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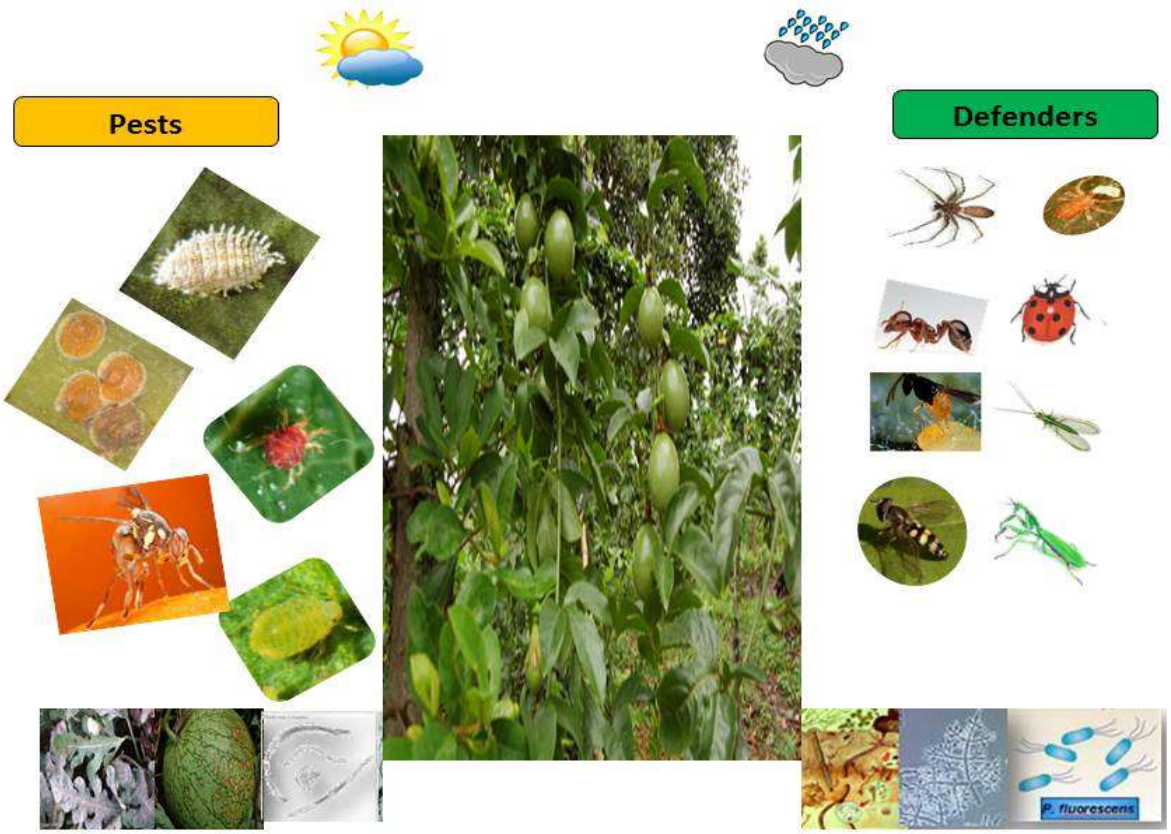
AESA BASED IPM PACKAGE

AESA BASED IPM – Passion fruit



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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

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

The AESA based IPM – Passion fruit, 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.

NIPHM Working Group:

Chairman : Dr. Satyagopal Korlapati, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. P. Jeyakumar, Director (PHM)
Core Members :

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise.
2. Dr. O. P. Sharma, Joint Director (A & AM), Agronomy Expertise.
3. Dr. Satish Kumar Sain, Assistant Director (PHM), Pathology Expertise.
4. Dr. Dhanaraj Boina, Assistant Director (PHM), Entomology Expertise.
5. Dr. Richa Varshney, Assistant Scientific Officer (PHM), Entomology Expertise.

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Shri. R. Murali, Deputy Director (Entomology),
3. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
4. Dr. Subhash Kumar, Deputy Director (Weed Science)

Contributions by External Experts:

1. Director of Research/Representatives, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415712, Dist - Ratnagiri.
2. Dr. Ashok, S. Halepyati, Chief Scientific officer, DR office, University of Agricultural Sciences, Raichur-584104
3. Dr. A. G. Sreenivas, Associate Professor (Agri. Entomology), College of Agriculture, UAS, Raichur-584104
4. Dr. Gururaj Sunkad, Professor (Plant Pathology), College of Agriculture, UAS, Raichur-584104
5. Dr. Jayalaxmi Ganguly, Indira Gandhi Krishi Vishwavidyalaya, Krishak nagar, Raipur
6. Dr. H.K. Singh, Indira Gandhi Krishi Vishwavidyalaya, Krishak nagar, Raipur
7. Dr. C.P. Khare, Indira Gandhi Krishi Vishwavidyalaya, Krishak nagar, Raipur

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

Ashok Dalwai
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture
& Cooperation)
Krishi Bhawan, New Delhi-110001

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]

संयुक्त सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperati
Krishi Bhawan, New Delhi-110001

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)

Dr.K. SATYAGOPAL IAS
Director General
Telephone : +91-40- 24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40- 24015346,

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Rajendranagar,
Hyderabad- 500030.
http://niphm.gov.in

PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR PASSION FRUIT

Passion fruit plant description:

Passion fruit, a native of tropical America (Brazil), belonging to the family *Passifloraceae* is a high value.The main cultivated varieties in India are yellow purple and gaint grenadille. The flowers are single and fragant, 5-7.5 cm wide, is borne at each node on the new growth. The nearly round or ovoid fruit, 1-1/2 to 3 inches wide, has a tough rind that is smooth and waxy and ranging in hue from dark purple with faint, fine white specks, to light yellow or pumpkin-color. Within is a cavity more or less filled with an aromatic mass of double walled, membranous sacs containing orange-colored, pulpy juice and as many as 250 small, hard, dark brown or black, pitted seeds.

Passion fruit stands out not only for its exotic and unique flavor and aroma but also for its amazing nutritional and medicinal properties. *P. edulis* Sims, the exclusive species of *Passiflora* seen growing at an altitude of 800-1500m above sea level. Within this species, there are two distinct forms, the standard yellow (*Passiflora edulis* f. *flavicarpa* Deg.) and the purple (*Passiflora edulis f. edulis*), differing in pH and starch content.

Passionfruit is a highly nutrient responsive perennial crop, climbing, mostly as vine with a shallow root system (root density remaining confined to top 20 cm soil depth). It produces an edible round or ovoid fruit and has a tough, smooth, waxy dark purple hued rind with faint, fine white specks. Inside, the fruit is more or less filled with an aromatic mass of double-walled, membranous sacs containing orange colored pulpy juice and as many as 250 small, hard, dark brown to black pitted seeds.

The total global supply of passionfruit is estimated at 8.52 lakh tons, with major producing countries comprising of Brazil, Mexico, Ecuador, Australia, Zimbabwe, Kenya and Columbia. Over 95% of the production is the yellow form for juice extraction, while purple contributes predominantly for fresh fruit trade. In India, passionfruit cultivation is confined to Kerala, Tamil Nadu (Nilgiri hills and Kodai Kanal), Karnataka (Coorg) and north-eastern states (Mizoram, Nagaland, Manipur and Sikkim) with an area and production of 9.11 thousand ha and 45.82 thousand tons.

