सत्यमेव जयते

AESA BASED IPM PACKAGE

Raspberry

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The AESA based IPM – Raspberry (*Rubus idaeus* L.) 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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Information on Region-wise Distribution of Pests Provided by:

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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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AESA BASED IPM PACKAGE FOR RASPBERRY

Raspberry - Plant description:

Raspberries (*Rubus* spp.) are an important commercial fruit crop, widely grown in all temperate regions of the world. Most important modern commercial red raspberry cultivars derive from hybrids between *Rubus idaeus* and *R. strigosus*. Some botanists consider the Eurasian and American red raspberries all belong to a single, circumboreal species, *Rubus idaeus,* with the European plants then classified as either *R. idaeus* subsp. *idaeus* or *R. idaeus* var. *idaeus,* and the native North American red raspberries classified as either *R. idaeus* sub sp. *strigosus,* or *R. idaeus* var. *strigosus.* Recent breeding has resulted in cultivars that are thorn less and more strongly upright, not needing staking.

Raspberry is the name given to two plant species in the genus *Rubus*, *R. idaeus* (red raspberry) and *R. occidentalis* (black raspberry) grown for their edible fruit. Raspberry plants have perennial root systems and biennial stems which are known as canes. The canes are woody, erect and shrub-like and generally undergo a period of growth one year and fruit production the next although primocane varieties exist that produce fruit in the first year. The canes may possess spines. Raspberry plants produce white or pink flowers with five petals which are surrounded by green sepals. After the plant has been pollinated, an aggregate berry is produced which consists of numerous druplets which are held together into the familiar raspberry fruit by tiny hairs. Raspberry canes can grow from 0.5 to in excess of 2 m (1.6–6.6 ft) in height and red raspberry will produce a commercial yield of fruit for 16–20 years, while black raspberry has a shorter lifespan and will produce for 4–8 years.

An individual raspberry weighs 3–5 g, and is made up of around 100 drupelets, each of which consists of a juicy pulp and a single central seed. A raspberry bush can yield several hundred berries a year. Unlike blackberries and dewberries, a raspberry has a hollow core once it is removed from the receptacle.

http://harvestnursery.com/blog/wp-content/uploads/2014/10/Boyne-Raspberry.jpg

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

- **1.1 Hadda beetle: *Epilachna vigintioctopunctata* (Fabricius) (Coleoptera: Coccinellidae)**
- **1.2 Fruit borer: *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)**
- **1.3 Cut worm: *Agrotis* spp. (Lepidoptera: Noctuidae)**
- **1.4 Aphid*: Aphis* spp. (Homoptera: Aphididae)**
- **1.5 Two spotted spider mite: *Tetranychus urticae* Koch (Arachnida: Acari: Tetranychidae)**
- **1.6. Thrips: *Frankliniella* spp. (Thysanoptera: Thripidae)**

2. Diseases

- **2.1 Bacterial blight: *Pseudomonas syringae* Van Hal**
- **2.2 Powdery mildew: *Sphaerotheca macularis* Braun and Takam**
- **2.3 Fruit rot disease: *Alternaria alternata* Keissi and *Cladosporium cladosporiodes* Bensch**
- **2.4 Cane *Botrytis* (Gray mold wilt): *Botrytis cinerea* De Bary**
- **2.5 Cane blight: *Leptosphaeria coniothyrium* Sacc.**
- **2.6 Spur blight: *Didymella applanta* Niessl**
- **2.7 Fire Blight: *Erwinia amylovora* Burrill and Winslow**
- **2.8 Anthracnose: *Elsinoe veneta* Jenkins**
- **2.9 Botrytis Fruit Rot*: Botrytis cinerea* Pers.**
- **2.10 Root Rots**: ***Pythium* spp*, Phytophthora* spp*, Rhizoctonia* spp *and Fusarium* spp**
- **2.11 Bacterial Blight: *Pseudomonas syringae* Van Hall**
- **2.12 Crown Gall and Cane Gall: *Agrobacterium tumifaciens* Smith & Townsend*, Agrobacterium rubi* Young et al.**
- **2.13 Verticillium Wilt: *Verticillium dahlia* Kleb*, Verticillium albo-atrum* Reinke & Berthold**
- **2.14 Leaf spot: *Sphaerulina rubi* Demaree & Wilcox**
- **2.15 Tomato Ringspot Virus**
- **2.16 Mosaic virus**

3. Weeds

Broad leaf weeds

- **3.1 Pig Weed: *Amaranthus viridis* Hook. F. (Amaranthaceae)**
- **3.2 Spiny Amaranth: *Amaranthus spinosus* L. (Amaranthaceae)**
- **3.3 Little mallow (cheese weed):*Malva parviflora* L (Malvaceae)**
- **3.4 Sowthistle: *Sonchus oleraceus (*Asteracea)**
- **3.5 Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)**
- **3.6 Horse purslane: *Trienthema portulacastrum* L. (Aizoaceae)**
- **3.7 False Amaranth: *Digera arvensis* Forrsk. (Amaranthaceae)**
- **3.8 False Daisy: *Eclipta prostrarta* L. (Asteraceae)**
- **3.9 Toothed Dock: *Rumex dentatus* L. (Polygonaceae)**
- **3.10 Wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)**

Grassy weeds

- **3.11 Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)**
- **3.12 Conch grass: *Agropyron repens* (Poaceae)**

3.13 Large crabgrass: *Digitaria sanguinalis* L.(Scop.) (Poaceae)
3.14 Wire grass: *Eleusine indica* L. (Poaceae)
Sedges
3.15 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
3.16 Annual sedge: *Cyperus compressus* L. (Cyperaceae)
4.Rodents
4.1 Soft furred field rat: *Rattus meltada*
4.2 Indian mole rat/ smaller bandicot: *Bandicota bengalensis*
4.3 common house rat: *Rattus rattus*
5. Birds

II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PESTS 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

- Treat the seed with recommended pesticides especially biopesticides
- Select healthy seeds and seedlings
- Follow proper spacing
- Soil health improvement (mulching and green manuring)
- Nutrient management especially through organic manures and biofertilizers 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 farmers should maintain proper soil fertility level through integrated nutrient management approach for best results.
- Proper irrigation
- Crop rotation

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

Farmers should

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

https://zzeed.files.wordpress.com/2009/12/raspberry_farm.jpg

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 orchard 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 Raspberry pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situation

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

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

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.

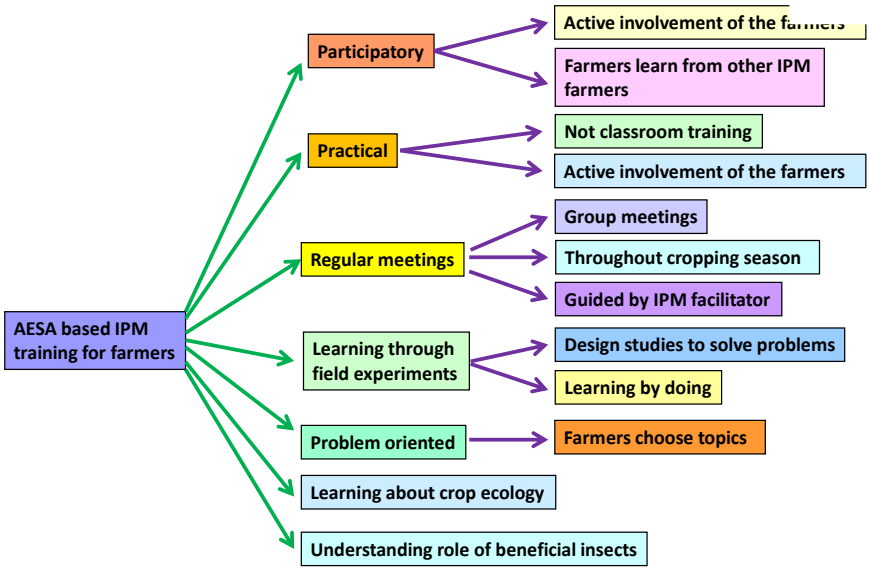
AESA and farmer field school (FFS)

AESA is a season-long training activity that takes place in the farmer orchard. 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 their 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 at the main orchard should commence soon after crop establishment after transplanting and at weekly intervals thereafter. In each of the fields, 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 buildup, 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.

