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AESA BASED IPM PACKAGE

KIWI

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Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

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

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Information on Region- wise Distribution of Pests Provided by:

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FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. During last century, IPM relied substantially on economic threshold level and chemical pesticides driven approaches. However, since the late 1990s there is conscious shift to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy.The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

Sincere efforts have been made by resource personnel to incorporate ecologically based principles and field proven technologies for guidance of the extension officers to educate, motivate and guide the farmers to adopt AESA based IPM strategies, which are environmentally sustainable. I hope that the AESA based IPM packages will be relied upon by various stakeholders relating to Central and State government functionaries involved in extension and Scientists of SAUs and ICAR institutions in their endeavour to promote environmentally sustainable agriculture practices.

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR KIWI

Kiwi plant description:

Kiwi, *Actinidia deliciosa*, is a deciduous climbing vine or shrub in the family Actinidiaceae grown for its edible fruits. The plant is vigorous and woody with nearly circular leaves which have long petioles and are alternately arranged on the stems. Young leaves and shoots are covered in tiny red hairs, while mature leaves are smooth and dark green on the upper surface and white and downy on lower surface. The kiwi plant produces fragrant white-yellow flowers singly or in clusters of 3 at the leaf axils (area between leaf and stem). The fruit is oval or ovoid in shape with green-brown skin covered in stiff brown hairs. The flesh of the fruit is bright green and juicy with many tiny black seeds. Kiwi plants can reach a height of 9 m (30 ft) and have an economic lifespan of 3 years, after which time fruit production begins to decline. Kiwi may also be referred to as kiwifruit or Chinese gooseberry.

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

1.1 Brown headed caterpillar: *Ctenopseustis obliquana* (Walker) (Lepidoptera Tortricidae)
1.2 Green headed caterpillar: *Planotortrix excessana* (Walker) (Lepidoptera: Tortricidae)
1.3 Greedy Scale: *Hemiberlasia rapax* (Comstock) (Hemiptera: Diaspididae)
1.4 Passion vine hopper: *Scolypopa australis* (Walker) (Hemiptera: Ricaniidae)
1.5 Two spotted mite: *Tetranychus urticae* (Koch) (Arachnida:Tetranychidae)
1.6 Thrips: *Heliothrips* spp. (Bouché) (Thysanoptera: Thripidae)

2. Diseases

2.1 Root rot, collar rot and crown rot: *Phytophthora* spp.
2.2 Leaf spots: *Altemaria* spp., *Colletotrichum* sp., *Fusarium* sp., *Penicillium* sp. and *Phoma* sp. etc.l
2.3 *Sclerotinia* rot: *Sclerotinia sclerotiorum* (Lib.) de Bary
2.4 Storage rot: *Botrytis cinerea* (de Bary) Whetzel
2.5 Bacterial leaf spot and blossom blight: *Pseudomonas viridiflava* (Burkholder) Dowson
2.6 Stem rot: *Rhizoctonia solani* Kuhn

3. Nematodes

3.1 Root Knot nematode: *Meloidogyne incognita* (Kofoid & White) Chit.

4. Major weeds

Broad leaf Weeds

4.1. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
4.2. Scarlet pimpernel *Anagallis arvensis* L (Primulaceae)
4.3. Creeping wood sorrel *Oxalis corniculata* L. (Oxalidaceae)
4.4. Goat weed *Ageratum conyzoides* L. (Asteraceae)
4.5. Pigweeds: *Amaranthus viridis* L. (Amaranthaceae)
4.6. Nettle leaf goosefoot: *Chenopodium murale* L. (Amaranthaceae)
4.7. Congress grass *Parthenium hysterophorus* L. (Asteraceae)
4.8. Horseweed plants: *Conyza canadensis* L. (Asteraceae)
4.9. Spurge: *Euphorbia hirta* (L.) Millsp*, E. geniculate* Orteg. (Euphorbiaceae)
4.10. White clover: *Trifolium repens* L. (Fabaceae)

Grassy weeds

4.11. Burmuda Grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
4.12. Bluegrass: *Poa annua* L. (Poaceae)
4.13. Cogon grass *Imperata cylindrica* (L.) Raeusch. (Poaceae)
4.14. Knot grass *Paspalum distichum* L. (Poaceae)
4.15. Canary grass: *Phalaris minor* L. (Poaceae)
4.16. Johnson grass: *Sorghum halepens* L. (Poaceae)
4.17. Hairy crabgrass: *Digitaria sanguinalis* L. (Poaceae)

Sedges

4.18. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
4.19. Yellow nutsedge: *Cyperus esculentus* L. (Cyperaceae)

5. Rodents

5.1 Indian mole rat: *Bandicota bengalensis* Gray
5.2 Soft furred vineyard rat: *Millardia meltada* Gray
5.3 Vineyard mouse: *Mus booduga* Gray

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

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the 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 vineyard 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 vineyard 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 white 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 vineyard situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are:

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

Principles of AESA based IPM:
Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting material
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.

- Proper irrigation
- Crop rotation

Observe the vineyard regularly (climatic factors, soil and biotic factors):

Farmers should

- Monitor the vineyard situation at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the vineyard situation 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. Several studies have documented such compensation through increased growth and photosynthetic rate.

Understand and conserve defenders:

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

Insect zoo:

In vineyard 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 vineyard 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 vineyard 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 kiwi 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 vineyard 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 and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making:

Farmers become experts in crop management:

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as vineyard 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 vineyard in groups (about 5 farmers per group). Walk across the vineyard and choose 20 plants/ acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the vineyard and their intensity.
    - Water: Observe the water situation of the vineyard.
    - Weather: Observe the weather condition.

- While walking in the vineyard, 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 vineyard situation in detail and present their observations and analysis in a drawing (the AESA drawing).

- Each drawing will show a plant representing the vineyard 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 vineyard 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

- Keeping 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 vineyard.
- 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 vineyard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL:

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

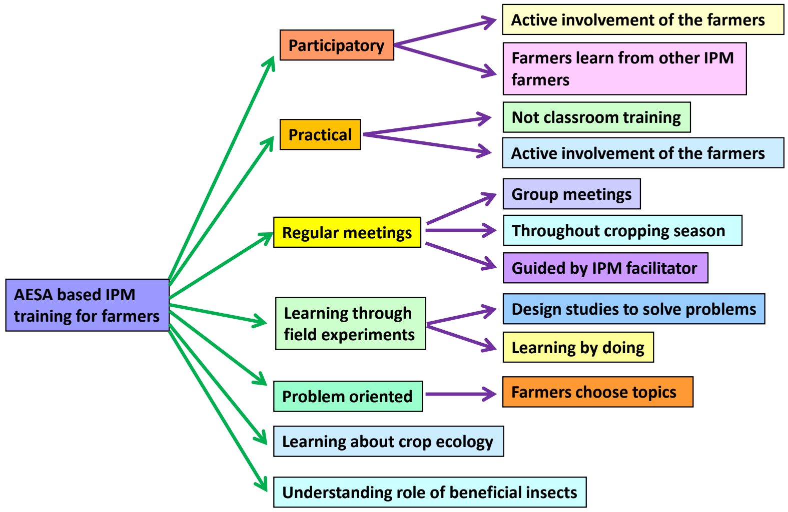
AESA and farmer field school (FFS):

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

Farmers can learn from AESA:

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

FFS to teach AESA based IPM skills:



B. Field scouting:

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

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

For insect pests:
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:
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.

D. Blue pan water/sticky traps

Set up blue sticky traps 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 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).

F. Nematode sampling:

Collect 100 to 300 cm^3 (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 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. 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 rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and vineyard application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their vineyard s, registration is not required).

