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AESA BASED IPM PACKAGE

Walnut

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Department of Agriculture and Cooperation
Ministry of Agriculture & Farmers Welfare
Government of India

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

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FOREWORD

One of the fallouts of green revolution based on intensive use of inputs including agrochemicals has been it adverse impact on the ecological balance in different agro-ecosystems of the country. The problem has been compounded by unscientific and indiscriminate use of the agrochemicals by the farmers. It is manifest by the problems of pesticide resistance, pest resurgence, pesticide residues and pest replacement, that one sees. This has necessitated promotion of environmentally sustainable agriculture practices. Integrated Pest Management (IPM) meets such a requirement. However, IPM strategies relying on economic thresholds & crop scouting, over the years has become synonymous with chemical pesticide based pest management. Growing awareness of the adverse consequences of agrochemicals is happily effecting a shift to ecological approaches that rely on the intrinsic strengths of the ecosystem services rendered by the agro-ecosystems. Bio-intensive pest management approaches that are ecologically sound, such as Agro-ecosystem Analysis (AESA) in conjunction with ecological engineering for pest management are gaining acceptance globally. Unlike ETL, AESA analyses the crop field situation critically with regards to both abiotic and biotic factors and their interaction for taking informed pest management decisions vis-a-vis a growing crop.

The Government is now emphasizing on soil test based nutrient management and safe & judicious use of pesticides. Under AESA based IPM, chemical pesticides are to be used only as a last resort, as per the policy of Government of India. Ecological engineering for pest management approach, a new paradigm, creates favourable conditions in the crop ecosystem & enhances natural enemies by providing food, shelter and alternate prey, thereby supporting biological control. Reliance on chemical pesticides for pest management can be reduced with such ecological approaches and the balance and stability can be restored in the agro-ecosystems.

The AESA based IPM package of practices for various crops developed by the experts, incorporating the latest knowledge/information on AESA based PHM in conjunction with ecological engineering for pest management will be useful for extension functionaries from State and Central Government agencies, researchers / scientists from ICAR/SAUs and farmers for managing important crop pests and disseminating novel and innovative technologies for sustainable agriculture.

A Dalwai 25/06/2015

Dated: 25.06.2015

[Ashok Dalwai]

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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Walnut- Plant description:

Walnut (*Juglans regia* L.; Family: Juglandaceae) is a deciduous tree grown for its edible seeds. Walnut trees are large and vigorous with a wide-spreading canopy. The trunk of the tree can reach 2 m in diameter and mature trees possess smooth, silver-gray bark. Walnut leaves are composed of an odd number of smaller, oval shaped leaflets which are bright green in color. The tree produces male flowers on catkins and female flowers on terminal clusters where the fruit develops. The fruit of the walnut tree is a fleshy green drupe in which the nut is encased. The kernel of the nut is protected by a corrugated woody shell. Walnut trees can reach 25–35 m in height and can live for periods in excess of 200 years. Walnut may also be referred to as Persian walnut, English walnut, common walnut or European walnut and originates from central Asia.

Walnuts are rounded, single-seeded stone fruits of the walnut tree commonly used for the meat after fully ripening. Following full ripening, the removal of the husk reveals the wrinkly walnut shell, which is usually commercially found in two segments (three-segment shells can also form). During the ripening process, the husk will become brittle and the shell hard. The shell encloses the kernel or meat, which is usually made up of two halves separated by a partition. The seed kernels – commonly available as shelled walnuts – are enclosed in a brown seed coat which contains antioxidants. The antioxidants protect the oil-rich seed from atmospheric oxygen, thereby preventing rancidity.

The world produces a total of 2.55 million metric tonnes of walnuts; China is the world's largest producer of walnuts, with a total harvest of 1.06 million metric tonnes. The other major producers of walnuts are Iran, United States, Turkey, Ukraine, Mexico, Romania, India, France and Chile.

I. PESTS

A. Pests of National Significance

1. Insect pests

1.1 Stem borer: *Aeolesthes sarta* Solsky (Coleoptera: Cerambycidae)

1.2 Bark beetle/Shot-hole borer: *Scolytus nitidus* Schedl (Coleoptera: Scolytidae)

1.3 Gypsy moth: *Lymantria obfuscata* Walker (Lepidoptera: Lymantriidae)

1.4 Leaf roller: *Archips argyrospilus* (Walker) (Lepidoptera: Tortricidae)

1.5 Mealybug: *Drosicha dalbergiae* (Stebbing) (Hemiptera: Margarodidae)

1.6 Grey weevil: *Myllocerus* sp. (Coleoptera: Curculionidae)

1.7 Walnut weevil: *Alcides porrectirostris* Marshall (Coleoptera: Curculionidae)

2. Diseases

2.1 Leaf spot: *Alternaria* sp

2.2 Leaf blotch: *Marsonina juglanse* (Lib.) Magnus and *Gnomonia leptostyla* (Fr.) Ces. & De Not.

2.3 *Dieback: Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk

2.4 Powdery mildew: *Phyllactinia* spp.

2.5 Walnut blight: *Xanthomonas campestris* (Pammel 1895) Dowson

2.6 Anthracnose: *Gnomonia leptostyla* (Fr.) Ces. & De Not.,

2.7 Phytophthora root and crown rot: *Phytophthora* spp

2.8 Armillaria root rot (Oak root fungus): *Armillaria mellea* (Vahl) P.Kumm.

2.9 Crown gall: *Agrobacterium tumefaciens* Smith & Townsend,

2.10 Walnut canker: Geosmithia morbida M.Kolařík, E.Freeland, C.Utley & Tisserat

3. Weeds

Broadleaf

3.1. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)

3.2 Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)

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

3.4 Sowthistles: *Sonchus* spp. (Asteraceae)

3.5 Congress grass: *Parthenium hysterophorus* L. (Asteraceae)

3.6 Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)

3.7 Sweet yellow clover: *Melilotus indica* (L.) All. (Fabaceae)

3.8 Toothed Dock: *Rumex dentatus* L. (Polygonaceae)

Grasses

3.9 Bermuda grass: *Cynodon dactylon* (Poaceae)

3.10 Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)

3.11 Blanket grass: *Axonopus compressus* (Sw.) Beauv. (Poaceae)

3.12 Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)

3.13 Knot grass: *Paspalum distichum* L. (Poaceae)

Sedges

3.14 Purple nutsedge: *Cyperus rotundus* L. (Cypraceae)

B. Pests of Regional Significance

1. Insect pests

1.1 Aphids: *Chromaphis juglandicola* (Kaltenbach) & *Panaphis juglandis* (Goeze) (Hemiptera: Aphididae)

1.2 Coding moth: *Cydia pomonella* Linnaeus (Lepidoptera: Lasiocampidae)

1.3 San Jose scale: *Quadraspidiotus perniciosus* (Comstock) (Hemiptera: Diaspididae)

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

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment and manage the crop pests by adopting various IPM practices on eco-friendly manner, viz., Cultural, Mechanical, Biological, Botanical & Chemical. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

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

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

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

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting materials
- Treat the seeds/seedlings/planting materials with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best

results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation

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

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

http://www.jacquewatkins.com/wp-content/uploads/2013/09/IMG_8081b.jpg

Plant compensation ability

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

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. 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 walnut insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Soil conditions

Decision taken based on the analysis of field situations :

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides(Botanicals, *Trichoderma viride, Trichoderma harzianum, pseudomonas fluorescens* .etc) and biochemical biopesticides (Insect regulators, Pheromone traps etc)such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 10tree/acre randomly. Observe keenly each of these plants and record your observations:
- Pests: Observe and count pests at different places on the vine .
- 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 orchard and their intensity.
- Water: Observe the water situation in the orchard.
- Weather: Observe the weather condition.
- While walking in the orchard, 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 analyse the orchard situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the orchard 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 orchard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Some questions that can be used during the discussion

- Summarize the present situation of the orchard?
- 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 problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.


