very small, spindle shaped, purple colour; fringed body with five longitudinal white waxy ridges on dorsal side, total developmental period was 6-11 days.

1. Adult

Damage symptoms:

- Damaged leaves characterized by the coppery brown discoloration; presence of numerous white cast skins of the mites along with the live mites; purple mites are prevalent on the under surface of mature leaves;

2.

3.

1,2,3: http://www.ces.ncsu.edu/depts/ent/notes/O&T/specificplants/note138/note138.html

Predators same as red spider mite.

*For management refer to page number----------

9. Pink mite:

Biology:

Egg: Eggs are shiny, globular in shape and lay singly on the under surface of the leaves. Eggs are hatch in 2-3 days

Nymph: There are two nymphal stages and they are white in colour. Population builds up initiates in November/December and attains peak in February/March and declined during May/June. Life cycle completed in 6-9 days.

Adults: Adults are very small, spindle shaped, pink colour; fringed body with five longitudinal white waxy ridges on dorsal side, young ones moult three times; incubation period ranges 3-5 days with two nymphal stages while total developmental period was 6-11 days.

Damage symptoms:

- Important mite pest of tea in southern India causes considerable damage. During early stages of attack leaves turn pale and curl upwards while severe infestation leads to brownish discolouration. Pink mites attack tender crop shoots where “Aassam” hybrids are more susceptible

Predators same as red spider mite

*For management refer to page number----------

10. Yellow mite:

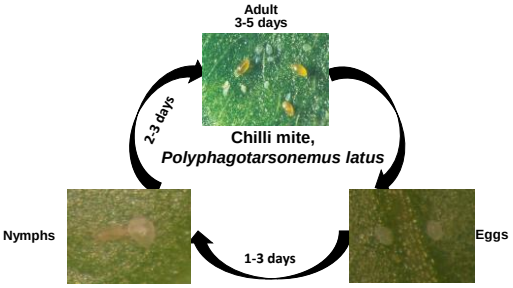
Biology:

Egg: Eggs are oval shaped and white in colour. Eggs are glued firmly on the leaf surface. Eggs large, obovate, flattened at the bottom; eggs hatches after 27-32 hours

Nymph: Nymphs white in colour.

Adult: Adults large, oval and broad and yellowish in colour. Females are yellowish and bigger than the males and they carrying the “female nymphs” on their back.

Life cycle:



Damage symptoms:

- Mite is seen on young leaves especially the top two to three leaves and the bud.
- Affected leaves become rough and brittle and corky lines.
- Downward curling.
- Internodes get shortened.

*For management refer to page number----------

Predators same as red spider mite.

11. Scarlet mite*:*

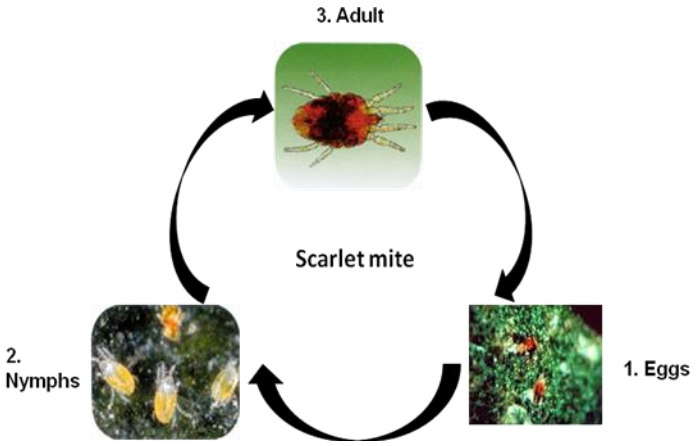
Biology:

Egg: Eggs are bright red, elliptical, laid in clusters; incubation period is 7-10 days.

Nymph: Developmental stages include three legged larva, protonymph and deutonymph and each developmental stage is followed by a quiescent stage.

Adult: Adult mite is scarlet red in colour and obovate in shape; reproduction is by parthenogenesis. Life cycle completed in 30-36 days.

Life cycle:



http://www.ikisan.com/Archive/archive9.htm

Symptoms of damage:

- Symptoms of attack first appear on either side of the midrib and gradually spread to the entire leaf; feeding leads to brown discolouration of leaves and severe infestation leads to defoliation.

Predators same as red spider mite.

