



सत्यमेव जयते

AESA BASED IPM PACKAGE

AESA based IPM - Grapes



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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

Ak 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)

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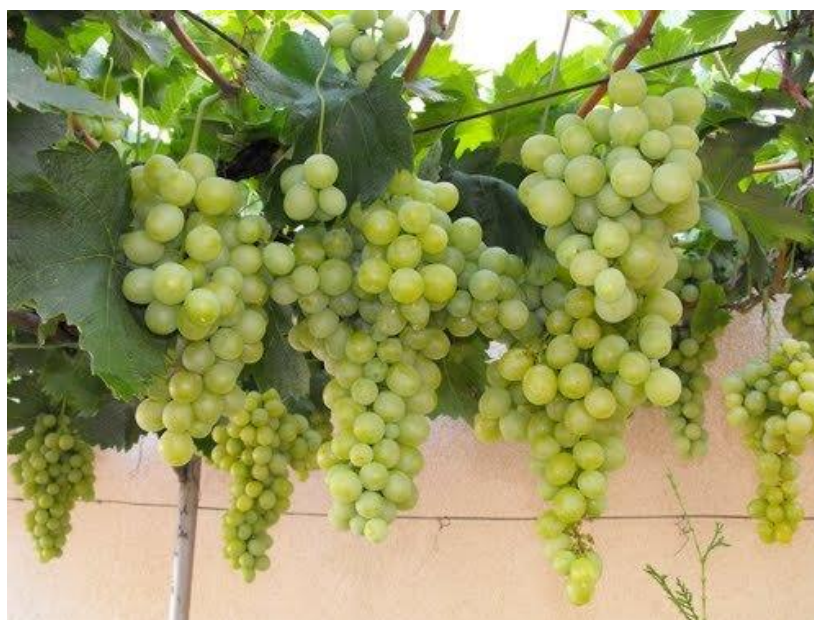
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AESA BASED IPM PACKAGE FOR GRAPES

Vitis (*Vitis vinifera* L; Family: Vitaceae) is a woody vine, with tendrils which help in supporting the weak stem, branching with long shoots (canes) from which secondary (and tertiary) shoots develop. Dead bark consisting of the old phloem and periderm is sloughed off as strips from old trunks and branches. Two types of bud are present at each node of the main shoot: the summer lateral bud and compound winter bud. From the summer bud, a shoot develops in the same year of formation (lateral shoot). The compound winter bud (the 'eye' or dormant bud) is formed by primary, secondary or tertiary buds. Primary buds normally grow in the spring after dormancy; secondary and tertiary buds do not develop unless the primary bud is damaged. A dormant bud which does not develop for one or more season is called a latent bud. Leaves are rounded to pentagonal, 12-25 x 10-20 cm, more or less indented, with 1, 3-5 or 7 lobes, margins irregularly toothed (with short to long teeth), from hairless to densely tomentose beneath. Flowers form branched clusters of 1-3 per shoot. Flowers are generally hermaphrodite, with five partly fused sepals, five green petals firmly united at the top forming a calyptra, detached at the base and falling off during anthesis. There are five stamens, a two-loculed pistil, one short style and one stigma; the superior ovary is formed by two locules each containing two ovules. The fruit is a fleshy berry, formed by a skin and a flesh (or pulp) containing the seeds. The grape berry is generally spherical or ellipsoid, >1 cm in diameter; the skin and pulp vary in firmness and colour (green-yellow, red, violet, blue for the skin), both varying in sugars, organic acids, polyphenols and other compounds. The juice is often sold in stores or fermented and made into wine, brandy or vinegar. In the wine industry, grape juice that contains 7–23% of pulp, skins, stems and seeds is often referred to as "must". In North America, the most common grape juice is purple and made from Concord grapes while white grape juice is commonly made from Niagara grapes, both of which are varieties of native American grapes, a different species from European wine grapes. In California, Sultana (known there as Thompson Seedless) grapes are sometimes diverted from the raisin or table market to produce white juice



I. PESTS

A. Pests of National Significance

1. Insect pests

- 1.1 Mealybugs: *Ferrisia virgata* Cockerell, *Maconellicoccus hirsutus*, *Pseudococcus maritimus*, *Ferrisia virgata* Cockerell (Hemiptera: Pseudococcidae)
- 1.2 Flea beetle: *Scelodonta strigicollis* (Olivier) (Coleoptera: Chrysomelidae)
- 1.3 Girdle beetle/Grape cane girdler *Ampelo glypterater* LeConte (Coleoptera: Cerambycidae: Curculionidae)
- 1.4 Thrips: *Rhipiphorothrips cruentatus* Hood (Thysanoptera:Thripidae)
- 1.5 Hoppers: *Empoasca fabae*, *Erythroneura comes* (Hemiptera: Cicadellidae)
- 1.6 Stem borers: *Celosterna scabrator* F., (Coleoptera:Cerambycidae)
- 1.7 Leaf eating caterpillar: *Spodoptera litura* F. (Lepidoptera: Noctuidae)
- 1.8. Grape leaf folder: *Desmia funeralis* (Hubner) (Lepidoptera: Pyralidae)

2. Diseases

- 2.1 Downy mildew: *Plasmopara viticola* (Berk. & Curt.) Berl.& de Toni
- 2.2 Powdery mildew: *Uncinula necator* (Schw.) Burr.
- 2.3 Anthracnose: *Elsinoe ampelina* (de Bary) Shear
- 2.4 Greenaria bitter rot: *Greenaria uvicola*Bark and Curt.
- 2.5 Bacterial leaf spot: *Xanthomonas campestris* pv. *Campestris* (Pammel) Dowson
- 2.6 *Alternaria* blight: *Alternaria alternata* (Fr.) Keissl., *Alternaria tenuissima* (Kunze) Wiltshire
- 2.7 Black rot: *Guignardia bidwelli*(Ellis) Viala & Ravaz
- 2.8 Post harvest berry rots caused by fungi
 - a. Blue mould rot: *Penicillium digitatum* (Pers.) Sacc.
 - b. Black mould rot: *Aspergillusniger* Van Tieghem
 - c. Green mould: *Aspergillus flavus* Link.
 - d. Rhizopus rot: *Rhizopus nigricans* Ehrenberg
 - e. Botrytis Bunch Rot or Gray Mold of Grape: *Botrytis cinerea* (De Bary) Whetzel

3. Nematodes

- 3.1 Root-knot Nematode: *Meloidogyne* spp.,

4. Weeds

Broadleaf

1. Pigweed: *Amaranthus viridis*, Hook. F. (Amaranthaceae)
2. Common purselane: *Portulaca oleracea* L. (Portualacaceae)
3. False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)
4. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
5. Goat weed: *Ageratum conyzoides* L. (Asteraceae)
6. Coat buttons: *Tridax procumbens* L. (Fabaceae)
7. Spanish needles: *Bidens pilosa* L. (Asteraceae)
8. Silk leaf: *Lagascea mollis* Cav. (Asteraceae)
9. Madras leaf-flower: *Phyllanthus madraspatensis* L. (Euphorbiaceae)

Grasses

10. Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)

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

Sedges

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

13. Flat sedge: *Cyperus iria* L. (Cypraceae)

B. Pests of Regional Significance

1. Insect pests

1.1. Red mites: *Tetranychus* spp. (Acari: Tetranychidae) (Maharashtra)

1.2. Rose chafer beetle: *Macrodactylus subspinosus* F., (Coleoptera: Scarabaeidae)

1.3 Cock chafer beetle: *Melolontha melolontha* L. (Coleoptera: Scarabaeidae)

1.4 Grape leaf roller: *Sylepta lunalis* Guen. (Lepidoptera: Pyralidae) (Delhi)

1.5 Scale Insects: *Aspidiotus lataniae* Signoret (Hemiptera: Diaspididae)

2. Diseases

2.1 Rust: *Phakopsora vitis* Ono

2.2 Leaf Spot: *Phomopsis viticola* Erincik and Madden (Andhra Pradesh)

2.3 Foot rot: *Cylindrocarpon* spp.

2.4 Irregular cane maturity due to *Botrydiplodia* sp.

3. Nematode

3.1 Reniform nematode: *Rotylenchulus reniformis* Linford and Oliveira (Andhra Pradesh, Maharashtra)

3.2 Dagger nematode: *Xiphinema americanum* Micol

II AGRO-ECOSYSTEM ANALYSIS (AESAs) 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 field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

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

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

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

Principles of AESA based IPM:

Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Treat the cuttings with recommended pesticides especially biopesticides
- Select healthy cuttings
- 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 vineyard regularly (climatic factors, soil and biotic factors):

Farmers should:

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



Understand and conserve defenders:

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

Insect zoo:

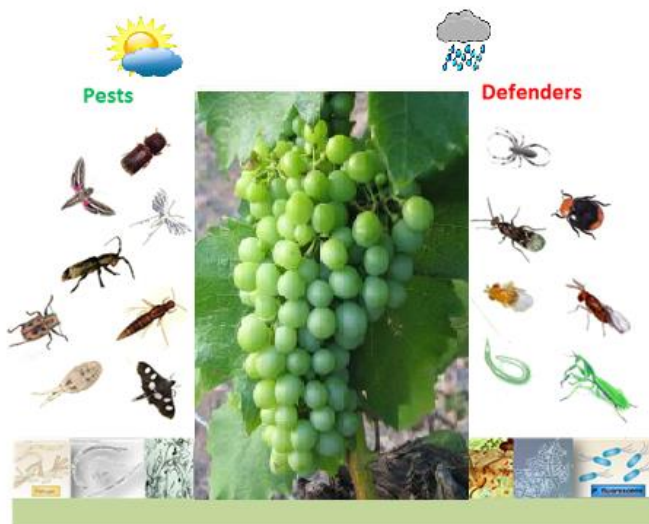
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial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

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of grape pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-ecosystem Analysis Chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situation

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2:1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides 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 field conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

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

AESA methodology:

- Go to the vineyard in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
 - Plant: Observe the plant health, crop stage, deficiency symptoms etc.
 - Insect pests: Observe and count insect pests at different places on the plant.
 - Defenders (natural enemies): Observe and count parasitoids and predators.
 - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
 - Weeds: Observe weeds in the field and their intensity.
 - Water: Observe the water situation of the field.
 - 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 field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field 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 field 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:

- **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 field.
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.

- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What are problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.



Advantages of AESA over ETL

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

AESA and farmer field school (FFS)

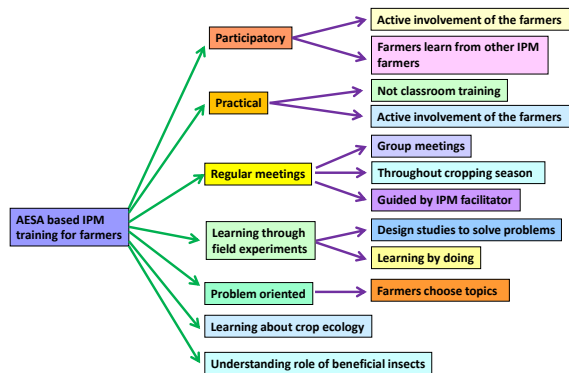
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

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



FFS to teach AESA based IPM skills



B. Field scouting:

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

Surveillance on pest occurrence at the main field should commence soon after crop establishment and at weekly intervals thereafter. In each field, 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:

For mealy bug: Count and record the number of both nymphs and adults on randomly selected shoot leaves) per plant.

For *Spodoptera*: Count the number of young and grown up larvae on each plant and record.

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

C. Surveillance through pheromone trap catches for *Spodoptera*

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

D. Blue sticky traps:

Set up blue sticky traps 15 cm above the canopy for monitoring thrips @ 4-20 traps (15 X 7.5 cm)/acre. Locally available empty tins can be painted blue/ coated with grease/ Vaseline/castor oil on outer surface may also be used as blue sticky trap. Count the number of pests on the traps daily and take up the intervention when the population exceeds 100 per trap

E. Light traps:

Set up light traps @1 trap/acre 1 feet 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). Count the number of thrips on the traps daily and take the appropriate decision regarding management practices

F. Nematode extraction:

Collect 100 to 300 cm³ (200-300 g) of 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. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004 a,b).

Natural enemies may require:

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelter such as overwintering sites, moderate microclimate etc.
3. Alternate hosts when primary hosts are not present.

Ecological engineering for pest management – Above ground:

- 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 like *Tridax procumbens*, *Ageratum* sp, *Alternanthera* sp, 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.

Ecological engineering for pest management – Below ground:

- 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.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/ cutting, and soil application (If Commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen, fruits, insects, etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, *Chrysoperla*, earwigs, etc.

Ecological Engineering Plants

Attractant plants



Carrot



Sunflower



Desmodium



Buckwheat



French bean



Alfaalfa



Mustard



Cosmos



Anise



Caraway



Dill



Chrysanthemum sp.



Maize

Urdbean

Repellent plants



***Ocimum* sp**



Peppermint/Spearmint

Trap plants



Marigold



Castor

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:

Pests/disease	Tolerant/ Resistant Variety
Nematode	Dogridge and 1613
Phylloxera	Dogridge and 1613
Powdery mildew	Chholth Red ,Skibba Red, Chholth white
Downy mildew	Amber Queen, Dogridge, Red Sultana
Anthracoese	Golden queen, Goldenmuscat, Bangalore blue
Powdery mildew and downy mildew	Bangalore blue, Concord, Champion, Catawba
Anthracoese	Pusa Navrang
Anthracoese and Cercospora leaf spot	Bangalore blue -
Anthracoese and Cercospora leaf spot.	Convent large black-
Grape diseases and pests	Berries yellow- green,Himrod-

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

IV. CROP-STAGE WISE IPM

Management	Activity
Pre sowing Stage*	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Deep ploughing of fields during summer to control nematodes population, to expose pupae and popagules of soil borne pathogens. • Soil solarization can be done for sterilizing the nursery mixture • Timely sowing should be done. • Field sanitation, rogueing. • Destroy the alternate host plants as well as crop debris • Crop rotation with non-cereals. • Adopt ecological engineering by growing the attractant, repellent, and trap crops around the field bunds.
Nutrients	<ul style="list-style-type: none"> • The rooted grapevine cuttings are planted in pits at an appropriate spacing depending on the soil, agro-climatic conditions and varieties. • Grape is a heavy feeder of nutrients. Nutrient should be supplied on the basis of soil test report, varieties and recommendation for the particular agro-climatic zone. • The land should be ploughed well and raise a green manure viz., sunhemp during monsoon and incorporate <i>in-situ</i> in August and September.
Weeds	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Plough the field in summer/ before planting to destroy existing weeds in the field.

	<ul style="list-style-type: none"> Grow the green manure crop to suppress weeds in rainy season. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> 2,4-D Sodium salt Technical @ 1 Kg in 200 l of water/acre Diuron 80% WP@ 0.8 Kg in 250 l of water/acre Paraquat dichloride 24% SL@ 0.8 l in 200 l of water/acre
Defoliators/ Subterranean pests Soil- borne- Pathogen	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Rabbing with paddy husk/ straw. For others follow common cultural practices
Sowing stage*	
Nutrients	<ul style="list-style-type: none"> At the time of planting, fill up the pits with well decomposed farmyard manure @ 50 Kg per pit mixed with top soil, <i>Trichoderma</i> species and AM @ 50g inoculum / plant.
Weeds	<ul style="list-style-type: none"> Use weed free seedling for planting. Remove existing weeds in and around the pits at the time of planting. Provide plastic or straw mulch around the seedling to prevent weed growth and to conserve moisture.
Root-knot nematode	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Intercropping of marigold reduces nematode population Nursery should be raised in nematode free sites or fumigated or solarized beds Repellant plants: Marigold Follow common cultural practices. Application of decomposed poultry manure @ 200g / sq. m
Leaf blight Anthracnose	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Irrigation by rose can. Use of resistant varieties such as– Bangalore Blue, Beauty Seedless, Bharat Early, Golden queen, Large white. <p><u>Chemical control:</u></p> <p>For anthracnose</p> <ul style="list-style-type: none"> Aureofungin 46.15%w/v. SP@ 0.005%, 300 l/acre or benomyl 50% WP@120 g in 250-280 l of water/acre or Carbendazim 50%WP@ 120 g in 240 l of water/acre or chlorothalonil 75% WP@ 0.2% or 200 g in 100l of water /acre or iprodione 50% WP@ 0.4-0.8 Kg in 200 l of water/acre or kitazin 48% EC @ 0.20%or 200 ml in 200 l of water As required depending upon crop stage and plant protection equipment used or mancozeb75%WP @ 0.6-0.8 Kg in 300 l of water/acre or ziram80%WP@ 0.6-0.8 Kg in 300-400 l of water/acre
Note: Apply <i>Trichoderma viride/harzianum</i> and <i>Pseudomonas fluorescens</i> as soil application (If Commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage	

