



AESA BASED IPM PACKAGE STRAWBERRY



Pests

Defenders



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FOREWORD

One of the fallouts of green revolution based on intensive use of inputs including agrochemicals has been its 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.

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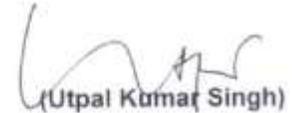
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FOREWORD

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.


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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.

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AESA BASED IPM PACKAGE FOR STRAWBERRY

Strawberry- Plant description:

Strawberry (*Fragaria sp.*) is a native of temperate regions, but varieties are available which can be cultivated in subtropical climate. In India it is generally cultivated in the hills. Its main center of cultivation is Nainital (district) and Dehradun in Uttarakhand, Mahabaleshwar (Maharashtra), Kashmir Valley, Bangalore and Kalimpong (West Bengal). In recent years, strawberry is being cultivated successfully in plains of Maharashtra around Pune, Nasik and Sangali towns. The strawberry is the most widely adapted of the small fruits.

The strawberry plant is a non woody perennial made up of a crown, leaves, runners, and a root system. The crown is a compressed modified stem where leaves, runners, branch crowns, and flower clusters (inflorescences) arise. Leaf size is variable. Older leaves usually die during the winter and are replaced by new leaves in the spring. Leaves are produced all season with most production occurring during long days, Strawberry plants have two types of roots primary roots & secondary roots. The secondary roots live for a period of days or a week & are constantly replaced. Primary roots conduct water and nutrients to the crown and last more than one season. In successive years, primary roots are produced higher on the crown, Flowers are borne in clusters. Strawberry flowers usually have five or more petals surrounding 20 to 35 stamens that differ in size and length within the same flower. Each stamen consists of the filament and the pollen producing anther. Anthers are a deep golden yellow when they contain pollen, but they turn pale as pollen is released.



I. PESTS

A. Pests of National Significance

1. Insect and mite pests

- 1.1 Red spider mite: *Tetranychus urticae* (Koch) (Trombidiformes: Tetranychidae)
- 1.2 Leaf roller: *Ancylis comptana* Frölich (Lepidoptera: Tortricidae)
- 1.3 Thrips: *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae)
- 1.4 White grubs: *Phyllophaga* spp. (Harris) (Coleoptera: Scarabaeidae)
- 1.5 Fruitfly

2. Diseases

- 2.1 Leaf spots: *Mycosphaerella fragariae* (Lindau)
- 2.2 Grey mold: *Botrytis cinerea* (De Bary)
- 2.3 Wilt: *Verticillium albo-atrum* (Wollenw)
- 2.4 Powdery mildew: *Sphaerotheca macularis* (Braun and Takam)
- 2.5 *Alternaria* spot: *Alternaria* sp
- 2.6 Red stele/Red core: *Phytophthora fragariae* Hickman
- 2.7 Black root rot: Complex disease (fungi & nematodes)
- 2.8 Anthracnose (black spot): *Colletotrichum fragariae* A.N. Brooks, *Colletotrichum gloeosporoides* (Penz.) Penz. & Sacc, *Colletotrichum acutatum* J.H. Simmonds
- 2.9 Angular leaf spot: *Xanthomonas fragariae* Kennedy & King

3. Weeds

Grass weeds:

- 3.1. Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
- 3.2 Goose grass: *Eleusine indica* (L.) Gaertn. (Poaceae)
- 3.3 Signal grass: *Brachiaria ramosa* (L.) Stapf (Poaceae)
- 3.4 Crab grass: *Digitaria* spp. (Poaceae)
- 3.5 Couch grass: *Elymus repens* (L.) Gould (Poaceae)

Broadleaf weeds:

- 3.6. Sorrel: *Oxalis latifolia* Kunth (Oxalidaceae)
- 3.7. Burclover: *Medicago denticulata* (Fabaceae)
- 3.8. Carpet weed: *Trianthema portulacastrum* L. (Aizoaceae)
- 3.9. Corn spray: *Spergula arvensis* L. (Caryophyllaceae)
- 3.10. Mock strawberry: *Duchesnea indica* (Andr.) Focke (Rosaceae)
- 3.11. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
- 3.12. Sweet yellow clover: *Melilotus indica* (L.) All. (Fabaceae)
- 3.13. Toothed Dock: *Rumex dentatus* L. (Polygonaceae)
- 3.14. Little mallow: *Malva parviflora* L. (Malvaceae)

Sedges

- 3.15. Yellow nut sedge: *Cyperus esculentus* L. (Cyperaceae)
- 3.16. Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

4. Rodents

- 4.1 Soft Furred Orchard Rat: *Melardia meltada*

B. Pest of Regional Significance

1. Insect pests

- 1.1 Cutworms: *Agrotis ipsilon* Hufnagel (Lepidoptera: Noctuidae)**
- 1.2 Hairy caterpillars: *Euproctis chryorrhoea* (Linnaeus) (Lepidoptera: Lymantriidae)**
- 1.3 Aphids: *Chaetosiphon fragaefolii* Cockerell; *Aphis Forbesi* Weed (Homoptera: Aphididae)**
- 1.4 Root louse: *Aphis Forbesi* (Weed) (Homoptera: Aphididae)**
- 1.5. Gram pod borer**
- 1.5. Tobacco caterpillar**
- 1.6. *Lygus* sp.**

2. Diseases

- 2.1 Anthracnose: *Colletotrichum* sp (Brooks)**
- 2.2 Wilt: *Fusarium* spp**
- 2.3 Post harvest rot: *Rhizopus nigricans* (Ehrenberg)**

3. Nematodes

- 3.1 Leaf nematodes/Strawberry crimp nematode: *Aphelenchoides fragariae* (Ritzema Bos and Christie)**
- 3.2 Stem nematodes: *Ditylenchus dipsaci* (Kuhn)**
- 3.3 Root knot nematodes: *Meloidogyne* spp (Goldie)**

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

A. AESA:

The integrated pest management (IPM) has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of orchard 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 orchard 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 orchard 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 Integrated Pest Management (IPM):

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially biopesticides
- Select healthy planting materials 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.)