*For management refer to page number----------

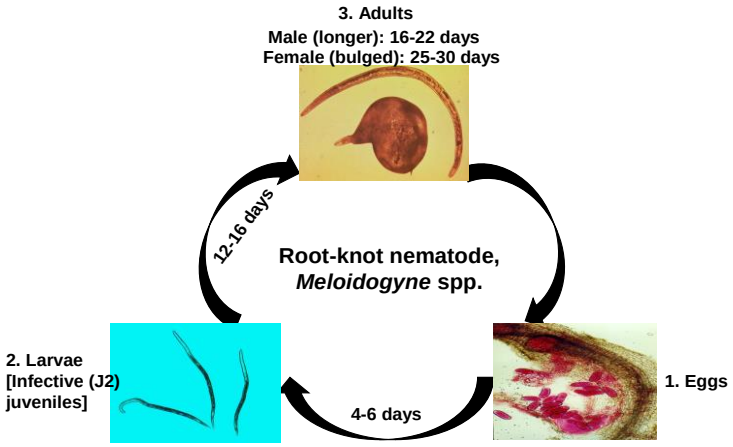
12. Root knot nematode:

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.
- Development of the first stage larvae occurs within the egg where the first molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.

- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:



1.http://keys.lucidcentral.org/keys/sweetpotato/key/
2. http://nematology.umd.edu/rootknot.html
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Infected plants in patches in the field
- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a '**beard root**' symptom
- Infected roots become knobby and knotty
- In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted
- Nematode infection predisposes plants to fungal and bacterial root pathogens

http://bioweb.uwlax.edu/bio203/s2009/bell_patr/interactions.htm

Survival and spread:
Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.
Secondary: Autonomous second stage juveniles that may also be water dispersed.
Favourable conditions:
Loamy light soils.
*For management refer to page number----------

Parasitoids

Egg parasitoid



1. *Trichogramma* sp **2. Mymarid,** **3. *Erythmelus helopeltidis*.**

Egg-larval parasitoid


4. *Tetrastichus* sp **5. *Chelonus* spp.**

Larval parasitoids




6. *Bracon* spp **7. *Campoletis* sp** **8. *Carcelia* sp** **9. *Telenomus* sp**

10. *Anagrus flaveolus*

11. *Stethynium*

12. Tachinid fly

13. *Cylindromyia* sp.

14. *Cotesia ruficrus*

Pupal parasitoids

15. *Ichneumon* sp

Nymphal/larval and adult parasitoids

16. *Aphidius*

17. *Aphelinus*

2. http://bugguide.net/node/view/869428/bgimage
3.http://www.nbaii.res.in/IndianMymaridae/Mymaridae/html/Mymaridae/Erythmelus_Enock.
4. http://www.pbase.com/image/135529248
5. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
7. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
8. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398

9 http://baba-insects.blogspot.in/2012/02/telenomus.html
10. http://www.plantwise.org/default.aspx?site=234&page=4279&dsID=5090
11.http://www.nbaii.res.in/IndianMymaridae/Mymaridae/html/Mymaridae/Stethynium_Enock.htm
12. http://www.oocities.org/brisbane_flies/TACHINIDAE.htm
13. http://nathistoc.bio.uci.edu/diptera/Cylindromyia.htm
14. http://www.uky.edu/~mjshar0/genera/Cotesia/cotesia.html
15. http://www.organicgardeninfo.com/ichneumon-wasp.html
16. http://biobee.in/products-and-services/solutions/bio-aphidius/
17. http://australianmuseum.net.au/image/Aphelinus-wasp-stings-aphid-Denis-Crawford/Kool

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Fire ant

7. Big-eyed bug

8. Earwig

9. Ground beetle

10. Pentatomid bug

11. Preying mantis

12. Predatory mite

16. Predatory thrips




17. *Oligota* spp. **18. *Orius* spp.** **19. Hover fly** **20. Mirid bug**

5. http://www.warpedphotosblog.com/robber-fly-and-prey
6.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021

9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
15. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
16. http://biocontrol.ucr.edu/hoddle/persea_mite.html
17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
18. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

IX. DESCRIPTION OF DISEASES

1. Blister blight:

Disease symptoms:

- Small, pinhole-size spots are initially seen on young leaves less than a month old. As the leaves develop, the spots become transparent, larger, and light brown.
- After about 7 days, the lower leaf surface develops blister-like symptoms, with dark green, water-soaked zones surrounding the blisters.
- Following release of the fungal spores, the blister becomes white and velvety.
- Subsequently the blister turns brown, and young infected stems become bent and distorted and may break off or die.