I. PESTS

A. Pests of National Significance

1. Insect and Mite Pests

1.1 Aphids: *Myzus persicae* (Sulzer), *Aphis gossypii* (Glover) and *Macrosiphum solanifolii* Thomas (Hemiptera: Aphidae)
1.2 Mealy bugs: *Planococcus citri* Risso, *Planococcus pacificus* Cox (Homoptera: Pseudococcidae)
1.3 Fruit flies: *Bactrocera latifrons*, *B. dorsalis*, *B. cucurbitae* (Diptera: Tephritidae)
1.4 Scales: *Coccus hesperidum* Linnaeus (Hemiptera: Coccidae), *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae)
1.5 Mites: *Brevipalpus phoenicis* (Geijskes) (Trombidiformes :Tenuipalpidae), *Tetranychus mexicanus* (McGregor) and *T. desertorum* Banks (Acari: Tetranychidae)

2. Diseases:
2.1 Brown spot: *Alternaria passiflorae* J.H. Simmonds, Proc. Roy. Soc. and *A. alternata*
2.2 *Septoria* Blotch (Spot) : *Septoria fructigena* Berk. & M.A. Curtis, Grevillea, *S. passifloricola* Punith and *S. passiflorae* Louw
2.3 Root and crown rot: *Pythium splendens* Hans Braun, *P. aphanidermatum* (Edson) Fitzp, *Phytophthora cinnamomi* Rands and *P. nicotianae* Breda de Haan
2.4 Fusarium wilt: *Fusarium oxysporum* Schlecht. emend. Snyder & Hansen
2.5 Woodiness Of Passion Fruit: *Passion fruit woodiness virus* (PWV) and *Cucumber woody virus* (CWV)
2.6 Scab or *Cladosporium* Rot: *Cladosporium cladosporioides* (Fresen.) G.A. de Vries

and *C. herbarum* (Pers.) Link

2.7 Anthracnose : *Colletotrichum gloeosporioides* (Penz.) Penz. &. Sacc

orchard

3. Weed :

Broadleaf:

3.1. Lamb's quarter : *Chenopodium album* L. *(*Chenopodiaceae)

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

3.3.Wild sage: *Lantana camara* L. (Verbenaceae)

3.4.Wire weed: *Sida acuta* Burm.f. (Malvaceae)

3.5.Siam weed: *Chromolaena odorata* (L) King & H.E. Robins (Asteraceae)

3.6..Buckthorm: *Rhamnus nepalensis* (Wall.) Lawson (Rhamnaceae)

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

3.8.Stinkbells: *Circaester agrestis* Maxim. (Circaestraceae)

3.9.Crofton weed: *Ageratina adenophora* (Spring.) (Asteraceae)

3.10.Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

3.11.Common purslane: *Portulaca oleracea* L. (Portulacaceae)

3.12.Pink knotweed: *Persicaria napalensis* (Meisn.) Miyabe (Polygonaceae)

Grassy :

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

3.14. Blue grass: *Poa annua* L. (Poaceae)

3.15. Itch grass: *Rottboellia exaltata* L.f. (Poaceae)

3.16. Johnson grass: *Sorghum halepense* (L) Pers. (Poaceae)

Sedges

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

4. Rodents

4.1 Soft furred orchard rat*: Rattus meltada*

4.2 Indian mole rat: *Bandicota bengalensis*

4.3 common house rat: *Rattus rattus*

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

A. AESA

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment and manage the crop pests by adopting various IPM practices on eco-friendly manner, viz., Cultural, Mechanical, Biological, Botanical & Chemical. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of 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 analyse 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 analyse 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 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 organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation.

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

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

Plant compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. The ability of the plant to compensate for the reduced acquisition of resources by the production of new organs or by remobilization of reserves may also mitigate biotic stress effects.

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

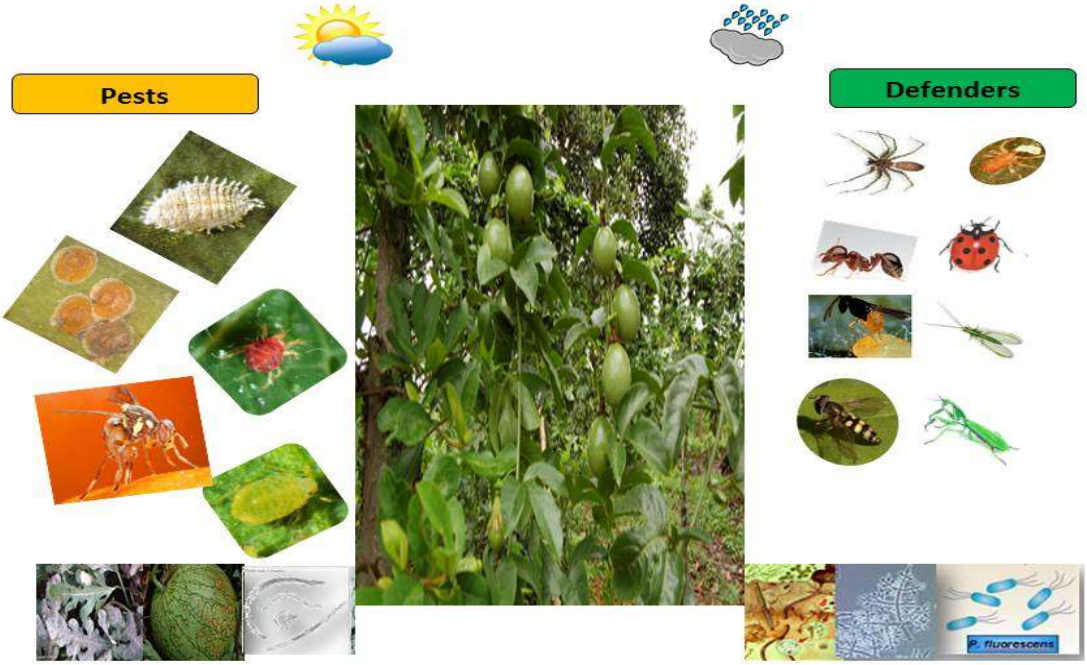
In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop orchard. Insect zoo concept can be helpful to enhance farmers' skill to identify 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 number passion fruit 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 passion fruit insect 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 orchard situations

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be 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 10 tree/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 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 build up?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

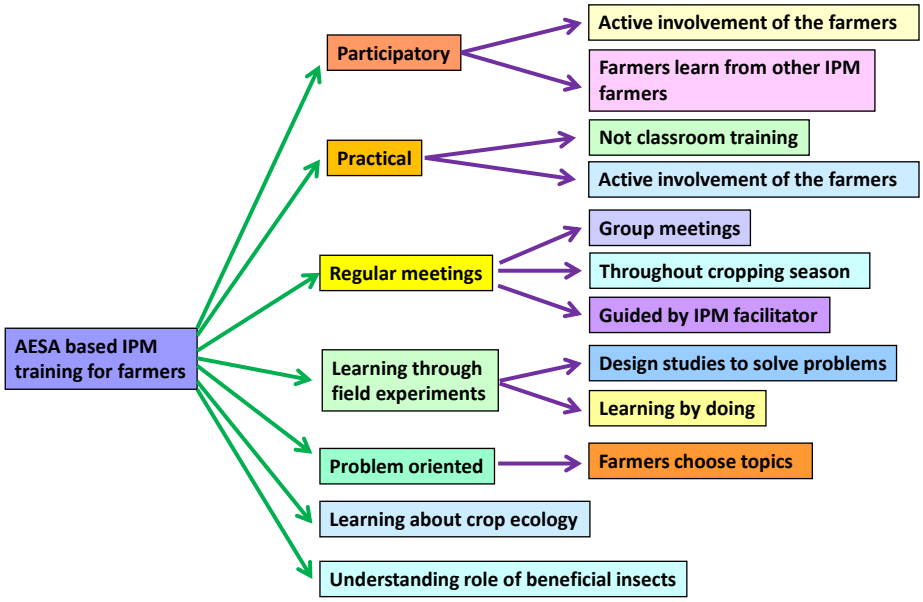
AESA and farmer orchard school (FFS)

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 build up
- 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 their exercise. However, other farmers also can do orchard scouting in their own orchards at regular intervals to monitor the major pest situation.