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

Model agro-ecosystem analysis chart



Decision taken based on the analysis of orchard situation

Soil condition :
Weather condition :
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 20 plants/ acre randomly. Observe keenly each of these plants and record your observations:
 - Plant: Observe the plant length, number of leaves, crop stage, deficiency symptoms etc.
 - Insect Pests: Observe and count insect pests at different places on the plant.
 - Defenders (natural enemies): Observe and count parasitoids and predators.
 - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
 - Weeds: Observe weeds in the orchard and their intensity.
 - Water: Observe the water situation of the orchard.

- Weather: Observe the weather conditions.
- 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 analyze 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):** Length of the plant, number of leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Planting materials; fertilizers; 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 orchard 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 orchard school (FFS)

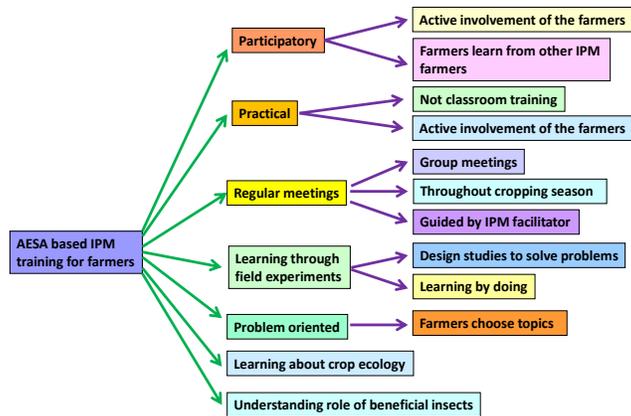
AESA is a season-long training activity that takes place in the farmer orchard. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning 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. Orchard scouting

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

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

For insect pest

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

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

For diseases:

Damage symptoms on the plant may be caused by weather, fertilizers, deficiencies, herbicides and soil problems and diseases. In many cases, the cause of the symptom is not obvious. Whenever scouting, be aware that symptoms of plant disease problems may be caused by biotic or abiotic factors like weather, fertilizers, deficiencies, herbicides and soil problems. In many cases, the cause of the symptom is not obvious. Very close examination and a laboratory culture or analysis is required to confirm the causal agent.

Basic examination techniques and details for specific diseases are given in the section on specific plant diseases.

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.

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). Always check plants that appear unhealthy. It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut into them to examine the roots for internal infections (discolouration & signs). Count the total number of stem damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves on each plant for lesions and determine the amount area of leaf infection. 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. Count the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

Stem and fruit sampling: Carefully examine the stems and fruits of plants for signs of fungal material diseases or lesions. The stems and fruits should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of plant, fruit infected due to disease and incidence should be recorded.

C. Surveillance through pheromone trap catches:

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

D. Yellow/blue pan water/sticky traps:

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

E. Light traps:

Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping insects. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm).

F. Nematode extraction:

Collect 100 to 300 cm³ (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 60 mesh sieve to collect cysts into first bucket; discard residue in second bucket. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of

the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

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 orchard 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 orchard
- 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



Sunflower



Dill



Cowpea



Carrot



Buck wheat



Mustard



Spearmint



French bean



Alfalfa



Anise



Caraway



Parsley

Repellent plants



***Ocimum* sp**



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*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Timely planting should be done. • Orchard sanitation, roguing • Destroy the alternate host plants and weeds. • Apply manures and fertilizers as per soil test recommendations. • Grow the attractant, repellent, and trap crops around the orchard bunds. • Growing tomato or marigold as a trap crop for the management of leaf miner • Plant tall border crops like maize, sorghum for the management of mites and thrips. • Crop Rotation with non-host crops
Nutrients	<ul style="list-style-type: none"> • Apply 10 to 20 tonnes/ acre farmyard manure/ vermicomposting at the time of orchard preparation
Weeds	<ul style="list-style-type: none"> • The soil is ploughed during summer with a soil turning plough
Soil borne pathogens, nematodes, resting stages of insects	<p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Apply neem cake/pongamia cake @ 100 Kg/acre or press mud @ 2 t/acre in soil at the time of last ploughing for reducing nematodes and soil dwelling pests.
Planting	
Nutrients	<ul style="list-style-type: none"> • Apply fertilizers based on the soil test report and recommendation for particular zone. Generally, 30-40 kg. N, 16-48 kg. P₂O₅ and 16-32 kg. K₂O/ acre may be applied according to soil type and variety planted. • Full dose of phosphorus and half dose of potash is given at the time of planting by placing the fertilizer at a depth of 15 cm between the rows.
Weeds	<ul style="list-style-type: none"> • The orchard is kept weed-free at the time of planting by harrowing and ploughing. Intercultural practices continued till the straw / plastic mulch is applied.
Soil borne pathogens, nematodes, resting stages of insects	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Use tolerant /resistant varieties • Avoid overlapping planting • Drip irrigation/judicious irrigation.
Bud and pre-bloom	
Nutrients	<ul style="list-style-type: none"> • Nitrogen is applied in two equal doses. First dose is given one month after planting and second dose is given at the time of flowering. Remaining half of potash is given at the time of flowering. • Four Foliar applications of liquid fertilizers (containing 0.5% N, 0.2 % P₂O₅ and 0.5 % K₂O) during August to February are also recommended for all strawberry growing areas.
Weeds	<ul style="list-style-type: none"> • The orchard is kept weed-free by machine tool weeding or hoeing.

	<ul style="list-style-type: none"> Use straw or plastic mulch to suppress the weeds between the rows.
Red Spider Mite	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Regular orchard scouting be conducted. Control weeds in and around the orchard. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> Conduct surveys for conservation of natural enemies (predators) like ladybird beetle, green lace wings, phytoseiid mite, Syrphid and observe P.D. ratio. Release ladybird beetle, green lace wings @ 2/plant
Alternaria Leaf spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Orchard scouting and vigilance regularly
Powdery Mildew	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> Clip off infested foliage and plant materials and destroy
Leaf Spot	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> Remove and burn trash from the previous crop. Avoid overhead irrigation.
Red stele	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Strawberries should not be planted in fields where red stele has occurred. Use only certified and resistant plants and select well-drained sites for strawberries.
Black root rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Use certified plants. Avoid poorly drained sites. Rotate planting sites and fumigate
Anthraco nose (black spot)	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Fumigation of soil Soil solarization Crop rotation with non-host crops Wash all soil from plant crowns prior to planting Weed around plants regularly Plant only disease free transplants Do not use excessive amounts of nitrogen fertilizer
Angular leaf spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Use only certified planting stock Crop rotation and avoid overhead irrigation
Bloom	
Nutrients	<ul style="list-style-type: none"> Nitrogen is applied in two equal doses. First dose is given one month after planting and second dose is given at the time of flowering. Remaining half of potash is given at the time of flowering. <p>Four Foliar applications of liquid fertilizers (containing 0.5% N, 0.2 % P₂O₅ and 0.5 % K₂O) during August to February is also recommended for all strawberry growing areas.</p>
Weeds	<ul style="list-style-type: none"> The orchard is kept weed-free by machine tool weeding or