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 vineyard 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 vineyard
- 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

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Maize

Mustard

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Repellent plants

***Ocimum* sp**

Peppermint

Border plants

Sorghum

Maize

Bajra

Intercrops

Blackgram

Groundnut

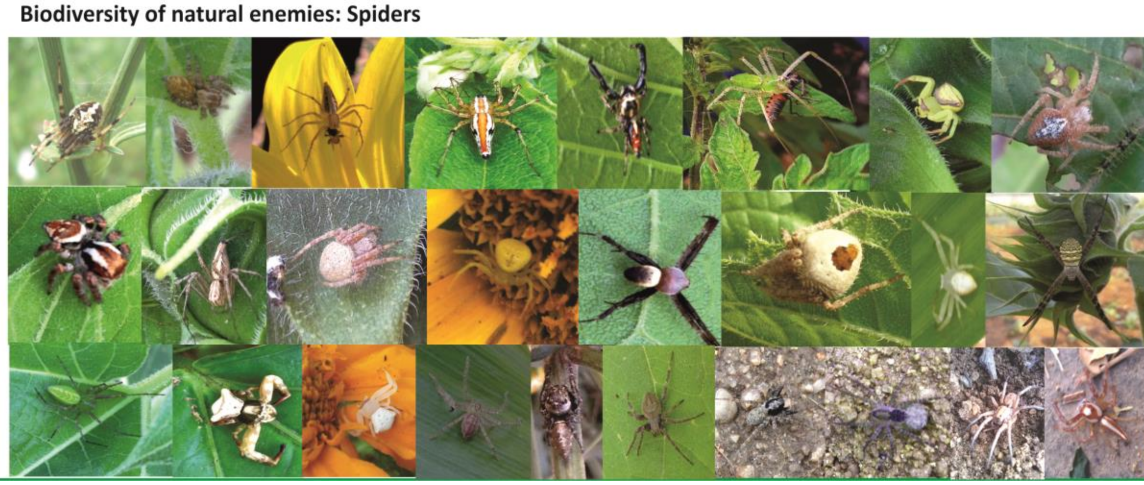
The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability,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



A. Resistant/tolerant varieties

***For detailed and updated information nearest KVK, SAU / ICAR Institute may be contacted**

IV CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
	<u>Common cultural practices:</u> • Deep summer ploughing to break hard pan and to facilitate rain water absorption & deep root penetration. • Timely planting should be done. • Vineyard sanitation. • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Apply manures and fertilizers as per soil test recommendations. • Do not leave FYM or compost exposed to sunlight as nutrients may be lost. • Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Pits of 1m x 1m x 1m size are dug at a distance of 6 m x 4 m and left exposed to sunlight. • The rows should be oriented in north – south direction for maximum light distribution. • Pits are filled with a mixture of 30 cm top soil, 40 kg farmyard manure and 45 g DAP .
Weeds	• Summer ploughing should be done to expose and destroy weed seeds/ rhizomes.
Soil borne pathogens, resting stages of insects	**<u>Cultural control:</u>** • Deep summer ploughing of vineyard s to control resting stages of insect pests.
Planting stage*	
	<u>Common cultural practices:</u> • Use healthy, certified and weed free seeds. • Grow resistant/tolerant varieties.
Nutrients	• Before transplanting, soil testing should be done to find out the soil fertility status. Nutrient should be provided as per soil test recommendations. • Planting is done in December January in pits already filled with farm yard manure and vines are trained on T bars . • Add mycorrhiza culture @ 50 grams per pit or a basket of soil taken from old Kiwi orchard to ensure mycorrhiza association with seedling roots.
Weeds	• Use weed free seedlings for planting. • Remove weeds from the pits before planting. • Green manuring and leguminous vegetables crops like bean, pea, red clover and white clover should be grown to manage the weeds between vine rows as well as to improve soil texture and fertility.

* Apply *Trichoderma viride/ harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their vineyard s, registration is not required).	
Vegetative stage	
	<u>Common cultural practices:</u> • Destroy crop debris • Provide irrigation at critical stages of the plant • Avoid water logging **<u>Common mechanical practices:</u>** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested plant parts collect and destroyed **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• The amount of manure and fertilizer to be applied is influenced by the age or size of tree, soil types, fertility, cultural practices and anticipated fruit yield.

Age (Year)	Quantity of manures and fertilizers (g/vine/year)			
	FYM	Urea	DAP	MoP
1	20	200	220	266
2	25	400	440	532
3	30	600	660	800
4	35	800	880	1064
5th year onwards	40	1000	1100	1330

	• The fertilizer should be applied in 2 equal doses, half to two third in January-February and the rest after fruit set in April-May. • The nutrients should be applied in 20-30 cm deep and 30 cms wide trench along the drip line of the tree.
Weeds	
	<u>Cultural control:</u> • Kiwi vineyards basins be maintained weed free by hand tool weeding or Mulching tree basin in April with plastic or straw mulch helps control weeds and conserves soil moisture. • Weeds between rows of vines are controlled by cultivating, mowing, tilling and planting cover crops or use black polyethylene mulch to prevent entry of light, to restrict germination of weed seeds and smothering of weeds • Use slashing and moving between the rows to control the weeds.
Passion vine	**<u>Cultural control:</u>**

hopper	• Heavy winter pruning of egg laying sites. • Spray them with Neem; it acts as a deterrent and anti-feeder. Biodegrades within two weeks when exposed to sunlight. Repeated application. • Companion plants such as geranium and petunia, marjorams, coriander, chamomile and yarrow **Biological control** • Egg parasitoids Aphelinidae (Hymenoptera), *Scolypopa australis.* predators:.Spider, birds •
Thrips	**Cultural control:** • Sprinkle water over the seedlings to check the multiplication of thrips **Biological control** • Release or augment the biological control agents like larval parasitoids- *Thripobius semiluteus and* predators like Predatory mite, predatory thrips, hover fly, mirid bug etc.
Phytophthora Root rot, collar rot and crown rot	**Cultural control:** • Control of the disease is reliant on good water management. • Kiwi should be planted in well-draining soils where water does not pool after rain or irrigation; • Vineyard should be allowed to dry out between irrigations
Brown headed leaf roller/ Green headed leaf roller	**Cultural Control** • Follow proper training and pruning in the vineyards. • Infested leaves should be removed and burned to destroy the eggs and caterpillars. **Biological control** • Release or augment the biological control agents like Predators: Predatory mite, Predatory Wasp and Larval parasitoids like *Trigonospila brevifacies*, Braconid wasp, *Dolichogenidea tasmanica, Goniozus jacintae*
Greedy scale	**Cultural Control** • Use propagative material that is free of scales. • Adequate plant spacing is important because armored scales seldom spread from plant to plant unless the crowns of the plants are in contact. • As plants grow, pruning maintains spacing and allows maximum coverage when using insecticides. **Mechanical Control** • Scraping and scrubbing to remove scales from plants are effective mechanical control tactics. **Biological control** • Release or augment the biological control agents like parasitoids Aphytis wasps, *Encarsia* sp. and predators: Green lacewings, Minute pirate bugs, and Ladybird beetle, C*hilocorus bipustulatus, Chilocorus infernalis, Chilocorus cacti*
Bacterial blight	• Control of the disease relies on the avoidance of injuries to the plant which allow bacteria to enter. • Infected areas should be pruned by cutting 1 foot below the edge of