Advantages of AESA over ETL

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

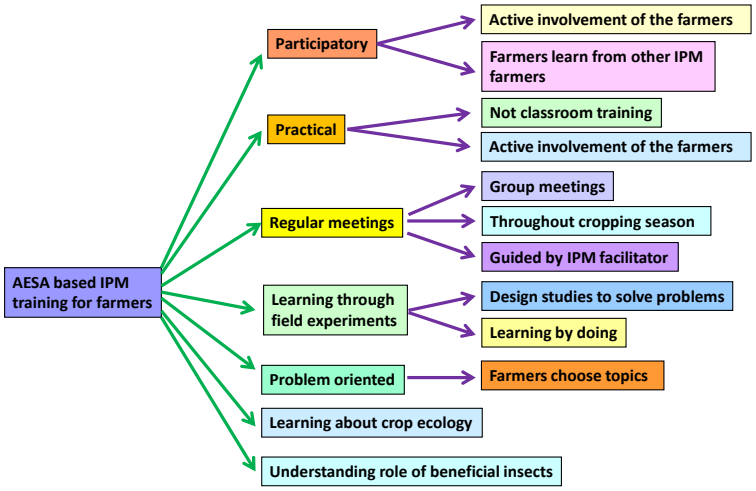
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

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

Surveillance on pest occurrence in the 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.

Sampling in fruit crops:

A person doing sampling is known as an inspector or scout. The fruit crops are perennial in nature and before starting the surveillance process an inspector or scout who is going to implement the activity should know about the nature of crop as well as different crop stages and its growth stages. Knowing crop and its nature helps in identifying the important pests and diseases because the pests and diseases infest and infect, respectively, certain stage or part of the plant.

Sampling patterns:

Different methods of sampling are reported and being utilized for sampling in crops as well as in fruit plants such as random, scattered etc. However, some of them are specific to the crop/disease/pests and growth stage (some of them are to be utilized at initial stage and/or for subsequent plant growth stage). Also the sampling methods may differ based on the nature and requirement of the study such as estimating disease incidence and/or disease severity. For a common orchard study, the assessment methods should not only be easy and quick in use for a

wide range of conditions, but also adequately reliable, reproducible, and accurate/precise. However, this is not always possible. Generally, in fruit crops the following sampling patterns are used:

- **Zig-zag pattern**. Sampling a fallow orchard or one with no obvious symptoms in the current crop to see the incidence as well as sampling of viral, wilt disease.
- **Circle pattern.** Sampling within the drip line of trees and shrubs and for powdery mildew, downy mildew and leaf spot diseases etc.
- **Star pattern**. Sampling from a damaged area.

Sampling frequency:

Sampling frequency or interval depends on pest generation interval or number of generations per year, potential for population increase between generations, stage of crop- pathogen infection etc. Generally, if initial survey is already implemented and some results are with the surveillance manager, then based upon the results of pest/disease incidence/intensity and weather parameters, the surveillance frequency/interval is decided to get comprehensive view of the pests and diseases development/population dynamics as well as biocontrol agent's population (if present in the crop ecosystem). In subsequent survey, monitoring for the pest, pathogen, and biocontrol agent must be carried out to get the following detailed information:

- **Relative pest measuring estimates:** Counting the representative samples in a given area.
- **Absolute pest measuring estimates:** Counting all individuals in a population in a given area which determine total pest population size in a given area. It is very effective pest surveillance research tool but very time consuming, therefore, not practical and/or not economically feasible.
- **Get an idea of number of pests per unit:** To estimate pests per plant and/or area to make the decision.
- **Get an idea of weather at the site:** In addition to the pest estimation, the prevailing weather conditions, which may affect pest development and/or population build up, are observed and recorded.
- **Get an idea of biocontrol agents:** To strengthen the management strategies, biocontrol agent population size, if available, in a given area is to be determined.

For insect pests:
Aphid, mealybug and scale: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

Stem borer, pin-hole borer: Count and record the number of stems/branches and damaged stems/branches due to stem borer and pin-hole borer on five randomly selected plants. Also, record the number of adults and nymphs on stems/branches.
Gypsy moth, grey weevil, defoliator, walnut weevil, codling moth: Count and record the number of shoots/branches/fruits and damaged shoots/branches/fruits and damaged shoots/branches/fruits due to gypsy moth, grey weevil, defoliator, walnut weevil, codling moth on five randomly selected plants. Also, record the number of adults and larvae/grub on shoots/branches/fruits.

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 soil problems. In many cases, the cause of the symptom is not obvious. Analyses 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: Examine unhealthy plants and also look for lesions / rots on the stems and roots of healthy plants. 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 for gypsy moth and codling moth:

Pheromone traps for gypsy moth and codling moth @ 4-5 traps/acre have to be installed, if available. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected field. Fix the traps to the supporting pole at mid height of 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. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water/sticky traps:
Set up yellow pan water trap/sticky traps 15 cm above the canopy for monitoring aphids @ 4-5 traps/acre. Locally available empty tins can be painted yellow 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).

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), 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 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 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, *Chrysoperla,* earwigs, etc.

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Mustard

Cosmos

Anise

Dill

Parsley

Marigold

Repellent plants

***Ocimum* sp**

Peppermint

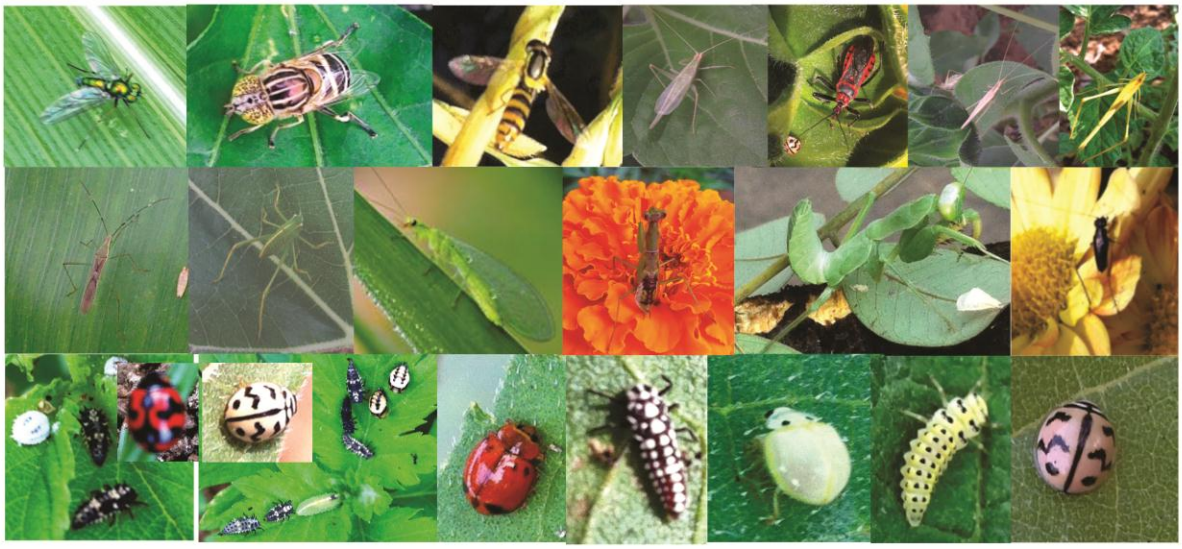
Marigold

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> • Destroy the alternate host plants • Sow the ecological engineering plants • Sow sorghum/maize/ pearl millet in 4 rows all around the main crop as guard/barrier crop • Plough the field before planting to destroy existing weeds in the field. • Apply manures and fertilizers as per soil test recommendations. • Grow the attractant, repellent, and trap crops around the field bunds. • Proper selection of cultivars having commercial value and suitable for effective cross pollination • Before planting of walnut trees, the proper soil selection be made, and the most suitable soil is loam with abundant organic matter. • Irrigate the plants I - 2 fortnights before expected harvesting. • To avoid wilting due to long dry spell of summer irrigate the plants. • Orchard management practices be followed strictly like clean cultivation. • Arrangement of efficient pruning tools be made before undertaking pruning job. • If the plants / trees exhibit the deficiency of micronutrients, especially of boron go for the application of the same on the basis of soil and leaf analysis. • 2 or 3 varieties of walnut are required to be planted for adequate pollination. • Apply balanced dose of chemical fertilizers and FYM to up keep the vigour of the plant and to reduce the attack of shot hole, back beetles and other pest. • Growing of flowering plants, especially Marigold and Maize on peripheries and legumes as inter cropping help in conservation of both predators and parasitoids and helps in nematode management.
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Prepare land by ploughing and harrowing. • The pits are dug in summer about a fortnight before planting and left undisturbed. • Pits of about 1m x 1m x 1m size are dug at a distance of 10 meter in square system of planting.
Water management	• Proper drainage as crop is water sensitive
Weeds	• Plough the field before planting to destroy existing weeds in the field.