	<p>hoeing.</p> <ul style="list-style-type: none"> • Use straw or plastic mulch to suppress the weeds between the rows.
Red spider mite	<ul style="list-style-type: none"> • Same as bud or prebloom stage
Leaf Roller	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Hand clipping of rolled leaves in trails and destroy • Regular monitoring
Root Louse	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Crop rotation with cowpea and legumes • Secure plants free from infestation • Dip the plants for some time in strong solution made by boiling stems or leaves of tobacco <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Application of neem cake
Aphids	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Clip off the leaves infested with aphids. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve and augment predators like coccinellids, Syrphids, green lace bug and parasitoids.
Cut worms	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Weed control is paramount to preventing a serious cutworm problem. • Pruning reduces overwintering larvae <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Installation of bird perches
Wilt	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices. <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoid plantation of tomato, potato, pepper, brinjal and raspberry
<i>Alternaria</i> leaf Spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoid planting infected plants • Monitoring: Scouting during humid weather with frequent showering
Powdery Mildew Leaf Spot Red stele Black root rot Anthracnose (black spot) Angular leaf spot	<ul style="list-style-type: none"> • Same as bud or pre-bloom stage
Petal fall/ fruit stage	
Red Spider Mite	<ul style="list-style-type: none"> • Same as bud or pre-bloom stage
Leaf Roller	<ul style="list-style-type: none"> • Same as bloom stage
Wilt	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Monitoring: regular monitoring and surveillance
<i>Alternaria</i> leaf spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Older leaves of the runner plants should be removed before the

	fruit set
Powdery Mildew Leaf Spot Red stele Black root rot Anthracnose (black spot) Angular leaf spot	<ul style="list-style-type: none"> • Same as bud or pre-bloom stage
Fruit development stage	
Weed	<ul style="list-style-type: none"> • Continue the straw or plastic mulch to suppress the weeds between the rows.
Red spider Mite	<ul style="list-style-type: none"> • Same as bud or prebloom stage
Vine weevil	<ul style="list-style-type: none"> • Same as bud or prebloom stage
Leaf roller	<ul style="list-style-type: none"> • Same as bloom stage
Root louse	<ul style="list-style-type: none"> • Same as bloom stage
Thrips	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Monitor with sticky traps. • Crop rotation should be adopted to avoid the pest infestation, especially with legumes and cow pea • Destroy refuse from the old orchards after harvest to reduce pest infestation • In hill system, renew the beds after harvesting of first fruiting season if pest population is there. If no problem is there maintain the orchard for 4-6 years old depending on profitability of crop
White grubs	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Collection and destruction of adult beetles in soapy water • Good cultivation before planting will injure grubs and expose them to birds and the sun • Installation of light trap • Leave one or two rows of strawberry plants to serve as a trap before plowing infested plantings under shortly after harvest • Rotate strawberry sites yearly with lettuce or cole crops • Soil solarization
Wilt	<ul style="list-style-type: none"> • Same as bud or prebloom stage
Powdery mildew, Leaf Spot Red stele Black root rot Anthracnose (black spot) Angular leaf spot	<ul style="list-style-type: none"> • Same as bud or prebloom stage
<i>Alternaria</i> leaf spot	<ul style="list-style-type: none"> • Same as planting stage
Gray mold	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoid excessive use of nitrogen

	<ul style="list-style-type: none"> • Avoid touching of berries on ground • Regular monitoring • Mulching, removal of debris and better air circulation between plants can help minimize losses.
Rodent	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Orchard sanitation • Community approach in control • Sticky traps
White buds	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Discard cultivating of all suspected plants and only healthy ones have to be used
Post-harvest/ dormant	
White grubs	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Cultivation of strawberries in sod land should be avoided • Avoid cultivation of strawberry beds near the trees as adults feed on them and lays the eggs <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Application of neem cake
Root louse	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Go for crop rotation in infested soils. • Plants should be free from infestation. • Dip plants for few minutes in tobacco solution (boil tobacco stem or leaves in water). • Regular monitoring has to be done. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Apply neem cake in the orchard.
Nematode	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Starve the land for 2-3 years without any cultivation of any crop • Grow crops like oats, mustard, peanuts, cowpea, corn and velvet bean to reduce the population.
Wilt	<ul style="list-style-type: none"> • Same as prebloom stage

Note: The pesticide dosages and spray fluid volumes are based on high volume spray.

** Pests of regional significance

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 orchards 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 orchards, adjacent "refuge" orchards, or habitat attractions within a treated orchard 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

Nutrient	Figure
<p>Copper: Deficiency causes yellowing of leaves and susceptibility to fungal diseases. Apply nutrient based on soil and plant test recommendations.</p>	 <p style="text-align: center;">Copper deficiency in strawberries causes yellowing of leaves and susceptibility to fungal diseases.</p>
<p>Boron: Boron is the most commonly deficient micronutrient in strawberry plantings as it is very prone to leaching. Boron deficiency causes many symptoms, but among the most obvious are deformed berries, asymmetrical leaves and stubby roots. Use a leaf analysis to check for and confirm boron deficiencies.</p>	 <p>http://www.fruit.cornell.edu/berrytool/strawberry/flowersandfruit/images/strsbdfruit299-opt.jpg</p>
<p>Albinism (lack of fruit colour during ripening): is a physiological disorder in strawberry. It is probably caused by certain climatic conditions and extremes in nutrition. Fruits remain irregularly pink or even totally white and sometimes swollen. They have acid taste and become less firm. Albino fruits are often damaged during harvesting and are susceptible to Botrytis infection and decay during storage.</p>	