Sucking pests:
Aphids and mites: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

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

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

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

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

C. Surveillance through pheromone trap catches for Fruit borer:
Pheromone traps for @ 4-5/acre have to be installed, if available. Fix the traps to the supporting pole at the height of mid canopy. Change of lures should be made at 2-3 week interval (regular interval) or based on loss of lure efficacy. During each week of surveillance, the number of moths/trap/week should be counted and recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Yellow pan water trap/sticky traps
Set up yellow pan water trap/sticky traps 15 cm above the canopy for monitoring aphid @ 4-5 traps/acre. Locally available empty tins can be painted yellow 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 of fruit borer and cut worm. 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. 2004a,b).

Ecological Engineering for Pest Management – Below ground:

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

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting 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, lacewing, earwigs, etc.

Plant Suitable for Ecological Engineering for pest Management
Attractants

Corn

Sunflower

Dill

Marigold

Buckwheat

Wheat

Mustard

French bean

Alfalfa

Berseem

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing/ planting*	
	<u>Common cultural practices:</u> • Collect and destroy diseased and insect infected plant parts. • Provide irrigation at critical stages of the crop • Avoid water stagnation. • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed **<u>Common mechanical practices:</u>** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested leaves and branches may be collected and destroyed • Handpick the caterpillars and the pupae which are found on leaves and destroy them in kerosene mixed water. • Use yellow sticky traps for aphids @ 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
Nutrients	• For raspberry cultivation, site should contain sufficient organic matter. • To increase organic matter statues, apply 10 to 20 tonnes/ acre farmyard manure at the time of field preparation. • Grow green manure crop to improve organic matter content in soil. • Apply recommended dose of fertilizers
Weeds	• The soil is ploughed during summer with a soil turning plough to eliminate weeds problem.
Damping off	• Give optimum irrigation

Sowing / planting	
Nutrients	• Apply fertilizers based on the soil test report and recommendation for particular zone. Generally, 30 kg each of P and K per acre should be applied at the time of planting.
Weeds	• Keep the berry rows weed free during the first season by harrowing & ploughing, Plough the field at the time of planting. • Tips should be pinched to facilitate branching when vines reached the trellies • Pruning should be restricted to the lower parts of vine hanging on the ground, during winter when vines are dormant
Vegetative stage	
	Common cultural practices: • Collect and destroy crop debris • Provide irrigation at the critical stages of the crop • Avoid water logging • Avoid water stress during flowering stage • Follow judicious use of fertilizers • Enhance parasitic activity by avoiding chemical pesticide spray, when 1-2 larval parasitoids are observed in the crops field. **Common mechanical practices:** • Collect and destroy disease infected and insect infested plant parts • Collect and destroy eggs and early stage larvae • Handpick the older larvae during early stages • 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. **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrient	• In case of slow growth of plants, nitrogen @ 30 kg per acre may be applied in soil around the plants. First half dose is given one month after planting and second half dose is given at the time of flowering. • Apply fertilizers as a band on each side of the row in the early spring before growth begins. • Foliar applications of liquid fertilizers (containing 0.5% N, 0.2% P_2O_5 and 0.5% K_2O) during August to February are also beneficial for all raspberry growing areas. • Adjust the amount of fertilizer applied depending on plant growth and yield.
Weeds	• Use straw or plastic mulch to suppress the weeds between the rows. or • Keep the rows weed-free by inter-row ploughing or machine tool weeding or hoeing. • Cover crops such as Oats, Rye or Rye grass may be sown between the rows when plants are set.
Hadda	**Cultural control:**

beetle	• Remove and destroy all the infected leaves, twigs and fruits to prevent further spread of pests
Fruit borer	**Mechanical control:** • Deep ploughing is likely to kill the diapausing pupae. • Hand picking of the caterpillar and pupae during the early stages of infestation reduces the pest damage • Remove the damaged and punctured fruits by caterpillars and grubs because these are source of pathogen infection **Biological control:** • Conservation and augmentation of natural predators like coccinellids, Chrysoperla, spiders, dragon flies must be followed • Augmentation of biocontrol agents like *Trichogramma brasiliensis, T. chilonis and T. pretiosum* should be carried out
Aphid and mites	**Cultural control:** • Remove and destroy all the infected leaves, twigs and fruits to prevent further spread of pests • Deep summer ploughing to expose soil inhabiting or resting stage of various stages of insect pests • In summer, keep the vines open, avoid crowding and excessive shading of vines • Plant the crop in well prepared, fertile land, but do avoid applying nitrogenous fertilizer, as this will promote new growth, which makes the plants juicy and attractive to aphids **Mechanical control:** • Collect and destroy different developmental stages of insect pests **Biological control:** • Conserve predators such as ladybird beetle, syrphids, coccinellids, chrysopids, wasp, surface bugs, spiders, different species of parasitic wasps and predatory mites through ecological engineering
Two spotted spider mite	**Cultural control:** • Cultural practices can have a significant impact on spider mites. Dusty conditions often lead to mite outbreaks. • Apply water to pathways and other dusty areas at regular intervals. Water-stressed trees and plants are less tolerant of spider mite damage. • Be sure to provide adequate irrigation. Midseason washing of trees and vines with water to remove dust may help prevent serious late-season mite infestations. **Biological control:** • Some of the most important are the predatory mites, including the western predatorymite, *Galendromus* (formerly *Metaseiulus*) *occidentalis,* and *Phyt oseiulus* mite species. • Various other insects are also important predators—sixspotted thrips (*Scolothrips sexmaculatus*), the larvae and adults of the spider mite destroyer lady beetle (*Stethorus picipes*), the larvae of certain flies including the cecidomyid *Feltiella acarivora* and various general predators such as minute pirate bugs, bigeyed bugs, and lacewing larvae.
Thrips	**Cultural control**

	• Thrips species that feed on many different plant species often move into gardens and landscapes when plants in weedy areas or grasslands begin to dry in spring or summer. • Avoid planting susceptible plants next to these areas, and control nearby weeds that are alternate hosts of pest thrips. Grow plants that are well-adapted to conditions at that site. • For example, plants adapted to grow in full sun can be stressed when planted in shady conditions and may be more susceptible to thrips damage. • Provide appropriate cultural care to keep plants vigorous and increase their tolerance to thrips damage. Keep plants well irrigated, and avoid excessive applications of nitrogen fertilizer, which may promote higher populations of thrips. • Old, spent flowers can harbor thrips, so their removal and disposal is sometimes recommended. However, the general benefit of this practice in landscapes is unknown; and old blossoms also commonly shelter beneficial predators of thrips. **<u>Biological control</u>** • Predatory thrips, green lacewings, minute pirate bugs, mites, and certain parasitic wasps help to control plant-feeding thrips. • To conserve and encourage naturally occurring populations of these beneficials, avoid creating dust and consider periodically rinsing dust off of small plants, avoid persistent pesticides, and grow a diversity of plant species.
Cane botrytis, cane blight and spur blight	**<u>Mechanical control:</u>** • Avoid plant damage either by the cultural practices or mechanical injury, or insect infestation • Avoid successive contact of diseased and healthy plants carrying out cultural practices in the field. • Maintain proper air circulation by pruning and cutting and maintain good water drainage • Avoid pruning or tipping when plants are wet or just before a rain • Maintain wind break to reduce damage to canes by wind • Use disease free material • Remove old canes at ground and destroy them.
Powdery mildew	**<u>Cultural control:</u>** • Remove diseased material in fall and destroy • Maintain proper row spacing and plant canopy aeration
Bacterial blight	**<u>Cultural control:</u>** • Maintain proper plant canopy aeration • Harden plants for winter properly
Root Rots	**<u>Cultural control:</u>** • Maintain well drained soil

