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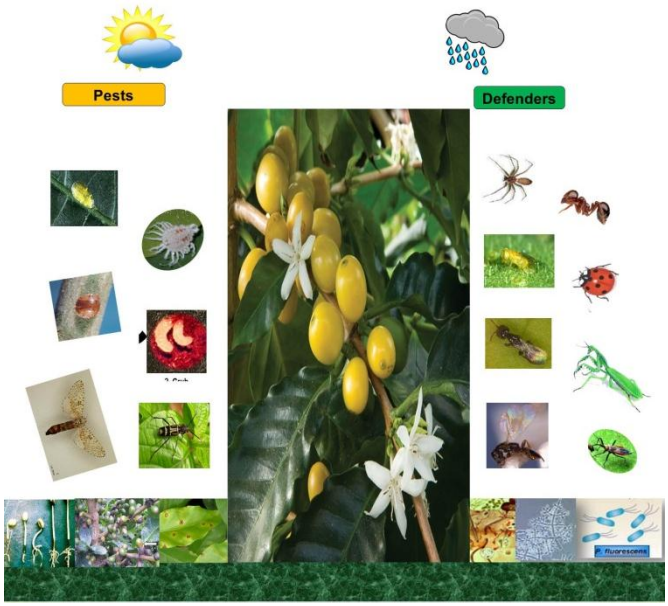
AESA BASED IPM PACKAGE
COFFEE



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Ministry of Agriculture and Farmers Welfare
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The AESA based IPM – Coffee was compiled by the NIPHM working group under the Chairmanship of Smt. V. Usha Rani, IAS, Director General, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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AESA BASED IPM PACKAGE FOR COFFEE

Coffee-Plant description:

The coffee plant (*Coffea arabica* L.; Family: Rubiaceae) is a woody perennial evergreen dicotyledon. It is a species of *Coffea* originally indigenous to the mountains of the southwestern highlands of Ethiopia. It is also known as the "coffee shrub of Arabia", "mountain coffee" or "arabica coffee". *Coffea arabica* is believed to be the first species of coffee being grown in southwest Ethiopia for well over 1,000 years. Plants grow between 1.5 and 12 m (5 and 39 ft.) tall and have an open branching system; the leaves are opposite, simple elliptic-ovate to oblong, 6–12 cm long and 4–8 cm broad, glossy dark green. The flowers are white, 10–15 mm in diameter and grow in axillary clusters. The seeds are contained in a drupe 10–15 mm in diameter, maturing bright red to purple and typically contains two seeds (the coffee seeds).

I. PESTS

A. Pests of Major Significance

1. Insect pests

1.1 White coffee stem borer: *Xylotrechus quadripes* (Chevrolat) (Coleoptera: Cerambycidae)

1.2Coffee berry borer: *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae)

1.3 Coffee root mealybug: *Planococcus citri* Risso & *P. lilacinus* Cockerell (Hemiptera: Pseudococcidae)

1.4.Shot hole borer: *Xylosandrus compactus* Eichhoff (Coleoptera: Curculionidae)

1.5 Brown scale: *Saissetia coffeae* Walker (Hemiptera: Coccidae)

1.6 Green scale: *Coccus viridis* Green (Hemiptera: Coccidae)

1.7 Cock chafers or white grubs: *Holotrichia* spp. (Coleoptera: Melolonthidae)

1.8 Hairy caterpillars: *Eupterote* spp. (Lepidoptera: Eupterotidae)

1.9 Coffee bean beetle: *Araecerus fasciculatus* (De. Geer) (Coleoptera: Anthribidae)

1.10 Red coffee borer: *Zeuzera coffeae* Nietner (Lepidoptera: Cossidae)

2. Diseases

2.1 Coffee leaf rust: *Hemileia vastatrix* (Berk.)

2.2 Black rot or koleroga: *Corticium salmonicolor* Berk. & Broome

2.3 Root diseases:

2.3.1 Brown root disease: *Fomes noxius* Corner

2.3.2 Red root disease: *Poria hypolateritia* Berk.

2.3.3 Sandavery root disease: *Fusarium oxysporum f.*sp*. coffeae*

2.4. Coffee trunk canker: *Ceratocystis fimbriata* (Ell. & Halst)

2.5. Berry blotch: *Cercospora coffeicola* (Cooke) Stev. & Wellman

2.6. Brown eye spot disease: *Mycosphaerella coffeicola* (Cooke) Stev. & Wellman

2.7. Coffee berry disease: *Colletotrichum kahawae* Waller & Bridge

***2.8.* Coffee wilt disease: *Fusarium xylarioides* Steyaert**

2.9. Coffee bark disease: *Fusarium stilboides* Wollenw

2.10 Damping off/Collar rot*: Pellicularia filamentosa* (Pat.) Rogers, *Rhizoctonia solani* Kühn

2.11.Die back/ Anthracnose: *Colletotrichum gloeosporioides* Mitchell

3. Weeds

Broadleaf

3.1. Slender amaranth: Amaranthus viridis L. (Amaranthaceae)

3.2. Climbing dayflower: *Commelina diffusa* L. (Commelinaceae)

3.3. Puncture vine: *Tribulus terrestis* L. (Zygophyllaceae)

3.4. Purslane: *Portulaca oleracea* L. (Portulacaceae)

3.5. Garden spurge: *Euphorbia hirta* L. (Euphorbiaceae)

Grasses

3.6. Bermuda grass: *Cynodonn dactylon* (L.) Pers. (Poaceae)

3.7. Large crabgrass: *Digitaria sanguinalis* L. (Poaceae)

3.8. Purple top chloris: Chloris barbata Swartz (Poaceae)

Sedges

3.9 Purple nutsedge: Cyperus rotundus L. (Cyperaceae)

4. Nematodes

4.1. Lesion Nematode: *Pratylenchus coffeae* Goodey (Tylenchida: Pratylenchidae)

4.2. Root-knot Nematode: *Meloidogyne incognita* Kofoid & White (Tylenchida: Meloidogynidae)

5. Non insect pests:

5.1. Mollusc: Giant coffee snail: *Achatina fulica* Férussac

5.2. Rodents and Bats.

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. Planter has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of 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 IPM:

Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially bio-pesticides
- Select healthy seeds and seedlings
- Follow proper spacing
- Soil health improvement (mulching and green manuring)
- Nutrient management especially through organic manures and bio-fertilizers based on the soil test results should be followed. If the dose of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosages are too low, the crop growth is retarded. So, the planters should maintain proper soil fertility level through integrated nutrient management approach for best results.
- 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 Pest: Defender ratio (P: D ratio)
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

Plant compensation ability:

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

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:

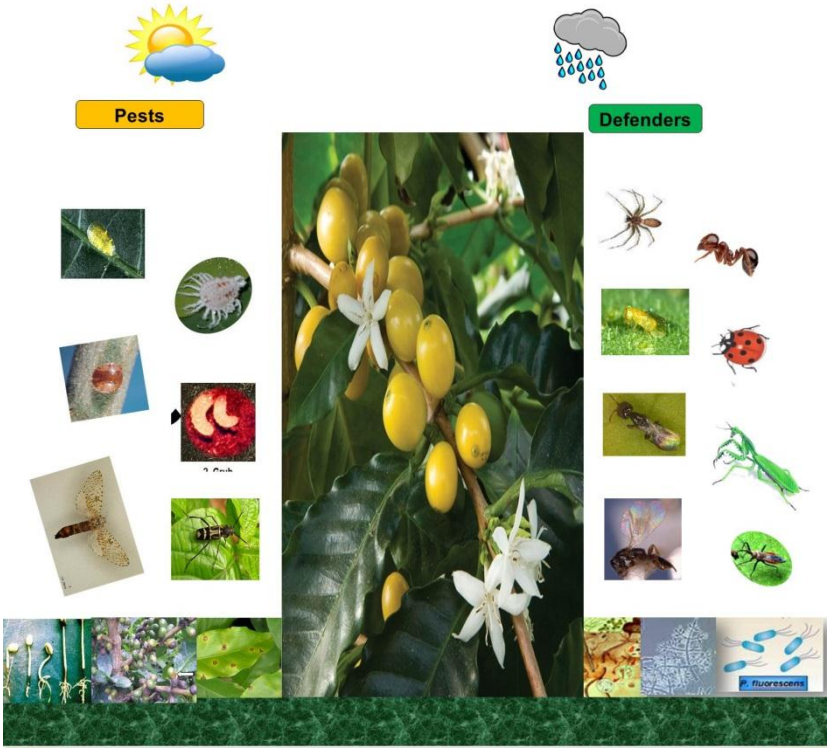
In field various types of insects are present. Some are beneficial and some may be harmful. Generally planters are not aware about it. Predators (friends of the planters) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance planters' skill to identify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

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Planter:



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 safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavorable, 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 bio-pesticides and biochemical bio-pesticides 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 plantation 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.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.
- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write

the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.

- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on whatfield 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

- Keep 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; Labour
- **Harvest:** Yield (kg/acre); Price of produce (Rs./Kg)

Some questions that can be used during the discussion

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


Advantages of AESA over ETL:

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. 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.

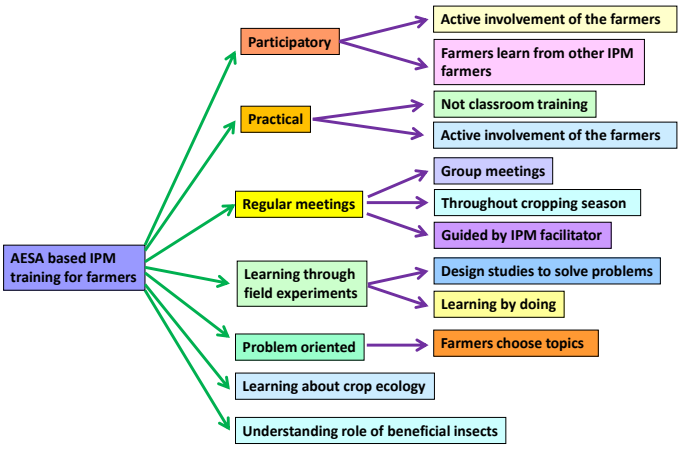
AESA and planter field school (FFS):

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

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

For mites: Count and record the number of both nymphs and adults on five randomlyselected leaves per plant.
For borer: To assess the extent of borer infestation in individual coffee field, the field 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 cmlong.

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 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 per cent area of leaf infection by counting the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

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

C. 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).

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).

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), vermin-compost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using bio-fertilizers based on soil test report.
- Application of bio-fertilizers with special focus on mycorhyza and plant growth promoting rhizobacteria (PGPR)

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 favorable. 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

Anise

Caraway

Marigold

Dill

Parsley

Mustard

Sunflower

Buckwheat

Cowpea

White Clover

Carrot

Fennel

Tansy

Crocuses

French bean

Repellent plants

***Ocimum* sp**

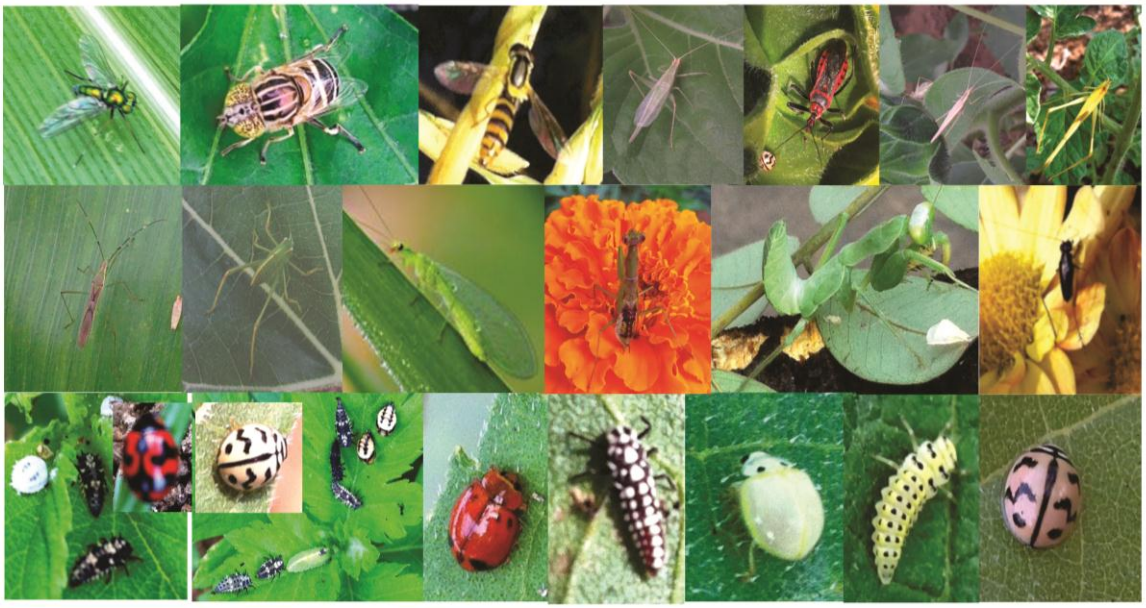
Peppermint

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.

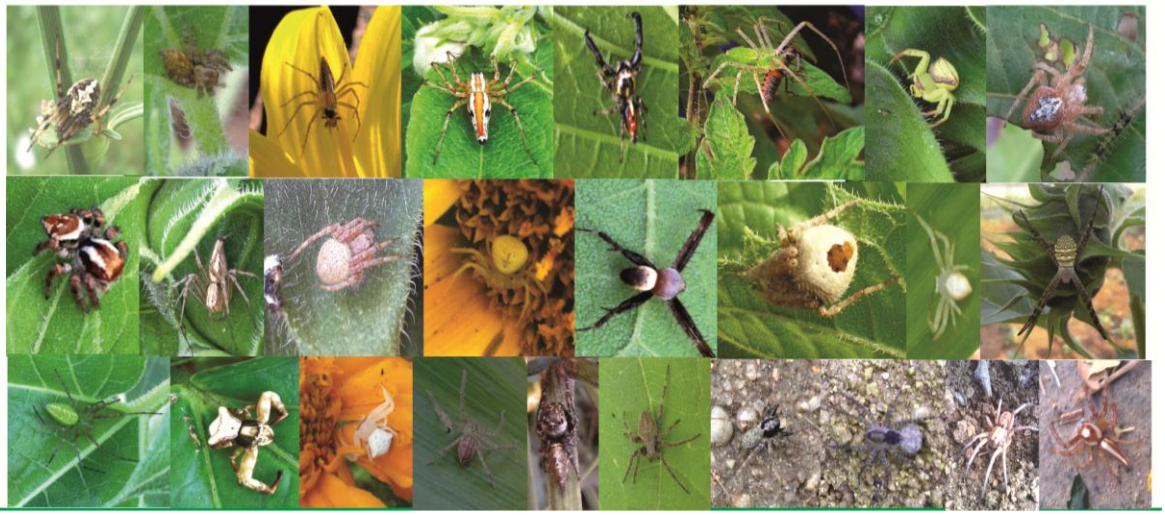
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

<table>
<tr><th>Management</th><th>Activity</th></tr>
<tr><td colspan="2">Pre-planting *</td></tr>
<tr><td></td><td><u>Common cultural practices:</u>
Destroy the alternate host plants
Apply manures and fertilizers as per soil test recommendations.
Land is cleared of heavy vegetation and large rocks prior to planting coffee. Selective retention of evergreen trees providing filtered shade at a spacing of 9 - 12 m is desirable.
The land should be divided into blocks of convenient size by laying out footpaths and roads in between. Uprooting and in situ burning should clear the ground level bushy growth.</td></tr>
<tr><td>Nutrients</td><td>Soil should be deep, friable, open textured rich in plant nutrients with plenty of humus and of slightly acidic nature (pH – 4.5 to 6.5)</td></tr>
<tr><td>Weeds</td><td>Keep boundaries of coffee plantations weed free to prevent dispersal of weed seed..
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.</td></tr>
<tr><td>Nematodes and soil borne pests</td><td><u>Cultural control:</u>
Use virgin soil for preparation of nurseries.
Nurseries should be located far away from infested plantations.
Gap filling should be practiced every year.
Use resistant/tolerant
<table><tr><td>Arabica varieties</td><td>Robusta varieties</td></tr><tr><td>Sln 795, Sln 7, Sln 9, Sln 10
HRC (Hawaian Red Caturra) and Chandragiri</td><td>Sln 274, Sln 3,
Peridenia
C x R</td></tr></table></td></tr>
<tr><td colspan="2">Nursery*</td></tr>
<tr><td>Nutrients</td><td>Apply nutrients on the basis of soil test report and recommendation for the agro-climatic zone.
Select light loamy soil of good drainage with high organic matter content with water and shade facilities.
Form raised beds of 15 cm height, 1m width and at convenient length.
Incorporate 30 - 40 kg of well rotten compost, 2 kg of finely sieved agricultural lime and 400 g of rock phosphate to a bed of 1 x 6 m size.
In heavy soils, it is necessary to add coarse sand for drainage and aeration.
Pre-sowing seed treatment with Azospirillum and Phosphobacterium should be done. Seeds are sown in in the bed 1.5 - 2.5 cm apart with the flat side down wards in regular rows and covered with a thin layer of fine soil and a layer of paddy straw. Water the beds daily and protect from direct sunlight by an over head</td></tr>
</table>