VII. COMMON WEEDS



1. Burmuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)



2. Goose grass: *Eleusine indica* (L.) Gaertn. (Poaceae)



3. Signal grass: *Brachiaria ramosa* (L.) Stapf (Poaceae)



4. Crab grass: *Digitaria* spp. (Poaceae)



5. Couch grass: *Elymus repens* (L.) Gould (Poaceae)



6. Sorrel: *Oxalis latifolia* Kunth (Oxalidaceae)



7. Burclover: *Medicago denticulata* (Fabaceae)



8. Carpet weed: *Trianthema portulacastrum* L. (Aizoaceae)



9. Corn spray: *Spergula arvensis* L. (Caryophyllaceae)



10. Mock strawberry : *Duchesnea indica* (Andr.) Focke (Rosaceae)



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



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



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



14. Little mallow : *Malva parviflora* L. (Malvaceae)



15. Yellow nut sedge : *Cyperus esculentus* L. (Cyperaceae)



16. Purple nut sedge : *Cyperus rotundus* L. (Cyperaceae)

VIII. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1. Leaf roller:

Biology:

The adult garden tortrix is a buff-brown moth that is about 1/4 inch (6 mm) long. Each of the forewings is marked with a dark brown diagonal stripe and a marginal spot producing a chevron pattern when at rest. A faint whitish line borders the anterior edge of the brown stripe. This character and the overall lighter color distinguish adult garden tortrix from orange tortrix. The slender caterpillars of the garden tortrix are nearly 1/2 inch (12 mm) long when mature. Caterpillars have light brown to green bodies and light brown heads. The head has a small, distinct dark brown spot on each side. Larvae and pupae overwinter in debris around the base of the plant.

Damage symptoms:

- It ties one or more strawberry leaves together with white webbing to create shelters.
- Larvae can also create shelters by binding leaves or the sepals of the calyx to fruit and may feed from these sheltered areas on the surface or internal tissues of fruit.

*For management refer to page number—24 & 25-----

2. White grub:

Biology:

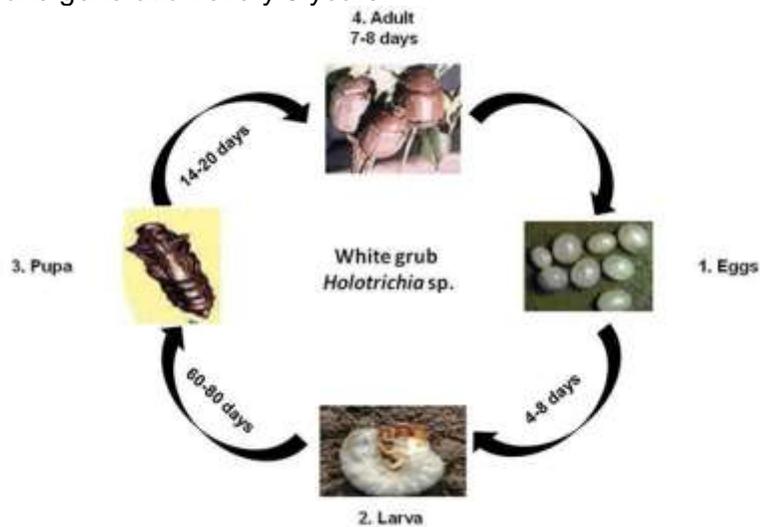
Egg - Eggs hatch in 3 to 4 weeks. A dull pearly white when first deposited, the oval to spherical egg turns dark just before hatching. It may be 1.5 to 3 mm in diameter. Small masses of 15 to 20 eggs occur in cells in the soil.

Larva - Newly hatched grubs feed on plant roots throughout the summer and complete 1/3 of their development before fall. These grubs burrow below the frostline (to a depth of 1.5 meters) and hibernate. The young grub is creamy white and about 5 mm long. The grub is about 26 mm long, and the mature grub about 30 mm long. The C-shaped grub has a distinct brown head; a shiny, smooth body; and three pairs of legs just behind the head. Two rows of hairs on the underside of the last segment distinguish May beetle grubs from similar grubs.

Pupa - The grubs become fully grown by late spring of the third year. At this time, they dig cells in the soil and pupate. Approximately the same size as the adult, the pupa may be creamy white, pale yellow, or dark brown. Pupae become adults by late summer but the beetles do not leave the ground.

Adult - Known as May beetles, the shiny reddish-brown to black adults are 19 to 26 mm long. The adult attack strawberry during spring. New May beetles overwinter in their earthen cells and emerge the following spring to feed and mate.

White grubs complete one generation every 3 years.



<http://www.omafra.gov.on.ca/IPM/english/strawberries/insects/white-grubs.html>

Damage symptoms:

- Plants affected by this insect can show early signs of wilting, remain small, weak, and both yield and fruit quality is affected.
- Soil disclosure at the bottom, the larve is seen gathering on the roots.
- If large numbers of insects are present, plants may die



Damage symptom

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf

*For management refer to page number---25 & 26-----

3. Thrips:

Biology:

Egg: Eggs are laid in plant tissue, both in flower bottoms and in leaves.

Larva: Subsequently, the larvae develop in stages. This development also occurs both in the leaves and in the flower bottoms of the plant.

Pupa: In the pre-pupating stage the greater part of the thrips drops on the ground and looks for some dirt or creep under plastic to pupate. When the pupae have come out, the adult thrips will move to the plants again and after a number of days they will start laying eggs.

Adult: Thrips wings are fringed with setae, small hairs. They are also known to be specially active in flying during hot and close weather. The best way to find thrips is by removing petals and the stamina of the flowers.

Damage symptoms:

- Both nymphs and adult thrips can injure the plant by rasping the plant bud, flower, leaf tissues and then sucking the exuding sap.
- Thrips feeding on strawberry blossoms cause the stigmas and anthers to turn brown and wither prematurely, but not before fertilization has occurred.
- With high populations, the surface of the berry may become cracked and discolored.
- Fruit damage includes surface russetting around planting materials from late green to ripe fruit. The fruit can take on a seedy bronze-like appearance.
- Larvae and adult thrips will be sucking on the fruits.
- Brown scaly sucking patches round the planting materials planting materials planting materials.