	the canker. • Disease severity can be reduced by protecting plants from freeze injuries during winter
Two spotted mite	**Cultural Control:** • Maintain proper plant canopy microclimate by using timely training and pruning of the plants. **Biological control** • Predatory mites like *Amblyseius*, *Metaseiulus*, and *Phytoseiulus*; ladybird beetles, *Stethorus*; the minute pirate bugs, *Orius*; the thrips, *Leptothrips*; and the lacewing larvae, *Chrysopa*. *Scolothrips sexmaculatus, Phytoseiulus persimilis,* • In greenhouses, the ghost ant, *Tapinoma melanocephalum* (Fabricius are good predator)
Leaf spots	• Ensure that land to be used for new kiwi plantings is completely cleared of roots which are greater than 1 inch in diameter. • Ensure kiwi vines are adequately irrigated but not overwatered
Sclerotium rot	• Implement deep ploughing during summer. • Use proper vineyard sanitation practices •
Botrytis fruit rot	• Remove infected leaves, debris and fruit mummies from the vineyard to prevent survival and spread of the pathogen. • Summer pruning is done to open the canopy for increased air movement and to reduce disease incidence
Reproductive stage	
Nutrients	• Micronutrient deficiency should be corrected by foliar spray of particular micronutrient. • In the bearing orchards, apply FYM and other fertilizers according to age of vines as given in table above. • Fertilizers are applied in tree basin about 30 cm away from the tree trunk. • Apply recommended micronutrients, if symptoms are observed.
Weeds	• Remove left over weeds from the vineyard to avoid further spread of weed seeds. • Use straw or black polyethylene mulch to avoid weed growth and to maintain soil moisture for longer period. • Mulching of vine basins with 10-15 cm thick dry grass also checks weed growth.
Brown headed leaf roller/ Green headed leaf roller	• Same as in vegetative stage
Greedy scale	• Same as in vegetative stage
Passion vine hopper	• Same as in vegetative stage

V. RODENT PEST MANAGEMENT

- ❖ Disturb and destroy the habitat (burrows) of the rodents by practicing clean cultivation
- ❖ Minimize the alternate food sources and secured habitation by removing the weeds and crop residues in/ around the vineyard s
- ❖ Practice burrow smoking using paddy straw or other natural smoking materials in 'ANGRAU/ NIPHM burrow fumigator' for 2-3 minutes for each burrow.
- ❖ Encourage the establishment of natural predator like barn owls by establishing barn owl perches/ wooden boxes in and around the crop vineyard s.
- ❖ Practice burrow smoking as individual and community, preferably on a campaign approach.
- ❖ Organize community rodent control campaigns using rodenticide poison baits through packeting and pocketing, before crop entering into reproductive phase (i.e. before P.I.). The optimum time for organizing mass rodent control campaigns will be 6 weeks after transplanting**.**

Action Plan for rodent management using rodenticide poison baits

- ❖ Practice poison baiting with anticoagulant, bromadiolone @0.005% (96 parts of broken rice + 2 parts of edible oil + 2 parts of 0.25% CB bromadiolone) on community approach.

  DAY – 1: Close all the burrows in the vineyard s, vineyard bunds, canal bunds and surrounding barren lands etc.

  DAY – 2: Count the re-opened burrows and treat the burrows with Bromadiolone chemical bait packets @ 10 g/burrow.

  DAY – 10: Observe the re-opened burrows and repeat baiting

- ❖ In cases of high level of infestation (>20 live burrows/acre) practice poison baiting with zinc phosphide @ 2.0% on community approach. PRACTICE PRE-BAITING TO AVOID BAIT SHYNESS

  DAY – 1: Close all the burrows in the vineyard s, vineyard bunds, canal bunds and surrounding barren lands etc.

  DAY – 2: Count the re-opened burrows and practice pre-baiting @ 20 g/burrow (98 parts of broken rice + 2 parts of edible oil)

  DAY – 4: Observe the re-opened burrows and treat the burrow with zinc phosphide poison bait (96 parts of broken rice + 2 parts of edible oil + 2 parts of Zinc phosphide) @ 10g/ live burrow. Collect the dead rats, if found any outside and bury them.

If any residual population is found, practice anti-coagulant poison susceptible individuals within the target population by providing unsprayed areas within treated vineyard s, adjacent "refuge" vineyard s, or habitat attractions within a treated vineyard that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

- ❖ Non Chemical poison bait: boil handful of wheat with pieces of bark of *Gliricidia sepium* and allow them to ferment overnight. Use the wheat grains as rat poison. Wheat grains may be wrapped in cloth dipped in the container for boiling. For a few minutes & may be taken out the next day.

VI. INSECTICIDE RESISTANCDE 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.

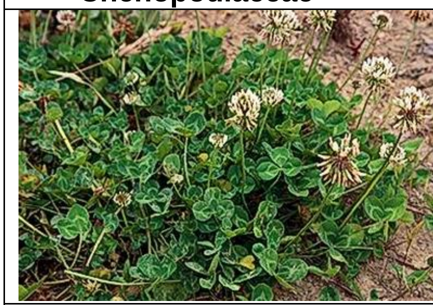
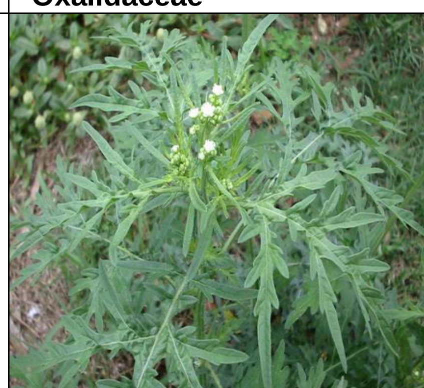
General strategy for insecticide resistance management: The best strategy to avoid insecticide resistance is prevention and including insecticide resistance management tactics as part of a larger integrated pest management (IPM) approach.

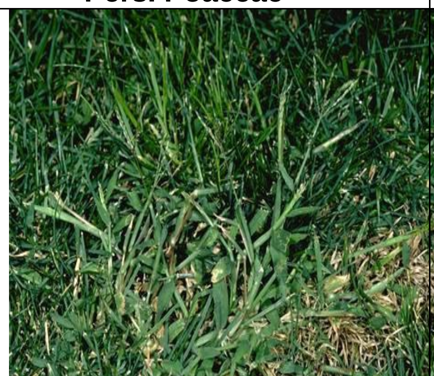
1) **Monitor pests:** Monitor insect population development in vineyard s to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.**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

VII. COMMON WEEDS

		
1. Lamb's quarters ***Chenopodium album* L.** **Chenopodiaceae**	**2. Pigweeds** ***Amaranthus* spp.** **Amaranthaceae**	**3. Nettle leaf goosefoot** ***Chenopodium murale* L.** **Amaranthaceae**
		
4. White clover: ***Trifolium repens* L.** **Fabaceae**	**5. Creeping wood sorrel** ***Oxalis corniculata* L.** **Oxalidaceae**	**6. Spurge:** ***Euphorbia hirta* (L.) Millsp** **Euphorbiaceae**
		
7. Goat weed: ***Ageratum conyzoides* L.** **Asteraceae**	**8. Congress grass:** ***Parthenium hysterophorus* L.** **Asteraceae**	**9. Horseweed plants** ***Conyza canadensis* L.** **Asteraceae**

		
10. Bluegrass: ***Poa annua* L.** **Poaceae**	**11. Burmuda Grass:** ***Cynodon dactylon* (L.)** **Pers. Poaceae**	**12. Johnson grass,** ***Sorghum halepense* L.** **Poaceae**
		
13. Cogon grass: ***Imperata cylindrical* L.** **Raeusch. Poaceae**	**14. Hairy crabgrass** ***Digitaria sanguinalis* L.** **Poaceae**	**14. Canary grass** ***Phalaris canariensis* L.** **Poaceae**
		