	pandal. Seeds germinate in about 45 days after which they are transplanted to a secondary nursery beds for raising bag nursery. **Bag nursery**- Polythene bags are filled with a prepared mixture containing jungle soil, FYM and sand in the proportion of 6:2:1. Seedlings are planted in polythene bags.
Weeds	• Keep the nursery weed free by hand pulling of the weeds.
Damping off	**Cultural control:** • Do not re-use old nursery soil • Avoid excess humidity in the nursery • Disinfect soil prior to seeding. • If the disease appears, affected seedlings and those surrounding them should be destroyed
Brown eye spot	**Cultural control:** • Improvement of tree nutrition and shading should be sufficient to control the disease
Coffee scales	**Cultural control:** • Destroy ant nests from the shade tree.s • Promoting conducive environmental conditions for growth of the white halo fungus (*Verticillium lecanii)* **Biological control** • Fungus**:** *Verticillium lecanii* • Predators: Ladybugs.Parasitiods :Parasitic wasps.
Planting stage	
Nutrients	• Selective shade lopping may be done After the summer showers, pits of 45 cm x 45 cm x 45 cm are dug at 2 x 2 feet. The pits are left open for weathering and then filled and heaped for planting. At the time of filling, apply 500 g of rock phosphate and 20 g mycorrhiza culture per pit along with top soil. • Planting is done along the contour in sloppy areas.
Weeds	• Plant cover crop to avoid ground exposure. • Use weed free compost and straw mulches. • Plant green manure crop between rows. • Closer spacing of plants, inter-planting with temporary shade trees (*Gliricidia, Erythrina),* use of quick growing planting materials will help uniform ground coverage and thereby reducing the weed growth.
Young coffee plantations	
Irrigation	• Promote irrigation in low rain fall areas. • Irrigation enhances the fruit set. • Promote backup irrigation after 15 days of blossom in robusta variety.
Nutrients	**Nutrient Management -** Apply major nutrients according to the age and growth stage of the crop as indicated in the table below;

<table>
<tr><td></td><td>
<table>
<tr><th>Age of plants</th><th>Pre-Blossom March N:P2O5:K2O</th><th>Post –blossom May N:P2O5:K2O</th><th>Post-monsoon October N:P2O5:K2O</th><th>Total</th></tr>
<tr><td>Young coffee 1st year after planting</td><td>15:10:15</td><td>15:10:15</td><td>15:10:15</td><td>45:30:45</td></tr>
<tr><td>2nd and 3rd year</td><td>20:10:20</td><td>20:10:20</td><td>20:15:20</td><td>60:45:60</td></tr>
<tr><td>4th year</td><td>30:20:30</td><td>20:20:20</td><td>30:20:30</td><td>80:60:80</td></tr>
<tr><td>Bearing coffee 5 years and above</td><td>40:30:40</td><td>40:30:40</td><td>40:30:40</td><td>140:90:120</td></tr>
<tr><td colspan="5">For heavy bearing plants, nutrient requirement is high so, additional dose of nutrient should be applied.</td></tr>
</table>
</td></tr>
<tr><td>Weeds</td><td>• Slash weeding is recommended before flowering of weeds.</td></tr>
<tr><td>Coffee scales</td><td><u>Cultural control:</u>
• Destroy ant nests from the shade tree.s
• Promoting conducive environmental conditions for growth of the white halo fungus (Verticillium lecanii)
<u>Biological control</u>
• Fungus: Verticillium lecanii
Predators: Ladybugs.Parasitiods :Parasitic wasps.</td></tr>
<tr><td>White coffee stem borer</td><td><u>Management:</u>
• Maintain optimum shade on the estates. (two tier system of shade trees).
• Trace the infested plants prior to flight periods i.e., before end of March and September every year by looking for ridges on the main stem and thick primaries. Collar prune the infested plants, uproot if the borer has entered into the root, and burn the affected plants immediately.
• Remove the loose scaly bark of the main stem and thick primaries using a coir glove or coconut husk to eliminate the craks and crevices which are used by the female beetle to place eggs on the stem. Scrubbing should be done just prior to the flight preferably during March to September as this operation is mainly aimed at preventing stem borer females from depositing eggs. but care must be taken not to damage the wood under the bark.
• Spray Chloropyrifos 20 EC at the dosage of 600ml in 200l of water along with 200ml of any wetting agent on the main stem and thick primaries during the early part of the flight period i.e., April and October every year.
• In hot spot areas i.e., open patches and estate borders with badly managed estates, adopt scrubbing or 10% lime coating or stem wrapping with empty fertilizer bags after removing affected plants by tracing.
• Pheromone trap can install in the field at a height of 1.8m to 2m from the ground. The traps should be spaced out in the form of a grid of 25 traps ha $^{-1}$ with a spacing of 20m between them.</td></tr>
</table>

Coffee berry borer	**Cultural and Mechanical control:**
	• Proper adoption of cultural practices and phytosanitary measures important for management of coffee berry borer.
	• Transportation of infested coffee to uninfected areas is the main reason for spread.
	• Gunny bags should be fumigated with aluminium phosphide (ALP) under pest control agency/ technical expert approved by PPA before delivery to estates to avoid cross infestation. Timely harvest.
	• Spread gunny bags or polythene sheets at the time of harvest to minimize gleaning.
	• Remove gleanings and left overs.
	• Maintain optimum shade and good drainage.
	• Dipping infested berries in boiling water for 2-3 minutes kills all the stages inside.
	• Drying of coffee beans with prescribed moisture content level during storage.
	  o Arabica (10% moisture content)
	  o Roubsta (11% moisture content)
	• Install broca traps@ 10/acre at the distance of 20meter to collect the beetles after the coffee harvest. Traps can be installed around the drying yard during drying
	
	Biological control
	
	• Application of spore suspension on the infested coffee bushes using a Knapsac sprayer during evening hours.

Shot hole borer	**Mechanical control:** • Prune the effected twigs 2.5 to 7cm below the sht-hole and burn • Remove and destroy all the unwanted / infested suckers during summer. • Maintain thin shade and provide good drainage in the estate. **Chemical control:** • Spraying of systemic fungicide Propiconazole (Tilt 25 EC) during August-September at the dosage of 0.02% a.i., i.e.,160ml in 200 l of water.
Root lesion nematode	**Mechanical control:** • Dig up the nursery site and expose the soil to the sun during summer. • Avoid obtaining nursery plants from unknown source **Chemical control:** • Drench the seedlings in the nursery bag with carbosulfan 25 EC at the rate of 280 ml in 200 l of water. **Mechanical control:** • Maintain adequate shade

Coffee mealy bug	• Control ants by dusting quinalphos 1.5% or methyl parathion 2% • Spray affected patches with 4 l of kerosene in 22 l of water along with 200 ml of any agricultural wetting agent. • If the roots are infested with mealy bug and fungal association, drench the soil near the root zone with any one of the above insecticide along with 160g of Bayleton 25WP in 200 l of water. • In case of young plants (2-4 years) drench with roger 30EC at 3.3ml per litre of water. **Biological control:** • *Leptomastix dactylopii*
Green Scale & Brown Scale	**Mechanical control:** • Control ants in the case of mealy bugs • Remove and burn weeds which harbor the scale. **Chemical control:** • Spray the affected patches with either quinalphos 25 EC at the dosage of 120 ml or dimethoate 30EC at 170ml in 200 l of water
Coffee red borer	• Follow common cultural practices and mechanical control
Hairy caterpillar, white grub	• Follow common cultural, mechanical and biological practices.
Coffee bean beetle	**Cultural control:** • Maintain optimum temperature, relative humidity and moisture content (less than111%)
Coffee leaf rust	**Cultural control:** • Wider spacing and appropriate pruning **Chemical control:** • Spray copper oxychloride 50% WP 1.5-2.2 kg in 300-400 l of water/acre
Coffee berry disease	**Cultural control:** • Provide recommended spacing specific to varieties • Assure proper shade. • Avoid retaining of infected berries.
Coffee wilt disease	**Cultural control:** • Promote resistant varieties. • Use disease free planting materials. • Uproot and destroy the infected trees. • Make a trench around the trees to depth of 30 cm and make sure the soil should be inside the circle.
Coffee stem canker	**Cultural control:** • Promote resistant varieties. • Use disease free planting materials. • Uproot and destroy the infected trees.