	• Use certified and disease free stocks • Do not follow strawberries, potatoes, tomatoes or raspberries in the rotation • Remove and destroy infected plants
Mosaic	**Cultural control:** • Avoid the sites where tomato has been grown in previous season • Control insect pests i.e vector (Aphids) **Mechanical control:** • Diseased plants should be rogued out and destroyed
Botrytis Fruit Rot	**Cultural control:** • Avoid dense planting • Increase air circulation, rigorous pruning, efficient weed control, avoid high applications of nitrogen • Harvest regularly and sell as soon as picked • Pick directly into shallow containers for market
Crown Gall and Cane Gall	**Cultural control:** • Plant only certified, disease-free nursery stock, and take care not to wound the plants, especially the root systems, at planting time. • Try to plant only in sites with no history of the diseases • Remove and burn the diseased roots and tops of the plant. Dispose of the soil surrounding the roots of the affected plant.
Verticilliu m Wilt	**Cultural control:** • To minimize this disease, choose a planting site with no known history of this problem. • Avoid land recently planted with tomatoes, potatoes, eggplants, peppers, strawberries, raspberries, or stone fruits; and land infested with horse nettle, ground cherry, red-root pigweed, and lamb's-quarter
Leaf spot	**Cultural control:** • Keep rows narrow and weeds controlled to improve drying of the plants in the row.
Tomato Ringspot Virus	• Follow common cultural, mechanical and biological practices **Cultural control:** • Planting stock that is free of tomato ringspot virus
Reproductive stage	
Weeds	• Left over weeds should be removed from the field before seed shattering to avoid further spread of weed seeds • Continue the straw or plastic mulch to suppress the weeds between the rows.
Fruit borer	**Mechanical control:** • Collect and destroy different such as infected fruits fallen on ground developmental stages of insect pests • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested leaves and branches may be collected and destroyed **Biological control:** • Make the release of different laboratory reared bioagents when necessary • Conservation and augmentation of natural enemies such as ladybird

	beetle, syrphids, coccinellids, chrysopids, wasp, surface bugs, spiders, different species of parasitic wasps and predatory mites
Birds damage	**Cultural control:** • Plants should be trained with the help of supporting wires to form a roof like structure to protect fruit from sun burn and bird damage. **Mechanical control:** • Fruits are frequently damaged by birds if these are allowed to overripe in the field. Therefore, over ripening of the fruits may be avoided to minimize the damage
Fruit rot, Botrytis fruit rot and fire blight	**Cultural control:** • Staking of plant to avoid direct contact of fruits with soil borne pathogen. • Avoid dense planting • Increase air circulation, rigorous pruning, efficient weed control, avoid high applications of nitrogen • Harvest regularly and sell as soon as picked • Pick directly into shallow containers for market • Cool fruit as quickly as possible
Cane botrytis, cane blight, spur blight, Powdery mildew, Bacterial blight, Root Rots, Mosaic, Botrytis Fruit Rot, Crown Gall, Cane Gall, *Verticilliu m* Wilt, Leaf spot and Tomato Ringspot Virus	• Follow common cultural, mechanical and biological practices

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including the initial frequency of resistance alleles present in the population, how rapidly the insects reproduce, the insects' level of resistance, the migration and host range of the insects, the insecticide's persistence and specificity, and the rate, timing and number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

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

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

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

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

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

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

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

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

VII. COMMON WEEDS

1. Pig Weed: *Amaranthus viridis* Hook. F. (Amaranthaceae)

2. Spiny Amaranth: *Amaranthus spinosus* L. (Amaranthaceae)

3. Little mallow (cheese weed) *Malva parviflora* L (Malvaceae)

4. Sowthistle : *Sonchus oleraceus Asteracea*

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

6. Horse purslane : *Trienthema portulacastrum* L. (Aizoaceae)

7. False Amaranth : *Digera arvensis* Forrsk. (Amaranthaceae)

8. False Daisy : *Eclipta prostrarta* (Asteraceae)

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

10. Wood sorrel : *Oxalis corniculata* L. (Oxalidaceae)

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

12. Conch grass : *Agropyron repens* (Poaceae)

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

14. Wire grass : *Eleusine indica* L. (Poaceae)

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

16. Annual sedge : *Cyperus compressus* L. (Cyperaceae)

VII. DESCRIPTION OF INSECT AND MITE PESTS

1). *Epilachna* beetle/ Hadda beetle/Spotted leaf beetle:

Spotted beetles are distributed from East Asia to South Asia and Australia. They are polyphagous, and feed predominantly on cucurbits, brinjal, potato, and kidney bean as well as eggplant. These beetles are considered to be one of the most serious groups of pests damaging eggplant. In addition, they also feed on other solanaceous plants such as *S. nigrum*, *S. xanthocarpum*, *S. torvum*, *Datura* sp., *Physalis* sp. and *Withania somnifera* (L.).

Biology:

E. vigintioctopunctata (in Latin, viginti means 20 and octo means 8) has 28 black spots on the forewing (elytra). *E. dodecastigma* (dodecam means 12 in Greek) has 12 black spots on the elytra. However, beetles with 14, 16, 18, 20, 22, 24 or 26 spots have been observed under field conditions, due to mating between females of *E. dodecastigma* and males of *E. vigintioctopunctata*.

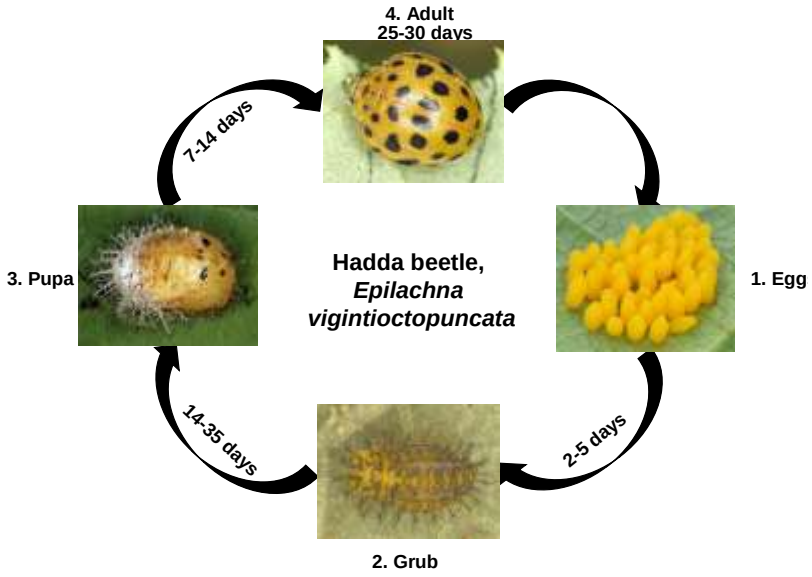
Egg: The females lay eggs mostly on the lower leaf surfaces. Each female lays about 100-400 eggs. The egg is spindle-shaped and yellowish in color. Eggs are laid in clusters of 10-40. The egg period varies from two to five days.

Grub: The grub is creamy white or yellowish in color with black spiny hairs on the body. The grub period is two to five weeks depending on the temperature. Grubs pupate on the leaves and stem.

Pupa: The pupa resembles the grub but is mostly darker in color, although it sometimes is yellowish in color. The pupa bears spiny hairs on the posterior, but not the anterior, part of the body. The pupal period is one to two weeks.

Adult: The subfamily *Epilachninae* contains plant-feeding ladybird beetles because most other ladybird beetles are predators, not plant pests. These brownish or orange- colored, hemispherical beetles are larger than other ladybird species.

Life cycle



1. http://bugguide.net/node/view/573366/bgimage
2. http://www.nbaii.res.in/insectpests/Epilachna-vigintioctopunctata.php
3.http://www.pestnet.org/SummariesofMessages/Pests/PestsEntities/Insects/Beetles/ Henosepilachnasp,Guam.aspx
4. http://lepidoptera.butterflyhouse.com.au/lynf/lynf.html

Damage symptoms:

- The grub and adult have chewing mouthparts. Hence, they scrape the chlorophyll from the epidermal layers of the leaves
- The feeding results in a typical ladder-like window. The windows will dry and drop off, leaving holes in the leaves. In severe infestations, several windows coalesce together and lead to skeletonization— the formation of a papery structure on the leaf

Skeletonization on leaves

Damage symptom

http://www.drkaae.com/InsectIDPt2/Chapter1Beetle%20Part1_files/image016.jpg

Parasitoid:

Larval and adult: *Pediobius foveolatus*

Predators: Reduviid bug/ assassin bug, Pentatomid bug,

*For management refer to page number---24 & 27----------

2). Fruit borer:

Biology:

Eggs: Eggs are spherical, dome-shaped with a flat base, 0.5 mm in diameter, yellowish and turn brownish as the embryo develops. They are laid singly on tender leaves and take 2-4 days for hatching.