16. Knot grass: ***Paspalum distichum* L.** **Poaceae**	**17. Yellow nutsedge:** ***Cyperus esculentus* L.** **Cyperaceae**	**18. Purple nutsedge:** ***Cyperus rotundus* L.** **Cyperaceae**
		
19. Scarlet pimpernel:		

***Anagallis arvensis* L** **Primulaceae**		

1. http://www.veggiegardeningtips.com/wp-content/uploads/2006/05/Lambs-Quarters.jpg
2. http://www.ipm.ucdavis.edu/PMG/IMAGES/A/W-AM-APAL-MP.003.jpg
3. http://www.ipm.ucdavis.edu/PMG/IMAGES/C/W-CH-CMUR-MC.001.jpg
4. http://www.ipm.ucdavis.edu/PMG/IMAGES/T/W-LG-TREP-MP.003.jpg
6. http://botany.cz/foto2/euphorbiahirtaherb1.jpg
8. http://www.sprig.co.za/wp-content/uploads/2014/08/parthenium_hysterophorus3.jpg
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12. http://www.ipm.ucdavis.edu/PMG/IMAGES/S/W-GM-SHAL-MP.002.jpg
13. http://www.pfaf.org/Admin/PlantImages/ImperataCylindrica2.jpg
14. http://www.ipm.ucdavis.edu/PMG/IMAGES/D/W-GM-DSAN-MP.001.jpg
17. http://www.ipm.ucdavis.edu/PMG/IMAGES/C/W-CY-CESC-MP.004.jpg
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Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification* Directorate of Weed Science Research, Jabalpur, India Pp 354.

VIII. DESCRIPTION OF INSECT PESTS

1) Brown headed leaf roller:

Biology:

Eggs: Females lay eggs in smooth masses composed of up to 150 individual eggs. egg development period is about 9 days

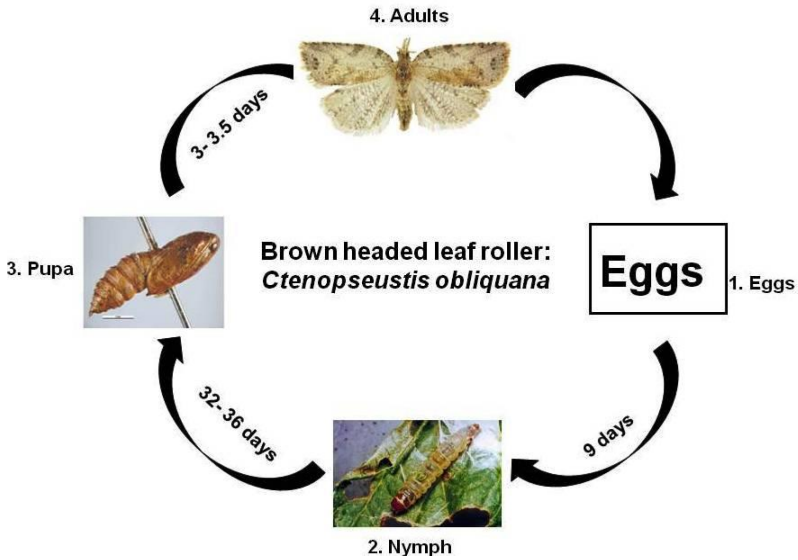
Larva: Early instar larvae web together shoot tips or roll leaves. Later instars feed on leaves, buds, and fruit of the host plant. Larval period is about male 32 and female 36 days. Larvae exhibited 5 or 6 instars

Pupa: Pupation occurs in the larval nest. prepupal period is about male 3 and female 3.5 days; pupal period is about male 16.4 and female 13.8 days.

Late instar larvae are approximately 20 mm in length with conspicuous pinacula. The head is dark brown to reddish brown and may be marked with faint red mottling. The prothoracic shield has dark shading on the lateral and posterior margins. Earlier instars have a black head and prothoracic shield.

Adults: Adults are brown to brownish gray with a variable wing pattern. Most individuals have several dark markings along the costa, including a remnant of the median fascia. Hind wings are mottled in both males and females. It completes 4-6 overlapping generations per year.

Life cycle:



Larva:http://idtools.org/id/leps/tortai/large/images/Ctenopseustis_obliquana/obliquana_HortResearch.jpg
Pupa: http://upload.wikimedia.org/wikipedia/commons/4/42/Ctenopseustis_herana_pupa_male.jpg
Adults: http://idtools.org/id/leps/tortai/large/images/Ctenopseustis_obliquana/obliquana3.jpg

Damage symptoms: They web together leaf edges or leaves and fruit to form a shelter to live in often rolling the leaves into a tube. The caterpillars eat leaves and fruit

Natural enemies of brown headed leaf roller:
Predators: Predatory mite, Predatory Wasp
Larval parasitoids: *Trigonospila brevifacies*, Braconid wasp, *Dolichogenidea tasmanica, Goniozus jacintae*

2) Green headed leaf roller:

Biology:

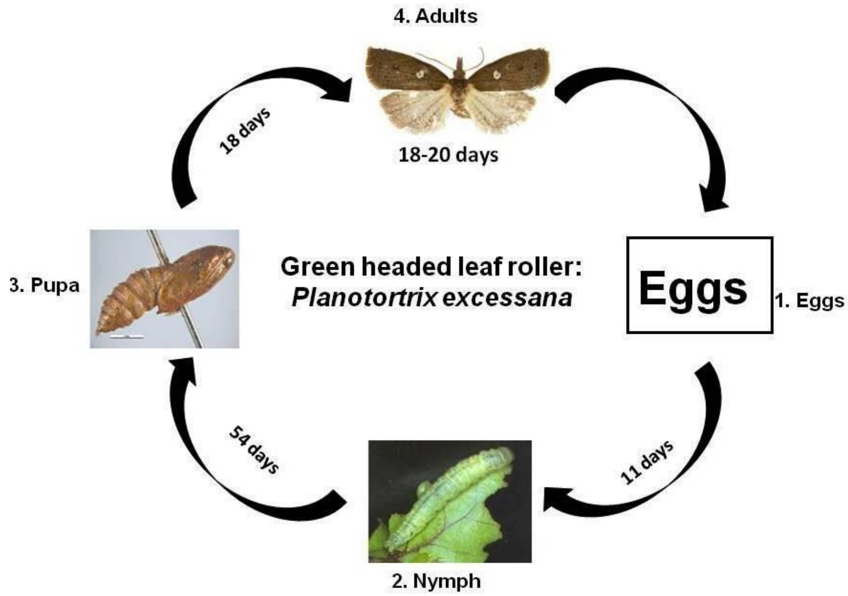
Eggs: Females lay eggs in masses that contain an average of 54 individual eggs. Egg masses of *P. excessana* have an opaque coating Egg development, 11 days;

Larva: Last instar larvae are approximately 25 mm long and entirely green. The head is transparent light brown to green and may have faint brown mottling. The prothoracic shield is pale green with no lateral shading. Ananal comb is present with 10-12 teeth. Larval period for male. 4 and female 54 days;

Pupa: Pupation takes place within the webbed foliage Pupal period for male and female 18 days;

Adults: Forewings are pale orange brown to dark reddish brown. Males are generally darker than females. Most individuals lack prominent wing markings except for a dark spot in the distal one-third of the forewing. Some individuals have a series of faint dark spots covering the wing and/or a white or pale spot in the basal one-third of the wing. Males have a forewing costal fold. Adult life span, .male. 20, .female. 18 days; 90% eggs laid in 10 days.