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.

For insect pests:
Scales, psylla and mealybugs: Count and record the number of both nymphs and adults on five randomly selected leaves/twigs per plant.
Twig girdler and borer: The number of girdles on five randomly selected twigs per plant should be counted and recorded.
Leaf roller and fruit flies: Total number of fruits, damaged fruits due to fruit fly and number of leaf roller damaged leaves and number of leaf roller larvae on individual plants should be counted and recorded.

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 fly:

Pheromone traps for fruit fly @ 4-5/acre have to be installed, if available.
Fix the traps to the supporting pole at a height of mid plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of flies/trap/week should be counted and recorded year round. The trapped flies should be removed after each recording.

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

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below ground:

There is a growing realization that the soil borne andplanting materials 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.

- Tree rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or tree residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, tree 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 trees along the orchard border by arranging shorter plants towards main tree 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 trees and pest repellent trees. The trap trees and pest repellent trees 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

Coriander

Carrot

Jatropha

Buckwheat

Chrysanthemum

Alfalfa

Mustard

Parsely

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Marigold

Repellent plants

***Ocimum* sp**

Peppermint

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

IV. CROP STAGE WISE IPM

Management	Activity
Nursery management	
	• Seed should be sown in well prepared seed bed or in polybag with a mixture of soil, compost and sand (2:1:1).
Root rot and crown rot	**Cultural control:** • The elimination of diseased tissues during the initial stages of the disease. • Proper drainage system to remove excess water.
Soil borne diseases, insect pests	**Common cultural practices:** • Summer deep ploughing to expose soil inhabiting/resting stage of various insects/pathogens. • Trimming of all orchard bunds to destroy existing rodent burrow. • Use tolerant/resistant varieties • Apply manures and fertilizers as per soil test recommendations. • Grow tall barrier crops like maize, sorghum etc. for management of aphids. **Common mechanical practices:** • Uproot and burn infected plants parts early to avoid spread of the disease. • Collection and destruction of larvae.
Nutrients	• - Nutrients should be applied based on soil test report and recommendation of the particular agroclimatic zone. • - Soil should be rich in organic matter. If required, add farm yard manure or vermicompost.
Weeds	• Deep ploughing during summer • Ploughing the orchard before planting to destroy existing weeds in the orchard. •
Planting	
Nutrient management	• Apply mycorrhizae @ 5 to 10 gin each pit. Apply nutrients as mentioned in Table # 1.
Weed management	• Use weed free planting material. • Remove all existing weeds from pits or furrows at the time of planting. • Seasonal vegetables (e.g. Turmeric, Ginger, Chilli, Soybean Beans, pea, Green leafy vegetables, mustard etc) may be grown as intercrop right from the first year.

Vegetative	
	Common cultural practices:

	• Destroy crop debris. • Provide irrigation at critical stages of the crop • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed **Common mechanical practices:** • Collection and destruction of rotten fruits, twigs and leaves. • The trellis should always run across the slop or in north-south direction for proper exposure to sunlight. • Pruning should be restricted to lower part of the vines hanging on the ground during winter when vines are dormant. • Use yellow sticky traps for whitefly and aphids and blue sticky trap for thrips @ 4-5 trap/acre. **Common biological practices:** • Conserve natural enemies through ecological engineering. • Augmentative release of natural enemies.
Nutrients	• Apply as mentioned in Table #1

Table #1. Schedule of manures and fertilizers for passion fruit grown in two premier belts of India

	Manures and Fertilizers	*South India*			*Northeast India*		
		Planting	*2-4 years*	*>4years*	*Planting*	*2-4 years*	*>4 years*
i.	*FYM (kg/vine)*	*5*	*10*	*15*	*2*	*4*	*6*
ii.	*Nitrogen (g/vine)*	*25*	*80*	*150*	*20*	*60*	*80*
iii.	*Phosphorus (g/vine)*	*10*	*30*	*50*	*10*	*40*	*40*
iv.	*Potassium (g/vine)*	*25*	*60*	*100*	*10*	*50*	*50*

Source: Sema and Maiti, 2006

Weeds	• Weed control should be done manually or mechanically. Care should be taken to avoid the damage to shallow roots of the vines • Mulching of plants around the root zone to conserve the moisture and fertility of soil.
Mites	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) **Cultural control:** • Periodic inspections of the orchard and other adjacent hosts, including weeds, are essential to verify the occurrence and first symptoms of mite attacks. • See common cultural practices. **Biological control:** • Spray neem or pongamia soap at 1% on lower surface thoroughly.
Aphids	• Follow common cultural, mechanical and biological practices (See page no 24 & 25). **Cultural control:** • High levels of nitrogen fertilizer favor aphid reproduction, so never use more nitrogen than necessary.

	Biological control: • Release 1st instar larvae of green lacewing (*Chrysoperla zastrowii sillem*i) @ 4,000 Nos/acre. • Spraying with tobacco decoction (1 kg tobacco boiled in 10 lit of water for 30 minutes and making up to 30 lit + 100 g soap).
Mealybugs	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) **Cultural control:** • Prune affected shoots during winter. • Destroy ant colonies. • Grow attractant plants to attract the defenders Bachelor's Buttons or cornflower (Centaure acyanus), coriander attract wasps. **Mechanical control:** • Collect and destroy the damaged leaves, twigs and stems • Use sticky barrier (5cm length) on trunk. **Biological control:** • Orchard release of Australian lady bird beetle (*Cryptolaemus montrouzieri*) @10 beetles per plant.
Scales	• Follow common cultural, mechanical and biological practices (See page no) **Biological control:** • When infestation in serious, two sprays of white oil, one in early December and one 4 to 6 weeks later are usually required. • Spray horticultural oil, if needed, year round. • Apply mixture of manure compost tea, molasses and citrus oil. • Conserve the *Aphytis* spp.
***Fusarium* wilt**	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute **Cultural control:** • Planting areas previously affected may be avoided. • Use of healthy seedlings and careful control of weeds to avoid root injury can check the spread of disease. • Usage of resistant root stocks or resistant hybrids from crosses between purple and yellow passion fruits.
Root and Crown rot	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute
Anthracnose	• Follow common cultural, mechanical and biological practices (See page no 24 & 25)