Planting*	
	Common cultural practices: • Collect and destroy plant parts infested with insect pest and diseases • Use weed free, healthy suckers for planting. • Remove and destroy crop residues. • Avoid planting during wet weather condition • Take up planting in shade free area • Avoid planting of pest infested saplings. **Common mechanical practices:** • Prune and destroy the scale, borer and canker infested twigs / branches. • Clip of diseased/ mildewed shoots. • Remove and destroy dead and drying trees from the orchards • Collection and destruction of egg masses of hairy caterpillar. • Collect and destroy the fallen walnut weevil infested fruits. • Whenever infestation of mealy bug is noticed, slippery bands of alkathane sheets above the ground be applied during April. • Collection and destruction of fallen foliage in autumn. • Burlap skirts around the tree trunks infested with hairy caterpillar for collection and destruction of larvae I pupae of the pest from May to end of June. • Cover the exposed part of the stem to sun with dry grass or gunny bugs soaked with methyl parathion (0.1%) once a month from March to October for • Controlling borer infestation. • Complete collection, destruction of foliage and pruned wood in the orchards after leaf fall. • Fallen fruits be collected and destroyed at every 10 days interval on the community basis.
Nutrients	• Planting is done in pits already filled with top soil and farm yard manure in 2:1 ratio. • Add mycorrhiza culture @ 50 g/pit or a basket of soil taken from old walnut orchard to ensure mycorrhiza association with walnut roots.
Weeds	• Use weed free seedlings for planting. • Remove weeds from the pits before planting. • Grow the recommended cover crops between the rows of walnut trees with recommended agronomic practices.
Pests, soil borne pathogens and other diseases	**Cultural control:** • Care should be taken that water should not stagnate near the root zone
Powdery mildew	**Cultural control:** • Use healthy infestation-free plants. • Aphids usually spread through infested stocks, avoid planting infested stocks.
Aphids	**Cultural control:**

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

Use resistant root-stocks belonging to Malling Merton series.
Ecological engineering with buckwheat attracts parasitoid, Aphelinus mali

</td></tr>
<tr><td>Vegetative stage:</td><td></td></tr>
<tr><td></td><td>
<u>Common cultural practices:</u>

Collect and destroy crop debris
Collect and destroy disease infected and insect damaged plant parts
Provide irrigation at critical stages of the crop
Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed
Remove weed plants

<u>Common mechanical practices:</u>

Handpick the older larvae during early stages
Collect and destroy plant parts infested with insect pest and diseases
Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water.
Use yellow sticky traps @ 4-5 trap/acre
Use light trap @ 1/acre and operate between 6 pm and 10 pm
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

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

For achieving higher yields of quality product, generally nutrients may be applied according to the age of plant as mentioned below;

<table>
<tr><th rowspan="2">Age of tree (years)</th><th colspan="3">Nutrient (grams per tree)</th></tr>
<tr><th>N</th><th>P2O5</th><th>K2O</th></tr>
<tr><td>1-3</td><td>10-20</td><td>30-40</td><td>20-30</td></tr>
<tr><td>4-6</td><td>30-60</td><td>40</td><td>40-80</td></tr>
<tr><td>7-10</td><td>100-250</td><td>40-60</td><td>100-250</td></tr>
<tr><td>11-14</td><td>250-750</td><td>75-200</td><td>750-1300</td></tr>
<tr><td>15th year and above</td><td>1800</td><td>500</td><td>1500</td></tr>
</table>

Apply manures @ 50kg per plant in Dec-Jan every year along with full dose of P and K.
Nitrogen is applied in 2 splits, first half at 2-3 weeks before flowering and the remaining half a month later.
The fertilizers should be applied in 20-30 cm deep and 30cms wide trench along the drip line of the tree.

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

Deep hoeing is recommended during the first year to check weed growth. Weeding should be done on regular basis especially

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

	around the plants. • To suppress the weeds between rows, leguminous crops and vegetables can be grown as intercrops in the initial years. • Use straw or plastic mulches to check the weed growth. • Use slashing and mowing between the rows to control the weeds.
Stem borer	• Follow common cultural, mechanical and biological practices **<u>Cultural control:</u>** • Keep the orchard healthy following good agricultural practices. • Kill the stem borer larvae by inserting a flexible wire inside the hole and plug the hole with the cotton wick soaked in petrol and seal it with mud. **<u>Mechanical control:</u>** • Prune and burn all attacked shoot and branches during winter.
Shot-hole borer	• Follow common cultural, mechanical and biological practices **<u>Cultural control:</u>** • Attacked shoots should be clipped off and destroyed. • Clean hole and pour kerosene/petrol/crude oil or formalin into the stem borer hole and subsequently close entrance of the tunnel by plugging with cotton wool and paste the mud. • Use light trap@1/acre
Leaf roller	• Follow common cultural, mechanical and biological practices
Mealybug	• Follow common cultural, mechanical and biological practices **<u>Cultural control:</u>** • Remove weeds and grasses by ploughing during June-July. • Plough orchards during summer to expose the eggs to natural enemies and extreme heat. • Flooding of orchard with water in the month of October kill the eggs. • Raking of soil under the tree trunks and mixing with some soil dust in the early part of November for control of early instar mealy bug • Soil solarization with thin polythene sheet for 30-40 days during hot summer • Fastening of alkathene sheet (400 gauge)/grease band of 25 cm wide afterwards mud plastering of trunk at 30 cm above the ground in the middle of December. • In July –August destruction of infested fallen leaves with scales **<u>Biological control:</u>** • Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds and releasing 10-15 grubs • Releasing 10-15 grubs of cocinellid predator, *C. montrouzieri* per tree.
Grey weevil	• Follow common cultural, mechanical and biological practices

	Cultural control: • Collection and destruction of infested and fallen fruits at weekly interval till fruit harvest. • Ploughing of orchard after harvest to expose hibernating adults, reduce, infestation levels. • Destroy all left over seeds in the orchard and also in the processing industries.
Walnut weevil	• Follow common cultural, mechanical and biological practices
Leaf spot	• Follow common cultural, mechanical and biological practices **Mechanical control:** • Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load.
San Jose scale, aphids****	• Follow common cultural, mechanical and biological practices **Cultural control:** • Grow attractant flowers for natural enemies: viz., sunflower family, carrot family plants, buckwheat etc. **Mechanical control:** • Pruning of infested branches and twigs • Collection and destruction of pruned infested material. **Biological control:** • Predators such as lady bird beetles - *Chilochorus bijugus, Pharosemnus horni, Coccinella septumpunctata, Chlilochorus tristis, Adalia bipunctala, Synharmonia* sp. *Exochomus quadripustulatus, Hippodamia convergens* @ 30-50 adults / infested tree. • Green lacewings (*Chyrsoperla* sp.) and *Syrphus* sp. @10-20 1st instar larvae/tree. • Parasitiods such as *Encarcia perniciosi* and *Aphytis diaspidis* @ 2000 / infested tree after 15 days of insecticidal sprays and 10 days after fungicidal sprays.
Downy leaf spot	• Follow common cultural, mechanical and biological practices
Leaf blotch	• Follow common cultural, mechanical and biological practices
Dieback	• Follow common cultural, mechanical and biological practices
Powdery mildew	• Follow common cultural, mechanical and biological practices **Cultural control:** • Spraying at full bloom needs to be avoided. **Mechanical control:** • Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load.
Walnut blight	• Follow common cultural, mechanical and biological practices
Anthracnose	**Cultural control:**