Damage symptom

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf

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

4. Red spider mite:

Biology:

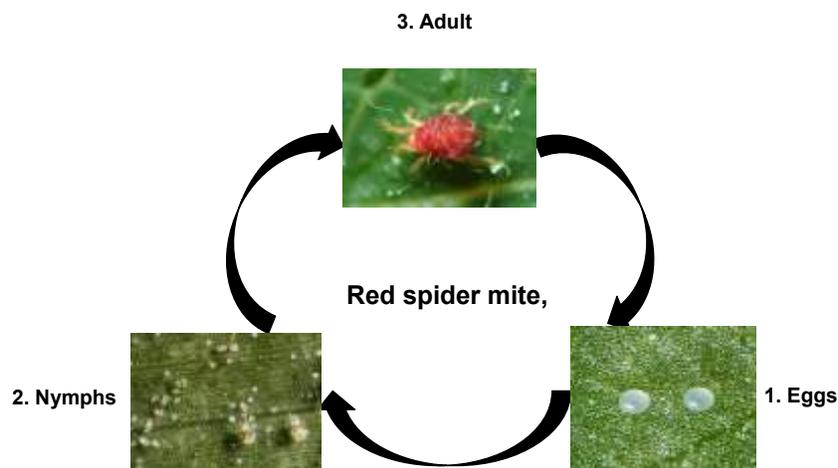
The two-spotted spider mite can live on strawberries, but also on numerous different crops. It is also present in different weeds, such as Black Nightshade, small stinging nettle and gallant soldier. The adult females overwinter in sheltered places in the crops. In spring they become active. Recognizing them, not the color is decisive but rather the two black spots on their body. Life stages comprises of egg, larvae, protonymph, deutonymph and adult. Life cycle will be completing in around 5-20 days depending on temperature.

Egg: From mid April eggs are laid on the underside of the leaves. Female lays 100 eggs in around 10 days, round clear initially and turn whitish as it matures

Nymph: The nymph vary in color, from yellow to light and dark green. Sometimes they are even orange in color.

Adults: males are wedge shaped 0.33mm and females are oval 0.4-0.5 mm, single dark spot on either side of body and generally yellow or greenish in color.

Life Cycle:





Damage symptoms

<http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=5771>

Damage symptoms:

- Spider mites rasp away leaf surfaces to feed on plant sap
- The first signs of damage are speckling and mottling on the surface of leaves.
- In heavy infestations, leaves turn purple, with white webbing between leaves.
- Plants that sustain infestations of greater than 75 mites per leaflet may become severely weakened and appear stunted, dry, and red in coloration.
- Severely damaged leaves die and drop



Damage symptoms

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf

*For management refer to page number—23, 24 & 25-----

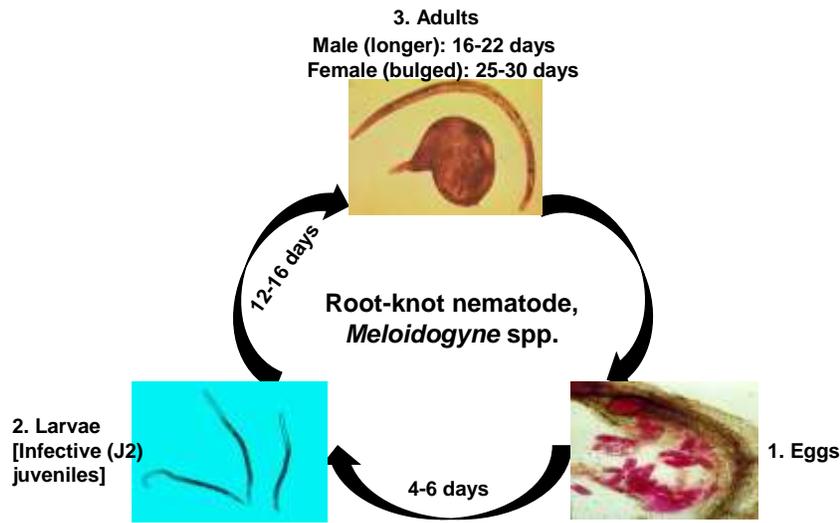
5. Root knot nematode

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female. They are microscopic in size.
- Development of the first stage larvae occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:

Life stages are microscopic in size



1. <http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnoses/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm>
2. <http://nematology.umd.edu/rootknot.html>
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Infected plants in patches in the orchard
- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a 'beard root' symptom
- Infected roots become knobby and knotty
- In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted
- Seedlings infected in nursery do not normally survive transplanting and those surviving have reduced flowering and fruit production
- Nematode infection predisposes plants to fungal and bacterial root pathogens

1.

2.



1. <http://utahpests.usu.edu/hm/utah-pests-news/up-summer12-newsletter/root-knot-nematodes/>
2. <http://extension.entm.purdue.edu/nematology/melonnems.html>

Survival and spread:

Primary: Egg masses survive in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum

Secondary: Autonomous second stage juveniles that may also be water dispersed

Favourable conditions:

- Loamy light soils

*For management refer to page number----22-----

Natural Enemies of Strawberry Insect Pests

Parasitoid:



***Typhia* (parasitic wasp)**

https://www.google.co.in/search?q=typhia+parasitic+wasp=210&es_sm=93&tbn=isch&biw=1280&bih=699&oq=typhia+parasitic

Predators



1. *Chrysoperla*



2. Coccinellid



3. Reduviid bug



4. Spider



5. Robber fly



6. Fire ant



7. King crow



8. Big-eyed bug



9. Ground beetle



10. Preying mantis



11. Geocoris spp



12. Predatory mite



13. *Oligota* spp.



14. *Orius* spp.



15. Hover fly



16. Mirid bug

5. <http://www.warpedphotosblog.com/robber-fly-and-prey>

6. <http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021>

7. <http://nagpurbirds.org/blackdrongo/picture/1639>

8. <http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/>

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>

13. <http://spirit-animals.com/praying-mantis/>

14. <http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm>

- 16. http://biocontrol.ucr.edu/hoddle/persea_mite.html
- 17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
- 18. [http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_\(cropped\).jpg](http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg)
- 19. <http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html>
- 20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

IX. Description of diseases

1. Leaf spots:

Leaf spot is one of the most common diseases of strawberries, occurring worldwide in most cultivars.

Disease symptoms:

- Initially, small, deep purple, round to irregularly shaped spots appear on the upper leaf surface
- These enlarge to between 3–6 mm in diameter. They retain a dark red margin, but the centers turn brown, then grey and finally white. Spots may join and kill the leaf
- The fungi also attacks the petioles, stolons, fruit stalks and fruit as shallow black spots.