	• For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute **Mechanical control:** • Pruning to eliminate affected areas and improve ventilation and light conditions helps to control the disease. • Fruit should not be harvested during wet conditions.
Scab	**Cultural control:** • High densities of seedlings have to be avoided in plant nurseries, as well as excessive irrigation. • Follow the common cultural practices.
Septoria blotch/spot	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute
Brown spot	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute
Woodiness virus	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institute
Reproductive	
Nutrients	• Zinc and Boron are the micro-nutrients taken up in largest amounts by the plant. With Zn deficiency, apply 20 g of zinc sulphate ($ZnSO_4.H_2O$) per plant, and of B, apply 6.5 g of boric acid (H_3BO_3) per plant.
Weeds	• Remove weeds manually or mechanically around the plants. • Apply the bio-mulch around the root zone of the plants.
Fruit fly	• Follow common cultural, mechanical and biological practices (See page no 24 & 25) **Mechanical control:** • Elimination of over-ripe fruits in which the flies breed and on which the adults feed. • Removal of wild host plant. • Installation of 10 traps/ha to monitor fruit fly. Hanging of bottle traps containing 100 ml of water emulsion of methyl eugenol (0.1%) + malathion (0.1%) during fruiting season.
Mealy bugs,Scales, Aphids and mites	• Follow practices mentioned in vegetative stage
For diseases	• Same as in vegetative stage.

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. NUTRIENT DEFICIENCIES

Symptoms of nutrient deficiency in passion fruit leaves:

Nutrient	Leaf age	Leaf symptoms and causes
N	Oldest	Light green and smaller area. Yellowing and premature falling. *Cause:* low composition of organic matter, acidity (lower mineralization), leaching, prolonged drought.
P	Old	Dark green, later yellowing from the edges to the centre. *Cause:* low composition of P in the soil, low pH (lower availability).
K	Old	Progressive chlorosis from the edges to the centre, necrosis and tissue "burn". *Cause:* low composition of K in the soil, leaching and excessive liming.
Mg	Old	Yellowish spots between the veins, wizened lamina curling down. *Cause:* soils low in Mg, acidity and excessive potassium in fertilization.
Ca	Young	Death of apical sprout, interveinal chlorosis and necrosis. *Cause:* low Ca composition in the soil, excessive potassium in fertilization.
S	Young	Chlorotic, yellowish veins on the bottom side of the leaves. *Cause:* low soil S composition, low organic matter content.
Cu	Old	Large and wide leaves, dark green in color and partially shrivelled, thickening of the veins on the upper side, curved downwards. *Cause:* low soil Cu composition, excessive liming and high levels of organic matter.
Mo	Old	Interveinal chlorosis. *Cause:* acidity, excessive sulphate.
B	Young	Plants atrophied, necrosis of the terminal sprout. Smaller and shrivelled leaves with waves along the edges. *Cause:* low soil B composition, low organic matter content, excessive acidity, leaching.
Fe	Young	Interveinal chlorosis. *Cause:* Excessive liming, elevated organic matter content, low soil Fe composition and elevated moisture.
Mn	Young	Chlorotic spots between the veins. *Cause:* excessive liming, elevated organic matter content, low soil Mn composition.
Zn	Young	Small leaves, gaunt and pointed lobes, milky white spots with yellow edges *Cause:* low soil Zn composition, excessive liming and phosphatized fertilization.

VII. COMMON WEEDS

1. Lamb's quarter : *Chenopodium album* L. (Chenopodiaceae)

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

3. Wild sage: *Lantana camara* L. (Verbenaceae)

4. Wire weed: *Sida acuta* Burm.f. (Malvaceae)

5. Siam weed: *Chromolaena odorata* (L) King & H.E. Robins (Asteraceae)

6. Buckthorm: *Rhamnus* sp (Rhamnaceae)

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

8. Stinkbells: *Circaester agrestis* Maxim. (Circaestraceae)

9. Crofton weed: *Ageratina adenophora* (Spring.) (Asteraceae)

10. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

11. Common purslane: *Portulaca oleracea* L. (Portulacaceae)

12. Pink knotweed: *Persicaria napalensis* (Meisn.) Miyabe (Polygonaceae)

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

14. Blue grass: *Poa annua* (Poaceae)

15. Itch grass: *Rottboellia exaltata* L.f. (Poaceae)

16. Johnson grass: *Sorghum halepense* (L) Pers. (Poaceae)

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

VIII. DESCRIPTION OF INSECT AND MITE PESTS

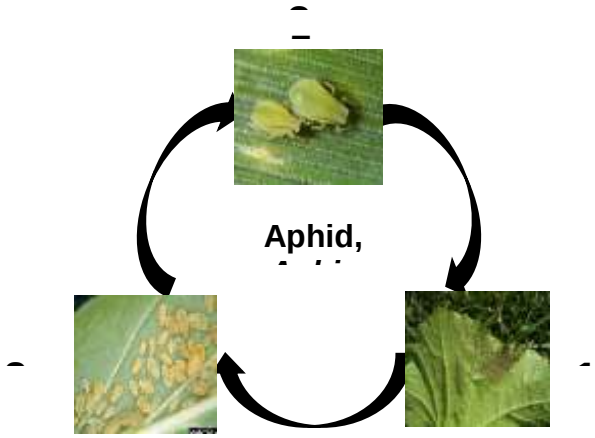
1) Aphid:

Biology:

Both winged and wingless forms breed parthenogenetically.

- Aphids reproduce in two ways: by laying eggs and giving birth to young ones. Which birth process is used depends on environmental conditions and the availability of food.
- When food is plentiful, aphids give birth to live young. Populations develop quickly as this pest has many young ones, a short lifespan and pre-adult insects can also give birth.
- Eggs hatch after three or four days. Young aphids, called nymphs, need five to eight days to become adults.
- It has 12-14 generations per year

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 cause malformation in foliage, and they are more important as disease vectors.
- *Myzus persicae* and *A. gossypii* transmit viral disease that causes hardening of fruits.
- *Myzus persicae* and *M. solanifolii* are vectors of the passion fruit woodiness virus.

Natural enemies of Aphids

Predators: *Scymnus*, *Chrysoperla*, *Aphidoletes*, *Syrphus* Coccinellids etc.
Parasitoids: *Lysiphlebus testaceipes*, *Aphidius colemani, Diaeretiella rapae*

*****For the management refer page no.....25 &28.....

2.Mealybugs

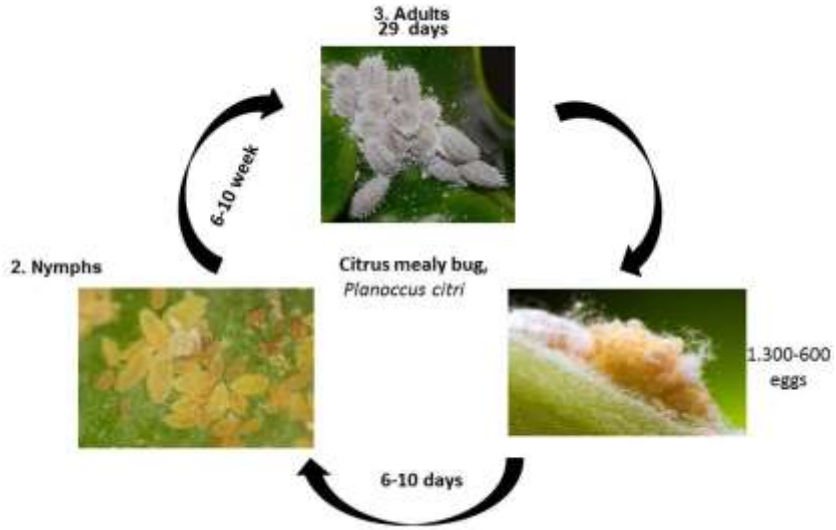
Citrus mealy bug, *P. citri*, is a small, oval- shaped sucking insect commonly found on passion fruit. Mealybugs characteristically aggregate on the plant, especially at leaf nodes and under dead leaves and trash. Aggregation may also occur under dried flower bracts. Secretion of a sugary solution from the mealy bugs promotes growth of a black fungal mould on the fruits and leaves.