	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Provide irrigation at critical stages of the crop • Avoid water stress and water stagnation conditions. • Enhance parasitic activity by avoiding chemical spray, when larval parasitoids are observed <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Collection and destruction of eggs, and larvae • Removal and destruction of dead vines along with root system from the garden is essential as this reduces the build up of inoculum (fungal population). • Collect and destroy diseased and insect infected plant parts • Use blue sticky traps for thrips @ 4-20 traps/acre. • Install pheromone traps @ 4-5 traps/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm <p><u>Common biological practices:</u></p> <ul style="list-style-type: none"> • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies. 																																														
Nutrients	<p>Table #. Recommended doses of nutrients (Kg/acre) for different varieties under different agro-climatic regions.</p> <table border="1" data-bbox="456 1037 1313 1787"> <thead> <tr> <th>Variety</th> <th>Region</th> <th>N</th> <th>P₂O₅</th> <th>K₂O</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Anab-e- Shahi</td> <td>North India</td> <td>150-240</td> <td>120-220</td> <td>75-480</td> </tr> <tr> <td>Telangana</td> <td>175</td> <td>122</td> <td>315</td> </tr> <tr> <td>South interior Karnataka</td> <td>200</td> <td>200</td> <td>400</td> </tr> <tr> <td>Beauty Seedless</td> <td>North India</td> <td>65</td> <td>-</td> <td>-</td> </tr> <tr> <td>Cheema Sahebi</td> <td>Maharashtra</td> <td>240</td> <td>96</td> <td>48</td> </tr> <tr> <td>Gulabi, Himrod, Perlette</td> <td>North India</td> <td>180-280</td> <td>185-530</td> <td>185-400</td> </tr> <tr> <td rowspan="3">Thompson Seedless</td> <td>North India</td> <td>180-440</td> <td>530</td> <td>530</td> </tr> <tr> <td>Maharashtra</td> <td>265-400</td> <td>200-350</td> <td>265-320</td> </tr> <tr> <td>South interior Karnataka</td> <td>120</td> <td>200</td> <td>400</td> </tr> </tbody> </table> <p><i>Source: The Grape Improvement, Production & Post-harvest management by</i></p>	Variety	Region	N	P ₂ O ₅	K ₂ O	Anab-e- Shahi	North India	150-240	120-220	75-480	Telangana	175	122	315	South interior Karnataka	200	200	400	Beauty Seedless	North India	65	-	-	Cheema Sahebi	Maharashtra	240	96	48	Gulabi, Himrod, Perlette	North India	180-280	185-530	185-400	Thompson Seedless	North India	180-440	530	530	Maharashtra	265-400	200-350	265-320	South interior Karnataka	120	200	400
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	<p><i>K.L. Chadha, S.D. Shikhamany.</i></p> <ul style="list-style-type: none"> • Apply nutrients through combination of organic manures (40%) and Inorganic fertilizers (60%). • In both the seasons prior to pruning the top 15 to 20 cm soil in the basin is dug out and heaped around the trunk. Organic manures are spread uniformly in the basins and then fertilizers are applied and covered with soil. • Apply fertilizers around root feeding zone i.e. at about 15 cm depth and 60 cm away from the trunk.
Weeds	<ul style="list-style-type: none"> • Regular weeding is important during the young stage of plants. • Break the crust with hand hoe each time after irrigation. • Plough the area between the basins during the pre-monsoon, post-monsoon periods. • Integrated weed management including cover crops, judicious use of herbicides, intercropping and hand weeding wherever necessary should be adopted. • Under highly weed infested orchards, apply 2, 4-D Sodium salt Technical (having 2, 4-D acid 80 % w/w) @ 1lit per acre in 200 l water to control broadleaf weeds or apply Diuron 80% WP @ 0.8 Kg per acre in 250 l water to control wide range of weeds or paraquat dichloride 24% SL @ 0.8 Kg/ acre in 200 l water as post-emergence directed inter row application at 2-3 leaf stage of grasses, sedges and broad leaf weeds. <p>Source: APHU (2010). Package of practices of important Horticultural Crops. Venkataramannagudem, West Godavari District – 534 101 (A.P.).</p>
Leaf eating caterpillar	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Growing of castor as trap crop all around the vineyard for oviposition. • Follow common cultural and mechanical practices. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Spraying NSKE 5 % against eggs and first instar larva • Follow common biological practices
Stem borer/cane borer	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Piercing the infested plants with a sharp needle or knife to kill the caterpillar in the stem. • Remove loose bark at the time of pruning to prevent egg laying • Follow common cultural practices. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Follow common biological practices.

<p>Hoppers</p>	<p><u>Cultural Control:</u></p> <ul style="list-style-type: none"> • Plant tall border crops like maize, sorghum or pearl millet to reduce hopper infestations. • Keep the nursery area clean, free of weeds and grasses to keep away the grass hoppers. • Removal of weeds and alternate hosts plants like hibiscus, okra, custard apple, guava etc. in vineyards. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Follow common biological practices. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray oxydemeton–methyl 25% EC @ 400 ml in 200-400 l of water/acre
<p>Mealybugs</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Removal of weeds and alternate host plants like hibiscus, okra, custard apple, guava etc in and nearby vineyards throughout the year. • Deep ploughing in summer or raking of soil in vineyards helps to destroy its nymphal stages and minimizing the incidence. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Remove and destroy the loose bark. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Release exotic predator, <i>Cryptolaemus montrouzieri</i> @ 10 beetles/vine • Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations viz., 50000 ppm formulation is sprayed at 1ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml per l, respectively. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Buprofezin 25% SC @ 400-600 ml in 200-400 l of water/acre or methomyl 40% SP @ 500 g in 200-400 l of water/acre
<p>Flea beetle</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Remove the loose bark at the time of pruning to prevent egg laying. • Shake vines to dislodge adult beetles, collect into trays containing kerosenated water (1 kerosene: 9 water) and destroy them. • Put bundles of dry shreds of banana on the pruned end of the vines in the evening. Beetles, which take shelter on these at night, can be shaken and collected in the morning and kill them. • Use high quality, large, vigorous seed- the quicker a seedling can establish itself the more damage it can withstand from flea beetles. • Seed early - a plant that establishes quickly can ward off flea beetles more effectively. Caution advised if high populations are seen early in fields when planting. Crops must be monitored daily upon emergence for damage. • Crop rotation - flea beetles over-winter along field edges and migrate so following a crop rotation does not make your crop immune to flea beetles, but if problems with flea beetles persisted the year before,

	<p>planting canola again will contribute to high populations once again.</p> <ul style="list-style-type: none"> • Direct seeding - provides a microclimate that warms slower than a conventionally seeded crop. Cooler temperatures slow flea beetle activity, reducing damage. • Increase seeding rates - increased plant populations means less damage to each specific plant. • Wider row spacing - reduces the attractiveness to the flea beetles <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Follow common practices. • Setting up of light trap @ 1/acre (6-10 pm). <p><u>Botanical control:</u></p> <ul style="list-style-type: none"> • Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations viz., 50000 ppm formulation is sprayed at 1ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml per liter dose, respectively. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Imidacloprid 17.8%SL @ 120-160 ml in 400 l of water/acre or lambda-Cyhalothrin 4.9%CS @ 100 g in 200-400 l of water/acre or malathion 50% EC @ 400 ml in 600-800 l of water/acre
Chafer beetle	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Eliminate hibernating site • Follow common practices. <p><u>Chemical control</u></p> <ul style="list-style-type: none"> • Malathion 50% EC @ 400 ml in 600-800 l of water/acre
Girdle beetle/Grape cane girdler	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Cutting of infested shoot below the lower girdle before adult emerge in the summer and destroy them may help to reduce the population of insects. • If low levels of grape cane borer are present in your vineyard, populations can be reduced by cultural practices such as removal and destruction of affected canes and excess dead wood from the canopy during pruning. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Malathion 50% EC @ 400 ml in 600-800 l of water/acre
Thrips	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Install 4-20 blue sticky coloured traps per acre to monitor thrips population. • Deep ploughing in summer or raking of soil in vineyards helps to destroy its nymphal stages and minimizing the incidence. • Removal of weeds and alternate host plants like hibiscus, okra, custard apple, guava etc. in and nearby vineyards in and around the vineyards throughout the year. • Collect and destroy damaged leaves, fruits and flowers. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Emamectin benzoate 5% SG @ 88 g in 200-400 l of water/acre or fipronil 80%WG @ 20-25 g in 300-400 l of water/acre or lambda-cyhalothrin 4.9% CS @ 100 g in 200-400 l of water/acre

Mite	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Proper irrigation scheduling reduces the water stress and also increases the humidity thereby reducing the mite population <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Several predatory insects and spiders feed on mites but the most efficient natural predators of mite pests are predatory mites.
Leaf folder/Leaf roller	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Simple method to control the pest population is to collect and burn the infested leaves. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Follow common practices.
Powdery mildew	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Cultural practices that reduce humidity within the vineyard, enable good air circulation through the canopy, and provide good light exposure to all leaves and clusters aid in managing powdery mildew. • Use an under vine irrigation system and manage it carefully, excess can favour the disease <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Benomyl 50 % WP @ 120 g in 250-280 l of water/acre or carbendazim 46.27% SC @ 0.1% or 100ml, 100l/acre or dinocap 48% EC @ 90 ml in 300 l of water/acre or flusilazole 40% EC @ 0.01% As required depending upon the stage of crop and type of plants protection equipment used or hexaconazole 2% SC @ 0.6-1.2 l in 200-300 l of water/acre or hexaconazole 5% EC @ 200-400 ml in 200 l of water/acre or kresoxim-methyl 44.3% SC @ 240-280 ml in 200 l of water/acre or lime sulphur 22% SC @ This liquid is used at one per cent in conventional sprayers: Doses 0.8-1 l/acre or myclobutanil 10% WP @ 0.04%, 200 l/acre or penconazole 10% EC @ 50ml/100Lt. water, Depending upon the requirement or sulphur 40% WP @ 1.2 Kg in 400 l of water/acre or sulphur 55.16 % SC @ 0.30% or 300 ml/100 l water as required or sulphur 80% WP @ 1-2 Kg in 300-400 l of water/acre or Sulphur 80% WG @ 0.75-1 Kg in 300-400 l of water/acre or sulphur 85% DP @ 6-8 Kg/acre or triadimefon 25% WP @ 0.010% in 300 l of water, depending upon the requirement
Downy mildew	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Pruning of the vines after the second week of October helps to minimize the damage by this disease. All affected portions of the vine should be removed at the time of pruning and destroyed immediately. • Downy mildew infected leaves should be selectively collected and disposed in compost pit. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Aureofungin 46.15% w/v. SP @ 0.005% , 300 l/acre or captan 50% WP @ 1 Kg in 300-400 l of water/acre or captan 75% WP @ 666.8 g in 400 l of water/acre or chlorothalonil 75% WP @ 0.2% or 200 gm/ 100l water in 40 l/acre or copper oxychloride 50% WG @ 0.24% or 240g/100l water or copper oxy chloride 50% WP @ 1 Kg in 300-400 l of water/acre or copper sulphate 2.62 % SC @ 0.4 l in 200 l of water/acre or cymoxanil 50% WP @ 0.24% or 240 g/100 l water as required