Disease symptoms

- 1. http://en.wikipedia.org/wiki/Mycosphaerella_fragariae
- 2. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/119558/strawberry-disease-control.pdf

Survival and spread:

- infected leaves from current and previous strawberry crops
- Splashing water from rain and overhead irrigation

Favourable conditions:

- Extended wet periods, particularly in late spring

*For management refer to page number—23, 24 & 25-----

2. Grey mold:

This disease occurs on a wide range of flowers, vegetables and fruit, including strawberries.

Disease symptoms:

- The fungi will attack flowers, fruit, petioles, leaves and stems
- Flowers and fruit stalks infected during flowering die rapidly. Green and ripe fruit develop brown rot
- This spreads over the whole fruit, which becomes covered with masses of dry, greyish spores
- The rot may start on any portion of the fruit, but is found most frequently on the calyx end or on the sides of fruit touching other rotten fruit



Disease symptoms

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/119558/strawberry-disease-control.pdf

Survival and spread:

- The fungi over-winters on plant debris and infects flower parts, after which it either rots the fruit or remains inactive until the fruit ripens further. Spores, which are produced continuously throughout the fruiting season, germinate to infect plants
- By wind and splashing water from rain or overhead irrigation

Favourable conditions:

- Low temperature, high humidity and frequent rain

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

3. Red stele/Red core:

Disease symptoms:

- Red stele affected plants become stunted and wilt in dry weather.
- Older leaves turn yellow or red particularly along the margin.
- The symptom that helps to identify red stele is the brick red discoloration in the center (stele) of live white roots.
- The red color may extend the length of the root, or it may show up for only a short distance above the dead root tip.
- This symptom is obvious only during winter and spring.
- The discoloration does not extend into the crown of the plant.
- Infected plants usually die by June or July.
- Growth of the plants will slow down and they will become dull bluish green. In spring the plants will convalesce somewhat.
- An affected plant will form no or only few flowers.
- The small fruits will dry out. The root-hair of the roots is lacking.
- When cutting the main roots, it will appear that the central cylinder has discolored red



Disease symptoms

http://www.shouragroup.com/v_Strawberry_e.htm

Survival and spread:

- Can be introduced with planting material or from a reserve in the soil from trash from previous crops

Favourable conditions:

- Found in a wide range of climates. The disease prefers poorly drained soils, high temperatures and plants under moisture stress.

*For management refer to page number---23, 24 & 25-----

4. Wilt :

This disease occurs through the temperate zones of the world. It affects a wide range of crops like tomato, potato and cotton. Most strawberry varieties are susceptible

Disease symptoms:

- Plants carrying a large crop will suddenly wilt, usually on a hot day in late spring or summer.
- Some plants do not recover, and die within a week.
- In surviving plants, older leaves take on a scorched look while younger leaves remain pale in colour and turgid until they also die off.
- Fruit on affected plants do not mature, remain small and have paler appearance.



Disease symptom

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/119558/strawberry-disease-control.pdf

Survival and spread:

- Soils in which susceptible crops have been grown
- The pathogen can survive in moist soil for many years
- By water, trash from susceptible crops, weeds, root contact between plants, soil and farm

machinery

Favourable conditions:

- A period of stress such as sudden increase in temperature, dry conditions or heavy crop load on plants

*For management refer to page number---25 & 26-----

5. Powdery mildew:

The disease affects all cultivated strawberries worldwide. No variety is resistant, but each differs in susceptibility.

Disease symptoms:

- An early symptom of the disease is upward curling of the leaf margins.
- This is followed by irregular, purple blotching on the upper leaf surfaces, often along major veins. The leaves feel brittle.
- This disease does not produce the masses of greyish white spores typical of powdery mildew on other crops.
- Powdery mildew can attack fruit at any stage.
- Dull immature and mature berries with prominent planting materials.



Disease symptoms

<http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=4260>
http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0011/119558/strawberry-disease-control.pdf

Survival and spread:

- Trash from previous and current strawberry crops.
- Wind

Favourable conditions:

- Warm, humid conditions

*For management refer to page number---23, 24 & 25-----

6. *Alternaria* spot:

Disease symptoms:

- Lesions or "spots" are more numerous on upper leaf surfaces and appear circular to irregular in shape.
- These lesions often have definite reddish-purple to rusty-brown borders that surround a necrotic area.

- Lesion size and appearance often are influenced by the host variety and the ambient temperature.
- The leaf spots sometimes cause severe problems, often depending on the variety planted.
- Susceptible varieties can be defoliated partly or completely by late summer. In years that are particularly favorable for disease development, they can be severely weakened.

Survival and spread:

- The fungi overwinter on infected plants, plant debris, and weed hosts.
- In the spring, spores are produced and are discharged by splashing rain into air currents. They then land on and infect new leaves.

Favourable condition:

- It is favoured by warm wet weather

*For management refer to page number---23 & 25-----

7.Black root rot:

Disease symptoms

- Normal strawberry roots are white, but naturally turn dark on the surface with age.
- The root system of a plant affected by black root rot is smaller with black lesions or with the roots completely black.
- Such plants become stunted and produce few berries and runners.

Survival and spread:

- Black spot is spread from infected plants and fruit by rain splash, overhead irrigation and on the hands of fruit pickers.

Favourable conditions:

- It is favoured by warm, humid and wet conditions.

*For management refer to page number-23, 24 & 25-----

8. Anthracnose (black spot):

Disease symptoms:

Leaf spot

- Round black or light gray lesions on leaves.
- Numerous spots may develop but leaves do not die.

Runners and petioles

- Dark brown or black sunken, circular lesions on stems, petioles and runners
- Plants may be stunted and yellow
- Plants may wilt and collapse
- Internal tissues discolored red

Crown rot

- Youngest plant leaves wilt during water stress in early afternoon and recover in the evening
- Wilting progresses to entire plant
- Plant death
- Reddish-brown rot or streak visible when crown is cut lengthways.

Bud rot

- Damp, firm dark brown to black rot on buds.
- Plants with single buds may die.
- Plants with multiple crown may wilt as disease progresses.

Flower blight

- Dark lesion extending down pedicel which girdles the stem and kills the flower; flowers dry out and die.
- Infection after pollination may result in small, hard, deformed fruit.