Biology:

- **Eggs:** Eggs are deposited as white cottony masses called ovisacs on trunk and stems of citrus plants, giving the appearance of cotton spread on plants. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female can lay from 300 to 600 eggs in her life period, which are deposited in groups of 5 to 20. Depending on the season, egg hatch may occur after 6 - 10 days or several weeks. An average of 29 eggs per day is laid by females.
- **Nymphs:** Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves, young twigs, and fruit buttons. Wax and honeydew secreted by crawlers are visible indicators of infestations. First instar female and male nymphs are called crawlers. The nymphs take 6 to 10 weeks to reach maturity. The nymphs are yellow, oval-shaped with red eyes, and covered with white waxy particles The female nymphs resemble the adult female in appearance, while male nymphs are more elongated. Female nymphs have four instars. Males differ greatly; they have three instars and a pre-pupal stage.
- **Adult**: Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females

are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Short waxy filaments can be seen around the margins of their oval body with a slightly longer pair of filaments present at the rear end of their body. Female mealybugs are wingless and, therefore, must be transported to subsequent host plants, although they are able to crawl for short distances. The immature can be blown by wind. Females can live for up to 29 days depending on the host plant. Males are similar in color to females and have two long backward-projecting white wax threads.

Life cycle:



Damage symptoms:

If a severe infestation occurs, loss of vigour, leaf drop, and fruit malformation may occur. Unchecked, an infestation may cause death of the plant.

Natural enemies of Mealy bug:

Predators: *Cryptolaemus montrouzieri*, *Harmonia octomaculata,* Lacewing larvae

Parasitoids: *Coccophagus sp.*, *Anagyrus coccidivorus*, *A. pseudococci, Leptomastidea abnormis*, *Leptomatrix dactylopii*

*****For the management refer page no...26 & 28.....

3. Fruit fly:

Biology:

- **Egg:** Female flies insert eggs under the skin of fruit in clusters of 10 to 50 about 1/25 to 1/8 inch below the fruit surface.
- The eggs measure about 1/25 by 1/250 inch and are white, elongate, and elliptical.
- They hatch in 1-1/2 days.
- **Maggot:** The white maggot is legless, and resembles an elongated cone. The mouth is at the pointed end of the body. There are 3 larval stages, or instars. The third instar is about 2/5 inch long. The entire maggot stage lasts for 11-15 days.
- **Pupae:** When mature, maggot drop to the ground and pupate in the soil. The puparium

is yellowish-brown and seed-like. Adults emerge in about 10 days.

- **Adults:** Generally, the abdomen has two horizontal black stripes and a longitudinal median stripe extending from the base of the third segment to the apex of the abdomen. These markings may form a "T" shaped pattern, but the pattern varies considerably. Females begin to lay eggs about 8 days after emergence from the puparium. Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under orchard conditions approximately 1,200 to 1,500 eggs per female is considered to be the usual production. Ripe fruit are preferred for egg laying, but immature ones may be also attacked.

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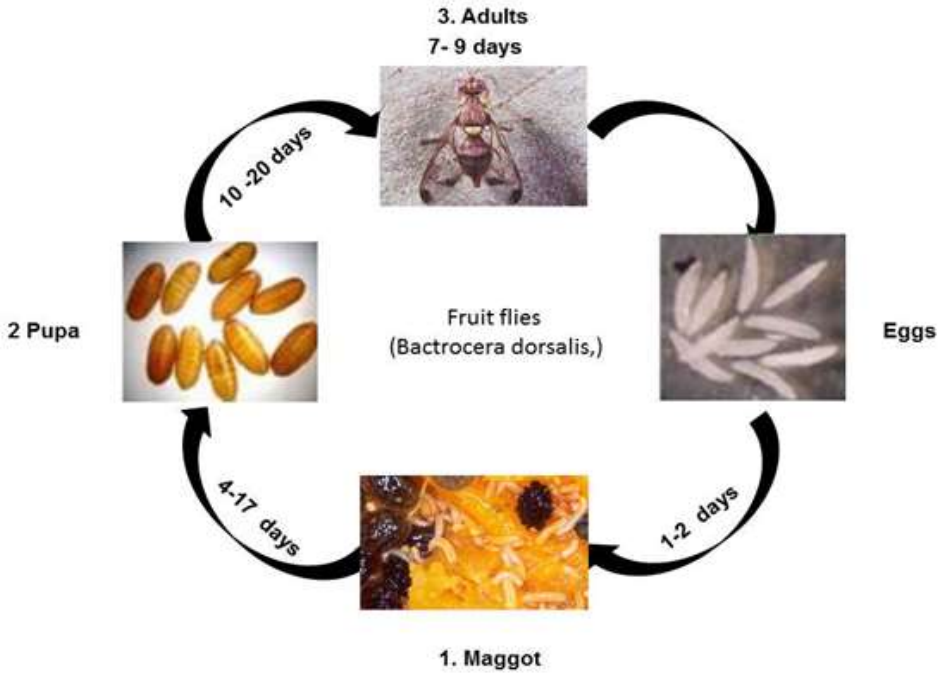
Life cycle:



Damage symptoms:

- Fly species feed upon the fruits of *Passiflora* spp., and also attack flowering buds.
- Fruit fly adult damage is caused by oviposition in green fruits, causing disfigurations of the fruit surface.
- The larvae damage the fruit by feeding on its pulp, contaminating it with bacteria and fungi and causing premature fruit drop. The oriental, melon, and Mediterranean fruit flies puncture the fruit while the rind is still tender.
- If the fruit is small and undeveloped, the damage may be sufficient to cause it to shrivel and fall from the plant. If the fruit is well developed, it may continue to maturity.
- Infested immature fruit shows characteristic skin blemishes. A few days after larval infestation, mature fruit will show wrinkling and breakdown.

Natural enemies of Fruit fly:

Parasitoids: *Opius fletcheri*

*****For the management refer page no.....27.....

4. Scales:

Biology:

- Females are viviparous.
- Eggs hatch just before being laid.
- Females produce 60 to 150 nymphs over a ten-day period. After a brief period of quiescence (2 to 4 hours), the nymphs leave the maternal scale and disperse on the host tree, preferably onto stems, but also onto foliage and fruits.
- The majority have settled one day later. Reproduction is greatest during uniformly hot and dry conditions.
  Summer heat, combined with even slight humidity, causes considerable mortality amongst newly emerged nymphs under the maternal scale.
- The imaginal moult usually occurs 5to 6 weeks after egg hatching.