	• Make a trench around the trees to depth of 30 cm and make sure the soil should be inside the circle.
Brown eye spot disease	**Cultural control:** • Brown eye disease is associated with a lack of in particular nitrogen and a lack of shade • Improvement of tree nutrition and shading should be sufficient to control the disease
Black rot	**Cultural control:** • Removal of diseased portions **Chemical control:** • Copper oxy chloride 50% WP 1.5-2.2 Kg in 300-400 l of water/acre
Berry blotch	**Cultural control:** • Maintain medium shade overhead
Dieback/Anthracnose	• Follow common cultural, mechanical and biological practices
Root rot	**Cultural control:** • Burn the plants at site, isolate affected patches by digging deep trenches, ring the bark and poison the shade trees while thinning. • Remove the affected plants and treat the soil at 1kg lime per plant to raise the soil pH. • Treat the soil around the affected area with PDCB or brassicol at 0.4%. Maintain the vigour of plants**.**
Reproductive stage	
Nutrients	As per table above. • The rate of fertilizer application for mature coffee varies with yield and soil test values. • 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 plantations are free from weeds.
Weeds	• Hand weeding around collar region of young 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.

Note: The dosages of pesticides use are based on high volume sprayer

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.

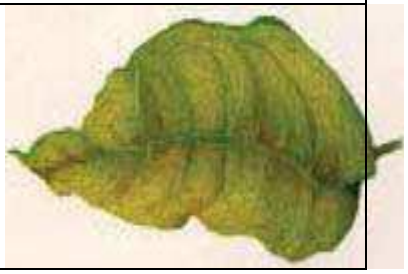
1) **Monitor pests:** Monitor insect population development in plantations to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** 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 plantations, adjacent "refuge" plantations, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

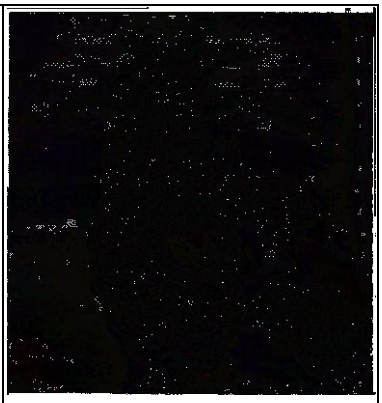
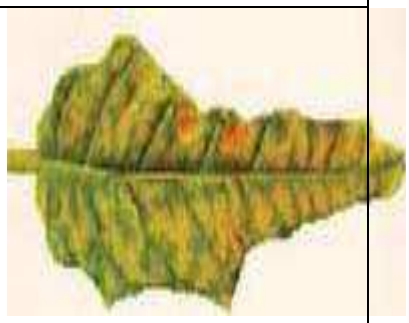
VI. NUTRITIONAL DEFICIENCIES/ DISORDERS

Nutrient deficiency symptoms & ameliorative measures

Nutrient	Deficiency symptoms & Ameliorative Measure	Excess Supply	Nutrient deficient leaves/plant
Nitrogen (N)	Yellowing of older leaves commencing from petiole, midrib, veins and extending to the whole leaf. Yellowing intensifies to olive or yellowish orange under more open conditions. Defoliation and die back, reduction in leaf size, poor growth when deficiency is severe. Remedial measure: Foliar application of 0.5 – 2.5% urea or soil application of N fertilizers.	Succulent growth, leaves will be dark green, thick and brittle; poor fruit set.	
Phosphorus (P)	Reduced growth of plant, restricted root development and leaves dark green. Symptoms appear in older leaves. Irregular yellow areas appear first which may spread to the whole leaf producing mottled appearance. Leaves may turn red or violet under severe conditions and drop easily. Remedial measure: Foliar application of 0.5% SSP or 1% DAP.	Shows up as deficiency of Zn, Fe, or Co. Interferes with N absorption.	
Potassium (K)	Necrosis or scorching of tip and margins in older leaves. Defoliation and dieback under severe deficiency. Remedial measure: Foliar application of 0.1% MOP.	Causes N deficiency in plant and may affect the uptake of other positive ions such as Mg and Ca	

Calcium (Ca)	Inhibition of bud growth; young leaves abnormally green; leaf tips may stick together; curling/cupping of young leaves; stem structure weakened; premature shedding of fruit and buds. Remedial measure: Liming of soil with good quality calcitic lime	Interferes with Mg absorption; high Ca usually causes high pH which then precipitates many of the micronutrient so they become unavailable to the plant.	
Magnesium (Mg)	In older leaves, large yellow areas (usually surrounded by a light green band) appear in between lateral veins and in either side of the midribs. Yellowing will gradually extend towards leaf margin. Severe deficiency leads to dark, necrotic spot on leaf tip and heavy defoliation. Remedial measure: Soil application of dolomitic lime or foliar spray of 0.1% Magnesium sulphate	Interferes with Ca uptake; small necrotic spots in older leaves; smaller veins in older leaves may turn brown; in advanced stage, young leaves may be spotted.	
Sulphur (S)	Yellowing of the youngest pair of leaves; chlorosis of mature leaves with newer leaves smaller in size and more chlorotic than the mature leaves; shoot growth is restricted; roots and stems are thinner, hard and woody. Remedial measure: Soil application of elemental S or fertilizer containing S.	Usually excess S is from air pollution	

Zinc (Zn)	Young leaves are abnormally small and narrow, lanceolate in shape with interveinal chlorosis; leaves bunched at the end of branch (rosette); short internodes; defoliation and dieback in severe deficiency. Remedial measure: Foliar spray of 0.25% Zinc Sulphate neutralized with spray lime.	Appears as Fe deficiency. Interferes with Mg.	
Iron (Fe)	Interveinal chlorosis primarily on young tissue, which may turn light green to yellowish and white when deficiency is severe; all veins including the smallest ones remain green giving a very fine mottling/ reticulation. Remedial measure: Provide good drainage.	Rare except on flooded soils	
Manganese (Mn)	Interveinal chlorosis in young leaves with checkered effect/coarse mottling; induced by excessively high pH. Remedial measure: Correcting soil pH	Smaller leaves, cupping of leaves along mid-rib; yellowing of the leaf margin; shortening of internodes; defoliation; found under strongly acid conditions	
Copper (Cu)	Young leaves twisted and bent along the midrib; may show slight chlorosis in leaf margins; secondary veins salient (“ribs”), brown symmetric spots.	Can occur at low pH; shows up as Fe deficiency. Watery and blackish spots in the central part of leaf can also occur.	

Boron (B)	Young leaves smaller, irregular in shape, leathery texture and without chlorosis; characteristic death of growing tip which turns black; development of lateral branches resulting in fan shaped structure. Remedial measure: Foliar application of boric acid 100g/200 litre water	No reduction in leaf size, mottled chlorosis near the margin, purple hue in the base of mid rib. Tips and margins of leaves exhibit chlorotic/necrotic spots coalescing into a marginal scorch; oldest leaves are affected first; plants are easily damaged by excess application	
Molybdenum (Mo)	Very rarely Mo deficiency occurs. Interveinal chlorosis on older leaves; twisted leaves (whiptail); marginal scorching and rolling or cupping of leaves; symptoms similar to N deficiency may develop.	Intense yellow or purple color in leaves; rarely observed	

PHYSIOLOGICAL DISORDERS IN COFFEE

Floral atrophy Pinking of flower

The robusta coffee is susceptible for drought conditions. Whenever the summer showers were scanty and soil moisture content is below 50% field capacity the flower buds move but turn in to pink color. This floral abnormalities result in more than 80% crop loss. Irrigation by sprinkler during second fortnight of February month will be useful to overcome this problem.