Larvae: Full grown larva may be green, pale yellow, pale brown or greyish but always with a

dark stripe on the lateral sides of the body. Body also bears inconspicuous tubercles and scattered small hairs. There are 6 larval instars and the entire larval development takes 20-25 days.

Pupa: Pupation takes place in the soil. Pupal period is 10-15 days. Moths emerge and make their way through the soil.

Adults: Adult moths are medium sized, with a wing span of 3-4 cm. They are extremely variable in colour from buff to light brownish to greyish-brown, marked with dark greyish irregular lines on the fore wing and a broad blackish band near the outer margin. Hind wing is dull whitish in colour, with outer margin broadly black. Sometimes there is a dark spot in the middle of fore wing.

Life cycle:

http://www.infonet-biovision.org/default/ct/76/pests

Damage symptoms:

- They feed on leaves and tender shoots and bore into the fruits
- Fungus and other diseases follow in the damaged fruits. One larva may feed on several fruits before completing development

Predators: Lacewing, Lady beetle, Spider, Fire ant, Dragon flies, Robber fly, Reduviid bug, Praying mantis, Black drongo, Wasp, Common mynah (King crow), (*Geocoris* sp), Big-eyed bug, Earwig, Ground beetle, Pentatomid bug

*For management refer to page number---24 & 27----------

3). Cut worm:

Adult cutworm and armyworm moths appear between April and July**.**

Biology:

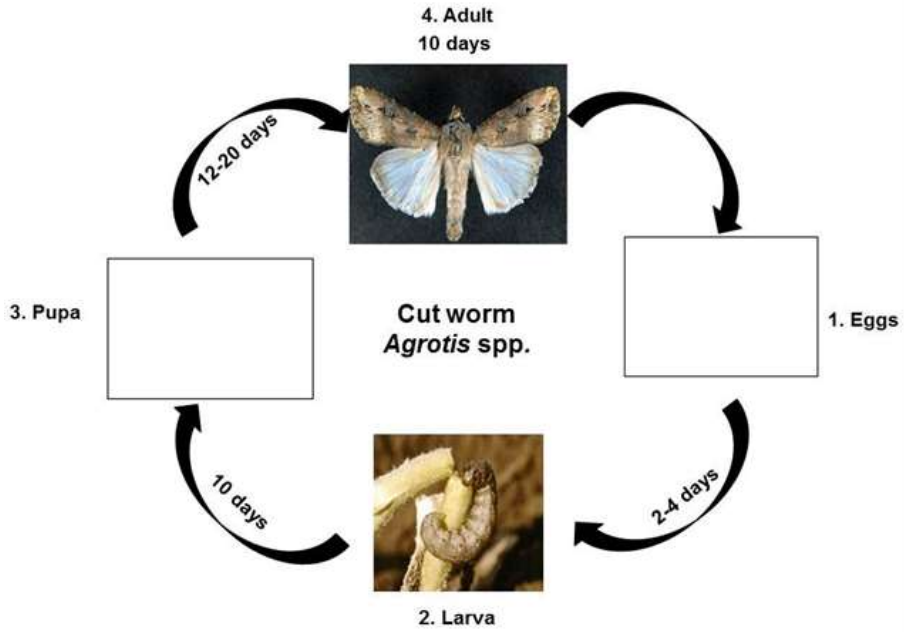
Egg: Females lay about 500 eggs on lower grass leaves over a 2- to 3-week period.

Larvae: Armyworms feed for 3 to 4 weeks, and are full grown at 1½ to 2”long. Armyworm larvae have 6 growth stages, or instars. The final instar lasts about 10 days

Pupae: Some species overwinter as a naked pupa in the soil, while some continue to develop through winter. Duration of the pupal stage is normally 12 to 20 days.

Adults: The adult preoviposition period is about seven to 10 days. Adult period varies around 10-20 days.

Life cycle:



2. http://utahpests.usu.edu/ipm/htm/advisories/small-fruit-and-vegetable-advisory/articleID=8341
4. http://entnemdept.ifas.ufl.edu/creatures/veg/black_cutworm.htm

Damage symptoms:

- Early season cutworms are a rare problem.
- Larvae may be present as buds swell and open and feed at night on primary buds and new growth.
- Cutworms and armyworms are the caterpillars of several species of night-flying moths. Plump, smooth and often, greasy-looking with greenish, brownish, grayish, or striped bodies up to 1 ¾"long, cutworms curl up tightly when disturbed. About the same size, armyworms are plump, sparsely-haired, and generally green to brown with dark longitudinal stripes running down the sides and back. Armyworms lay white or greenish eggs masses that darken as they near hatching.

Damage symptom

http://www.berriesnw.com/BerryDisordersDetail.asp?id=54

Predators: Lacewing, Lady beetle, Spider, Fire ant, Dragon flies, Robber fly, Reduviid bug, Praying mantis, Black drongo, Wasp, Common mynah (King crow), (*Geocoris* sp), Big-eyed bug, Earwig, Ground beetle, Pentatomid bug

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

4). Red spider mite:

Adult mites are 0.3-0.5 mm, greenish-yellow with two dark spots on the back. Nymphs are similar in appearance only smaller. Eggs are clear and round. All stages occur predominantly

on the lower leaf surface.

Biology:

Female two-spotted spider mites overwinter in crop debris on the ground. The overwintering adults are orange in colour. In spring they move to new growth and feed on leaves closest to the ground. There are many generations per year and eggs, nymphs, and adults are frequently present at the same time. As populations build and leaves age or become damaged, mites move up the plant to newer, more succulent growth. The time for one generation to develop, from egg to mature adult, ranges from to five days at 24ºC to three weeks at 12ºC.

Damage symptoms:

- Stippling on leaves
- Webbing and defoliation

http://www.omafra.gov.on.ca/english/crops/pub360/notes/rasptssm.htm

Stippling on leaves **Webbing and defoliation**

Predators: Predatory mites, Predatory thrips and *Oligota* spp

*For management refer to page number-----24 &27----------

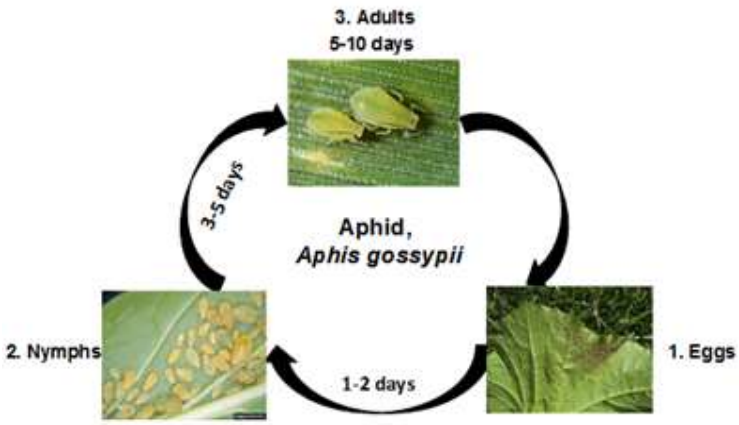
5). Aphids:

Aphids may be green, black, brown, red, pink, or some other color depending on the sap color of the host plant. They are usually slow-moving insects with pear-shaped bodies ranging from 1 /16 to 1 /8 inch long. There may be various sizes of wingless aphids (nymphs and adults) in a dense colony on a stem, on the underside of the foliage, or on the flowers.

Biology:

The life history of aphids is somewhat complicated and varies with the species. The simple life cycle is as follows: Overwintering eggs on branches and stems hatch in the spring to produce a wingless form known as the stem mother. The unfertilized stem mother gives birth to living young in great numbers. Several generations may occur in this fashion, but in due time some individuals will develop wings (alates) and migrate to another host. Here they may deposit eggs for the winter or, after a few generations, migrate back to the original host to lay eggs.