Damage symptoms
http://idtools.org/id/scales/factsheet.php?name=6882

Damage symptoms:

- Soft scales and diaspidids injure plants by sucking sap, and when in numerous can kill the plant.
- They sometimes heavily encrust the leaves, fruits, twigs or branches.

Natural enemies of scales

Parasitoids: *Aphytis* spp.

Predators: Ladybird beetle

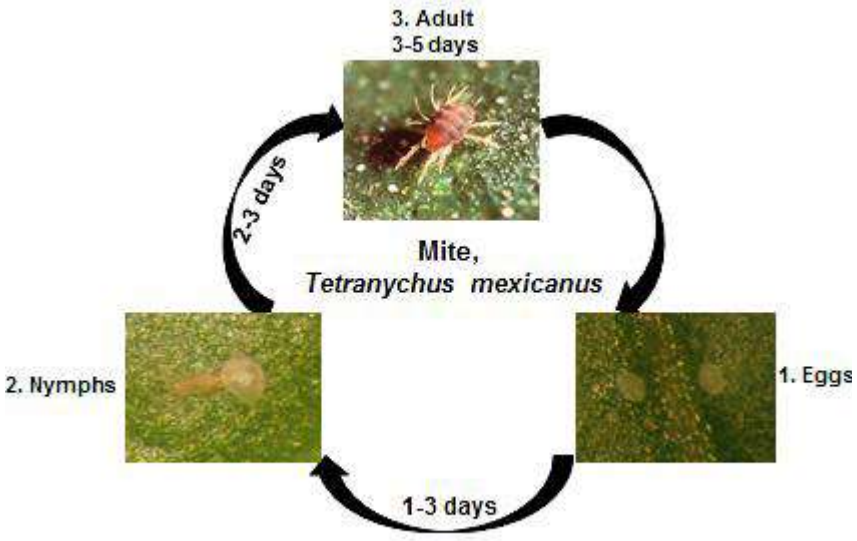
*****For the management refer page no....26 & 28.....

5. Mites

Biology:

Eggs: Eggs are deposited singly, in cracks, crevices, and other protected areas on the plant surface. These clusters of bright reddish orange eggs. Eggs have a stipe, a tail-like projection, that extends from the slightly pointed end that came out of the female mite last. This stipe often breaks off if the egg is handled. A day before hatching, the eggs become opaque white and the red eyes of the larvae are visible within.

Larvae: Larvae are six-legged, bright orange-red when newly emerged, but turn an opaque orange when fully grown.
Nymphs: There are two nymphal stages, the protonymph and the deutonymph. The protonymph is larger than the larva and has eight legs. The outer shell is transparent; light green, orange, black, and yellow patches may be seen within the body. The deutonymph is similar in appearance to the protonymph except for having an extra pair of legs, two additional setae (hairs), and being slightly larger.
Adults: Adult females are about 275 microns long, including the rostrum. The body is flat, light to dark green or reddish orange. Two pairs of legs extend forward and two pairs extend behind. The adult male is flat, reddish and more wedge-shaped than the female. Males do not have black markings. On average, adults lived for a maximum of 47 days at 68°F and a minimum of 7.5 days at 86°F with a relative humidity of 85 to 90 percent. Duration from egg hatch to adult required a minimum of 10.6 days at 86°F and a maximum of 27.3 days at 68°F.



Damage symptoms:

- Mites are scattered in reddish patches on the surface of the fruit, particularly around the stem end, along the midrib and veins of the leaf, especially on the under-surface.
- *Brevipalpus phoenicis* is responsible for general discoloration of the leaves, and necrosis, culminating in leaf drop.
- Attacked young stems dry from the extremity to the base and eventually die. With heavy and prolonged infestation, leaf fall increases and the vine has the appearance of dying back.
- At the same time, developing fruit may begin to shrivel and fall prematurely from the plant. If red spider mites are left uncontrolled, the plant may eventually die.
- Dense populations of spider mites produce silken webs that cover the leaves. Heavy infestations cause leaves to drop and plants to lose vigour.

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Natural enemies of Mites:

Predators: Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla* sp.), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*),

staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Anthrocnodax occidentalis*), predatory gall midge (*Feltiella minuta*), Predatory thrips etc.
*For management refer to page number-----25 & 28----------

Natural Enemies of Passion fruit insects

Parasitoids

Pupal parasitoids

1. Opius fletcheri

Nymphal and adult parasitoids

2.Aphidius colemani

3.Diaeretiella rapae

4.Lysiphlebus testaceipes

5.Coccophagus sp

6.Anagyrus pseudococci

7.Leptomatrix dactylopii

8. Aphytis sp.

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Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Fire ant

7.Hover fly

8. Mirid bug

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

14. *Geocoris* spp.

15. Predatory mite

16. Predatory thrips

17. *Oligota* spp.

18. *Orius* spp.

Birds

19.Black drongo

20. Common mynah

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IX. DESCRIPTION OF DISEASES

1. Brown spot:

Disease symptoms:

- *Alternaria passiflorae* causes reddish brown spots on the leaves. Under high humidity, spots normally grow larger up to 2 cm in diameter become round and zonate.
- Spores can form a black thin mass covering the middle of the lesion, being more abundant on the abaxial surface. Abscission of the affected leaves occur rapidly causing intense defoliation.
- In twigs dark brown lesions are more elongated and may cause girdling and death of the
terminal portion of these organs.

- Slightly circular spots occur on the mature fruits or when they are half way through their growth process. They are reddish brown, sunken affecting the pulp and damaging the commercial value.
- *Alternata* causes smaller spots with chlorotic haloes on leaves and can induce defoliation. The stem lesions rarely kill vines. Spots on fruits have dark green and greasy margins.

Survival and spread:

- The pathogen survives in infected leaves, twigs and fruits in the plant and on the soil.
- The conidia are dispersed by wind, water and rain and occasionally by infected seedlings.

Favourable conditions:

The disease is more intense under high humidity and abundant rainfall, along with rising temperatures. The disease appears in fruits during the rainy season and disappears during the dry season.

Damage symptom

http://plantpath.caes.uga.edu/extension/plants/field crops/sorghumheadmold.html

*****For the management refer page no..27.....

2. Septoria spot:

Disease symptoms:

- Leaves are the most affected organs, showing light brown slightly round necrotic spots normally encircled by a chlorotic halo. A single lesion per leaf is sufficient to cause abscission, and even leaves without visible symptoms may fall prematurely.
- When the disease reaches 15-20% of leaves in the same plant, partial or even complete leaf abscission is observed. In young twigs, lesions may promote girdling leading to wilt and twig tips death.
- Lesions on flowers are similar to those on leaves. The primary infection in the calyx may reach the stalk, causing the early drop of flowers. The infection may occur at any stage of the development of the fruits, affecting maturation or development.
- Leaf and fruit abscission, twig wilt and plant death may occur under disease favoring conditions.

Survival and spread:

- The fungus survives in infected tissues, mucilage in the cirrus is thought to aid survival.
- The conidia are released in the hyaline cirri and are agglutinated by a mucilaginous substance. Conidia contained in the cirri are spread by water, dew and insects.

Favourable conditions:

- Prolonged rains and mild temperature favour disease development. The optimum conditions for growth of fungus are temperature ranging from 5˚ to 35˚ C.