	<p>depending upon the crop stage and equipment used or cyazafamid 34.5% SC@ 80 ml in 200 l of water/acre or dimethomorph50%WP @ 400 g in 300 l of water/acre or fosetyl-AL 80% WP @ 560-800 g in300-400 l of water/acre or kresoxim-methyl 44.3% SC@ 240-280 ml in 200 l of water/acre or mancozeb75%WP @ 0.6-0.8 Kg in 300 l of water/acre or propineb70%WP @ 0.30%or300 g/100 l water As required depending uponcrop stageand plant protection equipment used or zineb75%WP@ 0.6-0.8 Kg in 300-400 l of water/acre or ziram80%WP@0.6-0.8 Kg in 300-400 l of water/acre or cymoxanil8%+ Mancozeb64%WP @ 600-800 g in 200-400 l of water/acre or famoxadone16.6%+ Cymoxanil22.1%SC @ 200 ml in 200-300 l of water/acre or fenamidone4.44%+ FosetylAI 66.7%WG@ 800-1000 g in 200-300l of water/acre or fenamidone10%+ mancozeb50%WDG @ 600 g in 200-300 l of water/acre or metalaxyl M 4%+ mancozeb 64% WP @ 200-400 l/acre of 0.25% or metalaxyl8%+ mancozeb 64% WP@ 200 l/acre of 0.5% or metiram 55% + pyraclostrobin 5% WG @ 600-700 g in 300 l of water/acre</p>
Anthracnose, Blight	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Prophylactic measures should be followed for effective control. • All affected twigs or canes showing cankers should be removed while pruning. • The pruned twigs and leaves should be burnt or buried deep in the soil. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Same as sowing stage.
Bitter rot and bacterial leaf spot, Rust	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Collecting and burning the infected plant parts minimizes the spread of the disease. • Increase air circulation in the vineyard • Remove disease cane from the vineyard during normal pruning operations in the dormant season. • Follow up hand pruning
Flowering & Fruiting stage*	
Nutrients	<ul style="list-style-type: none"> • Collect about 200 random petiole samples (fifth leave from the base) 45 days after summer pruning (flower bud initiation) and analyze for the nutrients. Spray the following nutrients for the correction of the deficiency. • Spray zinc sulphate @ 2g/l or magnesium sulphate @ 2g/l or magnesium oxide @ 1g/l or borax @ 1 – 2 g/l
Weeds	<ul style="list-style-type: none"> • Remove weeds around the plants. • Use straw or plastic mulch to avoid weed growth and to maintain soil moisture for longer period.
Leaf eating caterpillar	<ul style="list-style-type: none"> • Same as vegetative stage.

Stem borer/Cane borer	<ul style="list-style-type: none"> • Same as vegetative stage
Hoppers	<ul style="list-style-type: none"> • Same as vegetative stage.
Mealybugs	<ul style="list-style-type: none"> • Same as vegetative stage.
Flea beetle	<ul style="list-style-type: none"> • Same as vegetative stage.
Girdle beetle/Grape cane girdler	<ul style="list-style-type: none"> • Same as vegetative stage
Thrips	<ul style="list-style-type: none"> • Same as vegetative stage.
Hoppers	<ul style="list-style-type: none"> • Same as vegetative stage
Leaf roller/Folder	<ul style="list-style-type: none"> • Same as vegetative stage.
Powdery mildew, Downy mildew	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Remove abnormal un-harvested bunches from vines and burn them. • Remove all shoots emerging from the crown near ground. • Shoots hanging from trellises towards ground should be tied on trellises or can be removed if they are extra. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Same as vegetative stage
Blight, Anthracnose, Bitter rot and Bacterial leaf spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Promote good air circulation and light penetration by controlling weeds and suckers, proper pruning, and positioning or removing shoots for uniform leaf development. • Where possible, rows should be planted in the direction of the prevailing wind. Good air circulation and light penetration will promote faster drying of plant parts and reduce disease incidence. • Prevent wounding of berries by controlling insects, birds and other grape diseases.
Botrytis rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Careful handling in the field, pre-cooling and refrigeration helps in controlling the disease. • Pruning and thinning of the vineyard reduces • Humidity around the clusters.
Blue rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoiding injuries to the ripe berries helps to reduce soft rot. • Clean planting stock; (i) Disease wood removal and immediate burning; (ii) fungicide application at shoot extension and later if temperatures are cool.

Birds. bats	<p><u>Cultural:</u></p> <ul style="list-style-type: none"> • Remove nesting and roosting areas • Bird patrols: takes time and energy but still effective, wear bright colors • Pyrotechnics – bombs and whistlers • Whistles: Thunderer is the Cadillac of whistles • Site selection: no trees, open fields • Noise makers: propane canons, electronic scare devices • Nets: still the best option for full protection • Traps • Tape, balloons, kites, etc. • Trap crops
Postharvest	
Black mould Rot, blue mould rot, green mould rot, botrytis rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Careful handling and prompt refrigeration to 1-2 °C or below prevents the disease in storage. • Inclusion of SO₂ releasing pads in the boxes while packing helps to control the disease.
Rhizopus rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Inclusion of SO₂ releasing pads in the boxes 2 while packing, removing of diseased berries during grading, avoiding injury to the berries while packing and handling helps to restrict the growth of fungi. • Avoiding injuries to the ripe berries helps to reduce soft rot. <p><u>Physical control:</u></p> <ul style="list-style-type: none"> • Maintaining cold storage temperature between 40-10 °C prevents fungal growth.

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

- 1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
- 2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
- 3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
- 4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.
- 5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.
- 6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.
- 7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance

VI. NUTRIENT DEFICIENCIES AND ITS MANAGEMENT

1. Nitrogen:

Deficiency symptoms:

- Overall reduction in growth.
- Leaves become uniformly light-green or yellow. Reddening of petiole
- Berries may be small

Management:

- Soil application of urea @ 20-60 Kg/acre
- Foliar spray of urea (0.3 – 0.5%) 1- 4 times along the growing season , depending on the deficiency severity



Leaves are pale green, turning yellow



Vineyard with serious nitrogen deficiency

2. Potassium:

Deficiency symptoms:

- Starts as yellowing (white varieties) or bronze-reddening (red varieties) of older leaf margins.
- As the deficiency worsens, leaf margins become necrotic and curl upwards and inter-veinal chlorosis develops.
- Berry set can be poor.

Management:

- Soil application of 200- 320 Kg K_2O /acre for 2-3 years
- Foliar sprays of sulphate of potash (0.4 -1%), 3-4 times every 15 d before and after flowering.
- Other commercial fertilizers containing K can be used



Yellow coloration of leaf edges



Burning of leaf edges

3. Calcium:

Deficiency symptoms:

- Shoot tips become stunted and may die.
- Necrosis at the margin of young leaves, necrotic dots, rolling up leaden and yellow adult leaves
- Cluster stem necrosis and berry withering



Management:

- Soil application of quicklime slaked lime , dolomite , calcium carbonate(.02-0.6 t/acre)
- Foliar spray of calcium chloride (1%)



4. Magnesium:

Deficiency symptoms:

- Bright yellow (white varieties) or red (red varieties) wedge-shaped areas extend inwards between the veins on older leaves.
- When severe, necrosis extends inwards from the leaf margins.
- Fruit cluster stem necrosis and berry withering



White cultivars

Red cultivars

Management:

- Soil application of 20-40 Kg MgO/acre
- Foliar application of Magnesium sulphate (2% if MgO = 32% or if MgO = 16%) or magnesium chloride /nitrate (1-1.5%) 3-6 times every week, beginning from fruit set
- Sprays against stem necrosis by magnesium sulphate (as above).



Symptoms start off as white and then change to red

5. Phosphorus:

Deficiency symptoms;

- Vines may have stunted shoots and fruitfulness is likely to be poor.
- Appearance of red dots on basal leaves, especially on the mid or terminal lobes and at first distant from secondary veins.
- The red dots, at first randomly distributed, later line up at right angles to the secondary veins and form dark red bars, which coalesce into islands between green veins.