Life cycle:



Damage symptoms: They web together leaf edges or leaves and fruit to form a shelter to live in often rolling the leaves into a tube. The caterpillars eat leaves and fruit

Natural enemies of green headed leaf roller:
Predators: Predatory mite, Predatory Wasp
Larval parasitoids: *Trigonospila brevifacies*, Braconid wasp, *Dolichogenidea tasmanica, Goniozus jacintae*

3) Greedy scale:

Biology:
Eggs: Eggs are laid under the armor of the female where they develop and hatch.
Crawlers: The crawler stage is short, and crawlers do not feed. Crawlers may stay under the maternal armor several hours until outside conditions, especially temperature and humidity, are good. After they leave the cover, they wander for a period ranging from minutes to days, but usually a few hours.
Nymphs: Newly settled nymphs insert their piercing, sucking mouthparts into plant tissue and start feeding on plant juices. Female nymphs shed their skin twice as they grow and develop. Males have a 5 stage development and do not feed during the last two stages. The cast skins, called exuviae, are incorporated into the armor forming a dot near the center. The armor is non-living and is made of cast skins, threads, and liquid, all produced by the insect
Adults: Female greedy scales appear larvae-like. They remain under armor in one place throughout their lives to feed and reproduce. Males are tiny, winged creatures with eyes and legs. When mature they emerge from the armor in the late afternoon. They do not feed, living only a few hours to mate. Mate-finding is probably aided by pheromones secreted by females. Because of the late emergence and short life of males, they are rarely found in the vineyard.
Life cycle:

Damage symptoms:

- Infestations are spread by the mobile, young scale nymphs or 'crawlers' older nymphs and adults are sedentary. Scale insects attack the bark and fruit of kiwi.
- Heavy infestations affect the vigor of the plant and result in the presence of scales on fruit, causing it to be off grade

Natural enemies of Greedy scale:

Parasitoids: Aphytis wasps, *Encarsia* sp.
Predators: Green lacewings, Minute pirate bugs, and Ladybird beetle, C*hilocorus bipustulatus, Chilocorus infernalis, Chilocorus cacti*

4) Passion vine Hopper:

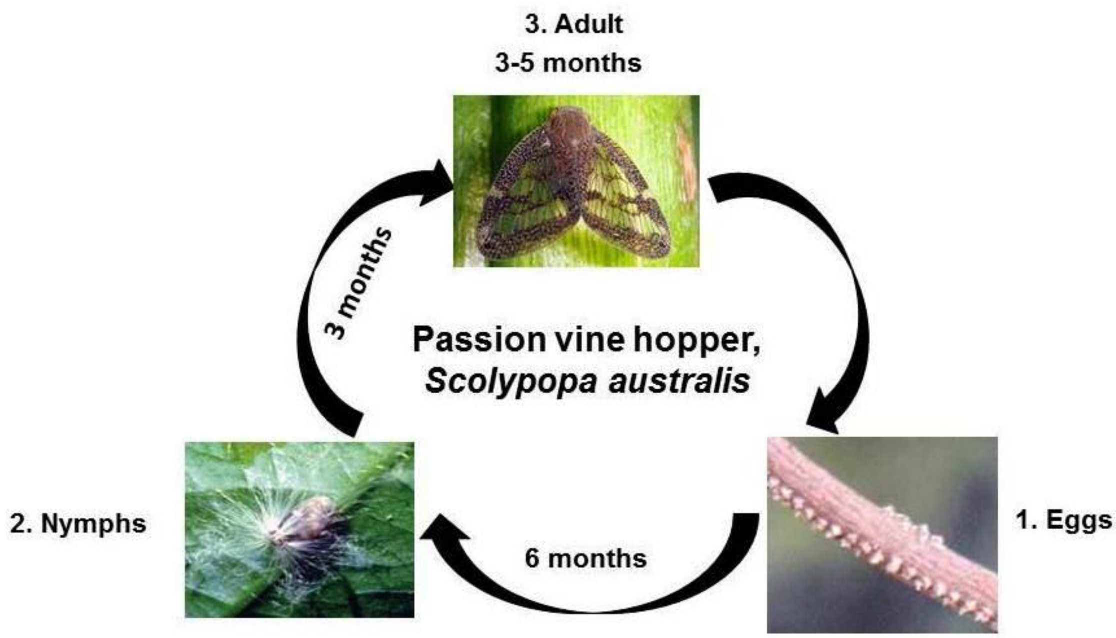
Biology:

Eggs: The Passion Vine Hopper population grows at the rate of one generation a year. They overwinter as an egg, with this stage lasting about six months. The eggs are inserted in plant stems, with relatively soft, dead or dying stems seem to be preferred.

Nymph: The nymph stage lasts about three months. They are greenish with a fluffy tail - visible around October.

Adult: The adult stage lasts about 3-5 months look for light brown small moths 8-10 mm around December.

Life cycle:



Adults:http://ketenewplymouth.peoplesnetworknz.info/image_files/0000/0006/9264/Hopper__Passionvine__Scolypopa_australis.JPG
Nymph: http://www.eastpack.co.nz/vdb/document/78
Eggs: http://www.kiwicare.co.nz/assets/Uploads/Problem-Images/Garden-Pests/_resampled/SetWidth300-Passion-vine-hopper-nymphs.jpg

Damage symptoms:

They suck sap from succulent shoots and the result is distortion of fruit and leaves. Plants will get stunted, wilted and dieback overall. Because of the copious production of honeydew the likelihood of sooty mould is very high.

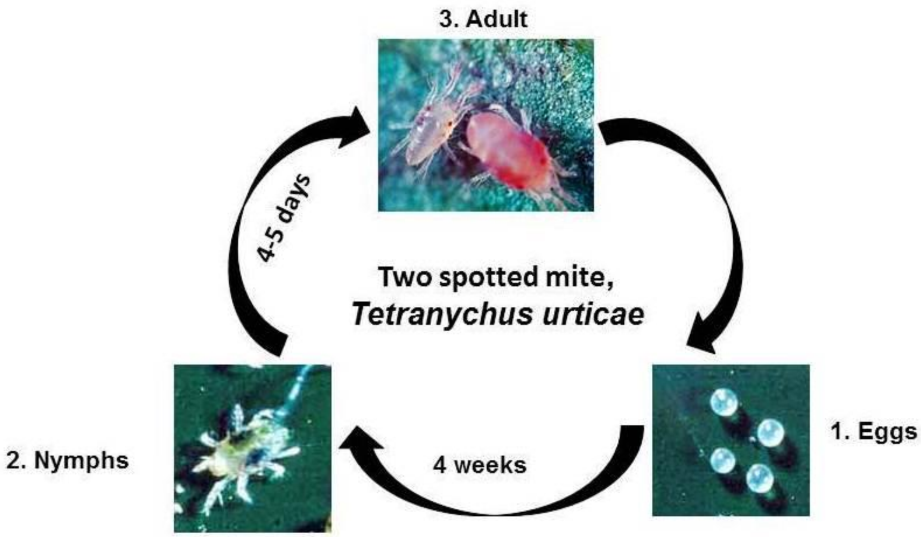
Natural enemies of Passion vine Hopper:

Parastioids:
Egg parasitoids: *Scolypopa australis,*
Predators:.Spider, birds

5) Two spotted spider mite

Biology:
Each female T. urticae mite lays 10-20 eggs per day, 80-120 altogether during its lifetime of up to 4 weeks. They are mostly attached to the silk webbing. The six-legged larvae hatch after 3-15 days. They molt three times within 4-5 days, towards protonymph, then deutonymph and at last adult. These instars all have eight legs. Before each molt there is a short quiescent stage. At favorable conditions the life cycle can be completed in about 1-2 weeks, including a pre oviposition period of 1-2 days. Often a change towards hot and dry weather leads to a very rapid increase of population density.