Life cycle:



1. http://www.flickr.com/photos/23293858@N04/2672985270/
2. http://pubs.ext.vt.edu/2902/2902-1081/2902-1081.html
3. http://www.flickr.com/photos/25848431@N02/7479982150/

Damage symptoms:

- Aphids are sucking insects that feed by thrusting a long beak into the plant tissue.
- They withdraw great quantities of sap, some of which they execrete as "honeydew".
- The honeydew makes the plant sticky. When trees are heavily infested with aphids, sidewalks, lawn furniture, and automobiles may become wet with honeydew.
- A sooty mold often develops with the honeydew blackening stems and foliage.
- This fungus is not parasitic to the plant, but reduces the amount of photosynthetic area.
- Leaves of plants may be distorted by aphids feeding on the undersides.
- Succulent stems may wilt or growth may be arrested by colonies of aphids. On the other hand, damage caused by aphids feeding on the bark of trees or woody shrubs cannot be readily seen.

Damage symptom

http://www.onthegreenfarms.com/fruit-vegetable/how-to-grow-organic-raspberries/

Nymphal and adult parasitoids: *Aphidius colemani, Aphelinus* spp.

Predators: Syrphid larva

*For management refer to page number-----24 & 27----------

Natural enemies for Rasberry of insect pests

Parasitoid:

Larval and adult

1. *Pediobius foveolatus*

http://www.nbaii.res.in/Featured%20insects/Pediobius_foveolatus.htm

Nymphal and adult

1. *Aphidius colemani* **2. *Aphelinus* spp.**

1. http://biobee.in/products-and-services/solutions/bio-aphidius/
2. http://australianmuseum.net.au/image/Aphelinus-wasp-stings-aphid-Denis-Crawford/kool

Predators:

1. Lacewing

2. Lady beetle

3. Spider

4. Fire ant

5. Dragon fly

6. Robber fly

7. Reduviid bug

8. Praying mantis

9. Wasp

10. Big-eyed bug

11. *Oligota* spp

12. Syrphid larva

13. Earwig

14. Ground beetle

15. Pentatomid bug

16. Predatorymites

17. Predatory thrips

Birds

9. Black drongo

10. Common mynah

1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.blogspot.in/
3. http://en.wikipedia.org/wiki/Wolf_spider
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://en.wikipedia.org/wiki/Dragonfly
6. http://www.warpedphotosblog.com/robber-fly-and-prey
7 http://www.corzonneveld.nl/selected/2007/tessin/Malvaglia/Rhinocoris%20Apis%20287%20med.jpg
8. http://spirit-animals.com/praying-mantis/
9 http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
10. http://bugguide.net/node/view/598529
11http://www.fugleognatur.dk/forum/show_message.asp?MessageID= 560188&ForumID=33
12. http://en.wikipedia.org/wiki/Aphid
13. http://www.flickr.com/photos/johnhallmen/2901162091/
14.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html
15.http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.html
16. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
17. http://biocontrol.ucr.edu/hoddle/persea_mite.html
18 http://nagpurbirds.org/blackdrongo/picture/1639
19 http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/

IX. DESCRIPTION OF DISEASES

1). Botrytis Fruit Rot:

Disease symptoms:

- As berries ripen, few infected druplets can develop a watery rot and golden or tan color
- Soft, gray fungal spores grow on these watery spots when humidity is high Mid to late part of the season when problems arise

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm

Infected berries

Favourable conditions:

- High relative humidity in cooler weather, (16-26^{o}C) encourages the mold growth
- Post harvest, high relative humidity in the cooler encourages mold growth
- Infected berries leak on to other berries, spreading disease

Survival and spread:

- Overwinters on canes, dead leaves and mummified berries
- Spores (conidia) are dispersed by air, water or harvesting and ultimately infect different floral parts including stamens and petals.
- For man Pre-harvest, wet weather during blossom time, disease remains latent
- Disease is spread by spores by wind and splashing water (rain and overhead irrigation)
- More mature and over ripe fruit becomes, the greater the risk

For management refer to page number—26 & 27----------

2. Cane Botrytis (Grey Mold Wilt):

Disease symptoms:

- Appear mid summer
- Pale brown lesions (with no purple cast)
- Often have conspicuous band patterns or watermarks, due to the irregular growth patterns of the fungus
- When primocanes turn brown in the fall, the lesions become indistinguishable from healthy tissue
- after several weeks of low temperatures the lesions turn gray or white
- Sclerotia form during winter and emerge as shiny black blisters in the spring
- When the surface tissues are scraped away healthy green tissue underneath is exposed
- Cane botrytis does weaken the stem
- In spring difficult to tell difference between spur blight and cane botrytis, in fact both can be present on the same cane as both occupy the same ecological niche and do similar things to plant growth

Pale brown lesion on canes

http://www.omafra.gov.on.ca/english/crops/pub360/notes/raspcanebotf1.jpg

Favourable conditions:

- Wet weather or high humidity
- Poor air circulation
- Spread mainly by wind but also by splashing water (rain or overhead irrigation)
- Disease overwinters on canes

Survival and spread:

- Spores (conidia) are dispersed by air, water or harvesting and ultimately infect different floral parts including stamens and petals.

*For management refer to page number----25 & 27----------

3. Cane Blight:

Disease symptoms:

- Dark brown to purplish cankers form at wound on new canes
- As cankers enlarge and extend down the canes, lateral shoots can suddenly wilt and die
- Wilting death may also occur on the side shoots of second-year canes
- Affected canes are brittle and snap off easily
- Fruiting canes often die between flowering and fruiting
- Scrape the brown spot on cane with knife, will be brown discoloration under the bark

Infected canes

Infected twig

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm

Favourable conditions:

- Two most important factors for disease; a wound for the disease to enter and water to wash the organism into wound

- Wet weather, spores ooze from the fruiting bodies
- Spores spread on the wind
- Young canes are susceptible

Survival and spread:

- Overwintering sclerotia produce grey masses of conidia in damp spring weather
- However, botrytis inoculum can come from many sources of decaying plant debris

*For management refer to page number- 25 & 27----------

4. Spur blight:

Disease symptoms:

- Dark red, purple or chocolate brown spots below the spur, on young bark around buds of new shoots
- Canes have silvery grey appearance in the winter
- Diseased areas enlarge and girdle the stem, as a result the leaves fall off, especially on the lower parts of stem
- Infected bark may dry out and crack by late summer
- Yields and winter hardiness are reduced
- Fungus survives year to year on the infected canes

Purple or chocolate brown spots below the spur Infected bark

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm

Favourable conditions:

- Cool rainy weather
- Spores spread by wind and splashing water
- Spores present at all times
- Disease enters at leaf nodes and stems

Survival and spread:

- Primary spores (ascospores) are discharged from May to August.
- Inoculum comes only from old fruiting canes.
- Secondary spores (conidia) are also produced. Conidia splashed about in July and August probably cause the most damage.