Survival and spread:

- The pathogens survive on leaves or stems and in fallen plant host debris.
- Disease is readily spread by the dispersal of spore by wind.

Favourable conditions:

- Cloudy and wet weather favors infection.



Photo courtesy: Mycology and Microbiology Department, Tocklai Tea Research Institute, Jorhat, Assam

*For management refer to page number----------

2. Red rust:

Disease symptoms

- Leaves develop lesions that are roughly circular, raised, and purple to reddish-brown. The alga may spread from leaves to branches and fruit.
- Most algal spots develop on the upper leaf surface.
- Older infections become greenish-gray and look like lichen. *Cephaleuros* usually does not harm the plant.

Survival and spread:

- The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris.

Favourable conditions:

- Frequent rains and warm weather are favorable conditions for these pathogens. For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae

Photo courtesy: Mycology and Microbiology Department, Tocklai Tea Research Institute, Jorhat, Assam

Disease symptoms

*For management refer to page number----------

3. Brown blight, grey blight:

Disease symptoms:

- Small, oval, pale yellow-green spots first appear on young leaves. Often the spots are surrounded by a narrow, yellow zone.
- As the spots grow and turn brown or gray, concentric rings with scattered, tiny black dots become visible and eventually the dried tissue falls, leading to defoliation. Leaves of any age can be affected.

Survival and spread:

- The pathogen survives in decay plant debris which is the sourse of primary infection.
- When young twigs of susceptible cultivars are cut and used to root new plants, latent mycelium in the leaf tissue may start to invade nearby cells to form brown spots, and this may lead to death of leaves and twigs.

Favourable conditions:

- The disease is favored by poor air circulation, high temperature, and high humidity or prolonged periods of leaf wetness.

Photo courtesy: Mycology and Microbiology Department, Tocklai Tea Research Institute, Jorhat, Assam

***For management refer to page number----------**

4. Twig die back, stem canker:

Disease symptoms:

- The first symptoms include browning and drooping of affected leaves. As the disease spreads into the shoots, they become dry and die. The entire branch can die from the tip downward.
- Dying branches often have cankers-shallow, slowly spreading lesions surrounded by a thick area of bark.

Survival and spread:

- The fungus usually requires wounded plant tissue to gain entry and initiate infection.
- Spores are spread when splashed by rain and can survive for several weeks on pruned branches left in the field.

Favourable conditions:

- Rainy weather favors its spread, and dry conditions promote its development.

1. **2.**

http://bioweb.uwlax.edu/bio203/s2009/bell_patr/interactions.htm

***For management refer to page number----------**

5. Brown root rot disease:

Disease symptoms

- Tea plants of all ages are susceptible to this disease. Affected bushes occur in patches, usually around old tree stumps, but sometimes isolated bushes are affected.
- Plants become weaker and their leaves begin to turn yellow and finally wilt and defoliate, eventually leading to death of the plant.

- Longitudinal cracks are usually present on the collar above the soil level but also on the tap root and lateral roots.
- Scrapping of the bark at the collar region reveals sheets of creamy white mycelia and the wood has a strong mushroom like-smell.

Survival and spread:

- Disease is spread by spores carried by wind, lodges on stumps of shade trees; infection spreads mainly through root contact and alternate hosts are Coffee, *Grevillea*, *Albizia and Erythrina*.

Favourable conditions:

- Disease is common in low elevation areas. Humid and rainy season favour the development of disease.

***For management refer to page number----------**

6. Red root rot disease:

Symptoms:

- Disease is also called as Poria root disease of tea.
- First symptoms appear as yellowing of the leaf followed by wilting and then sudden death of the bush or entire bush with the weathered leaves are attached to the stem for several days.

Survival and spread:

- The pathogen is soil borne and mycelium present in the soil is the source of primary infection.