Life cycle:



Eggs: http://www.aces.edu/~azm0024/extension/images/twospotspmite_adult1.jpg
Adults: http://www.cropscience.bayer.com/~/media/Bayer%20CropScience/Global-Portal/Compendium/Pests/Tetranychus-urticae/tetranychus_urticae3b_600-jpg.ashx?w=600&bc=ffffff&as=true

Damage symptoms:
It penetrates plant cells, preferably on the undersides of leaves, and ingests their contents. Each minute 1-2 dozen cell can be destroyed this way. The first visible symptoms are small whitish speckles, mainly around the midrib and larger veins. When these spots merge, the empty cells give areas of the leaf a whitish or silvery-transparent appearance.

Natural enemies of two spotted spider mite

Predators of two spotted spider mite: *Scolothrips sexmaculatus, Phytoseiulus persimilis, Stethorus punctillum*

6) Thrips:

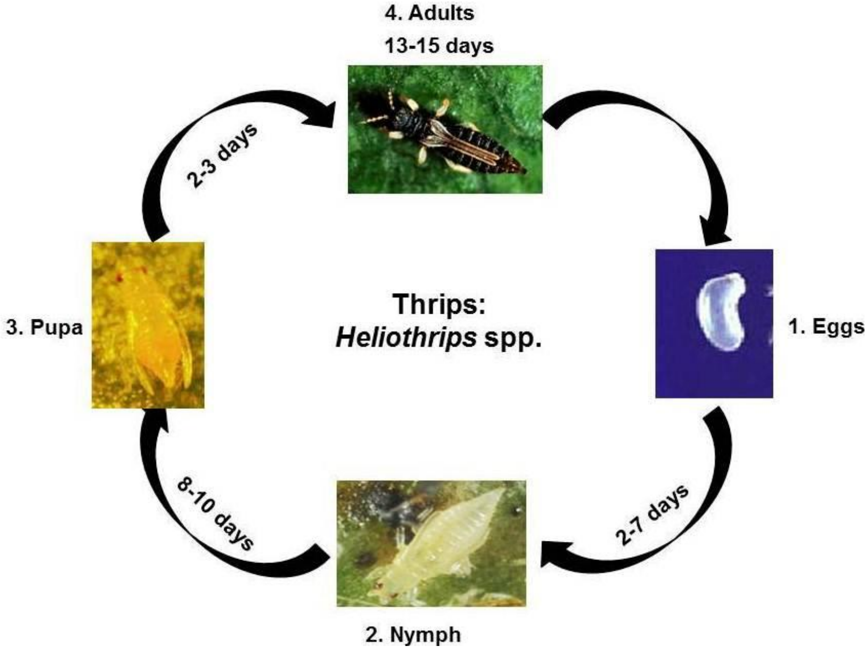
Biology:

Eggs: White, elongate and banana-shaped. Females insert eggs inside plant tissues above the soil surface. The eggs are microscopic.

Larva: Two larval instars, pre-pupa (3rd instar), and pupa (4th instar). Mature larvae approximately 1 mm (0.04 in.) in length. Whitish larval stage with red eyes; turn yellowish in color with maturity but retain red eyes. Pre-pupa and pupa are whitish to slightly yellow. Larvae resemble adults, but wingless. The larval abdomen is up-turned and has a dot of excrement on it. The excrement can cause spotting on the leaves.

Adults: 1.3 - 1.7 mm in length. Blackish-brown body with lighter posterior abdominal segments and white legs. Abdomen golden in newly emerged adults. Four translucent wings with numerous fringes surrounding each wing, folded back over the thorax and abdomen when at rest. Antennae have eight segments.

Life cycle:



http://www.hiddenvalleyhibiscus.com/forum/index.php?action=dlattach;topic=439.0;attach=1778
http://entnemdept.ufl.edu/creatures/orn/thrips/greenhouse_thrips06.jpg
http://169.237.77.3/news/images/heliothripshaemorrhoidalislarge.jpg

Damage symptoms:

Thrips uses its mouth-parts to rasp the leaf surface, rupture the epidermal cells, and feed on exuding cell contents. Feeding spots turn yellow then brown, and the surrounds become silvery where air enters the emptied cells

Natural enemies of thrips:

Parasitods:

Larval parasitoids: *Thripobius semiluteus*

Predators: Predatory mite, predatory thrips, hover fly, mirid bug etc.

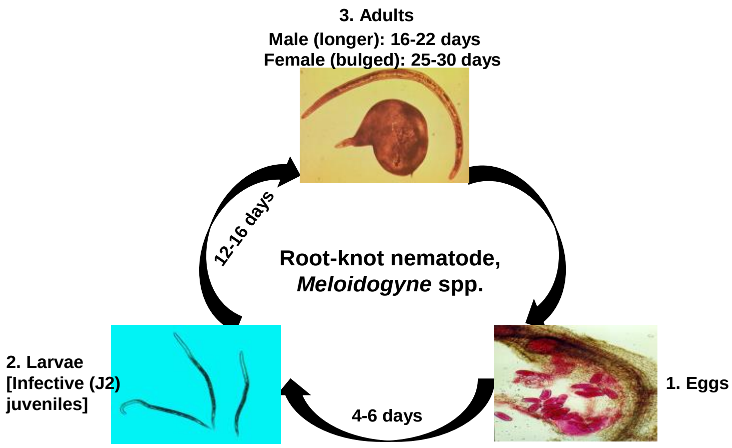
7. Root knot Nematode:

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.

- Development of the first stage larvae occurs within the egg where the first molt 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:



1.http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/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:

- 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
- Nematode infection predisposes plants to fungal and bacterial root pathogens

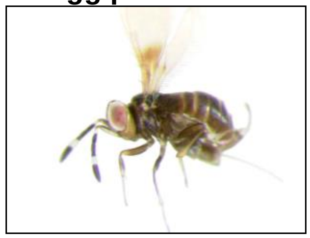
Survival and spread:

Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.
Secondary: Autonomous second stage juveniles that may also be water dispersed.
Favourable conditions: Loamy light soils.

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

Natural Enemies of Kiwi Insect Pests

Parasitoids
Egg parasitoids



1. *Ablerus* sp.

Larval parasitoids

2. *Thripobius semiluteus*

3. Braconid wasp

4. *Trigonospila brevifacies*

5. *Dolichogenidea tasmanica*

6. *Bracon* spp.

7. Goniozus jacintae

8. *Encarsia* sp

1. http://cache.ucr.edu/~heraty/Azotinae/1801touched.jpg
2. http://www.entocare.nl/english/foto's/foto's%20website%20oud/Thripobius_ad_urs.jpg
3. http://bugguide.net/images/cache/0H6RLHERTZIZ2LLZULJL2LFL6LYLWLLZ3ZKR2L0RULZZTZFLWLIZALFL9LHZFZ0RHH7Z1LJLWLIRYZRZ2LJLELFLNL.jpg
6. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
7. http://nature.berkeley.edu/millslab/Images/projects/Goniozus_adult240x140.jpg
8. http://www.zsm.mwn.de/hym/i/encarsia.jpg

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Predators of Kiwi Insect Pests