Pre mature berry drop in coffee

The pre mature berry drop occurs in both arabica and robusta coffee due to soil saturation effects on account of continuous heavy rainfall during monsoon period. Normally this kind of physiological disorder will be seen in the month of July which coincides with heavy monsoon rainfall. The crop loss will be to an extent of 40 to 50% based on quantum and intensity of rainfall during monsoon. Under normal rainfall pattern the pre mature berry drop will be 10 to 15%. Pre monsoon foliar application of Bordeaux mixture along with plant growth regulators (α NAA) will reduce pre mature berry drop in coffee and helps to achieve economical and sustainable yields.

VII. COMMON WEEDS

The term weeds refers to vegetation that invades crops, that is, the plants that grow where the agriculturist does not want them to grow and thus limit and interfere with the growth and production of crops. Weeds compete with coffee plants for sunlight, nutrients, water and space. Not all weeds interfere in the same manner with the development of crops.If weeds are not managed in time they will extract soil moisture, deplete the nutrients and suppress the growth coffee finally plants assume a sickly appearance. Produces small beans and reduces the yield in established coffee and in young clearings weeds are serious problems particularly during first three – four years.

Commonly found Weeds in Coffee plantations

Elephant grass, Spanish needle, *Bidens pilosa, Ageratum conyzoides, Oxalis latifolia, Eupatorium odoratum, Cynodan dactylon, Setaria homonyma, Cyperus rotundus* and other dicots weeds are common.

Monocot weeds – *Cyperus* sp., *Cynedon doctylon*, Elephant grass, *Paspalum* sp., etc

Dicot weeds – Eupatorium, Drimeria, Tridax, etc.

Some of the common weed photos and its habitants

I) Monocot weeds	
Weed Photo/s	**Weed Descriptions**
	***Cynodon dactylon* Pers.** ***Family*:**Graminae (Poaceae) ***Common name*:** Bahama Grass, Hariyli ***Morphology*:** Grass ***Habit*:** A perennial grass extensively creeping by means of scaly rhizomes or by strong flat stolons, very common in plains and hills; culms 7.5 to 30 cm high, slender. ***Stem*:** The underground stems are hard, brittle, thick and occur at varying depth in soil. ***Leaf*:** Leaves linear, finely acute, 7.5 to 12.5 cm long; spikes 3 to 6, more or less erect ***Flower*:** Spikelets light green or purplish, sessile, laterally compressed, alternately 2-seriate, imbricate and 1-flowered.***Fruit*:** Grain is munute, oblong somewhat flattened, rounded on black. ***Propagation*:** Seeds and underground stolons ***Habitat*:** It is a highly nutritious fodder grass and is extensively used as lawn grass.
. 	***Dactyloctenium aegyptium (L.) P.* Beauv .** ***Family*:** Poaceae ***Common name*:** Buffalo Grass ***Morphology*:** Grass ***Habit*:** An annual, grass growing in waste places and dry cultivated lands. ***Stem*:** Culms 10-62.5 cm high. ***Leaf*:** Leaves flat, 5 to 20 cm long, glabrous ***Flower*:** Inflorescence of 2 to 5 spikes in terminal umbel, dark olive-grey, digitately radiating; the rachis projecting in a point beyond the spikelets.***Fruit*:** Caryopsis. ***Propagation*:** Seeds ***Habitat*:** Cattle graze this readily. A common weed of waste places.

	***Digitaria bicornis* (Lam.) Roemer & Schultes** ***Family*:** Poaceae ***Morphology*:** Grass ***Habit*:** Annual ***Stem*:** Culms tufted, to 40cm; nodes sparsely bearded to glabrescent. ***Leaf*:** Blades oblong, 8(13) x 0.8 cm, flat. ***Flower*:** Racemes 2-8, to 15 cm, digitate, or in 1 or 2 whorls on a common axis, to 1.5 cm long; pectinate (bristles patent & protruding in fruit); upper lemma to 2.5 mm, equal to palea. ***Fruit*:** Caryopsis ***Propagation*:** Seeds ***Habitat*:** Waste land weed
	***Pennisetunm cenchroides* Rich.** ***Family*:** Gramineae (Poaceae). ***Morphology*:** Grass ***Habit*:** Perennial grass ***Stem*:** It consists of aerial branches and under-ground rhizomiferous stems, bearing thick fibrous roots and numerous buds covered by scarious sheaths. ***Leaf*:** Leafsheath is slightly compressed; keeled, with scattered long hairs outside, shorter than the internodes ***Flower*:** Inflorescence is a raceme of spikes, with spikes mostly densely arranged, The spikes have involucels, consisting of two series of bristles. Spikelets oblong-lanceolate, ***Fruit*:** Lodicules are not present. ***Propagation*:** Seeds and stem bits ***Habitat*:** Grown in all kind of soil and grows even when the soil is dry
	***Cyperus rotundus* L.** ***Family*:** Cyperaceae ***Common name*:** Nut Grass, Nutsedge ***Habit*:** stems trigonous, up to 1 m high; tubers not zoned, perennial. ***Stem*:** Stem sparsely tufted. ***Leaf*:** Leaves shorter or longer than stem, narrow, numerous; bracts usually 3, up to 60 cm long ***Flower*:** spikelets spreading, linear to lanceolate, up to 2.5 cm long; Tubers have a very high capacity for survival under adverse conditions. ***Fruit*:** Fruit is a broadly bovid, trignous, seed-like nut, grayish black in colour. ***Propagation*:** Seeds and nutlets ***Habitat*:** A very troublesome perennial weed, occurring in dry cultivated lands, gardens and in semi irrigated land. It is an obnoxious weed with a very high propagation potential. This is one of the world's top ten worst weeds.
II) Dicot weeds	

	***Ageratum conyzoides* L.** ***Family*:** Compositae(Asteraceae). ***Common name*:** Geratum ***Morphology*:** Broad leaved weed ***Habit*:** Erect softly hairy, annual herb, growing to a height of 70cm. ***Stem*:** Branched, terete., ***Leaf*:** Leaves opposite, petiolate, ovate, crenate, serrate.***Flower*:**Heads small, homogamous, in dense corymbose; involucre companulate, bracts 2-3 seriate, striate, sub-equal; receptacle flat, naked or with caducous scales; corolla tubular, equal limb 5-cleft, regular; blue or white; anthers; appendaged, base obtuse; style arms elongate, obtuse. ***Fruit*:** Achenes 5-angled; glabrous or the angles slightly hispid; pappus paleaceous, scaly, 5-awned, serrate below. ***Propagation*:** Seeds ***Habitat*:** A common weed in garden lands, pastures and other damp and shady places; generally associated with sugarcane crop.
	***Borreria articularis* (L.f.) F. N. Will** ***Family*:** Rubiaceae ***Common name*:** Morphology*:* ***Broad leaved weed*** ***Habit*:** A hispid procumbent annual herb with long internodes. ***Stem*:** Long prostrate or procumbent branches usually dark pink in colour. ***Leaf*:** Opposite, almost sessile, ovate, stipules connate with marginal bristles. ***Flower*:** Flowers small, axillary or terminal fascicles with long narrow corolla tube, white or pink; stamens 4; gynoecium inferior, bicarpellary, syncarpus, bilocular with only one ovule in a locule on axile placenta ***Fruit*:** Fruit two-seeded mericarp; seeds pale red, oblong with a ventral groove. ***Propagation*:** Seeds ***Habitat*:** A common dry land weed associated with ragi, groundnut and pulses. A weed with many biotypes capable of adjusting to the drought conditions.