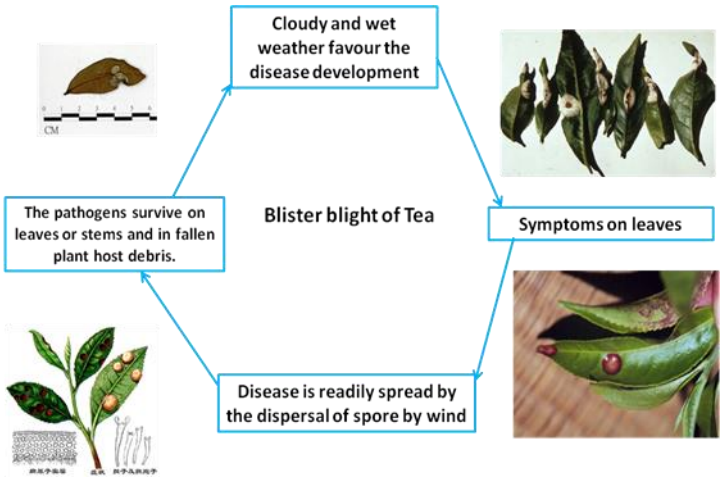
Favourable conditions:

- Humid and rainy season favour the development of the disease.

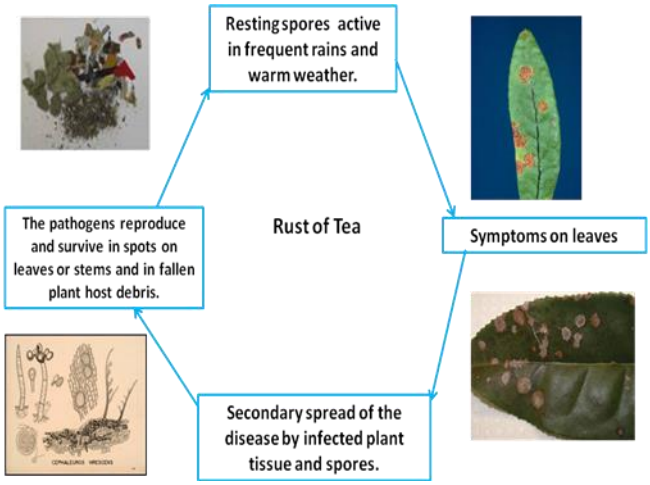
***For management refer to page number----------**

Disease cycle:

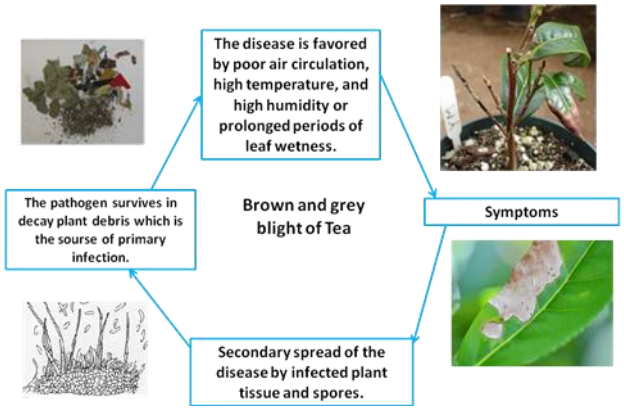
1. Blister blight:



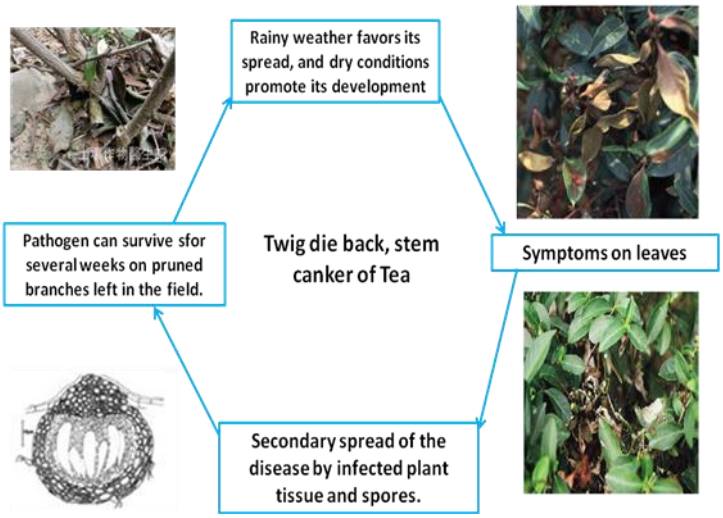
2. Rust:



3. Brown and grey blight



4. Twig die back, stem canker



X. SAFETY MEASURES

A. Pre-harvesting:

Harvesting is a very vigorous process that requires hard work and perseverance in order to coax the most out of the tea plant. Two processes exist for harvesting tea: course plucking and fine plucking. For both techniques harvesting tea is usually done by hand because machines damage the leaves too much for them to be of any use.