Management:

- Apply ammonium mono phosphate as an N source (11-52-0)



http://www.honeycreek.us/leaf_chart.php

6. Sulphur:

Deficiency symptoms :

- Reddening of young leaves. Red dots near the edges of adults leaves. Red dots may coalesce later into red bars at right angles to the vein leaves can drop
- Reduced growth lignification is impaired
- Small and loose cluster, due to reduced fruit set

Management:

- Soil application of 20-40 Kg/acre P_2O_5

7. Boron:

Deficiency symptoms:

- Shoot tip death and short internodes, resulting in shoots with a zigzag appearance.
- Yellowing or reddening dots rolling down, corrugation and odd shapes in young leaves
- Fruit set is often poor and bunches often have 'hen and chicken' berries
- Browning of hypodermal cells and breaking of berry

Management:

- Soil application of borax(Sodium tetraborate) 12-32 Kg/acre
- Foliar application of solubor(20.5%B),0.25% 3 times every 15 days ,beginning from 5th -6th



Symptoms on young leaves

leaf development stage



Loose cluster due to poor fruit set

8. Iron:

Deficiency symptoms :

- Young leaves show inter-veinal chlorosis.
- When severe, leaves are likely to be very pale with necrotic blotches. Shoots are likely to be stunted in their growth.
- Loose cluster shot berries



Management:

- Soil application of Fe-EDTA or foliar application of Ferrous Sulphate (250g/100 litre water) + citric acid (50g)+ liquid detergent



9. Manganese:

Deficiency symptoms :

- Stunted growth
- Interveinal chlorosis or reddening of adults leaves . mosaic like arrangement of yellow /red spots , bordered by the smallest green veins
- Delay of berry ripening

Management:

- Foliar sprays of manganese sulphate (0.2 -0.5%) , 3 times, one before and two after flowering
- Foliar sprays of Manganese



Yellowish coloration between veins

chelates.

10. Zinc:

Deficiency symptoms :

- Short internodes, resulting in shoots with a zigzag appearance.
- Shoot tips have small upward curling of leaves.
- Mottled, light-coloured interveinal colouring on leaves. Small, poorly developed bunches with 'hen and chicken' berries.

Management:

- Soil application borax (sodium tetraborate) 12-16 Kg/acre
- Foliar sprays of zinc sulphate (.5 - 1.0%) neutralized with calcium carbonate, 3 weeks before flowering



Irregular growth of young leaves

Source: http://afghanag.ucdavis.edu/a_horticulture/fruits-trees/grapes/presentations/powerpoint/PPT_NUTRI_REQUIRE_FOR_GRAPEVINES.ppt

Physiological disorders:

i) Water berries:

Symptoms:

- Water berry is associated with fruit ripening and most often begins to develop shortly after berry softening.
- The affected berries become watery, soft, and flabby when ripe. They are almost normal in size but their flesh is not firm.
- They shrivel and dry by the time of harvest. Such berries mostly confine to the tip of the main rachis or its branches.
- This disorder occurs due to dense cultivation and inadequate nourishment available to all the berries in a cluster.
- Excessive irrigation and nitrogenous fertilizers should be avoided during berry development to reduce water-berry formation.










ii) Cluster-Tip wilting:



Symptoms:

- Light brown lesions on the apical end of the rachis affect the conductivity of the rachis.
- This results in shriveling and drying of the rachis at the tip of the bunch. Cluster pinching or berry thinning should be done to reduce excessive crop load on the vines.
- Ensuring adequate irrigation during the berry development and protection of bunches

from direct sunlight also help in reducing the incidence of cluster-tip wilting.
iii) Shot berries:
Symptoms: <ul style="list-style-type: none"> • Shot berries are smaller, sweeter, round and seedless as compared to normal berries. • They are formed due to delay in pollination and fertilization of a few flowers or due to inadequate flow of carbohydrates into the set berries. • Boron deficiency, incorrect application of Gibbrellic Acid and girdling are the reasons for shot-berry formation. • Boron or Zinc deficiencies should be corrected. Application of GA at proper stage should be ensured.
iv) Pink berry:
Symptoms: <ul style="list-style-type: none"> • As the bunch approaches maturity some berries in the bunch develop pink colour at random. • The pink colour changes to dull red colour rendering the bunch unattractive. Incidence of pink berries is low in the early season crop and increases with the rise in temperature late in the season. • Indiscriminate use of Etherel for berry colouration can also cause this disorder. • This is a serious problem in Thompson Seedless variety in Maharashtra.
v) Bud and flower drop:
Symptoms: <ul style="list-style-type: none"> • Flowers drop from the clusters just before and after opening. The buds drop on shaking the panicle. • Excessive bud and flower drop results in reduction of yield. Atmospheric temperature, high phosphorus and total salt contents of the soil are the different factors causing this malady. • Judicious irrigation practices and canopy management practices to improve ventilation during the flower development helps to minimize the flower bud and young berries drop. <p>This phenomenon is prevalent in North India in the states of Punjab, Haryana and Rajasthan.</p>
vi) Poor cane maturity:
Symptoms: <ul style="list-style-type: none"> • In this disorder, shoots fail to mature and their barks remain green until late in autumn. • Such shoots turn pink-red due to low temperature in winter. It is more serious in vineyards, where the shoot growth is vigorous and dense; vines are planted closely and excess nitrogen and irrigation are provided. • Judicious shoot pinching to check excessive vegetative growth; shoot thinning 30 days after summer pruning to prevent mutual shading of the shoots and promote light interception are some of the suggested remedial measures. • Poor cane maturity is a common phenomenon observed in peninsular India

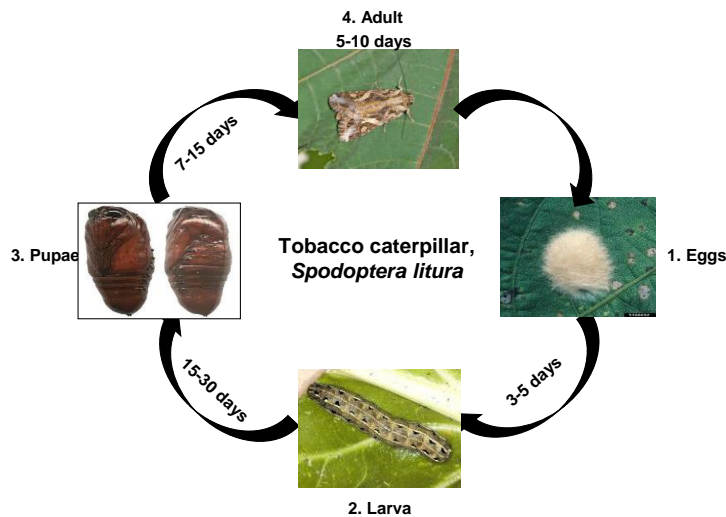
VII. COMMON WEEDS

		
<p>1. Pigweed: <i>Amaranthus viridis</i> Hook. F. (Amaranthaceae)</p>	<p>2. Common purselane: <i>Portulaca oleracea</i> L. (Portulacaceae)</p>	<p>3. Carrot grass: <i>Parthenium hysterophorus</i> L. (Asteraceae)</p>
		
<p>5. Goat weed: <i>Ageratum conyzoides</i> L. (Asteraceae)</p>	<p>7. Spanish needles: <i>Bidens pilosa</i> L. (Asteraceae)</p>	<p>8. Madras leaf-flower: <i>Phyllanthus madraspatensis</i> L. (Euphorbiaceae)</p>
		
<p>9. Silk leaf: <i>Lagascea mollis</i> Cav. (Asteraceae)</p>	<p>10. Barnyard grass: <i>Echinochloa crusgalli</i> (L.) Beauv. (Poaceae)</p>	<p>11. Bermuda grass: <i>Cynodon dactylon</i> (L.) Pers. (Poaceae)</p>

 <p>12. Purple nutsedge: <i>Cyperus rotundus</i> L. (Cypraceae)</p>	 <p>12. Flat sedge: <i>Cyperus iria</i> L. (Cypraceae)</p>	
<p>APHU (2010). Package of practices of important Horticultural Crops. Venkataramannagudem, West Godavari District – 534 101 (A.P.). http://upload.wikimedia.org/wikipedia/commons/thumb/6/60/Amaranthus_viridis.jpg/220px-Amaranthus_viridis.jpg Naidu, V.S.G.R. 2012, <i>Hand Book on Weed Identification</i> Directorate of Weed Science Research, Jabalpur, India Pp 354. http://agritech.tnau.ac.in/agriculture/plant_nutri/.html http://nhb.gov.in/report_files/Grapes/GRAPES.htm</p>		

VIII. DESCRIPTION OF INSECT PESTS

<p>1. Leaf eating caterpillar:</p>
<p>Biology:</p> <ul style="list-style-type: none"> • It is found throughout the tropical and sub tropical parts of the world, wide spread in India. • Besides grapes, it feeds on cotton, castor, groundnut, tomato, cabbage and various other cruciferous crops. • Egg: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days. • Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. • Larval stage lasts 15-30 days. • Pupa: Pupation takes place inside the soil, pupal stage lasts 7-15 days. • Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing. Pest breeds throughout the year. • Moths are active at night. • Adults live for 7-10 days. Total life cycle takes 32-60 days. • There are eight generations in a year. <p>Life cycle:</p>



1. <http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3>
2. <http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050>
3. <http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf>
4. <http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html>

Damage symptoms:

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.
- Irregular holes on leaves initially and later skeletonisation leaving only veins and petioles
- Heavy defoliation.