*For management refer to page number---25 & 27----------

5. Powdery Mildew:

Disease symptoms:

- Powdery white growth on leaf underside, growing tip or fruit
- Young canes, stunted, distorted, spindly and can die back
- Young berries fail to mature to full size, wither and die

Powdery white growth on plant and inflorescence

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm
http://www.fruit.cornell.edu/berrytool/raspberry/leavesstems/Rasppowderymildew.htm

Favourable conditions:

- Most prevalent in years when weather is dry and air circulation is poor, (warm and humid weather)
- Can affect winter hardiness

Survival and spread:

- Resting spores in soil and airborne spores

*For management refer to page number-26 & 27----------

6.Anthracnose:

Disease symptoms:

- Purple spots with grey-white centres form on new canes, leaves and petioles
- Spots enlarge on canes to form sunken pits
- On second-year canes, these lesions can coalesce into cankers that girdle the cane and cause it to dry out and crack. Infected canes are more susceptible to winter injury and produce weak growth in the spring
- Fruit infections occur when there is abundant inoculum and wet weather in the green fruit stage
- Fruit symptoms include shrunken brown druplets or withered, dry seedy fruit

Purple spots with grey-white centres Infected canes

http://www.omafra.gov.on.ca/english/crops/pub360/notes/raspanth.htm

Favourable conditions:

Infection requires three to twelve hours of wetness; only very young green tissue is infected

Survival and spread:

- Ascospores are rain-splashed and air-borne from infected canes in early spring
- Conidia are rain-splashed from overwintering infected canes in the spring and throughout the summer to new growth

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

7. Fire Blight:

Disease symptoms:

- Can girdle canes. Lesions become water soaked
- Carmel colored bacterial ooze comes out of lesions in beads during humid periods
- Diseased plant parts become purplish black
- Infected berries do not mature, become brown, dry up, become very hard and remain on pedicel

Disease symptom

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp9186

Favourable conditions:

- Apple bacterial pathogen strain will attack raspberry, but not vice versa
- Warm temperatures (18-25^{o}C) and light rain favor infections, prolonged host flowering due to wet cool springs
- Flowers, fruit, cane tips that are succulent become infected

Survival and spread:

- Bacteria remain present on diseased plant material
- Honeybees and other insects, birds, rain and wind can transmit the bacterium to susceptible tissue. Injured tissue is also highly susceptible to infection, including punctures and tears caused by plant-sucking or biting insects,
- Bacteria enter in the plant, either flower or tough mechanical damage

*For management refer to page number-------27----------

8. Bacterial Blight:

Disease symptoms:

- Very similar to fire blight symptoms
- Blackening or browning of tissue
- Slow in spreading unlike fire blight
- Can also be confused with several other disorders like winter injury, cane borer, or some herbicides

Favourable Conditions:

- Cool and moist weather

Survival and Spread:

- Overwinters on the canes and buds
- Bacteria is systemic in the plant, and infection spreads as long as weather is cool and wet, once weather begins to warm up disease subsides until fall

*For management refer to page number—26 & 27----------

9.Crown Gall and Cane Gall:

Disease symptoms:

- Crown and cane gall are characterized by the spongy, rough, pinhead- to golf ball-sized, tumor-like swellings that become brown, woody knots with age.
- Crown galls develop in the spring on the underground parts--the roots and crown of the

plants.

- Cane galls develop as whitish eruptions on the fruiting canes in mid-June.
- These eruptions later turn brown and then black and begin to disintegrate.
- More intense gall formation seems to occur in years with higher incidence of winter injury.
- The diseases cause the production of dry, seedy berries and the stunting and prevention of new cane formation.
- Weakened canes are broken easily by the wind and are more susceptible to winter injury.
- The plants might show water stress and nutrient deficiency symptoms since the movement of water and nutrients throughout the plant is disrupted.
- With cane gall, black and purple raspberries are more often infected than red raspberries and blackberries.


Disease symptoms

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm

Survival and spread:

- Both diseases are caused by soil-borne bacteria (crown gall: *Agrobacterium tumifaciens* and cane gall: *Agrobacterium rubi*) that infect the plant only through wounds.
- Wounds can result from natural causes (e.g., insect feeding, frost damage) or from mechanical causes (e.g., pruning, cultivating, harvesting).
- The bacteria overwinter in the soil and in galls.

Favourable conditions:

- Bacteria are then spread by splashing rain, running water, cultivation, and pruning from soil and infected plants.
- As the galls enlarge, the soil can become heavily infested and will remain so for many years.

*For management refer to page number---26 & 27----------

10.Root Rots:

Disease symptoms:

- Unthriftiness
- Appear to be suffering from lack of moisture or nutrients, but when these are added, there is no response
- Leaves are smaller than normal, shorter petioles and become wilted or discolored
- Fruiting canes produce fruit that is stunted and never sizes up

berries may be seedy

- Roots are dark brown to black, with discoloration extending to the crown
- Rootlets are sparse or non - existent


Disease symptoms

http://www.omafra.gov.on.ca/english/crops/pub360/notes/raspphytof2.jpg
http://1dct5c1pgitquqsqt26j9h41.wpengine.netdna-cdn.com/wp-content/uploads/2014/10/IMG_1594_WR-225x300.jpg

Survival and spread:

- A soil-borne fungus causes *Phytophthora* root rot.
- The fungus produces spores that swim in water and infect roots and crowns when soil conditions are very wet.

Favourable conditions:

Infections can take place whenever soil temperatures are over 10ºC and the soil is wet, but most frequently in spring and fall.

*For management refer to page number—26 & 27----------

11.Verticillium Wilt:

Disease symptoms:

- Shoots are stunted and leaves, starting at the base of the infected plant, turn yellow, wilt, and drop.
- The entire shoot will wither and die shortly thereafter.
- Raspberry canes might show a blue or purple streak from the soil line extending upward.
- This purple streak is not detectable on raspberry canes.
- Fruiting canes, infected the previous year, either die in the spring or develop yellow and stunted leaves.
- If the canes die before reaching maturity, the fruit becomes mummified. Losses are heavier in black raspberries than in red raspberries.

Disease symptom

http://pnwhandbooks.org/plantdisease/pathogen-articles/pathogens-common-many-plants/fungi/verticillium-wilt-pacific-northwest

Survival and spread:

- These fungi can exist in the soil prior to planting or may brought in on planting stock or may move in on wind-blown soil.
- The fungi can survive either in plant debris or free in the soil.

Favourable conditions:

- The fungus is favored by cool weather and is most severe in poorly drained soils following a cool, wet spring

*For management refer to page number—26 & 27----------

12.Leaf spot:

Disease symptom:

- Greenish black spots develop on the upper leaf surface of new leaves.
- These progress to whitish grey with a distinct margin and sometimes a shot hole in the centre.
- Severely infected leaves drop prematurely.

Disease symptoms

http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm
http://www.fruit.cornell.edu/berrytool/raspberry/leavesstems/images/raspleafspot68-opt.jpg

Survival and spreads:

- The fungus infects only raspberries and overwinters on old leaves and canes. Young rapidly expanding leaves are infected.

Favourable conditions:

- Infections occur throughout the summer especially during periods of wet weather.

*For management refer to page number- 26 & 27----------

13.Mosaic disease

Virus diseases cause various symptoms that include leaf curl and pucker and a yellow-mottled discoloration known as mosaic. Virus infected plants often produce small crumbly berries and low yields.

Disease symptoms:

- Poor vigor, low yields and poor fruit quality
- Short stand longevity
- Leaf symptoms most evident during cool weather, can range from puckering, curling and crinkling
- Berries may be dry seedy and lack flavor

Disease symptoms

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp9186/$FILE/raspberry_mosaic.jpg

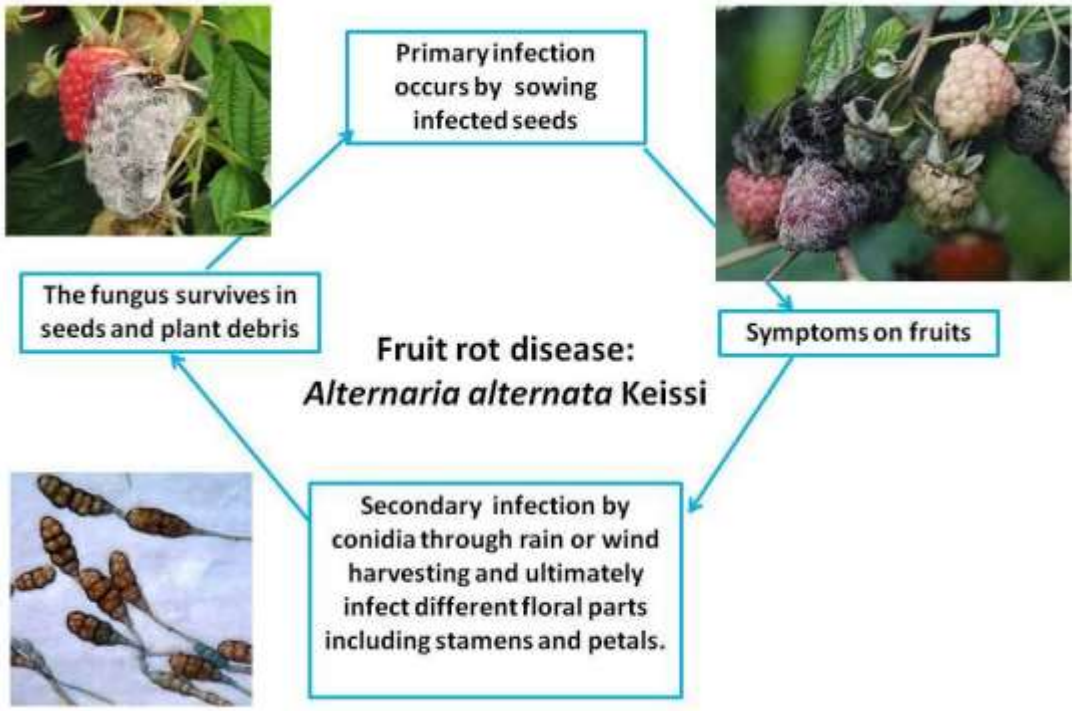
Survival and spread:

- Aphids transmit raspberry mosaic and raspberry leaf curl virus from infected to healthy plantings.