	• Removing leaf debris from around plants • Avoiding wetting foliage when irrigating. • Spacing trees adequately to increase air circulation and applications of nitrogen fertilizer in Spring to delay leaf maturity and reduce the development of lesions.
***Phytophthora* root and crown rot**	**Cultural control:** • Planting trees in well-draining soils • Drainage can be improved by levelling soil or installing drainage systems • Avoid wetting tree trunks when irrigating ensure graft union is several centimeters above the soil line when planting trees.
Armillaria root rot (Oak root fungus)	**Cultural control:** • Diseased or dead plants should be uprooted and removed. • Planting resistant rootstocks is the most effective method
Crown gall	**Cultural control:** • Plant disease-free nursery stock. • Plant trees in well-draining soils. • avoid wounding the plants
Walnut canker	• Follow common cultural, mechanical and biological practices
Reproductive stage	
Nutrient	• Nitrogen is applied in 2 parts, first half at 2 weeks before flowering and the remaining half in two splits at 3 weeks after fruit set and during early July. • The band application of nitrogenous fertilizers should be preferred over broadcasting. • Under rainfed conditions, apply N through 1 or 2 foliar sprays of urea (0.5%) after fruit set. • Apply recommended micronutrients, if symptoms are observed. • Fruits are deformed under boron deficiency. To avoid boron deficiency, apply H_2BO_3 (0.1%) as foliar spray.
Weed	• Remove weeds around the plants/trees. • Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period. • Mulching tree basins with 10-15 cm thick dry grass also checks weed growth. During the initial 2-4 years, pea, bean, soybean, and cowpea enrich the soil and give economic returns also.
Stem borer	• Same as in vegetative stage
Codling moth**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Apart from aforesaid practices, regular monitoring is mandatory for moths, • For codling moth: Use synthetic codling month for mating disruption at a height of 6-8 feet or Dispensers should be deployed within 1 meter of the top of the canopy prior to spring emergence during late May to 3rd week of July.
San Jose scale, aphids	• Same as in planting and vegetative stages
Downy leaf	• Same as in vegetative stages

Spot, **Leaf blotch,** **Dieback,** **Powdery mildew,** **Walnut blight,** **Anthracnose,** ***Phytophthora* root and crown rot,**	

Note: The dosages of pesticides are 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 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.

3) Take an integrated approach to managing pests. Use as many different control measures as possible. 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.

4) Time applications correctly. Apply insecticides when the pests are most vulnerable. Use application rates and intervals recommended by the manufacturer, university insect management specialist, county Extension agent, or crop consultant.

5) Mix and apply carefully. While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, using techniques recommended by the manufacturer etc.

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

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

VI. NUTRITIONAL DEFICIENCIES/DISORDERS

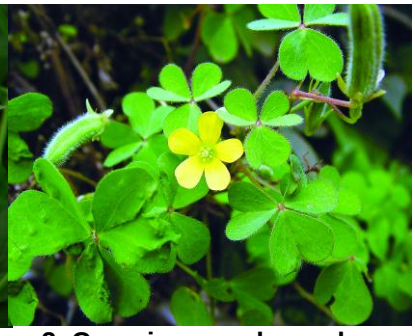
Boron

Symptoms: Severe B deficiency symptoms in walnut trees consist of long, leafless shoots, mostly in the tops of trees, and flattened and twisted shoots at the tips. These shoots die during the following winter. Browning of margins and interveinal tissues on leaves of walnut tree. To correct Boron deficiency, apply Boron @ 150 to 400 mg per lit of water as foliar spry.

http://www.salinitymanagement.org/Salinity%20Management%20Guide/sp/sp_7b.html

VII. COMMON WEEDS

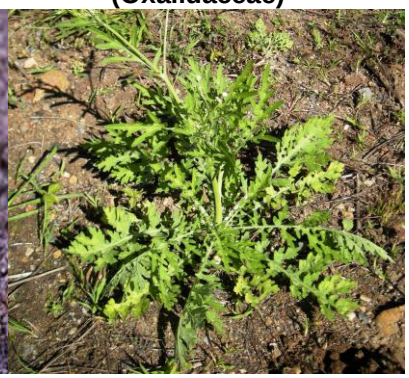
1. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)



2. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)

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

4. Sowthistles: *Sonchus* spp. (Asteraceae)



5. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)

6. Lambs quarter : *Chenopodium album* L. (Chenopodiaceae)

7. Sweet yellow clover : *Melilotus indica* (L.) All. (Fabaceae)

8. Toothed Dock : *Rumex dentatus* L. (Polygonaceae)

9. Bermuda grass: *Cynodon dactylon* (Poaceae)

10. Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)

11. Blanket grass: *Axonopus compressus* (Sw.) Beauv. (Poaceae)

12. Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)

13. Knot grass: *Paspalum distichum* L. (Poaceae)

14. Purple nutsedge: *Cyperus rotundus* L. (Cypraceae)

VIII. DESCRIPTION OF INSECT PESTS

1) Stem borer:

A. sarta is found in mountains up to an altitude of 2000 m. The area of origin of the pest is thought to be Pakistan and Western India, from which it spread westwards to Afghanistan and Iran and northwards to the Central Asian countries of the former USSR where it was first found in 1911 (in Samarkand, UZ). The pest continues to increase its range in these countries.

Biology:

Egg: Females lay 1–3 eggs in slit-like niches in the bark of trunks and large branches shortly after leaving the pupation cells and for about two months. Each female lays 240–270 eggs in its life span. The egg period is 9 –17 days.

Grub: Newly hatched grubs are light-coloured and about 4 mm long. Each grub makes its own tunnel (even if there are several eggs at the same place) between the bark and the wood. Excreta are ejected through the entry hole. At the bottom of this gallery, the larva overwinters protected by a double plug made from borings. The next spring, grub continues to feed, making tunnels deep into the wood. At the end of July, they prepare pupation cells protected by double plugs made from borings. The grown up grub is covered with golden hairs, 60 –70 mm long, with black mandibles.

Pupa: Pupation occurs in these cells. Pupal period is two weeks. The adults stay in the pupation cells to over winter and leave them only in the spring.

Adult: The adult has an elongated dark grey-brown body, 28– 47 mm long, with elytra covered with short silvery hairs. Shiny silvery spots form two irregular bands crossing the elytra. The male is usually smaller than the female. The male has antennae 2.5 times as long as the body, whereas the female antennae are shorter than the body Adults usually leave their pupation cells in April or the beginning of May at an average daily temperature of 20 °C. They are generally active in the evening and night. During the daytime, they hide under the bark, in larval tunnels, in winter tunnels and in other refuges.

Adult:

http://www.agri.ohio.gov/public_docs/photos/caps/CLB_topside.jpg

Damage symptoms:

- Grubs enter the wood and, at the end of the first season of development, make a long (about 25 cm) tunnel upward and then turns to form a downward gallery of 15 cm
- Large emergence holes in trunks and large branches
- Borings at the basis of infested trees
- The adult beetles are conspicuous and may be seen sitting on the trunks
- Branch and tree dieback indicated by wilting and drying of leaves

Natural enemies of stem borer:

Predators: Lacewings, ladybird beetles, carabids, syrphids, anthcorid bugs, reduviid bugs, nabid bugs, capsid bugs, big-eyed bugs, earwig, spiders, ground beetle, pentatomid bugs, red ants, preying mantis, *Oligota* spp., *Orius* spp., mirid bug, robber fly, black drongo, common mynah etc

*For the management refers page number 26 & 28

2) Shot-hole borer:

Biology:

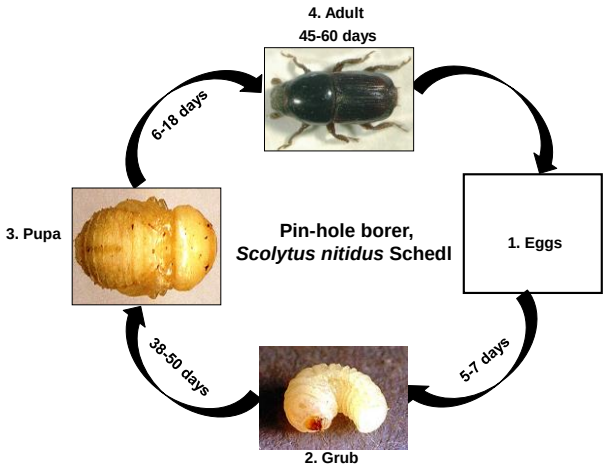
Egg: Bark dissections showed that eggs were deposited in small individual chambers on both sides of the mother gallery at regular distances throughout its length. On an average 52 eggs were laid per female, approximately 26 on each side of the mother gallery. The egg is slightly oval, shining, pale white and minute about 0.64 mm in length and 0.48 mm in width. The eggs in the egg niches were covered by the boring dust. The eggs hatched after an incubation period of 5-7 days.