Fruit rot

- Light brown water-soaked spots on ripening fruit which develop into firm dark brown or black round lesions



Anthracnose lesion on strawberry runner and fruit rot



Flowers and fruit symptomatic of anthracnose

Cut through strawberry crown revealing discoloration

[file:///H:/7th%20batch%20\(30-09-2015\)/Strawberry%20_%20Diseases%20and%20Pests,%20Description,%20Uses,%20Propagation.html](file:///H:/7th%20batch%20(30-09-2015)/Strawberry%20_%20Diseases%20and%20Pests,%20Description,%20Uses,%20Propagation.html)

Survival and spread:

- This is a major disease of strawberries, affecting most parts of the plant.
- It can cause serious losses throughout the season.
- Plants that are planted in infected soil become infected by splashing water and soil
- Fungus survives in soil for up to 9 months.

Favourable conditions:

- It is favoured by warm wet weather

*For management refer to page number—23, 24 & 25-----

9. Angular leaf spot:

Disease symptoms:

- Very small water-soaked lesions on lower surfaces of leaves which enlarge to form dark green or translucent angular spots which ooze bacteria.
- Lesions may coalesce to form reddish spots with a chlorotic halo.



Disease symptom

[file:///H:/7th%20batch%20\(30-09 2015\)/Strawberry%20_%20Diseases%20and%20Pests,%20Description,%20Uses,%20Propagation.html](file:///H:/7th%20batch%20(30-09%202015)/Strawberry%20_%20Diseases%20and%20Pests,%20Description,%20Uses,%20Propagation.html)

Survival and spread:

- Bacterium survives in crop debris and overwintering plants can survive for long periods on plant debris but cannot live free in soil.
- Bacteria can be spread by splashing water.

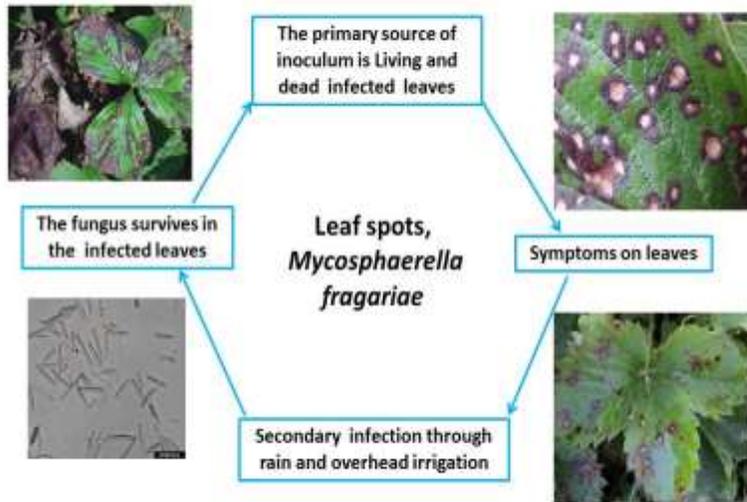
Favourable conditions:

- Spring season is responsible for the development of diseases.

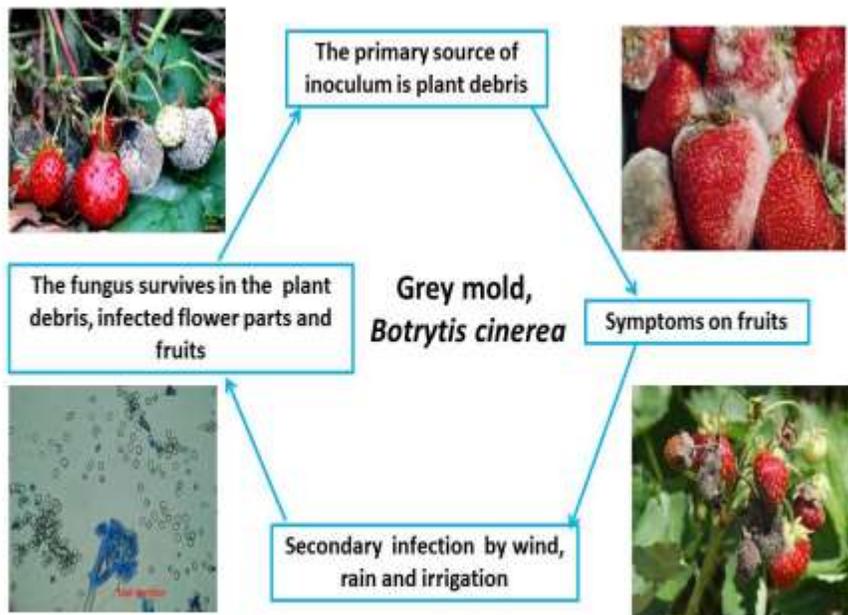
*For management refer to page number----24 & 25-----

Disease cycle:

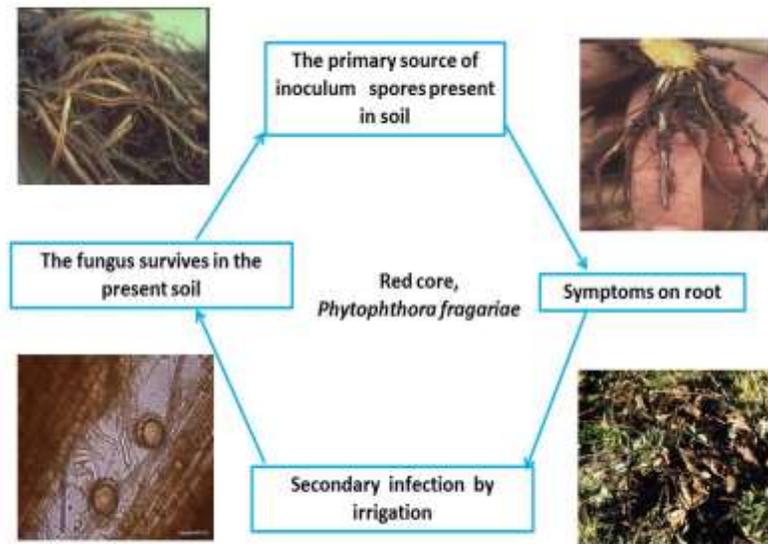
1. Leaf spot:



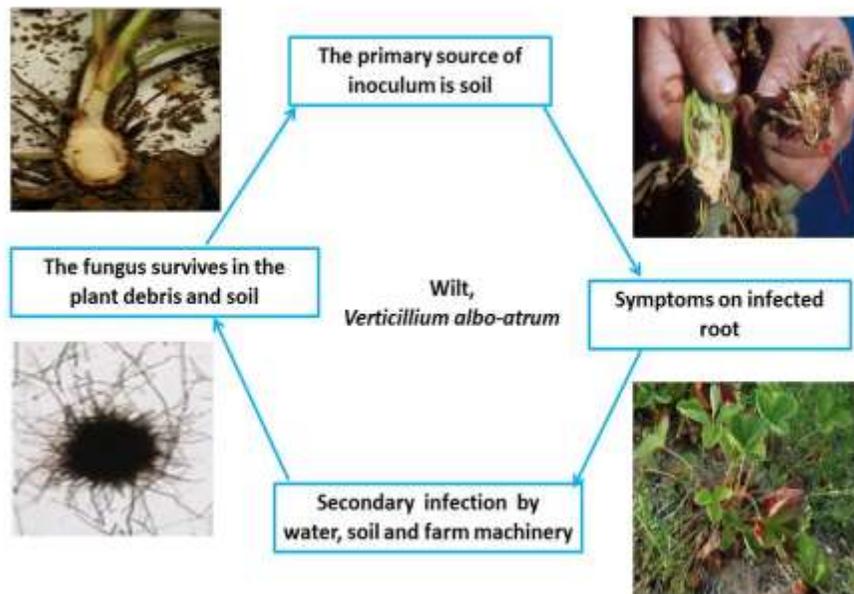
2. Grey mould:



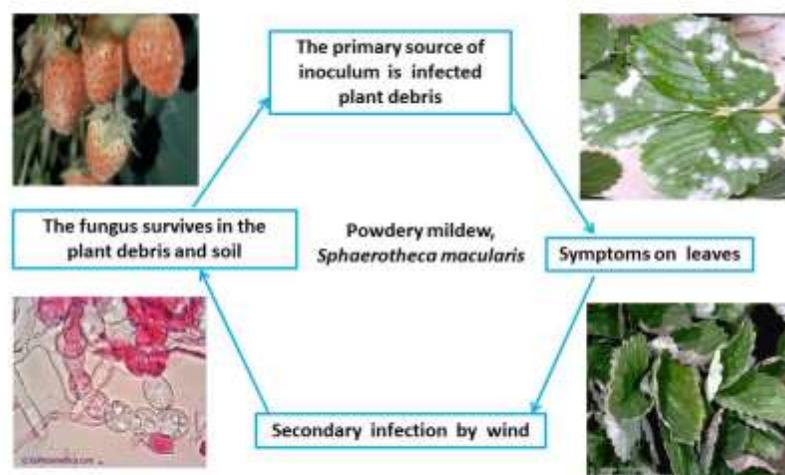
3. Red stele/Red core:



4. Wilt:



5. Powdery mildew:



X. Safety measures

A. At the time of harvest

The fruit ripens during late February to April in the plains and during May and June at high elevations like Mahabaleshwar, Nainital and Kashmir. For local market the fruit should be harvested when fully ripe, but for transport to distant markets, it should be harvested when still firm and before colour has developed fully all over the fruit. Harvesting should be done preferably daily. Since fruit is highly perishable, it is packed in flat shallow containers of various types (cardboard, bamboo, paper trays etc.) with one or two layers of fruits. Harvesting should be done early in the morning in dry conditions. Washing the fruit bruises it and spoils its lustre. Strawberries are generally harvested when half to three fourths of skin develops colour. Depending on the weather conditions, picking is usually done on every second or third day usually in the morning hours. Strawberries are harvested in small trays or baskets. They should be kept in a shady place to avoid damage due to excessive heat in the open orchard. Strawberries are highly perishable and hence a great deal of care in harvesting and handling as well as its marketing also requires to be organised carefully. Usually the fruit is picked in the early morning and sent to the market in the afternoon of the same day or is picked in the late afternoon, stored overnight in a cool place, and sent to market the following morning.

B. During post-harvest storage

Fruits can be stored in cold storage at 32⁰C upto 10 days. For distant marketing, strawberries should be pre-cooled at 4⁰C within 2 hrs. of harvesting and kept at the same temperature. After pre-cooling, they are shipped in refrigerated vans.

Packing is done according to the grades for long distance markets. Fruits of good quality are packed in perforated cardboard cartons with paper cuttings as cushioning material. Fruits of lower grades are packed in baskets.

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 orchard should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the orchard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3	Early sowing in the season	Avoid late planting as this may lead to reduced yields and incidence of white grubs and diseases.
4	Always treat the planting materials with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use planting materials without seed treatment with biocides/chemicals.
5.	Row planting with proper depth and moisture content is essential for proper establishment	Do not sow planting materials beyond 5-7 cm depth.
6.	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 orchard.
7.	Maintain optimum and healthy plant stand.	Orchard plants 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 test recommendations.	Do not apply any micronutrient mixture after planting without test recommendations.
10	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
11	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per orchard observation.	Do not apply chemical pesticides within seven days of release of parasitoids.
13	Apply NPV 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	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XV. References

- <http://www.ipm.ucdavis.edu/PMG/GARDEN/PLANTS/INVERT/blvinwee.html>
- <http://www.ipm.ucdavis.edu/PMG/selectnewpest.strawberry.html>
- <http://www.vissers.com/?/en/strawberryplants/pests-and-diseases>
- <http://urbanext.illinois.edu/strawberries/insects.cfm>
- http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf
- http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/119558/strawberry-disease-control.pdf
- <http://www.indiaagronet.com/indiaagronet/crop%20info/strawberry.htm>
- http://nhb.gov.in/report_files/strawberry/STRAWBERRY.htm
- <http://www.daff.qld.gov.au/plants/fruit-and-vegetables/fruit-and-nuts/strawberries/pests-and-diseases-strawberries>
- <http://extension.psu.edu/plants/gardening/fphg/strawberries/diseases/leaf-spots>
- http://www.shouragroup.com/v_Strawberry_e.htm
- http://en.wikipedia.org/wiki/Anthonomus_rubi
- <http://homeguides.sfgate.com/strawberry-plants-grubs-28752.html>
- <http://www7.inra.fr/hyppz/RAVAGEUR/6antrub.htm>