<http://www.nrcgrapes.nic.in/zipfiles/ExtFol24%20MgmtOfCaterpillar.pdf>

Damage symptoms

Natural enemies of leaf eating caterpillars:

Parasitoids: **Egg:** *Trichogramma chilonis*, *Telenomus* spp.; **Larval:** *Campoletis chloridae*, *Peribeia orbata*, *Glipapanteles africanus*, *Carcelia* sp, 6. *Ichneumon* spp., *Cotesia ruficrus*, *Chelonus carbonator*; **Pupal:** *Blepherella setigera*, *Sarcophaga dux*, *Sarcophaga albiceps*, *Brachimeria lasus*, *Lasiochalcidia erythropoda*.

Predators: *Chrysoperla zastrowi sillemi*, *C. crassinervis*, King crow, braconid wasps, dragon flies,

spider, praying mantids, *Harpactor costalis*, *Rhynocoris fuscipes*, *R. squalis*, *Polistes stigma*, *Coranus spiniscutis*,

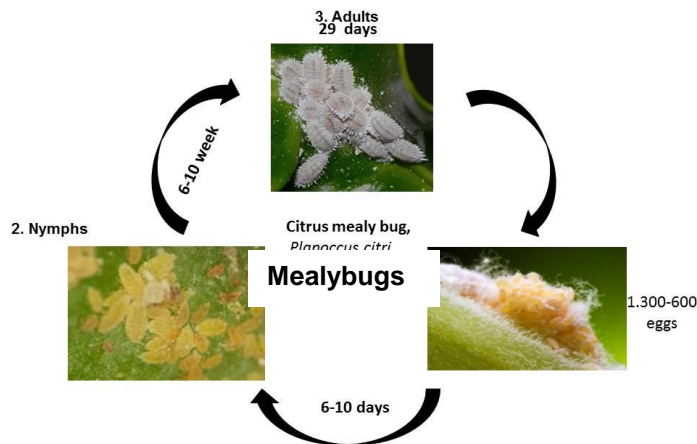
*For management refer to page number-----

2. Mealybugs:

Biology:

- **Egg:** These eggs are orange in colour (*M. hirsutus*) or yellowish white (*P. citri*). They hatch in about 5 days
- **Nymph:** The first instar nymphs are also called as crawlers, which are mobile.
- They settle on the plants, start sucking the sap and form the colonies.
- Crawlers are orange in colour (*M. hirsutus*) or yellowish white (*P. citri*).
- The total nymphal period is 19 days for male and 21 days for female. The male nymph forms a cottony cocoon in which the pupal stage is found mainly in the winter season
- **Adult:** The adult female mealybugs are pinkish (*M. hirsutus*) or yellowish white (*P. citri*) and sparsely covered with white wax. The male and female mealybugs are similar in early stages.
- The female passes through three nymphal instars while male passes through four nymphal instars.
- The adult male has a pair of wings and a pair of halteres. Males are very rare and female mealybugs are commonly found causing the damage in the field.
- Mealybug completes the life cycle in about 30 days. Without mating, they are known to reproduce partheno-genetically throughout the year.

Life cycle:



Damage symptoms:

- Nymphs and adult mealybugs suck the sap from the trunk cordons, buds, spurs, aerial roots, leaves, shoots, nodes, flower panicles and bunches.
- Infestation of the growing point especially with the pink mealybug results in malformation of leaves and shoot tips.
- Honeydew excreted by mealybug nymphs and adults, support the growth of sooty mould on leaves, shoots and bunches.

- Sooty and sticky bunches harbouring mealybugs and their white cottony wax masses are unfit for marketing as table grapes.
- Raisins cannot be prepared from such infested bunches.
- The pest attack weakens the grownup vines.
- In case of severe mealybug infestation young vines often die.
- The grape mealybug causes losses up to 100 per cent in severe cases in the vineyard.



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Damage symptoms

Natural enemies of mealybug:

Parasitoid: Parasitic wasps,

Predator: Coccinellid (*Cryptolaemus montrouzieri*)

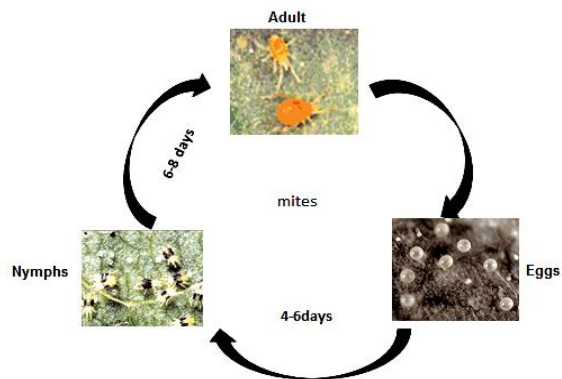
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3. Mites:

Biology:

- **Egg:** Eggs are found on the upper surface of the leaves when the population levels are high. Eggs are also laid in its webbing.
- Freshly laid eggs are minute measuring 0.1 mm white, spherical, transparent and appear like a water droplet.
- Later they change into dull white, gradually turn brown and then become transparent along sides with red spot visible before hatching. The female mite produces 30-50 eggs. Hatching takes place in 4-6 days.
- **Nymph:** The newly hatched nymphs have translucent larva has six legs. Dark spots appear soon after feeding on the dorsal side.
- The protonymph and deutonymphal stage has eight legs. The deutonymph stage is similar in appearance to an adult female but smaller. Nymphal period is 6-8 days.
- **Adult:** Freshly emerged adult females are 0.5 mm long and devoid of spots but as the feeding begins, the spots become more distinct. Usually two large, diffuse spots appear forward. Adult spider mite females are reddish. Their pointed abdomens and smaller size easily recognize males. Adult mites live for about 15 days. Breeding is rapid in summer months
- Life cycle completed in 10-14 days depending on weather conditions.

Life cycle:



Damage symptoms:

- Both nymphs and adults suck the cell sap from lower surface of tender leaves causing the cells to collapse and die.
- In heavy infestations, the mites remove chlorophyll up to 70% leading into development of brown burnt patches on the infested leaves, which wither and finally dry.
- Discoloration of leaves leads to reduction in photosynthesis thereby affecting the vigour of the plants.
- Severe infestation of spider mites results in delay in maturing and ripening of bunches and reduction in sugar content thereby affecting the quality of grapes



1.

2.

3.

Damage symptoms

1,2,3: <http://www.nrcgrapes.nic.in/zipfiles/mite-Eng.pdf>

Natural enemies of mites:

Predators: Predatory mites, predatory beetles such as small staphilinids (*Oligota* spp.), ladybird beetle, lacewing, predatory thrips, anthocorid bug (*Orius* spp.), mirid bug; *Lacanicillium* (*Verticillium*) *lecanii*, *Beauveria* spp. (entomo pathogenic fungi)

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4. Thrips:

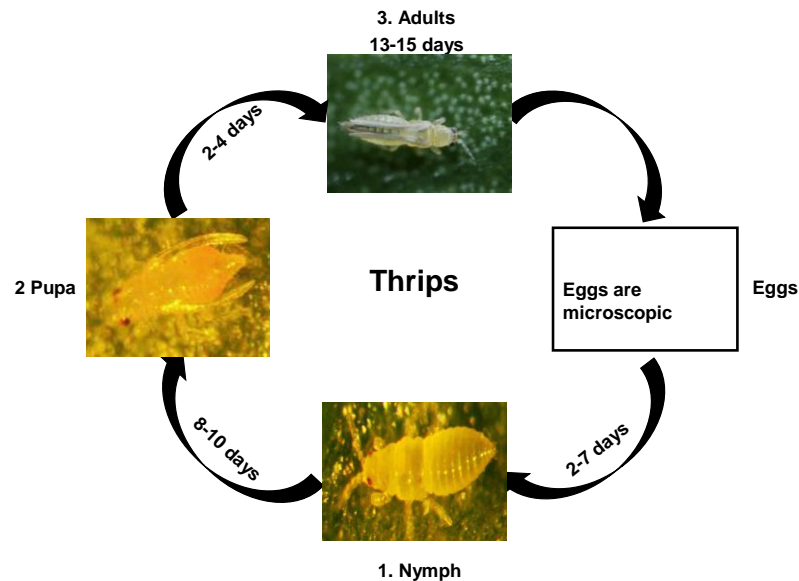
Biology:

- **Egg:** Hyaline, globular laid in mass. Eggs are inserted in the tender tissue on the underside of the leaves. Hatching takes place in 8-10 days
- **Nymph:** Nymphs tiny, slender, fragile and straw yellow in colour. After feeding, nymphs move down to the soil and pupate in the top 8-18 cm. Nymphs are similar to adults but

are without wings.