Grub: The grub on hatching was a minute white dot almost motionless, measuring 0.75 mm in length and 0.45 mm in width. As soon as the feeding started the larva became curved, legless grub and light creamy in colour. A full grown larva was 5.77 mm long and 1.89 mm wide. The head capsule measurements revealed that the larva passed through 5 instars before changing into pupa. The larval phase extended for 38-50 days.

Pupa: The pupation took place at the ends of the larval galleries in pupal cells. The pupa was soft, white, averaging 4.05 mm in length and 1.60 mm in width. The pupal stage lasted for 6-18 days.

Adult: The adult emerged from the pupal chamber by tunnelling straight through the bark over it. After emergence, adults flew to the crown of other suitable trees to produce the next generation. The cylindrical adult averages 4.00 mm long and 1.68 mm wide. It has shining black pronotum and dark red brown elytra with declivous abdomen. The adults lived for 45-60 days.

Life cycle:



2. http://insect.pnwhandbooks.org/sites/insect.pnwhandbooks.org/files/relatedimages/614-36_0.jpg
3. http://www.zin.ru/Animalia/Coleoptera/images/scol_ob4.jpg
4. http://www.barkbeetles.org/images/768x512/2105031.jpg

Damage symptoms:

- Grub tunnels in the sapwood on the trunk or branches
- Grub bore into the sap wood and making irregular tunnels.
- Feeding the vascular tissues
- interruption of nutrient and water transport on the tissue
- Drying of terminal shoot in early stage
- Frass comes out from several points and sometimes sap oozes out of the holes
- Wilting of branches or entire tree
- The bark of infested twigs, branches and trunks is perforated with many small round holes. In stone fruits, gum often will appear in and around these holes.
- Pin-hole borer damage usually is limited to weak, declining trees, and infestations frequently hasten tree or limb death

Emergence/exit holes of adult pin-hole borer

*For the management refers page number…26……

3) Gypsy moth:

Biology:

Egg: The egg mass is approximately 1.5 inches long and 0.75 inches wide. Eggs are attached to trees, houses, or any outdoor objects. The eggs hatch in spring (April) into caterpillars. Incubation period 5 to 24 days

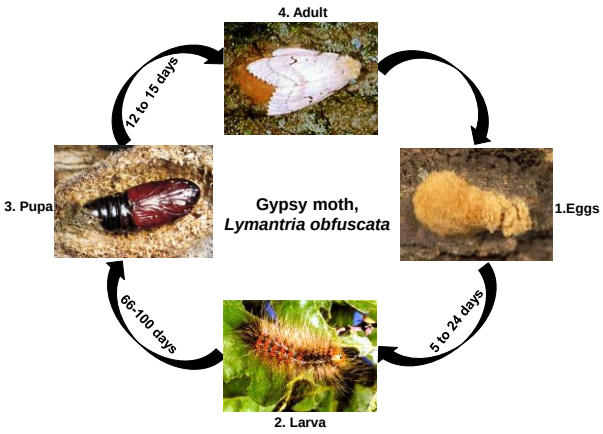
Larva: They have five pairs of blue dots followed by six pairs of red dots lining the back. In addition, they are dark colored and covered with hairs. Young caterpillars primarily feed during the day whereas the older caterpillars feed at night. When present in large numbers, the older caterpillars feed day and night. Older caterpillars are approximately 1.5 to 2.0 inches long. Larval period 66-100 days.

Pupa: In early summer, Gypsy moth caterpillars enter a pupal or transitional stage. The pupae are dark brown, shell-like cases approximately two inches long and covered with hairs. They are primarily located in sheltered areas such as tree bark crevices or leaf litter. Pupal period ranged from 12 to 15 days.

Adult: Adult Gypsy moths emerge from the pupae in 10 to 15 days. Females have white to cream-colored wings, a tan body, and a two-inch wingspan. Female Gypsy moths cannot fly. Females lay between500 to 1,000 eggs in sheltered areas such as underneath the bark of trees.

Both the adult female and male can be identified by the inverted V-shape that points to a dot on the wings. Male and female moths lived for a period of about 3.5 to 6.0 days and 7.0 to 9.0 days.
Gypsy moth has only one generation per year.

Life cycle:



1. http://urbanext.illinois.edu/gypsymoth/biology.cfm
2,3,4. http://urbanext.illinois.edu/gypsymoth/photos.cfm

Damage symptoms:

• Caterpillars are gregarious but voracious feeder.
• They eat voraciously on leaves at night time.
• Under heavy infestation entire leaf is eaten sparing only hard vein.
• Defoliation of host completely results in failure of fruit formation.

Natural enemies of gypsy moth:

Parasitoids: *Exorista* sp*, Drina* sp*, Apanteles* sp*, Saracophages* sp, *Poilania* sp, *Anilastus* sp*, Anithomyia* sp*, Euplectrus* sp*, Brachymeria* sp, *Monodontomerus* sp, *Hyposoter* sp*, Pimpla* sp etc.

Predators: Lacewings, ladybird beetles, carabids, syrphids, anthcorid bugs, mirid bugs, reduviid bugs, nabid bugs, capsid bugs, spiders,

red ants etc.

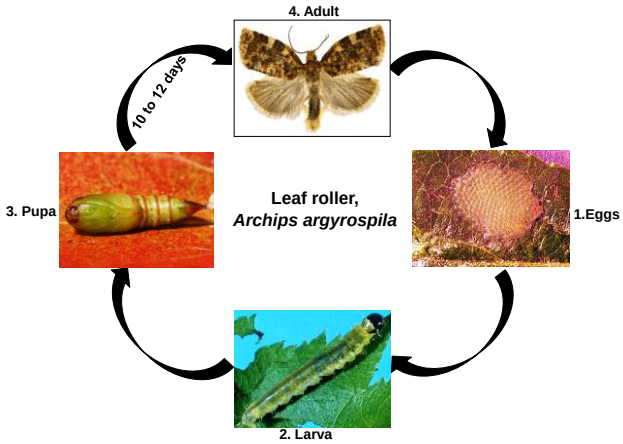
Entomopathogenic fungus: *Fusarium pallidoroseum*
*For the management refers page number……

4) Leaf roller:

Biology:

Egg: Eggs are laid in masses on the twigs of the host and covered by the female with a substance that hardens to create a smooth, hard surface.
Larva: First instar larvae bore into the buds of their host plant. Later instars roll or tie leaves together or tie them to fruit. They feed on the leaves, flowers, buds or fruits of the host plant. Later instars roll or tie leaves together or to fruit and partially emerge from the shelter to

feed.
Pupa: Pupation occurs within the larval shelter and adults enclose in 10-12 days.
Adult: The adult flight period lasts approximately 3 weeks. The length of the forewings is 6-10.2 mm for males and 8.5-11.7 mm for females. Adults have a variable forewing colour consisting of combination of reddish brown, dark brown and tan.
This species completes a single generation per year.
Life cycle:



1. http://insect.pnwhandbooks.org/node/1622/print
2. http://mothphotographersgroup.msstate.edu/Files1/Live/CCC/CCC3648b-cat-300.jpg
3.http://bugguide.net/images/raw/QZEL3LULYL1LMZSHGRVL0ZLHPRHH0RNLFLULZZ2LJLWLQRNLMZLHQZVLSZLH6RDL8RQH2RZHERKHIR.jpg
4. http://idtools.org/id/leps/tortai/large/images/Archips_argyrospila/argyrospila_m1.jpg

Damage symptoms:

- **Buds** - Small entry holes in buds, chewed petals and flower parts.
- **Blossoms** - Petals webbed together, often remaining attached through petal-fall; inner flower parts eaten.
- **Leaves** - Chewed, rolled and tied together with silk.
- **Fruit** - Deep irregular holes in small fruit resulting in large russeted scars in mature fruit.