Damage symptoms

http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

*****For the management refer page no....27.....

3.Root and crown rot:

Disease symptoms:

- Phytophthora root and crown rot disease affects both adult as well as nursery plants. Mild cholorosis is followed by wilting, defoliation and death. Cortical tissues of the plants are exposed.
- Plant intumescence and bark fissures are found in the collar. Injured leaf shows a burned appearance. Occurrence of foliar blight followed by drop of flowers is observed.
- There is a change in leaf color from colorless to pale green, with leaves reaching a light copper colour. The affected plant shows burned -like black twig tips and flowers which eventually die. Large grayish- green aqueous spots can be viewed in fruits, which easily fall down.

Transmission:

- The disease appears in specific spots and spreads from one plant to another.

Favourable conditions:

- High disease incidence is observed in clay soils during rainy periods when temperatures vary between 26 -30˚C.

Crown rot diseasesymptom

http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

*****For the management refer page no.....26.....

4. Fusarium wilt:

Disease symptoms:

- The glossy green leaves of young passion fruit plants show a pale green colour and mild die back. Drop of lower leaves, general plant wilting and sudden death take place as the disease progresses.
- In adult plants, the disease causes yellowing of young leaves, followed by plant wilt and death. Symptom development may be unilateral or encompasses the entire plant.
- The vascular system becomes darkened at the root, collar, stem and twig areas. The disease typically affects the xylem vascular system, leading to the impermeability of vascular walls and preventing the translocation of water to other plant parts.
- Under high relative humidity conditions, lesions and fissures can be found in the plant collar and stems.

Survival and spread:

- Inside an orchard the fungus is spread by soil movements (machines, implements, shoes etc) and by run off or irrigation water.
- Resistant chlamydospores enable long term survival of the fungus in the soil.

Favourable conditions:

The disease intensity is greater in sandy soils and favored by high temperatures and relative humidity

Disease symptom

http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

*****For the management refer page no.....26.....

5.Anthracnose:

Disease symptoms:

- Spots, initially 2-3 mm in diameter and oily in appearance, are produced on the leaf. They become dark brown, round or irregularly shaped and 1 cm in diameter. The centers of spots become brittle and may break apart. Lesions also develop on petioles.
- As foliar lesions coalesce, large areas of the leaf die, resulting, eventually, in abscission. Dark brown spots, 4-6 mm in diameter, are produced on the branches and tendrils, eventually turning into cankers. Severe lesions can cause the death of shoots and a partial blighting of the plant
- Affected flowers abort, and immature fruit abscise. Lesions on fruit initially are superficial and light brown, and later become sunken and greyish to dark brown. They may be larger than 1 cm in diameter and may reach interior portions of the fruit. As fruit mature, the spots enlarge and become oily or light tan.
- The fruit skin becomes papery and acervuli are formed on lesions here and on leaves. Under high humidity, masses of red and orange spores form in acervuli.

Dieback, characterized by reduced elongation of shoots, shortened internodes and an eventual wilting and death of these structures are the symptoms normally associated with anthracnose.

Survival and spread:

- The fungus survives and sporulates in infected tissues and crop residues of passion flower.
- Fungal dissemination in the orchard is carried out by raindrops infected seeds, seedlings and cuttings.

Favourable conditions:

- Long raining periods and average temperatures of 27˚C are the ideal conditions for the occurrence of epidemics.

Disease symptoms

http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

***For the management refer page no.....27.....

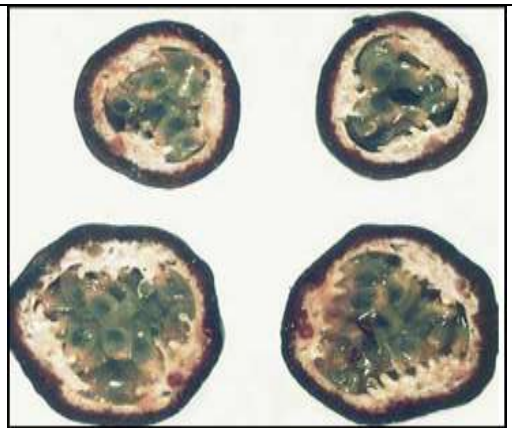
6.Woodiness virus:

Disease symptoms:

- Infection causes a noticeable reduction in the development of plant. Leaves display severe mosaic, rugosity and distortion**.**
- Plants affected with PWV and CWV produce woody and deformed fruits. Severe mosaic, epinasty, defoliation and premature death of plants are associated with infection of PWV.
- Other common symptoms are leaf mottling and ring spot on the younger leaves. Fruits are symptom less or may show mild molting. Chlorotic spots on the leaves and dappled or faded fruits are often found.

Transmission:

- Viruses are normally transmitted by several species of aphids in a non persistent, non-circulative way. They can also be transmitted through grafting and experimental mechanical inoculation. Mechanical transmission by knifes, scissors and nails during cultural practices of trimming are observed. None of the viruses are found to be transmitted through seeds.



http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

Disease symptoms

***For the management refer page no.....27.....

7. Scab:

Disease symptoms:

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- Infected plant show small round spots on the leaves. Spots are initially translucent, later become necrotic showing greenish-grey centers which correspond to fungal fructification.
- Lesions can perforate leaves, occur on veins and cause them to be deformed leading to abscission. Similar spots may appear on bud sepals or open flowers. High numbers of lesions on flower buds or on peduncles can greatly reduce the number of flower buds.
- Twigs and twig tips initially show lesions similar to the ones on leaves, which later turn into cankers of elongated and sunken aspect that become greenish - grey, where the pathogen fructification takes place. As scar tissue forms, branches become weakened and break in the wind.
- On small fruits, symptoms are slightly sunken with small dark circular spots. On bigger fruits lesions on fruit skin grow and become corklike, prominent and brownish. Lesions do not reach the inner fruit and consequently do not affect juice quality. Several lesions may form on the same fruit causing it to be deformed and stunted.
- The disease mainly affects young tissues of leaves, branches, tendrils, flower buds and fruits, when not controlled cause significant damages. In fieldorchard conditions it causes death of the twigs, can delay flowering and reduce the commercial quality of fruit.

Survival and spread:

- Dissemination of the fungus occurs through infected seedlings, by wind and sprinkler water.

Favourable conditions:

- High relative humidity promotes the infection. The disease severity is high in spring time when temperatures are mild.