The ideal conditions for harvesting tea are usually at high altitudes with a good amount of rainfall.

With fine plucking you should harvest only the bud, second and third leaves so that you get the most from a harvest of tea.

Harvesting tea needs to be done in the early morning. Young and tender buds that have silvery white fuzz on them should be harvested. This type of harvesting tea makes very fine and delicate flavoured tea. It is usually lighter and sweeter in taste.

Harvesting tea using the coarse plucking technique produces a lower quality of tea than fine plucking. In coarse plucking you will also harvest the bud but will include more than two leaves whilst harvesting the tea. This is generally done at a very fast pace. This technique of harvesting tea makes a stronger flavour tea than that of fine plucking.

Pre-Harvest interval of Plant Protection Formulations (PPFs):

The safe pre-harvest intervals for the commonly used PPFs are shown below:

PPFs	Pre harvest interval (Days)*
Propargite 57 EC	7-12
Fenazaquin 10 EC	9-12
Spiromesifen 240 SC	14
Bifenthrin 8 SC	3-5
Hexythiazox 5.45 EC	12
Wettable sulphur 80%	10
Lime Sulphur	10
Deltamethrin 2.8 EC	4-10
Thiamethoxam	6-10
Dicofol	10-16
Ethion	7-10
Quinalphos	8-21
Fenpropathrin	8
Copper	7-14
Paraquat	7

*Depending on the locations

XI. DO'S AND DON'TS IN IPM

- Monitor the incidence of pests by assessing their populations in the field.
- Mark the areas from where the pest attack starts
- Start appropriate control measures in the beginning of the season
- Integrate cultural control methods with biological and chemical control measures.
- Use bio-formulations (botanical formulations and entomopathogens) wherever possible
- Use pesticides only when it is absolutely essential
- Do not allow the pests to cross the ETL
- Do not reduce the recommended concentration of pesticides
- Do not mix two or more pesticides.
- Do not unduly drench soil.
- Do not add wetting agents unless recommended
- Do not allow the growth of weeds in ravines, along drains, foot-paths and vacant patches.
- Do not allow cattle inside the tea field

- Cattle trespass and movement of workers through areas treated with chemical pesticides should be prevented as far as possible.
- Date expired pesticides should not be purchased or used in the field.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms poisoning	First aid measures and treatment of poisoning	Waiting period from last application to harvest (days)
Insecticides					
1.	Carbofuran Extremely toxic 	Class I b highly hazardous	Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting, diarrhea, epigastric pain, tightness in chest	**Treatment of poisoning** : Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed	-
2.	Quinalphos Highly toxic 	Class II Moderately hazardous	Excessive salivation, sweating, rhinorrhea and tearing. Muscle twitching, weakness, tremor, in-coordination. Hedache, dizziness, nausea, vomiting, abdominal cramps, diarrhea. - Respiratory depression, tightness in chest, wheezing, productive cough, fluid in lungs. - Pin-point pupils, sometimes with blurred or	**Treatment of poisoning**: For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	7

			dark vision. - Severe cases: seizures, incontinence, respiratory depression, loss of consciousness.		
3.	Fenpropathrin		Salivation, weakness, ataxia, tremors, convulsions, gastrointestinal irritation, nausea, vomiting and diarrhea.	**First aid measure:** Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person. **Treatment of poisoning**: Possible mucosal damage may contraindicate the use of gastric lavage. Treatment is supportive and symptomatic. Diazepam has been recommended to reduce the central nervous system effects	7
4.	Propargite		Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed. Harmful if absorbed through skin. Harmful if inhaled.	**First aid measure:** Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person **Treatment of poisoning**: No specific antidote. Treatment is essentially symptomatic.	7
5.	Dicofol Moderately toxic	Class III	Headache, palpitation, nausea, vomiting, flushed	**Treatment of poisoning**: No specific antidote. Treatment is	15-20