Natural enemies of leaf roller:

Predators:, Lacewings, ladybird beetles, carabids, syrphids, anthcorid bugs, mirid bugs, reduviid bugs, nabid bugs, capsid bugs, spiders, red ants etc.

*For the management refers page number……26……

5) Grey weevil:

Biology:

Egg: Female *Myllocerus* spp. may lay up to 360 eggs over a 24-day period, and larvae emerge in 3-5 days. Eggs are laid directly on organic material at the soil surface. Eggs are less than 0.5 mm, ovoid and usually laid in clusters of 3-5. The eggs are white or cream-colored at first, then gradually turn brown when they are close to hatching.

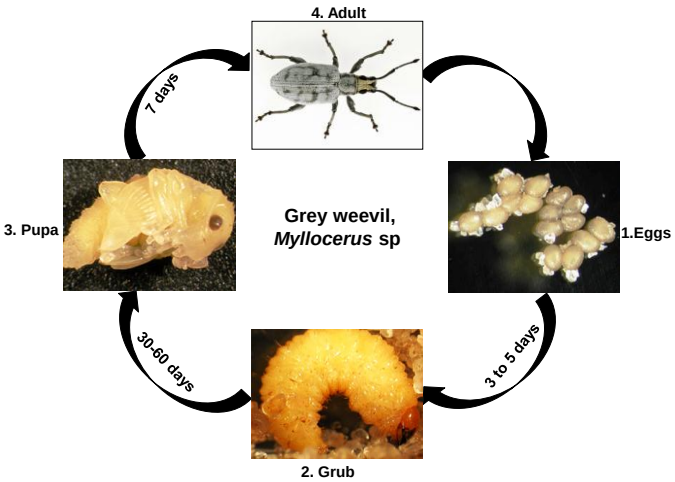
Grub: The grub range in size from 1.09 ± 0.05 mm as first instar grub to 4.0 ± 0.05 mm as

fourth instar grub and are beige-white with a reddish brown head. They burrow into the soil where they feed on plant roots for approximately one to two months.

Pupa: The grub pupates in the soil for approximately one week.

Adult: Adult weevils vary in length from approximately 6.0 to 8.5 mm; the female weevil is slightly larger than the male by 1.0 to 2.0 mm.

Life cycle:



1,2,3,4. http://entnemdept.ufl.edu/creatures/orn/sri_lankan_weevil.htm

Damage symptoms:

- When adult weevils feed on leaves, they feed inward from the leaf margins (or edges), causing the typical leaf notching.
- There are some instances where the leaf material is almost completely defoliated, where the weevil has fed along the leaf veins.
- The adults prefer new plant growth.
- Intense feeding by numerous weevils may cause plant decline or stunting.
- Young seedlings may not survive a large amount of feeding damage.
- With healthy plants, however, the feeding damage may be considered cosmetic if the plant recovers.

Adult feeding damage on leaves

*For the management refers page number…27……

6) Codling moth:

The rate of development will vary with temperature, proceeding more rapidly in warmer weather and climates. Depending on the climate, codling moth can have two, three, and sometimes four generations per year.

Biology:

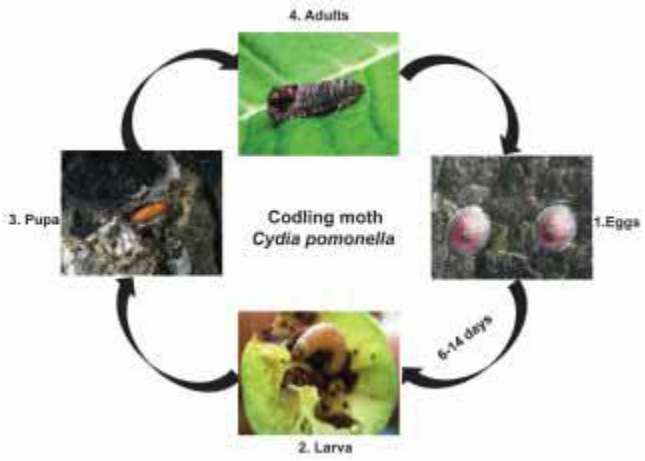
Egg: Eggs are deposited singly on apples and leaves. Each egg is about the size of a pin head and is translucent, gradually darkening as the egg nears hatching (Figure 6). Eggs hatch in six to 14 days, depending on temperature. Within 24 hours of hatching the larvae burrow into the fruit. The first instar larvae have a pink body with a black head and are approximately 1/10 inch in length. The number of eggs laid per female ranges from 30 to 70.

Larva: After the eggs hatch, young larvae seek out and bore into fruit or developing nuts. Codling moth overwinters as full-grown larvae within thick, silken cocoons under loose scales of bark and in soil or debris around the base of the tree. Larvae are cannibalistic. Full grown larva pinkish or creamy white with brown head and pupates in the soil litter.

Pupa: After completing development they leave the fruit and drop from the trees to search out pupation sites and continue the life cycle in the soil or on debris under the tree; some crawl back up the tree to pupate in bark crevices. The larvae pupate inside their cocoons in early spring and emerge as adult moths mid-March to early April. The moths are active only a few hours before and after sunset, and they mate when sunset temperatures exceed 62°F.

Adult: Adults are about 1/2 to 3/4 inch long with mottled gray wings that they hold tent like over their bodies. Their appearance blends well with most tree bark, making them difficult to detect. If you are trapping the adults, you can distinguish codling moth from other moths by the dark, coppery brown band at the tip of their wings. Adult forewings are dark grayish with waxy lines with a copper colored eye like circle toward margin.

Life cycle:



1. http://www7.inra.fr/hyppz/RAVAGEUR/6cydpom.htm
2. http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/codling-moths06
3. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=5
4. http://ukmoths.org.uk/show.php?bf=1261

Damage symptoms:

• It is a direct pest and hence causes severe damage to the fruit.

• Neonate larva enters the fruit through calyx and feeds on seed.
• Infested fruits lose their shape and fall prematurely.
• 30 to 70 per cent apple fruits are rendered unmarketable.

Natural enemies of coding moth

Parasitoid: *Trichogramma* spp.

Predators: *Parus major, Passer domesticus*

*For the management refers page number…28……

7). San Jose scale:

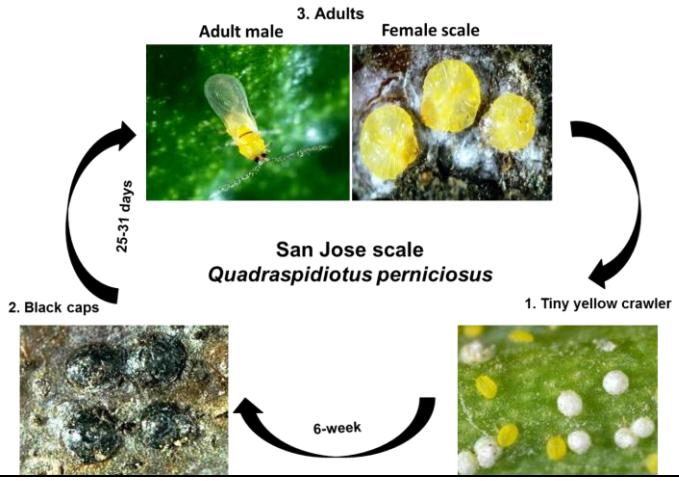
Pest of 700 different species of fruits, shrubs and ornamental plants. Pest is active from March to December. Passes winter black cap stage in tree bark.