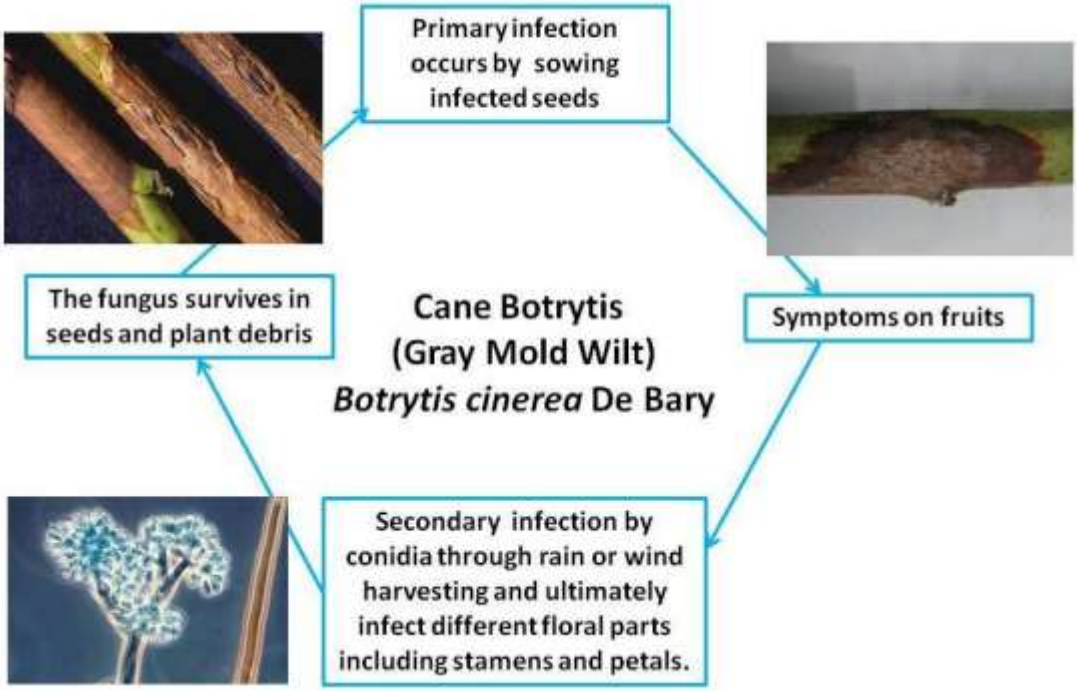
*For management refer to page number---26 & 28----------

Disease cycles:

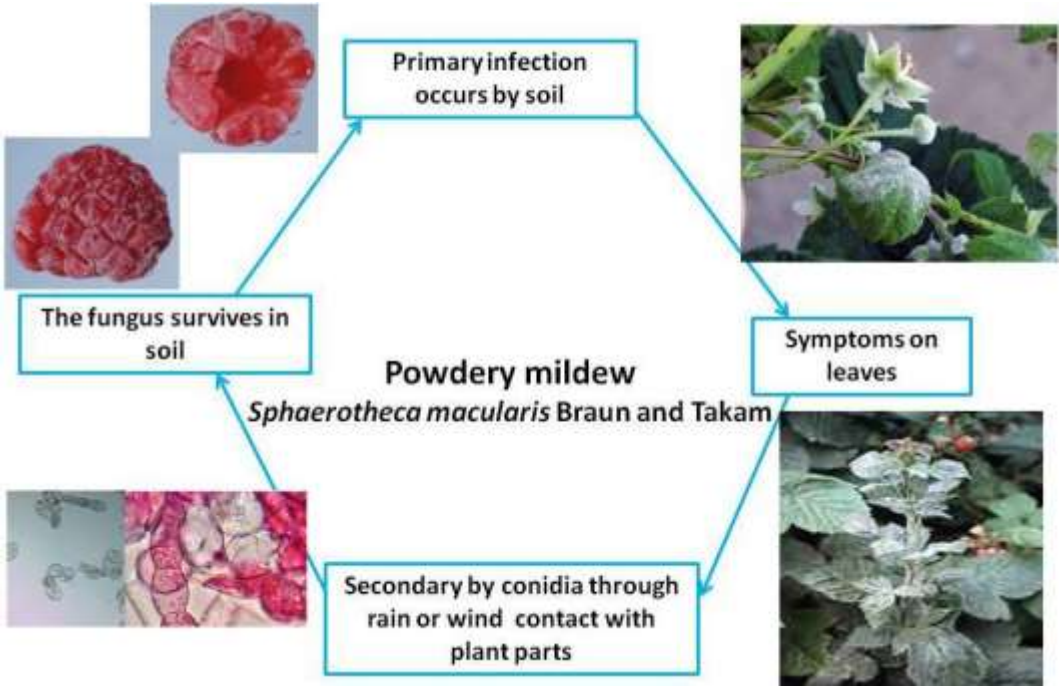
1. **Fruit rot disease:**



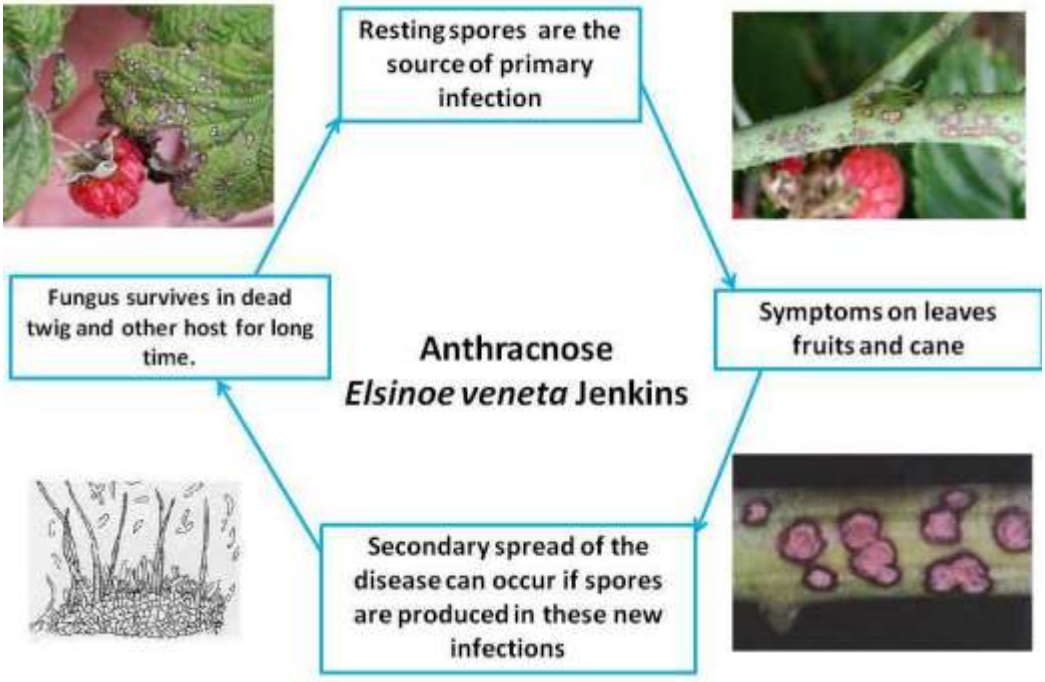
2. **Cane blight:**



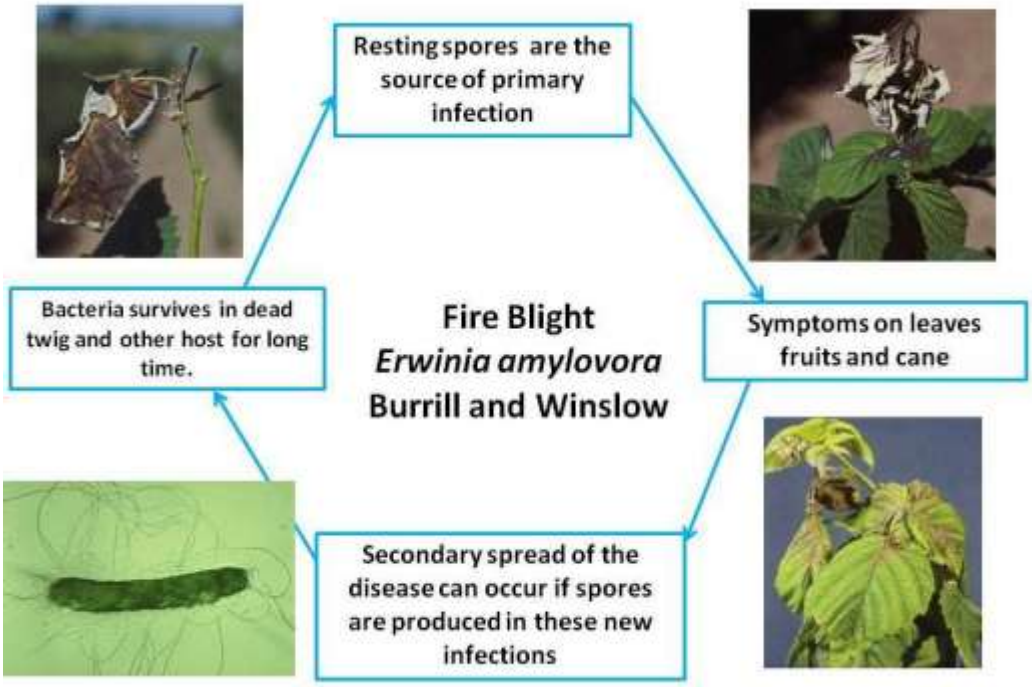
3. Powdery mildew:



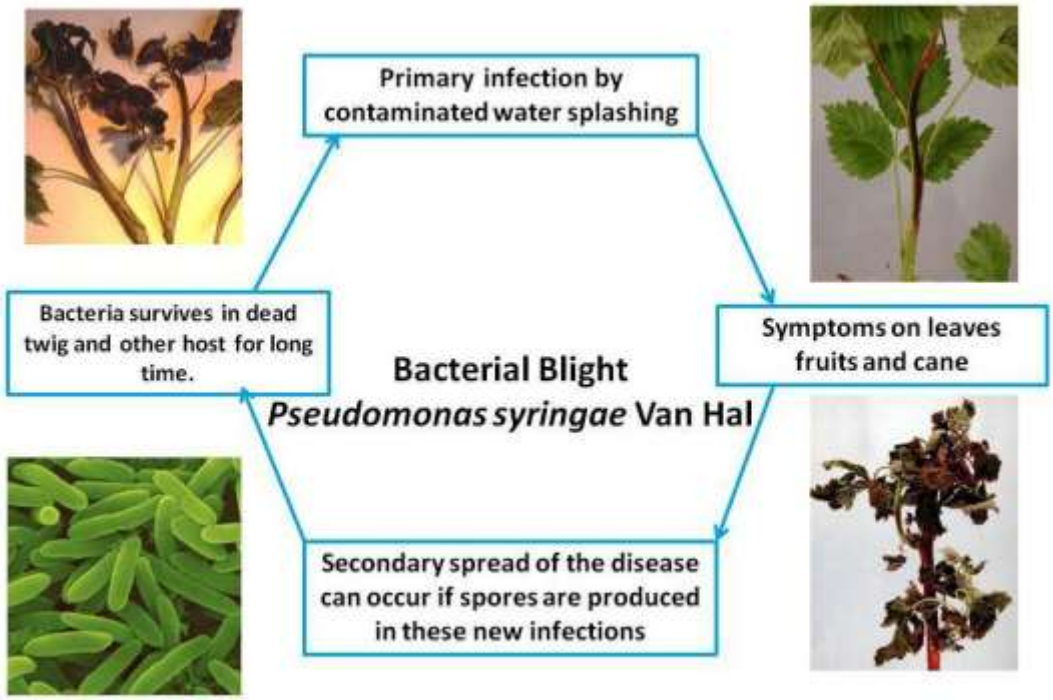
4. Anthracnose:



5. Fire Blight:



6. Bacterial blight:



X. SAFETY MEASURES

A. At the time of harvest:

All varieties will begin to produce fruit in their second season. In some cases, ever-bearers may bear small berries in their first autumn. In early summer, berries will ripen over a time of about 2 weeks. It is needed to pick berries every couple of days. Try to harvest berries on a sunny day when they are dry. Don't tug too hard on your raspberries when picking.

B. During post-harvest storage

Raspberries can be kept refrigerated for about 5 days. If the fruit is to be made into preserves, it should be done straight off the plant. Raspberries can be frozen. Make a single layer of berries on a cookie sheet. When frozen, place into airtight bags.

XI. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation of Cover crops between the rows.	Avoid mono-cropping of the cover crops between the rows.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Plant early in the season	Avoid late planting as this may lead to reduced yields and incidence of diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only CIBRC recommended pesticides against a particular pest at the recommended dose, at the right time, with right methods with standard equipments e.g. Flat-fan or flood- jet nozzles for herbicides.	Non-recommended pesticides should not be applied in the Orchard field.
8.	Maintain optimum and healthy plant stand.	Orchard plants should not be exposed to moist deficit stress at their critical stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).

13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
14	In case of pests which are active during night spray recommended biopesticides/ chemicals at the time of their appearance during evening time.	Do not spray pesticides at midday since, most of the insects are not active during this period.
15	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites.	Do not spray pesticides only on the upper surface of leaves.
16	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
17	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XV. REFERENCES

- http://zorach.wordpress.com/2010/06/15/black-raspberries-and-japanese-wineberries/
- http://ppqs.gov.in/ipmpakpra.htm
- http://books.google.co.in/books?id=zBA2zCQiceAC&pg=PA410&lpg=PA410&dq=Hadda++beetle+natural+enemies&source=bl&ots=loWRMJ35Qo&sig=v9eIZl56M4y4bozrrw3q2a3jUDE&hl=en&sa=X&ei=oMRpU6fqF8SXuATov4G4Cw&ved=0CC8Q6AEwAA#v=onepage&q=Hadda%20%20beetle%20natural%20enemies&f=false
- http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp9186
- http://fruit.wisc.edu/wp-content/uploads/2011/06/Raspberry-Pest-Management-for-Home-Gardeners.pdf
- http://www.omafra.gov.on.ca/english/crops/facts/rasppest/rasppest.htm
- http://urbanext.illinois.edu/raspberries/insects.cfm
- http://www.extension.umn.edu/garden/yard-garden/fruit/integrated-pest-management-for-home-raspberry-growers/
- http://www.berriesnw.com/BerryDisordersDetail.asp?id=54
- http://eol.org/data_objects/13157307
- http://www.almanac.com/plant/raspberries
- http://www.asparagusgardener.com/aspraspberryplants.html
- http://en.wikipedia.org/wiki/Raspberry
- http://www.hort.purdue.edu/ext/ho-44.pdf
- www.dpi.nsw.gov.au/primefacts
- http://agrihortico.com/tutorialsview.php?id=136
- http://www.ipm.ucdavis.edu/PMG/WEEDS/IMAGES/sowthistles.jpg