- **Adult:** Adults with heavily fringed wings. Total life cycle is completed in about 15 days.
- *S. dorsalis* is found in almost all chilly growing areas. It is a polyphagous pest. Besides chilli, it also infests brinjal, cotton, groundnut, castor, bottlegourd, guava, tea and grapevine. It is more common on un-irrigated chilli crop than irrigated one.

Life cycle:



1,2,3: http://entnemdept.ufl.edu/creatures/orn/thrips/chilli_thrips.htm

Damage symptoms:

- Damage is caused both by nymphs and adults by rasping the lower surface of the leaf with their stylets and sucking the oozing cell sap.
- The injured surface is marked by the number of minute spots thereby producing a speckled silvery effect.
- Curling of the leaves is observed in case of heavy incidence.
- The thrips also attack blossoms and developing berries.
- The affected berries develop a corky layer and become brown and fetches low price in the market.



Damage symptoms

<http://agropedia.iitk.ac.in/content/chilli-thrip>

Natural enemies of thrips:

Predators: Predatory mite (*Amblyseius swirskii*), predatory thrips (*Aeolothrips* spp.), anthocorid bug (*Orius insidiosus*) etc.

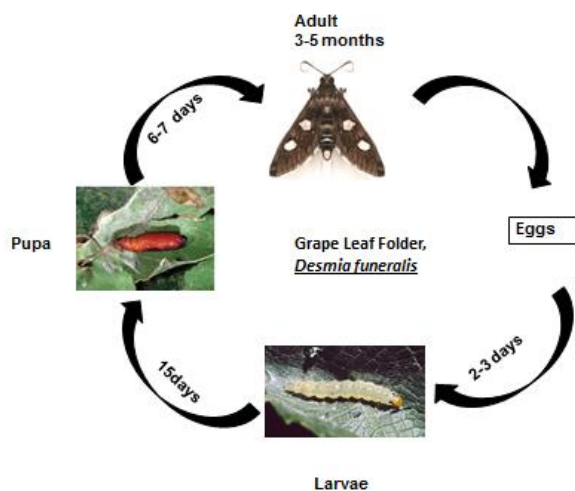
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5. Grape leaf folder:

Biology:

- **Egg:** Eggs are small (about 1/32 inch long), flat, iridescent, elliptical structures laid singly on the underside of a leaf, often in the angles between a vein and the leaf surface.
- **Larva:** Larvae are 3/4 inch long when fully grown. They are glossy, translucent yellow green on the sides and somewhat darker above, with scattered fine yellow hairs on each segment.
- The head and prothoracic shield are light brown, and there are light brown spots on the sides of the first two thoracic segments. Larvae wiggle vigorously when disturbed and drop to the ground.
- **Pupa:** Pupae average a little over 1/2 inch long; they are light brown just after pupation, but soon turn dark.
- **Adult:** The adult is a very dark brown, almost black, moth with a wingspread of about 1 inch. The front wings each have two white spots. The hindwings of the female also have two white spots, while those of the male have only one large white spot. There are two white bands across the abdomen. The male antennae are thickened and distorted in the center; the female antennae are smooth

Life cycle:



Damage symptoms

- A larva is large enough it folds the leaf, exposing the under surface; the edge is held in place by bands of silk thread.
- It is within the protection of this fold that the larva feeds, skeletonizing the leaf of the upper surface.

- When the larvae are numerous the injury to the vine becomes conspicuous, even at a considerable distance, because the light color of the under surface of the folded leaves contrasts boldly with the dark green of the upper side normally presented, thus giving the vine a patchy appearance.
- Larvae roll muscadine leaves, which are thinner than bunch grape leaves.



1

2.

3.

Damage symptoms

1. <http://www.ipm.ucdavis.edu/PMG/D/I-LP-DFUN-CD.004.html>
2. http://entnemdept.ufl.edu/creatures/fruit/grape_leaffolder.htm
3. <http://ebookey.org/search.php?q=Grape+Pest+Management%2C+Third+Edition&sa=Search>

Natural enemies of leaf folder:

Larval parasitoid: *Bracon cushmani*, *Cardiochiles* spp

Predators: Lacewing, spider

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

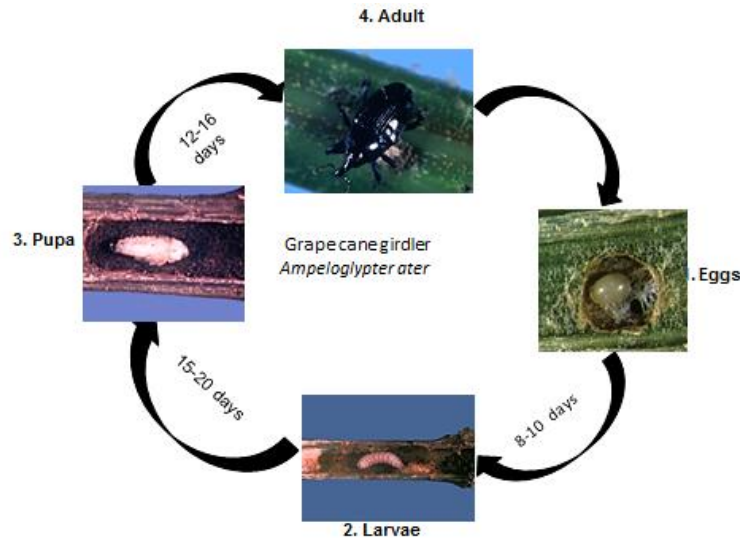
6. Girdle beetle/grape cane girdler:

Biology:

- **Egg:** The female hollows out a small cavity in the shoot, places a single egg into it and fills the egg cavity with frass. Then she proceeds to girdle the cane at two places: just below the egg cavity and several inches above.
- The egg is 0.7 mm long, and off-white. It takes about 10 days for the egg to hatch.
- **Larva:** The fully-grown larva is white with a brown head, legless, and measures 8 mm in length.
- It burrows in the center of the shoot on either side of the egg cavity larval development takes over a month. The shoot in which the larva feeds either breaks off at the girdled point or dies back to the first node below the egg cavity and drops to the ground
- **Pupa:** The pupa is light-colored but becomes darker just prior to emergence. Some of the adult features such as legs and snout are already clearly visible in the pupal stage. Development to the adult is completed after about two weeks.
- **Adult:** The shiny-black adults are small, 3 mm long weevils with a characteristic curved snout. Except for their color they resemble the reddish-brown adults of the grape cane gallmaker, *Ampelogypter sesostris*.
- The adult beetles emerge from infested canes during August and subsequently overwinter in trash on the ground.

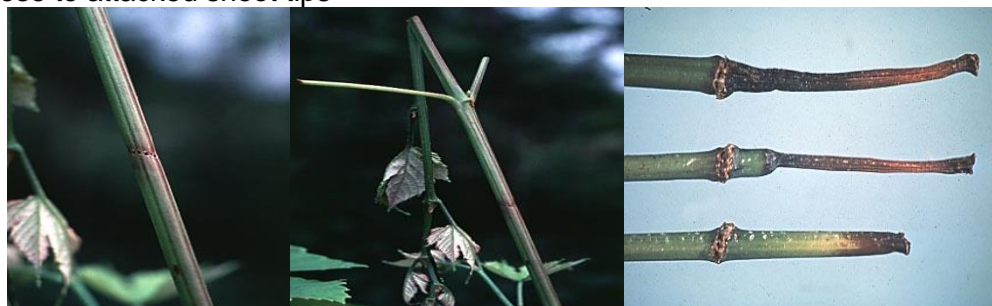
- In May of the following year the adults leave their over wintering sites. When grape shoots are 30 to 50 cm long, usually in late May before grape bloom, the female begins to lay her eggs and girdle new canes.
- Egg-laying continues for about one month.

Life cycle:



Damaged symptoms:

- The girdling by the female causes the terminal growth of the new shoots to bend over above the upper girdle and drop to the ground
- Later the whole infested shoot dies back to the lower girdle and falls from the vine Vines 'pruned' by the grape cane girdler have a ragged appearance suggesting serious injury to the plant.
- Girdling of the terminal growth has little or no effect on the crop unless fruit-producing nodes are close to attacked shoot tips



1.

2.

3.

Damage symptoms

1,2: <http://www.nysipm.cornell.edu/factsheets/grapes/pests/gcg/gcg.asp>

3: <http://www.ipmcenters.org/pmsp/pdf/VA-NCwinegrapesPMSP.pdf>

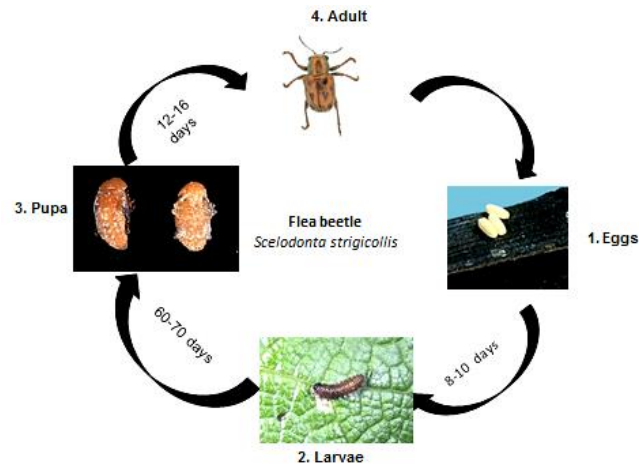
*For management refer to page number-----.