1. ***Stethorus punctillum***

2. ***Chilocorus bipustulatus***

3. ***Chilocorus infernalis***

4. ***Chilocorus cacti***

5. Coccinellid

6. Predatory mite

7. ***Phytoseiulus persimilis***

8. Spider

9. ***Scolothrips sexmaculatus***

10. Mirid bug

11. ***Chrysoperla***

12. Predatory wasp

13. Hover fly

14. Black drongo

15. Common Mynah

References

1.http://barry.fotopage.ru/gallery/files/46/CRW_1724.jpg
2. http://www.zin.ru/animalia/coleoptera/images/w_800/crw_5371.jpg
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4.http://bugguide.net/images/cache/MH1H4HAHUH4Z5LPZHLEZQL8ZRL2ZGH5ZGH5Z8HCHRLUZ5LNZ7L9ZPHRR7LRR2H9ZXL9Z9HBZ6HWZ4LNZGL6Z4H6ZIH.jpg
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12. http://bugguide.net/images/raw/URRQ9RJKVRYKVRJK1R50FQU0K0KQFRQQTR603R20H090FQU0CRN0Q0U0R020TRYKVRM09R50CQ40FQ.jpg
13. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html
14. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/

IX. DESCRIPTION OF DISEASES

1) Root rot, collar rot and crown rot

Disease symptoms:

- Reduced shoot growth. Leaves are small and chlorotic.
- Vines may collapse suddenly or show a gradual decline in productivity over several seasons.
- Red-brown discoloration of roots and root crowns which is visible when root is cut in two.


1. Dark roots are rotting due to *Phytophthora*. 2. Crown region of the plant showing discoloration of the cambium.

1.http://pnwhandbooks.org/plantdisease/sites/default/files/imagecache/image_lightbox/images/kiwi_phytophthora_12-0834a.jpg
2.http://pnwhandbooks.org/plantdisease/sites/default/files/imagecache/image_lightbox/images/kiwi-root-rot.JPG

Survival and Spread:

- The pathogen survives as oospores on the affected plant tissues in soil and on weed hosts.

Favourable conditions:

- Atmospheric temperature in the range of 10-20 °C and relative humidity 90% favours disease development.

2) Bacterial leaf spot and blossom blight:

Disease symptoms:

Symptoms include angular shaped spots, often associated with a halo, although not all leaf spots clearly exhibit the halo, brown discolouration of buds and, in advanced stages of infection, the leakage of red-rusty gum. Not all symptoms appear at the same time.

http://si.wsj.net/public/resources/images/OB-KT638_kiwi1__G_20101108034009.jpg
http://www.freshfruitportal.com/wp-content/uploads/2010/11/Kiwifruit-Leaf-Damage.jpg

Survival and spread:

- Disease is spread via windborne pollen, strong winds and heavy rainfalls. It is also believed to be spread by footwear, vehicles and orchard tools, animals and humans.

Favourable conditions:

- Favourable conditions are cool temperatures, persistent rains and high humidity. It temperature sensitive and active between 10 to 20 degrees.

3) Fungal Leaf spot:

Disease symptoms:

Vines may completely collapse; white mycelial mats may be present under bark close to the soil line; cortical tissue has a dark discoloration and white mycelial strands are present; root-like rhizomorphs extend from roots into soil*.*

Survival and spread:

- The fungal pathogen survives on diseased wood and roots below ground for many years

Favourable conditions:

- Disease emergence favored by continually damp soil

4) Storage Rot

Disease symptoms:

Symptoms of decay and signs of the pathogen develop as shriveled fruit that may have gray fungal growth mostly at the stem end and occasionally around the sepals or over the entire surface of the fruit. Diseased internal fruit tissues appear water-soaked and dark green. In advanced stages of the disease black, irregular-shaped sclerotia of the fungus up to about 0.2 inch (5 mm) in diameter may form on the infected fruit.

http://www.agri.ankara.edu.tr/bitkikoruma/1383_1252002154.pdf
http://fruitandnuteducation.ucdavis.edu/files/148444.jpg
***Botrytis* infected leaf and fruits**

Survival and spread:

- This disease is more severe when rainy weather occurs during bloom or especially at harvest.

Favourable conditions:

- The pathogen requires wetness for spore germination and infection

5) **Rhizoctonia stem Rot:**

Disease symptoms:

The pathogen causes a reddish brown dry cortical root rot that may extend into the base of the stem. Later in the season, infections at the base of the plant (cortical rot) may result in plants snapping off during high winds. Foliar symptoms yellowing or wilting of leaves.

Survival and spread:

- Pathogen survives on infected crop debris and soil which are source of primary inoculums.

Favourable conditions:

- The disease is more prevalent during rainy season.
- High soil moisture and moderate temperature along with high humidity leads to the development of the disease.

6. Sclerotinia rot

Disease symptoms:

- Infected fruit and stem first appear water soaked.
- Fluffy white cottony fungal growth is seen on infected area.
- Small hard black fungal structures known as sclerotia eventually develop embedded in the cottony mold.
- Fruits are often infected through the blossom end and became rotted and watery sclerotia may be inside these rotted fruits.

Survival and Spread:

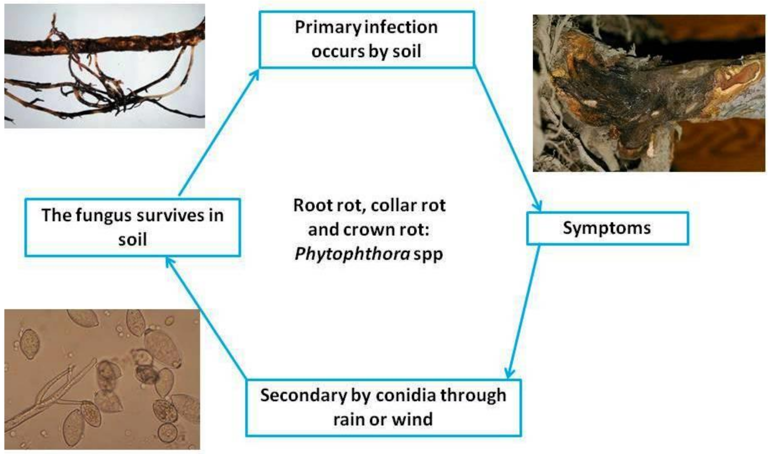
- The pathogen survives as mycelium in dead or live plants and as sclerotia in infected plant parts or on the soil surface or with seed as contaminant.

Favourable conditions:

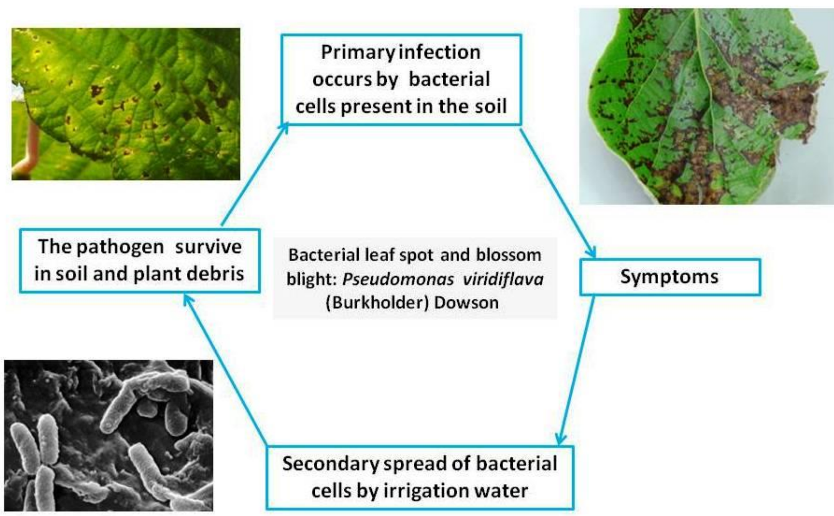
- High humidity (90-95%) and average temperature (18-25 ^{o}C) along with wind current favours the disease development.