	***Oxalis corniculata* L.** ***Family*:** Oxalidaceae ***Common name*:** Indian Sorrel ***Morphology*:** Broad leaved weed. ***Habit*:** A creeping herbaceous perennial weed with long-stalked trifoliate ***Stem*:** Stem creeping. ***Morphology*:** Broad leaved weed. ***Leaf*:** Leaves.Leaves radicular cauline, usually digitate, leaflets obcordate. ***Flower*:** Flowers yellow, umbellate on slender long peduncles; sepals 5, fused, imbricate; petals 5, free; stamens 10 in two whorls of 5 each; ovary superior, pentacarpellary, syncarpous; ovules many attached to axile placenta. ***Fruit*:** Fruit a loculicidal capsule. ***Propagation*:** Seed ***Habitat*:** Common weed occurring in moist situations and garden land.
	***Portulaca oleracea* L.** ***Family*:** Portulacaceae ***Common name*:** Indian Purslane ***Morphology*:** Broad leaved weed. ***Habit*:** Herbs, usually succulent. ***Stem*:** The main stem is short and erect; they grow to a length of 4-20 inches and are green or reddish in colour. ***Leaf*:** The leaves are alternate at the base, ***Flower*:** Flowers are without stalks, from 2-6 in number and are collected together in clusters at the ends of branches. Sepals are 2 and fleshy; they are united at the base and are free above. Petals are 5 and are yellow in colour. Stamens vary in number from 8-20 and surround the ovary. The ovary is 1-celled, many ovuled and is half inferior; stylar branches are from 3-6. ***Fruit*:** Fruit is dry, dehiscing transversely by the upper part enclosed by the sepals, ***Propagation*:** By seed.***Habitat*:** In all areas.

***Bidens pilosa* L.**
***Family*:** Compositae (Asteraceae)
***Morphology*:** Broad leaved weed
***Habit*:** Erect, glabrous or pilose or pubescent, annual herb.
***Leaf*:** Opposite, variable, 3-fid, 3-foliate, or 1-2 pinnatifid.
***Flower*:** Heads on long stout peduncles, variable in length, with or without rays, in corymbose panicles; ray flowers 1-seriate, white, neuter or rarely female; disk flowers bisexual, yellow, fertile; involucre campanulate; bracts broad with scarious margins; receptacle flat or convex, subtending the bisexual flowers; corolla of ray flowers ligulate, of disk flowers tubular, limb 5-lobed; anther base obtuse; style arms hairy at the tip.
Fruit: Achenes black, slender, exceeding the involucre; pappus with 2-4 short, stout, spinescent awns covered with recurved hooks.
***Propagation*:**Achenes
***Habitat*:** Common weed of cultivated and waste places, in plains and hills, also associated with coffee in plantations.

Damage by weeds

1. Affect the proper establishment of young coffee
2. Harbour pests and diseases
3. Compete for moisture, nutrients, light & space and reduce yields upto 30-50%
4. Interfere with operations like spraying & harvesting

Methods of Weed Management Control

1. Manual weeding
2. Cultural methods
3. Mechanical weeding
4. Chemical weeding

VIII. DESCRIPTION OF INSECT PESTS

1. Scale:

1.1 Green Scale:

Biology:

- **Eggs:** Eggs are whitish green and elongate-oval and are laid singly and hatch beneath the female where they are protected. Eggs hatch from a few minutes to several hours after being laid
- **Nymphs:** Nymphs, or immature green scales are oval, flat and yellowish green in color, and have six short legs. There are three nymphal stages before becoming an adult, each stage being larger and more convex than the previous stage.
- **Adult:** The adult female is shiny pale green with a conspicuous black, irregular U-shaped internal marking that is dorsally visible to the naked eye. Two sub-marginal black eye spots are also present and can be seen with a hand lens. The outline shape may be described as elongate-oval and moderately convex. Adult scales are 2.5 to 3.25 mm. Dead scales are light brown or buff color and the black internal marking is lost.

Adult

1.2 Brown Scale:

Egg: The eggs are laid underneath the carapace of the adult female. The eggs are translucent or whitish just after oviposition and later turn pale yellow and ultimately orange. They measure approximately 1/100 inch (0.25 mm) long and 1/200 inch (0.13 mm) wide.

Nymph: The first instars are called crawlers. They are flat, oval, greenish-brown to pale amber, have six legs, and are about the same size as the eggs. This is the only mobile stage of female hemispherical scales. Crawlers move about the leaf area in search of a suitable feeding sight until one is found. The remaining two nymphal stages are essentially stationary at the site selected by the crawler, only under adverse conditions will female nymphs move small distances. The body colour of the last two instars ranges from pale yellow to greenish brown to dark pink. The second and early third instar body shape has an irregular outline and lies flat

Adult: The mature female scale has a convex, light to dark yellow-brown, smooth and polished, helmet-shaped carapace. When the scale occurs on flat surfaces, the carapace is almost hemispherical, but on small stems it is elongate. The adult stage is incapable of locomotion and measures about 1/12 inch (2 mm) long. Females have a 2 to 3 day waiting period before beginning to lay eggs and lay eggs for 4 to 6 days before dying.

Immature and mature adults

Damage symptoms:

1. Nymphs and adults suck sap from under surface of the leaves
2. Honeydew excrete – development of sooty mould fungus
3. Defoliation of badly affected trees can occur.

Damage symtoms

Natural enemies of scale insects:

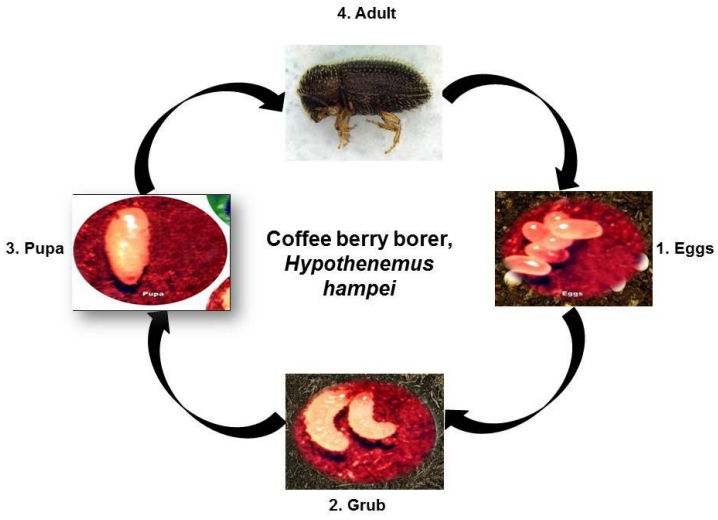
Parasitoids: *Aphytis* spp., parasitic wasp etc.
Predators: Ladybird beetle, Red ant, praying mantis etc.
There are a number of natural predators of coffee scale such as wasps, ladybugs and *Verticillium* fungus.
For the management refer page no…….

2.Coffee berry borer:

Biology:

Egg: The egg is elliptical, crystalline and yellowish toward maturity. Its length varies from 0.52 to .69 mm.
Larvae: The larva is white-yellowish, without legs, with a "C"-shaped body and a wide thoracic region. The head is light brown, with visible and forward-extending mandibles.
Pupae: The pupa is milky- white and yellowish towards maturity. Many of the adult's characteristics can be seen in the pupal stage. The pupa varies from1.84 to 2.00 mm long.
Adults; The adult is elongated with a cylindrical body slightly arched towards the end of the abdomen. It is about 1.50–1.78 mm long and its body is bright black, although yellowish when emerging from the pupa. The head is ventrally located and is protected by the pronotum.

Life cycle:



Damage symptoms:

- Pin hole at the tip of the berries (novel region)
- Severe infestation - two or more holes may be seen.
- Female beetle bores into the berries through the navel region make tunneling and feed inside content
- Powdery substance pushed out through the holes.

Damage symptom

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html

Natural enemies of coffee berry borer:

Parasitoids: *Cephalonomia stephanoderis*; *Prorops nasuta, Phymastichus coffea, Heterospilus coffeicola*.

Predators: Red ant, anthocorid bug, ground beetle, praying mantis, predatory birds etc.

For the management refer page no…….