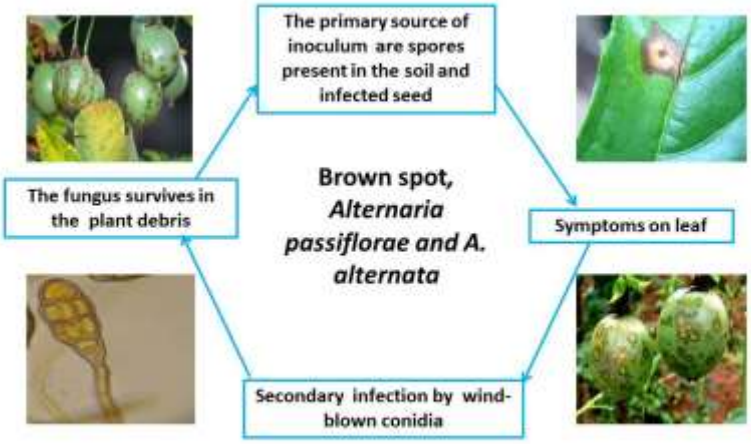
Disease symptoms

http://www.kau.in/sites/default/files/documents/diseases_of_passion_fruit.pdf

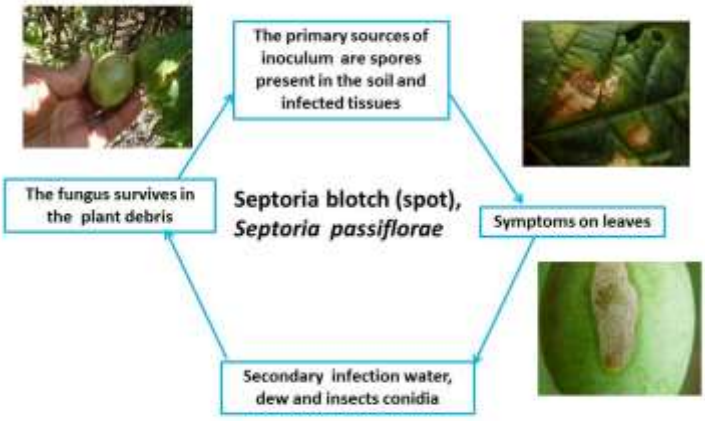
***For the management refer page no.....27.....

Disease cycles:

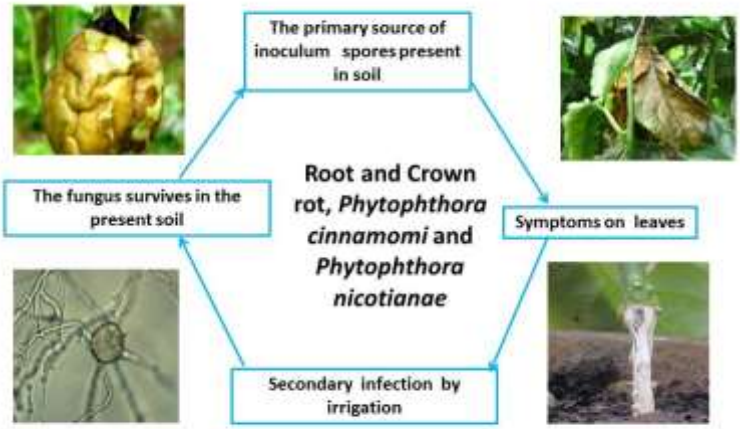
1. Brown spot:



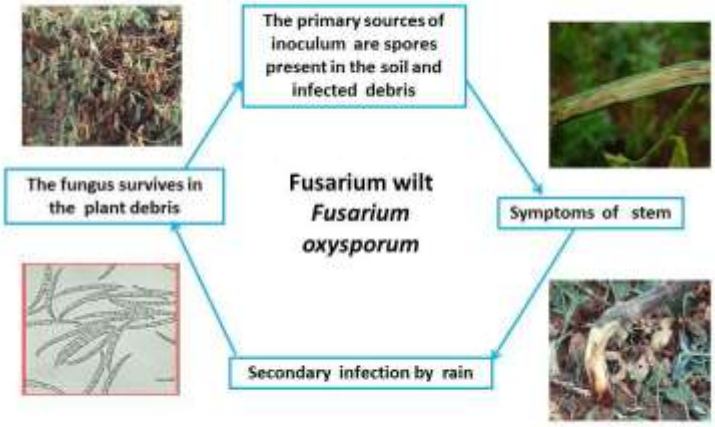
2. Septoria blotch:



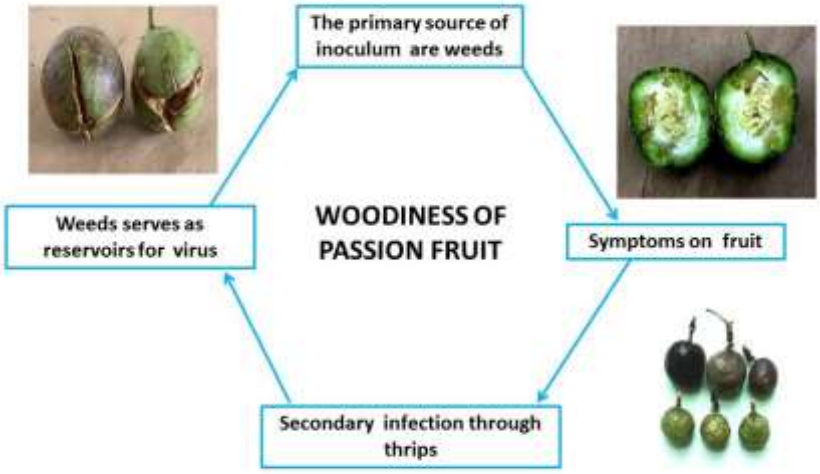
3.Root and Crown rot:



4. Fusarium wilt:



5. Woodiness of passion fruit:



X. SAFETY MEASURES

A. <u>At the time of harvest:</u>

The vines start yielding fruits after 10 months of planting and bearing reaches optimum by 16-18 months. There are two main periods of fruiting from August to December and March to May. Fruits take 80-85 days to reach maturity. Slightly purple coloured fruits along with a small portion of stem / pedicel should be picked up. The fruits should be marketed quickly to prevent loss in weight and their appearance. The rind becomes wrinkled on drying but the pulp remains in good condition for several days.

<u>B. Post-harvest storage:</u>

For storage, the fruits are washed and dried and placed in bags. The fruit can last for 2–3 weeks and it is sweetest when slightly shriveled. Fruits bound for the factory are packed in crates or boxes and transported within 2–5 days. Passion fruit is generally not consumed as a table fruit due to numerous (about 250) small, hard, dark brown seeds in fruit and its commercial value lies in its processing in preparation of juice, concentrate, squash, icecream, confectionery etc. or in blending its juice with other fruit juices to enhance the flavour. There is very good demand of juice/concentrate in foreign markets.

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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 recommended varieties such as Kaveri (hybrid between purple and yellow) as these are tolerant to collar rot, wilt, etc. (In the absence of this variety, farmers' experience is that purple variety is superior to yellow variety).	Do not grow under-script materials; source and varieties of seedlings should be ascertained
3.	Select a gentle slope for passion fruit cultivation for proper maintenance of drainage.	Avoid flat land as drainage; maintenance is difficult and costly.
4.	Follow healthy agronomic practices such as selection of healthy seedlings, timely sowing, maintaining good spacing, trellis, etc.	Poor agronomic practices lead to poor yield and unproductive plantation.
5	Encourage intercropping with annuals (soybean, etc.) and maintenance of good hedge plants to support predators.	Absence of intercrop and hedge plants may contribute to poor productivity of fruits.
6	Always treat the seeds with approved chemicals/bio pesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
7.	Maintain appropriate number of honey beecolonies which act as pollinators.	Absence of pollinator insects may lead to poor yield of fruits.
8.	Good and periodic surveillance for pests and diseases; mechanical removal of diseased leaves, etc.	Poor surveillance may lead to poor yield; do not keep the infected plant materials in the orchard.
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 orchard observation	Do not apply chemical pesticides within seven days of release of parasitoids.
15	Spray pesticides thoroughly to treat the	Do not spray pesticides only on the upper

	under surface of the leaves, particularly for mites etc.	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.

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