<u>Disease cycles</u>:

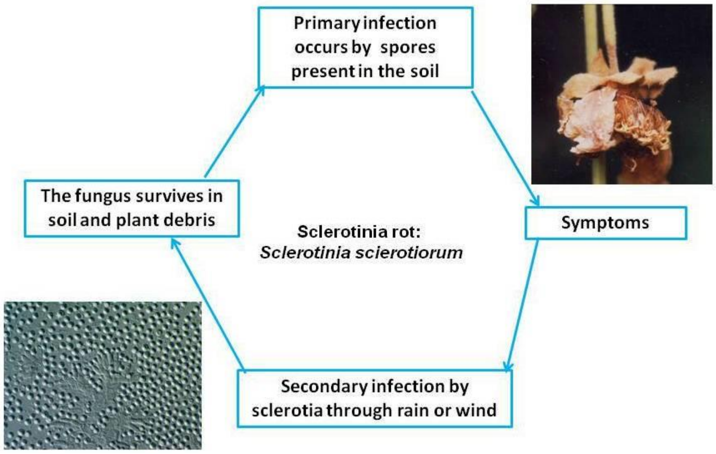
1. Root rot, collar rot and crown rot:



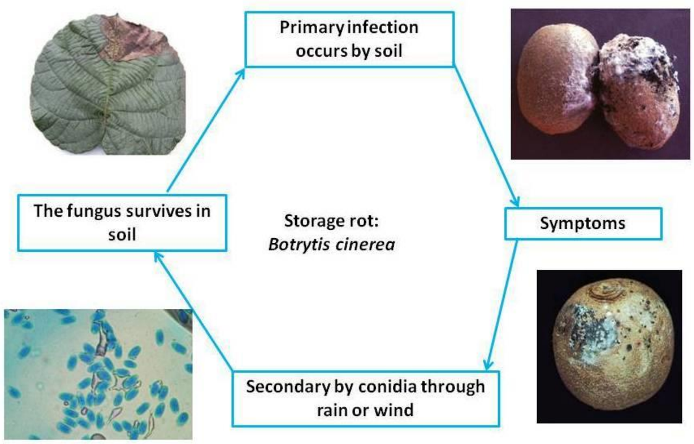
2. Bacterial leaf spot:



3. **Sclerotium rot:**



4. **Storage rot:**



XI. DESCRIPTION OF RODENT PESTS

1) Lesser bandicoot: *Bandicota bengalensis*	
• Distributed throughout India and infests almost all crops. • Robust rodent (200 to 300 g body weight) with a rounded head and a broad muzzle. Dorsum covered with grey-brownish rough hairs. Tail is naked, shorter than head and body. • Breeds throughout the season and litter size 6-8 in normal conditions. • Nocturnal and fossorial. Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil. • It is a major pest in irrigated rice crop	
2) Vineyard mouse: *Mus booduga*	

• Distributed in peninsular India to cutch in Punjab, Uttar Pradesh, Bihar, Odisha and in North east. • Habitats especially irrigated crop vineyard s. • Tiny mouse (10g) with slender, short, naked and bicolor tail • Nocturnal and fossorial. • Breeds throughout the year • Individually it is a minor pest but, accumulated losses will be more.	
3). Soft furred vineyard rat: *Millardia meltada*	
• Distributed in Punjab, Uttar Pradesh southwards to western and southern India, also found in foothills of eastern Himalayas. Found mostly in semi arid areas. • Small rodent (40-60gm) with soft fur, dorsum light grey and bicolored tail equal to the head and body. • It is associated with *T. indica* and *Musboodga* in northern part and with *Bandicota bengalensis* in southern part. • Nocturnal and tonsorial with simple burrows.	
Rodent damage at various growth stages	

X. SAFETY MEASURES

A. At the time of harvest:

Maturity Indices

- Minimum of 6.5% soluble solids content (SSC) at harvest
- Minimum flesh firmness of 14 lbf (penetration force with an 8-mm = 5/16 inch tip). Late harvested kiwifruits retain their firmness better than early harvested fruit and have higher SSC at harvest and when ripe

Quality Indices

- Freedom from growth cracks, insect injury, bruises, scars, sunscald, internal breakdown, and decay
- Minimum of 14% SSC when ripe (ready to eat); a kiwifruit at 2-3 lb flesh firmness is considered ripe

B. At the time of post harvest:

To ensure that fruits are a high quality, it is important to discard any damaged or diseased fruits prior to transport or storage so as to prevent them from having a negative effect on the healthy fruits. Kiwifruit must be firm and their skin and pulp must not be damaged either mechanically or by rot pathogens. To prevent injury to adjoining fruits, the stem-ends must be removed completely.

Temperature	Relative humidity	Maximum duration of storage
1.6°C	93%	6 months
0 - 0.5°C	90%	6 months
-0.5 - 0°C	90 - 95%	3 months

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 vineyard should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the vineyard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid monocropping.
3.	Grow only recommended varieties.	Do not grow varieties that are not suitable for the season or the region.
4	Sow/plant early in the season	Avoid late sowing/planting as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved biopesticides/chemicals for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
6.	Sow/plant in rows at optimum depths Under proper moisture conditions for better establishment.	Do not sow/plant seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition.	Crops should not be exposed to moisture deficit stress at their critical growth stages.
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 pheromone trap or	Do not apply chemical pesticides within seven days of release of parasitoids.

	as per vineyard observation	
14	Apply *Sl* 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.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XIII. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
2. **Do not** purchase leaking containers, loose, unsealed or torn bags; **Do not** purchase pesticides without proper/approved labels.
3. While purchasing insist for invoice/bill/cash memo

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** expose to sunlight or rain water; **Do not** store weedicides along with other pesticides.
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

1. Never carry/ transport pesticides along with food materials.
2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement
7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution
8. Concentrated pesticides must not fall on hands etc. while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipment

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

F. Precautions for applying pesticides

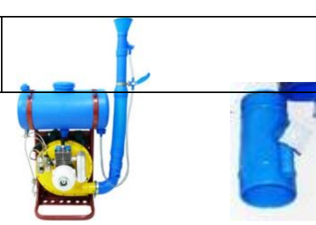
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction

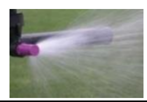
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc. with soap water after spraying
5. Containers buckets etc. used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the vineyard immediately after spraying
7. Avoid tank mixing of different pesticides

G. Disposal

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

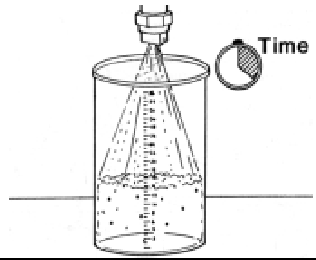
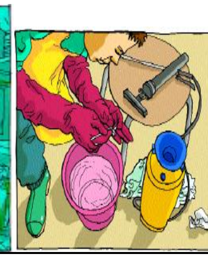
XIV. PESTICIDE APPLICATION TECHNIQUES

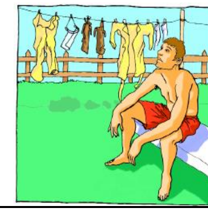
Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) for crawling and soil borne pests ii) for small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min ***or*** • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Vineyard flying pest/airborne pest			
Vegetative stage	Insecticides and	• Motorized knapsack sprayer or mist blower	

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

XV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying	

	under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	  
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	 
5.	Do not apply in hot or windy conditions.	 
6.	Operator should maintain normal walking speed while undertaking application.	

7.	Do not smoke, chew or eat while undertaking the spraying operation	   
8.	Operator should take proper bath with soap after completing spraying	  
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVI. REFERENCES

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