Biology:

Nymph: Female San Jose scales give birth to living young that emerge from under the edge of the scale covering. Each female gives birth to 200-400 nymphs. These tiny yellow crawlers wander in a random fashion until they find a suitable place to settle. Immediately upon settling, the crawlers insert their mouthparts into the host plant and begin feeding and secreting a white waxy material (white cap stage); eventually the waxy covering turns black and is known as the black cap stage. Later the covers turn various shades from gray to black.

Adult: Immature male and female scales are indistinguishable until the first molt. At this time, the male scale covering begins to elongate, while the females remain circular. Males molt a total of four times. Following the final molt, adult male scales emerge from the scale covering as tiny, yellow winged insects. They mate with the females who remain under the scale covering. Female insect body covered with grey scales. Yellow lemon coloured female is visible when covering is lifted. Female scales are very prolific and over a 6-week period can produce approximately 400 young. San Jose scale produce living young called crawlers; most other scales produce eggs. Crawlers move around for a short period in search of a suitable place to settle. It takes 25 days for males to mature and 31 days for females
Five to six generations in a year.

Life cycle:



1.http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-NM.008.html
2. http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-NM.017.html
3 http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-AD.021.html

Damage symptoms:

- Nymph and female scales attack all above ground parts.
- Feeding site turns into a characteristic purplish red colour.
- Initially growth of plant is checked but as scale increases in number plant may die.
- Fruits will have distinct “measles” spots on the surface.

Natural enemies of San Jose scale:

Parasitoids: *Encarsia* sp, *Aphytis* sp

Predators: Ladybird beetle

*For the management refers page number…29……

Natural Enemies of Insect Pests of Walnut

Parasitoids

Egg parasitoid

1. *Trichogramma* spp.

Larval parasitoids

2. *Exorista* sp

3. *Apanteles* sp

4. *Euplectrus* sp,

5. *Monodontomerus* sp

6.*Hyposoter* sp

7. *Pimpla* sp

Pupal parasitoid

8.*Brachymeria* spp.

Nymphal/larval and adult parasitoids

1. 9. *Aphidius* sp

10. *Encarsia* sp

2. http://baba-insects.blogspot.in/2012/02/telenomus.html
3. http://www.discoverlife.org/IM/I_MWS/0724/320/Exorista_larvarum,I_MWS72456.jpg
4. http://www.waspweb.org/Ichneumonoidea/Braconidae/Microgastrinae/Apanteles/images/Apanteles%20galleriae_habitus.jpg
5. http://m9.i.pbase.com/o6/94/339594/1/82820059.SlyNmplg.IMG_0116.JPG
6. http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/images/chalc639.jpg
7. http://www.cedarcreek.umn.edu/insects/newslides/025016424xxxapl.jpg
8.http://www.nhm.ac.uk/researchcuration/research/projects/chalcidoids/database/media.dsml?IMAGENO=chalc519&VALGENUS=Brachymeria&VALSPECIES=euploeae
9. http://www.biolib.cz/IMG/GAL/142492.jpg
10. http://biobee.in/products-and-services/solutions/bio-aphidius/
11. http://www.syngenta.com/global/Bioline/en/products/allproducts/Pages/Encarline-f.aspx

Predators

1. Lacewing

2. Ladybird beetle

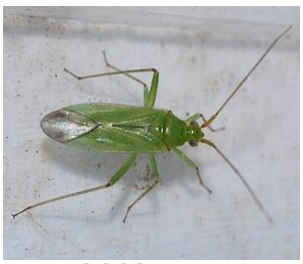
3. Reduviid bug

4. Spider

5. Robber fly

6. Red ant

7. Hover fly



8. Mirid bug

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

14. *Oligota* spp.

15. *Orius* spp.

Birds

16.Black drongo

17.Common mynah

18. *Parus major*

19. *Passer domesticus*

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
8. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
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/
14. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
15. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
16. http://nagpurbirds.org/blackdrongo/picture/1639
17. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
18 http://en.wikipedia.org/wiki/Great_Tit
19. http://www.ecowalkthetalk.com/blog/2011/03/11/mohammed-dilawar-world-sparrow-day-march-20th/passer-domesticus-house-sparrow-photo-salim-ali-foundation/

IX. DESCRIPTION OF DISEASES

1. *Alternaria* leaf spot/blight:

Disease symptoms:

- Leaf spots appear on the leaves in late spring and early summer. Initially, they are 1/8 to 1/4 inch in diameter, round, brown, and occasionally have a purple border.
- As spots age, they often turn tan to ash gray. Some spots undergo secondary enlargement, becoming irregularly shaped.
- Heavily infected leaves often abscise, resulting in defoliation (defoliation is greater when mites are present). Fruit infections result in small, dark, raised pimple-like lesions associated with the lenticels.
- Twig lesions, which are somewhat sunken, round, blackish spots bordered by cracks, occur on susceptible cultivars such as Indo but have not been observed on Delicious.



1, 2: http://www.ces.ncsu.edu/fletcher/programs/apple/plantpath/ALTERfact.html
3.http://previews.agefotostock.com/previewimage/bajaage/db1b88d3d7dfc45410eae00ea3adca91/gwg-bev1534.jpg

Disease symptoms

Survival and spread:

- Primary infection occurs about one month after petal fall the following year.

Favourable conditions:

- The disease is favoured by mperatures between 77 and 86 °F (25–30 °C), and by wet conditions.
- Infection occurs at optimum temperatures with 5.5 hours of wetting and an outbreak can become serious within two days of infection.

*For the management refers page number…27……

2. Powdery mildew:

Disease symptoms:

- Disease appeared when the buds become develop into new leaves and shoots.
- Small patches of white or grey powdery masses on under surface of leaves occur.
- Leaves grow longer and narrower than normal leaves and the margin is curled.
- Twigs covered with powdery mass.
- Affected fruits remain small and deformed and tend to develop roughened surface.

Survival and spread:

- The fungus survives in the form of a resting spores mycelium or encapsulated haustoria

in the buds and the secondary spread occur through air borne conidia.

Favourable conditions

- Powdery mildew Infection occur in the temperature 10-25% and 70 % RH. Infections can occur when the temperature lies between 10 to 25°C.

*For the management refers page number…24, 27 & 29……

3.Leaf blotch:

Disease symptom:

- Brown, roughly circular leaf spots, a few mm in diameter
- The spots merge together to form larger, irregular brown blotches, often with a yellow margin
- Severely affected leaves shrivel and fall prematurely
- Sunken brown blotches may develop on petioles, young shoots and the outer case of the fruit. Some affected fruits may fall
- Developing nuts shrivel and turn black

Disease symptom

http://www.donsgarden.co.uk/pests/573

Survival and spread:

- The fungus survives in plant debris, the secondary spread occur through air borne conidia.

Favourable conditions:

- Walnut leaf blotch is a fungal disease that is favoured by wet weather.

*For the management refers page number…27 &29……

4.Walnut blight:

Disease symptom:

- Small, water-soaked spots on immature fruit which darken and rapidly enlarge; bacterial exudate may be present during wet weather.
- If infection occurs prior to shell hardening then the kernels shrivel; infections which occur later may cause kernel discoloration but the fungus does not usually invade the kernel; catkins which become infected are dark and shriveled.
- New shoots may also be attacked and lesions may girdle the stem, killing the shoot above; lesions may form on tree bark and may also extend into the pith causing cankers to form; lesions on leaves are brown with a green-yellow perimeter; leaf lesions may

coalesce to form large necrotic areas.


Disease symptoms

http://www.lutherburbankonline.com/VOLUME%2011/images/V11_C2_9.jpg
tps://pesticideguy.files.wordpress.com/2013/02/46-walnut-blight.jpg

Survival and spread:

- In lesions on plant parts and can also survive for long periods in diseased plant tissues.