		slightly toxic	face, irritation of nose, throat, eyes and skin, allergic manifestations etc.	essentially symptomatic	
6.	Phosalone		Headache, weakness, tightness in the chest, blurred vision, non-reactive pinpoint pupils, salivation, sweating, nausea, vomiting, diarrhea, abdominal cramps.	**First aid measure:** Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious person **Treatment of poisoning**: No specific antidote. Treatment is essentially symptomatic	-
7.	Thiamethoxam			**First aid measure:** Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious. **Treatment of poisoning**: No specific antidote. Treatment is essentially symptomatic.	7
8.	Profenophos Highly toxic 	Class II b- Moderately hazardous	Moderate-nausea. salivation, lacrimation, abdominal cramp, vomiting, sweating, Slow pulse, Muscular tremors, meiosis.	**First aid measure:** Remove the person from the contaminated environment. In case of (a) Skin contact-Remove all contaminated clothings and immediately wash with lot of water and soap: (b) Eye contamination -Wash the eyes	7

				with plenty of cool and clean water; (c) Inhalation - Carry the person to the open fresh air, loosen the clothings around neck and chest, and' (d) Ingestion -If the victim is fully conscious. Induce vomiting by tickling back of the throat. Do not administer milk alcohol and fatty substances. In case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty. give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor /Primary Health Centre immediately along with the original container, leaflet and label. **Treatment of poisoning:** For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults. 0.5-1.0 mg for children) is recommended, repeated at 5-10 minute intervals until signs of atropinization occur. Speed is imperative Atropine injection 1 to 4 mg. Repeat 2mg when toxic symptoms begin to recur (15-16	

				minute intervals), Excessive salivation - good sign, more atropine needed: Keep airways open, Aspirate, use oxygen insert endotracheal tube. Do tracheotomy and give artificial respiration as needed. For ingestion lavage stomach with 5% sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes-wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2-PAM (2-pyridinc aldoxime methiodide). 1g and 0.25g for infants intravenously at a slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophyllin, aminophyllin. Barbiturates or phenothiazincs. Do not give atropine to a Cyanotic patient. Give artificial respiration first then Administer atropine.	
9.	Deltamethrin Highly toxic	Class II - Moderately hazardous	Headache. Palpitation, nausea, vomiting flushed face. Irritation of nose, throat eyes and skin, allergic manifestations etc.	**Treatment of poisoning:** No specific antidote treatment is essentially symptomatic.	3

					
10.	Bifenthrin Highly Toxic 	Class II Moderately hazardous	Symptoms of overexposure include bleeding from the nose, tremors and convulsions	**First aid measures:** Drink 1 or 2 glasses of water and induce vomiting by touching the back of the throat with a finger. Never induce vomiting or give anything by mouth to an unconscious person. Contact a medical doctor. **Treatment of poisoning:** Gastric lavage using an endotracheal tube may be preferred to vomiting. Reversible skin sensations (paresthesia) may occur and ordinary skin salves have been found useful in reducing discomfort.	11
11.	Fenazaquin	Class II Moderately hazardous		**First aid measures:** Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on the left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature.	7
12.	Hexythiazox Moderately toxic	Class III slightly hazardous	-	**-**	5

					
Fungicides					
1.	Sulphur Slightly toxic 	-	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	**Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic	-
2.	Copper oxychloride Moderately toxic 	Class III slightly hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	**First aid measures:** Rush to the nearest physician. **Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic.	-
3.	Propiconazole Moderately toxic 	Class III Slightly Hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	**Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic.	7

XIII. BASIC PRECAUTIONS IN PESTICIDES 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.

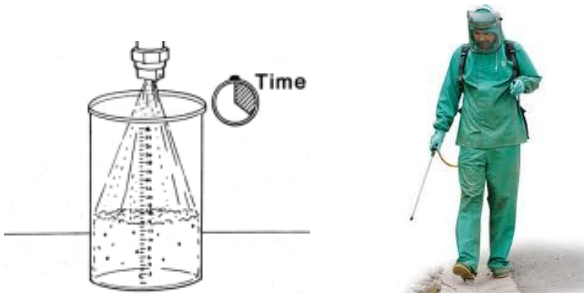
XIV. PESTICIDE APPLICATION TECHNIQUES

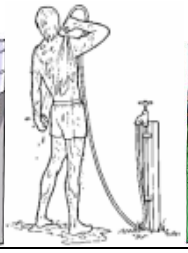
<table>
<tr><td colspan="4">Equipments</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td>Vegetative stage
i) For crawling and soil borne pests

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	

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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