3. White coffee stem borer:

Biology:

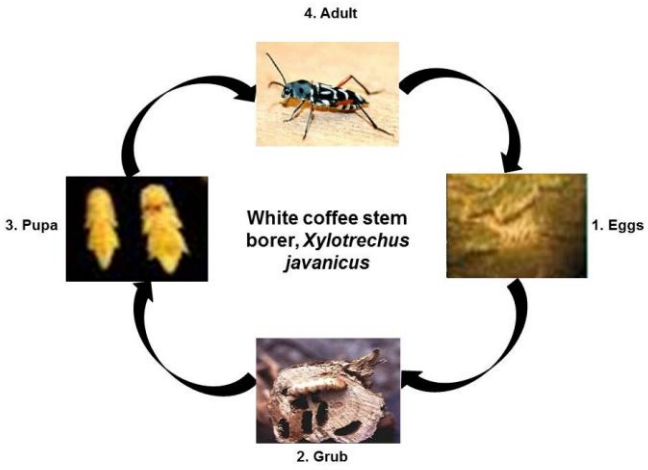
Egg: The adult female lays her eggs, at a rate of one or two per day over about a month,

under the bark of the stem of the coffee tree and usually within 50 cm of the stem base. The eggs, cream coloured and about 5 mm long by 2 mm wide,

Grub: Creamy-white, flattened larvae. Mature larvae are between 3 and 5 cm long, legless and taper from about 1 cm wide at the head to about 0.5 cm wide at the tail.

Adult: Adult - slender, long beetle (2.5 cm).Forewings are black with white bands. Males are generally smaller than females. Head shows distinctly raised black ridges and the hind leg F femur extends beyond the apex of the Elytra**.** In the Female, the black R ridges on the head are not much conspicuous and the hind leg femur does not extend beyond the apex of the Elytra

Lifecycle :



2,4: http://w3.gre.ac.uk/~hd18/chemecol/cwsbcfc.html1,3: http://bhandaribishnu.blogspot.in/2009/06/nepalese-students-society-in-hannover.html

Damage symtpms:

- Larvae enter into the hardwood and make the tunnels may extend even into the roots.
- Tunnels - tightly filed with the excreta of the grubs.
- Infested plants show visible ridges around the stem.
- Yellowing and wilting of leaves.
- Young plants (7 to 8 years old) attacked by the borer may die in a year

Natural enemies of White coffee stem borer:

Parasitoids: *Allorhogas pallidiceps (D. strioliger), Campylonerus* sp*, Doryctus compactus, Doryctus coxalis, Eeurytoma* sp*, Iiphiaulax* sp*, Metapelma* sp*, Gasteruption* sp*, Scleroderma* sp*, Scleroderma vigilans, Aapenesia* sp*, Avetianella* sp.etc.

Predators: Red ant, anthocorid bug, ground beetle, praying mantis, predatory birds etc.

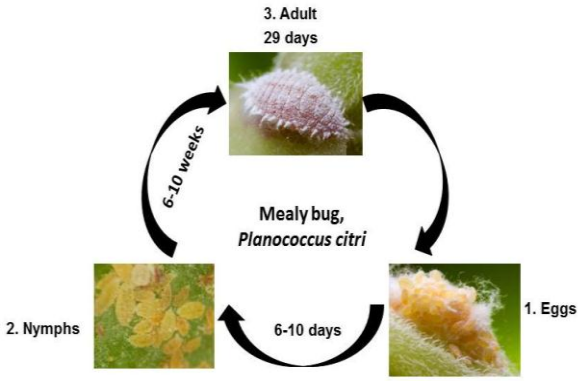
For the management refer page no…….

4. Mealybug:

Biology:

- **Eggs:** Eggs are deposited as white cottony masses called ovisacs. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female lay 300 to 600 eggs in a life period, which are deposited in groups of 5 to 20.
- **Nymphs:** Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves and young twigs. Wax and honeydew secreted by crawlers are visible indicators of infestations. The nymphs are yellow, oval-shaped with red eyes, and covered with white waxy particles. The female nymphs resemble the adult female in appearance, while male nymphs are more elongated. Female nymphs have four instars.
- **Adult**: Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Short waxy filaments can be seen around the margins of their oval body with a slightly longer pair of filaments present at the rear end of their body.

Life cycle:



Damage symptoms:

- Young plants – susceptible for heavy infestation.
- Infest tender branches, nodes, leaves, spikes, berries and roots
- Both nymphs and adults suck the sap from the leaves.
- Severe infestation - Chlorotic leaves, aborted flower buds and small berries
- Honey dew excrete – development of sooty mould fungus (affects photosynthesis)


Damage symptom

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html#7

Natural enemies of mealybugs:
Parasitoid: *Leptomastix dactylopii* etc.
Predators: Ladybird beetle *Cryptolaemus montrouzieri*, spider, reduviid etc.
*For the management refer page no….

Natural Enemies of Insect Pests of Coffee

Parasitoids

Larval/grub parasitoids


1. *Cephalonomia* sp


2.*Proropsnasuta*


3.*Eeurytoma*


4.*Gasteruption*

Nymphal/larval and adult parasitoids


5*. Aphytis*


6. *Leptomastix*

1. http://www.nbair.res.in/Biocontrol_Agents/Insects/Cephalonomia%20stephanoderis.htm
2. http://www.nbair.res.in/Introductions/Insects/Prorops%20nasuta.htm
3. http://www.insectimages.org/browse/detail.cfm?imgnum=5410741
4. http://aramel.free.fr/INSECTES14ter-3.shtml
5. http://www.cnr.berkeley.edu/biocon/What%20is%20Biological%20Control.htm
6. http://www.nbair.res.in/Introductions/Insects/Leptomastix%20dactylopii.htm

Predators

1. Ladybird beetle

2. Spider

3. Reduviid

4. Red ant

5. Black drongo

6. Common mynah

7. Ground beetle

8. Praying mantis

9. Wasp

4. 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
5. http://nagpurbirds.org/blackdrongo/picture/1639
6. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
7. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
8. http://spirit-animals.com/praying-mantis/
9 http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm

IX. DESCRIPTION OF DISEASES

1. Coffee leaf rust:
Disease symptoms: • Infection occurs on the coffee leaves. • The first observable symptoms are small, pale yellow spots on the upper surface of the leaves. • As these spots gradually increase in diameter, mass of orange urediniospores (= uredospores) appear on the undersurface. • The fungus sporulates through the stomata rather than breaking through the epidermis as most rusts do, so it does not form the pustules typical of many rusts. • The powdery lesions on the underside of the leaves can be orange-yellow to red-

orange in color, and this colour expression has considerable variation from one region to another.

Disease symptoms

Survival and spread:

- *Hemileia vastatrix* survives primarily as mycelium in the living tissues of the host, and since infected leaves drop prematurely; this effectively removes a huge amount of potential inoculum from the epidemic.
- But a few green leaves always persist through the dry season, and dry urediniospores can survive about 6 weeks, so there is always some viable inoculum to infect the newly formed leaves at the start of the next rainy season.

Favourable conditions:

- Rain or dew, high humidity. The whole process of infection requires about 24 to 48 hours of continuous free moisture, so while heavy dew is enough to stimulate urediniospore germination, infection usually occurs only during the rainy season.

*For the management refer page no…….

2. Brown eye spot disease:

Disease symptoms:

- Symptoms appear as small, chlorotic spots on leaves that expand to 3/16 to 5/8 inch in diameter.
- The outer portion of the leaf spot becomes brown, and the center appear grey.
- The eye-like appearance of the infected spot distinguishes it from other leaf spot diseases.
- Affected leaves may defoliate prematurely.

Disease symptoms

Survival and spread:

- Pathogen survives in leaf debris.

Favourable conditions:

- High humidity, rain, warm temperatures and drought, stress after flowering favours the disease.

*For the management refer page no…….

3. Damping off /Collar rot :

Damage symptoms:

- The fungus causes pre-emergence and post emergence damping off.
- In post-mergence damping off, collar region near soil level is infected leading the rotting of tissues and death of seedlings.

Disease symptoms

Survival and spread:

- Pathogen survives in the soil in the form of sclerotia which is the source of primary inoculum. The pathogen is dispersed as sclerotia, and these sclerotia dispersal occur by means of wind, water or soil movement between host plants.

Favourable conditions:

- Presence of host plant, frequent rainfall/irrigation and increased temperatures in spring and summer favours the development of disease.

*For the management refer page no…….