Favourable conditions:

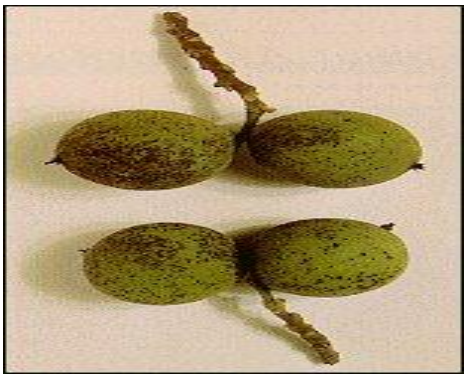
- Spring session is responsible for the development of diseases.

*For the management refers page number…28 & 29……

5.Anthracnose:

Disease symptoms:

- Brown to black lesions on leaves, petioles, shoots and/or husks which fade toward the center and may be surrounded by a chlorotic halo; spots may coalesce to form large necrotic patches, usually located close to leaf margins.
- Lesions on shoots, petioles and leaf midribs become elongated and sunken.

Disease symptoms

https://www.plantvillage.com/en/topics/walnut/infos/diseases_and_pests_description_uses_propagation
http://na.fs.fed.us/spfo/pubs/fidls/walnut_anthr/wal_anthr_fig2.jpg

Survival and spread:

- Pathogens survive in infected plant debris.

Favourable conditions:

- Infections are much more obvious on the flowers and fruit. Outbreaks are common after warm wet weather.
- During the rainy season, the rain water trickling through the diseased leaves is richly laden with the spores of the pathogens to cause further infections.
- The fungus may not always cause immediate disease, which sometimes only becomes apparent after harvest.

*For the management refers page number…28 & 29……

6.Phytophthora root and crown rot:

Disease symptoms

- Slow growing trees with reduced vigor; leaves of tree turning yellow and wilting; shoots and branches dying back.
- if tree is girdled at the trunk or root crown then death occurs, usually within one growing season
- Infected tree roots are necrotic and discolored black or brown; most roots eventually die; trees with crown rot may exhibit cankers of the root crown which extend above the soil line; cankers are visible as discolored bark and possess a zonate appearance when the bark is removed.

Disease symptoms

http://pnwhandbooks.org/plantdisease/sites/default/files/images/walnut_phytophthora_root_rot_dsc_0098.jpg
http://pnwhandbooks.org/plantdisease/sites/default/files/images/walnut_phytophthora_root_rot_dsc_0079.jpg

Transmission and favourable conditions:

- Periods of 24 hours or more of saturated soil favor *Phytophthora* infections.
- Conversely, good soil drainage and more frequent but shorter irrigations reduce the risk of root and crown rot.
- These fungi are more active in soils with high moisture and in temperatures ranging from 13 to 21° C.

*For the management refers page number…28 & 29……

7.Armillaria root rot (Oak root fungus):

Disease symptoms

- Small, discolored leaves which drop early; death of branches; death of plant; clusters of

honey-colored mushrooms may sprout at base of plant.

Disease symptom

http://fruitandnuteducation.ucdavis.edu/files/154404.jpg

Survival and spread:

- Fungus survives on dead roots in soil

Favourable conditions:

- Moist soil and humid conditions favour the development of disease.

*For the management refers page number…28 & 29……

8.Crown gall:

Disease symptoms

- Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk.
- Galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard.
- If galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die.

Disease symptoms

http://ucce.ucdavis.edu/files/repository/calag/img6203p114b.jpg
http://www.science.oregonstate.edu/bpp/bot350/slides/crwngallwalnut.jpg

Survival & transmission:

- The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall.

*For the management refers page number……28……

9. Walnut canker:

Disease symptoms

- From a distance, trees affected by TCD will show flagging and branch dieback. Close examination of the bark surface of tree branches will show pinhole-sized WTB entrance or emergence holes.
- Attacked branches are usually 1.5 cm or greater in diameter. Dark wet cankers are often found next to beetle holes. Upon removal of the surface bark of the canker, several beetle feeding or reproductive galleries as well as areas of necrotic phloem tissue may be observed. As the beetles and pathogen spread, new cankers form and coalesce, girdling branches.
- TCD gets its name from the large number of dark cankers that rapidly develop on affected branches. As the upper branches die, the crown of the tree dies and the tree attempts to re-sprout branches from the trunk.
- At this stage WTB may colonize and inoculate the fungus into the main stem of declining trees. Removal of bark from affected trees will show WTB galleries, which are 1 to 2 inches long and etched against the grain on the wood surface.

Survival & transmission:

- The fungal pathogen colonizes and kills the phloem.
- Dead tissue is limited to the phloem and cambium and the fungus does not penetrate woody tissues.
- Secondary saprophytic fungi may opportunistically colonize the wood beneath cankers.

Disease symptoms

http://agriculture.mo.gov/plants/pests/cankers_240.jpg
http://www.aces.edu/ucf/images/KCanker_13.JPG

Survival and spread:

- In lesions on walnut, and can also survive for long periods in diseased plant tissues

- Leaf miners helps in the dissemination of the pathogen.

Favourable conditions:

- Spring seasion is favourable for the development of disease

*For the management refers page number…28……

X. SAFETY MEASURES

A. At the time of harvest:

Orchard floor should be maintained under sod culture. Walnuts should be harvested when hull colour changes from green to yellowish with cracks. Irrigate the orchard / walnut plantation 1-2 fortnights before expected harvest. Before knowing off nuts, orchard floor should be cleaned and covered with tarpuline sheet. Immature nuts should not be harvested and over matured conditions favour for pest infestation. Nuts should be properly dehulled, washed and dried to avoid the attack of moulds.

B. During post-harvest storage:

Walnuts like other tree nuts, must be processed and stored properly. Poor storage makes walnuts susceptible to insect and fungal mold infestations; the latter produces aflatoxin, a potent carcinogen. A mold-infested walnut batch should not be screened and then consumed; the entire batch should be discarded. The ideal temperature for longest possible storage of walnuts is in the 0 to -3^{o} C and low humidity for industrial and home storage. If refrigeration technologies are unavailable, Walnuts are best stored below 25°C with high humidity. Temperatures above 30°C and RH > 70% lead to rapid and high spoilage. Above 75% RH threshold, fungal molds that release dangerous aflatoxin can form. Harvesting with 2 to 8% moisture gives best color, flavor and high nutrient content.

XI. DO'S AND DON'TS

S. No.	Do's	Don'ts
1.	In the month of May to June with bright sunny days Deep ploughing should be done in the inter row spacing	Do not allow the plants to reach flowering stage in the field and do not irrigate the plant base for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds, if any.
2.	Intercropping should be changed for every season	Avoid monocropping in intercrop.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Always treat the seeds/seedlings/planting material with approved chemicals/biopesticides for the control of seed borne diseases/pests. Always use treated planting material for sowing	Do not use seeds/seedlings/planting material without treatment with biopesticides/chemicals.

5.	Plant the seedlings at 5-7 cm depth with proper moisture content (Not conditions)	Do not plant seedlings beyond 5-7 cm depth.
6.	Apply only CIBRC recommended dose of hectares in the evening time with flat fan or flat set nozzles.	Non-recommended pesticides should not be applied in the Orchards.
7.	Maintain optimum plant production	Orchard plants/ trees should not be exposed to moisture deficit stress at their critical stages.
8	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9	Use micronutrient mixture after planting based on test recommendations.	Do not apply any micronutrient mixture after planting without test recommendations.
10	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on pest management practices based on AESA and P: D ratio only.	Do not take any pest management decision without considering AESA and P: D ratio
11	Install pheromone traps, if available, at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	Release of parasitoids only as per field observation and requirement	Do not apply chemical pesticides within seven days of release of parasitoids.
13	Apply NPV for early instar larvae, if available, at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
14	Use of non persistent pesticide/ herbicides / fungicides reduce the residual effect on crops environment	Do not apply pesticides during preceding 7 days before harvest.
15	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop; otherwise it may not attract the pests and natural enemies.

XVI. REFERENCES

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