4.Black rot:

Disease symptoms:

- The most important symptom is dark brown or black decaying leaves, twigs and developing berries from which the name black rot is derived.
- The leaves hang down by means of fungal mycelial strands – mycelial threads can be seen on twigs and petioles.
- Sclerotia can be seen all over the affected areas. Infection leads to defoliation and berry drop..

Diseased leaves

Survival and spread:

- The fungus mostly spreads by contact from leaf to leaf through the vegetative mycelium.
- The pathogen spread through infected plant debris.
- Mycelium lies on twigs throughout year.

Favourable conditions:

- High humidity, rain and warm temperatures favour the disease.

*For the management refer page no…….

5. Berry blotch:

Disease symptoms:

- Necrotic spots on the exposed surface of green berries enlarge and cover the major portion. Fruit skin shrivels and sticks fast to the parchment.

Neorotic spots **Enlarged spots** **Shrunken berries**

Survival and spread:

- The pathogen is seed borne and conidia are spread by wind.

Favourable conditions:

- High humidity, rain and warm temperatures favours the disease.

*For the management refer page no…….

6. Die back or Anthranose:

Disease symptoms:

- On infected leaves circular to greyish spots of 2-3 mm in dia. appears.
- On berries small dark coloured sunken spots are formed. Beans become brown. Die-

back also occurs.

Dark coloured sunken spots

Survival and spread:

- The fungus occurs as a saprophyte on dead tissue on the outer layer of the bark, which provides the major source of inoculum.
- Fungus release large numbers of water borne conidia during the wet season.
- Conidia are spread by rain water percolating through the canopy and rain splash can disperse conidia between trees.
- Long distance dispersal occurs primarily by the carriage of conidia on passive vectors such as birds, machinery etc.

Favourable conditions:

- High humidity, rain and warm temperatures favors the disease.

*For the management refer page no…….

7.Root Diseases:

Disease symptoms:

- Stump or brown root disease: Affected bushes show a gradual yellowing of leaves and defoliation and death of plant.
- Affected roots are brittle and show dark brown wavy lines of the fungus.

- Red root disease: Affected bushes show a gradual yellowing of leaves and defoliation and death of plant.
- Affected roots show dark red encrustation of the fungal mycelium. When the root is washed with water red colour of fungus mycelium could be confirmed.

- Fusarial root disease or wilt: Affected plants show sudden wilting and yellowing of leaves leading to defoliation and death of aerial parts.
- Roots turn brown to pinkish.

Root rot

Survival and spread:

- The fungus survives in soil or plant debris, which is the source of primary inoculum.

Favourable conditions:

- The disease is favoured by cool and moist soils.

X. SAFETY MEASURES

A. Pre-harvest: Depending on the variety, it will take approximately 3 or 4 years for the newly planted coffee trees to begin to bear fruit. The fruit, called the coffee cherry, turns a bright, deep red when it is ripe and ready to be harvested. In most countries, the coffee crop is picked by hand, a labor-intensive and difficult process, though in places like Brazil, where the landscape is relatively flat and the coffee plantations immense, the process has been mechanized. Whether picked by hand or by machine, all coffee is harvested in one of following ways:

Fly picking: Small scale picking of ripe berries during October to February

Main picking: Well-formed and ripened berries are harvested during December. Bulks of the yields are obtained from this picking.

Stripping: Picking of all the berries left irrespective of ripening.

Cleanings: This is collection of fruits that have been dropped during harvesting. Unripe fruits should be scrupulously sorted out before using the fruits for pulping. They may be dried separately as cherry.

B. During post-harvest:

Before coffee beans are shipped, however, they have to be stored, and to prevent them spoiling or losing quality, a number of precautions have to be taken. These include paying particular attention to humidity, storage facility location, and storage duration. The preferred place to store coffee is in the vicinity of its production site, i.e., a relatively high altitude with low air moisture. If it is too humid, beans are not separated from their husk (sun-dried pulp) or hull (parchment membrane) until before sending them for shipping. Coffee beans should be stored in low moisture conditions so as not to be attacked by mold. The maximum water level safe in the bean is 12% by weight. After reaching this by thorough drying, any re-wetting and air borne moisture absorption must be prevented (e.g. Rain, fog, condensation).

Raw coffee beans are often stored for years before roasting. Their sturdy structure usually prevents them from being spoiled by external agents; however, nothing can be done against the inherent biochemical activity in the seed. In this case, some minor components transform into other components which taste woody and harsh after roasting

XI. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season / the region.
3.	Always treat the seeds with approved chemicals/bio-pesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with bio-pesticides/chemicals.
4.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
5.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
6.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids

12.	In case of pests which are active during night spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since; most of the insects are not active during this period.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips, etc. and for Bordeaux spray	Do not spray pesticides only on the upper surface of leaves.
14	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15.	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. Safety parameters in pesticide usage

S. No	**Pesticide classification as per insecticide rules 1971 Colour of toxicity triangle**	**WHO classification of hazard**	**Symptoms of poisoning**	**First aid measures and treatment of poisoning**	**Safety interval (days)**
Fungicide					
1	Copper oxychloride Moderately toxic 	Class III slightly hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	

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. **Don't** 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' nt** transfer pesticides to other containers; **Don't** expose to sunlight or rain water; **Don't** 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. **Don't** mix granules with water; **Don't** eat, drink, smoke or chew while preparing solution.
8. Concentrated pesticides must not fall on hands, etc. while opening sealed container. **Don't** 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. Equipments

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

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Don't** apply on hot sunny day or strong windy condition; **Don't** apply just before the rains and after the rains; **Don't** 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

G. Disposal

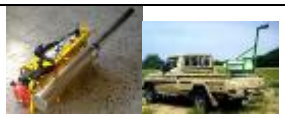
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XIV. PESTICIDE APPLICATION TECHNIQUES

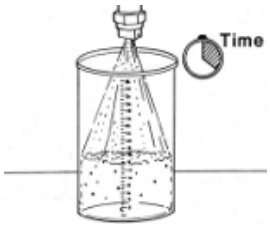
<table>
<tr><th></th><th></th><th colspan="2">Equipment</th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td rowspan="2">Vegetative stage

i) for crawling and soil borne pests

ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• 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>  </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 fungicides</td><td>• Motorized knapsack sprayer or mist blower (Droplets of small size)</td><td>  </td></tr>
</table>

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

XV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	  
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	 
5.	**Don't** apply in hot or windy conditions.	

		 
6.	Operator should maintain normal walking speed while undertaking application.	
7.	**Don't** smoke, chew or eat while undertaking the spraying operation	 
8.	Operator should take proper bath with soap after completing spraying	  
9.	**Don't** blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVI. References

- http://entnemdept.ufl.edu/creatures/orn/scales/green_scale.htm
- http://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/systematics/scale-insects/species-information-sheets/saissetia-coffeae
- http://entnemdept.ufl.edu/creatures/orn/scales/green_scale.htm
- http://blog.plantwise.org/2011/09/16/coffee-berry-borer-thriving-due-to-climate-change/
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html
- http://w3.gre.ac.uk/~hd18/chemecol/cwsbcfc.html
- http://bhandaribishnu.blogspot.in/2009/06/nepalese-students-society-in-hannover.html
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html
- http://www.alexanderwild.com/keyword/planococcus%20citri/
- http://cals.arizona.edu/crops/citrus/photos/figure21.jpg\
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html#7
- http://www.nbair.res.in/Biocontrol_Agents/Insects/Cephalonomia%20stephanoderis.htm
- http://www.nbair.res.in/Introductions/Insects/Prorops%20nasuta.htm
- http://www.insectimages.org/browse/detail.cfm?imgnum=5410741
- http://aramel.free.fr/INSECTES14ter-3.shtml
- http://www.buglogical.com/whitefly-control/encarsia-formosa/
- http://www.cnr.berkeley.edu/biocon/What%20is%20Biological%20Control.htm
- http://www.nbair.res.in/Introductions/Insects/Leptomastix%20dactylopii.htm
- 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
- http://nagpurbirds.org/blackdrongo/picture/1639
- http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
- http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
- http://spirit-animals.com/praying-mantis/
- http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm
- http://en.wikipedia.org/wiki/Hemileia_vastatrix
- http://www.fao.org/docrep/008/ae939e/ae939e0b.htm