7. Flea beetle:

Biology:

- **Egg:** Yellow to orange, cylindrical in shape, rounded on 1 end and 1mm in length and 0.4 mm in width. Eggs are laid near the buds or loose cane.
- **Larva:** Newly hatched larvae is dark brown in colour but later turns light brown, 7-9 mm in length, and whole body is covered with back shiny and rectangular plates of various sizes which gives the spotted appearance of larvae
- **Pupa:** Pupae bright yellow, 4-6 mm long, and with conspicuous reddish brown eyes. Wings and legs are off white colour.
- **Adult:** Adults are oval in shape, metallic shining blue, and 4-5 mm in length. The antennae are thread like. The thighs of hind legs are enlarged and enabling the adult to jump quickly when disturbed.

Life cycle:



1,2,3,4: <http://www.nysipm.cornell.edu/factsheets/grapes/pests/gfb/gfb.asp>

Damage symptoms:

- The adult beetles scarp the sprouting buds after each pruning.
- Damaged buds fail to sprout. The beetles also feed on tender shoots and leaves, and tendrils causing substantial damage.
- The tender shoots may wither and drop down. The losses are heavy when the sprouting buds are damaged after forward pruning.
- Damage is caused by adult beetles feeding on primary buds, which prevents them from developing into shoots, thus resulting in a decreased yield.
- The greatest economic loss occurs when beetles feed on buds from “bud swell” until the “first leaf separates from the shoot tip” stages.
- Once shoot growth reaches 7 cm, damage caused by the grape flea beetle normally does not affect yield.
- Although primary damage is caused by adult flea beetle to the developing buds, larval damage can also occur on the foliage and is typically limited to several leaves and vines.



1.

2.

Damage symptoms

1. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_postharvest_grapes.html

2. http://pdc.umn.edu/prod/groups/cfans/@pub/@cfans/@pdc/documents/asset/cfans_asset_175589

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

8. Rose chafer beetle:

Biology:

- **Egg:** chafer needs sandy soil to lay eggs, plants on sandy sites are most likely to be infested. It feeds on plant material for 3 to 4 weeks, lays eggs in the soil, and then dies soon afterwards.
- **Grub:** The eggs hatch in 1 to 2 weeks, and the small white grubs feed on the roots of grasses and weeds. The rose chafer overwinters as larvae in the soil.
- **Adult:** The adult chafer is pale green to tan color, slender, approximately ½ inch long, with a reddish head and long, spiny, reddish brown legs.



Larva

Adult

Damage symptoms

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

9. Grapevine stem borer:

Biology:

- **Egg:** Capsule shaped eggs are laid singly in each of the slits and the slits are covered with a hard gummy substance.
- **Larva:** Newly hatched flat-headed cream coloured grubs burrow into the trunk or arms and feed inside and make them hollow.
- **Pupa:** Larvae pupate within 3-5 days, dark brown in colour.
- **Adult:** An adult beetle is about 4 cm long and dull yellow with minute spots. They remain inside the vine up to May. Thereafter, they pupate inside the tunnel made in

the vine. The insect is a borer, the grub of which bores in to stem and branches and causes drying and withering of affected branches.

- The adult beetles start emerging from the vines during July to September by making a round hole on the vine. Female beetles make conspicuous slits on the bark of the trunk and arms of the vine.



Newly hatched grub

Larva inside cane

Adult

Courtesy: www.nhb.gov.in

Damage symptoms:

- Presence of saw dust like substance under the vine indicates the damage done by the grub. Damaged vines get weakened and growth gets affected.
- The maturity of berries is also delayed which ultimately affects the grape production in terms of both yield and quality.



Damage symptoms

Courtesy: www.nhb.gov.in

Natural enemies of stem borer:

Predators: Lacewing, coccinellids, King crow, dragon fly, spider, robber fly, praying mantis , *Ovomermis albicans*, a nematode.

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

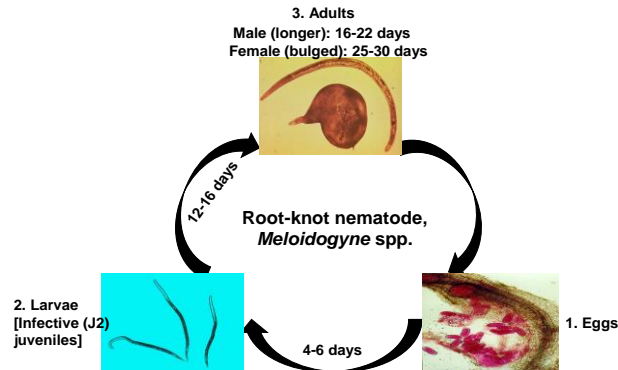
10. Root-knot nematode:

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

Damage symptoms:

- Infected plants in patches in the field
- 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



Damage symptoms

https://www.google.co.in/search?q=damage+symptoms+of+grapes+by+nematode&espv=210&es_sm=122&source=Inms&tbn=isch&sa=X&

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 Grape Insect and Mite Pests

Parasitoids Egg parasitoids



1. *Trichogramma* sp



2. *Telenomus* sp

Egg-larval parasitoid



3. *Chelonus* spp.

Larval parasitoids



4. *Bracon* spp.



5. *Ichneumon* spp.



6. *Carcelia* spp



7. *Campoletis* spp.

Pupal parasitoid



8. *Brachymeria euploeeae*

- 2 <http://www.pbase.com/image/135529248>
- 3 <http://baba-insects.blogspot.in/2012/02/telenomus.html>
- 4 <http://www.nbaii.res.in/Featured%20insects/chelonus.htm>
- 6 <http://www.organicgardeninfo.com/ichneumon-wasp.html>
- 7 http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
- 8 <http://www.nbaii.res.in/Featured%20insects/Campoletis.htm>
- 13 <http://www.nhm.ac.uk/researchcuration/research/projects/chalcidoids/database/media.dsmi?!MAGENO=chalc519&VALGENUS=Brachymeria&VALSPECIES=euploeeae>

Predators



1. Lacewing



2. Ladybird beetle



3. Reduviid bug



4. Spider



5. Robber fly



6. Red ant



7. Black drongo



8. Common mynah



9. Big-eyed bug



10. Earwig



11. Ground beetle



12. Pentatomid bug



13. Preying mantis



14. *Dicyphus hesperus*



15. Predatory mite



16. Predatory thrips



17. *Oligota* spp.



18. *Orius* spp.



19. Hover fly



20. Mirid bug

5. <http://www.warpedphotosblog.com/robber-fly-and-prey>
6. <http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021>
7. <http://nagpurbirds.org/blackdrongo/picture/1639>
8. <http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/>
9. <http://bugguide.net/node/view/598529>
10. <http://www.flickr.com/photos/johnhallmen/2901162091/>
11. <http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html>
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asoptinae/Eocanthecona.htm
13. <http://spirit-animals.com/praying-mantis/>
14. <http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm>
15. <http://www.dragonfli.co.uk/natural-pest-control/natural-enemies>
16. http://biocontrol.ucr.edu/hoddle/persea_mite.html
17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
18. [http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_\(cropped\).jpg](http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg)
20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

IX. DESCRIPTION OF DISEASES

1. Downy mildew:

Disease symptoms:

- The fungus is an obligate pathogen which can attack all green parts of the vine.
- Symptoms of this disease are frequently confused with those of powdery mildew. Infected leaves develop pale yellow-green lesions which gradually turn brown. Severely infected leaves often drop prematurely.
- Infected petioles, tendrils, and shoots often curl, develop a shepherd's crook, and eventually turn brown and die.
- Young berries are highly susceptible to infection and are often covered with white fruiting structures of the fungus. Infected older berries of white cultivars may turn dull gray-green, whereas those of black cultivars turn pinkish red.

Survival and spread:

- The fungus overwinters mainly in the fallen leaves which are the source of primary infection. Secondary infection occurs by motile zoospores by splashing rain.

Favourable conditions:

- The most serious outbreaks have been found to occur when a wet winter is followed by

a wet spring and a warm summer with intermittent rains.



1.

2.

Disease symptoms

1,2:https://www.google.co.in/search?q=downy+mildew+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=a20MU4ybOcuprAew4IBQ&ved=0CAkQ_A

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

2. Powdery mildew:

Disease symptoms:

- Powdery mildew, caused by the fungus *Uncinula necator*, can infect all green tissues of the grapevine.
- Tissues are generally susceptible to infection throughout the growing season.
- Diseased leaves appear whitish gray, dusty, or have a powdery white appearance. Petioles, cluster stems, and green shoots often look distorted or stunted. Berries can be infected until their sugar content reaches about 8%.
- If infected when young, the epidermis of the berry can split and the berries dry up or rot. When older berries are infected, a netlike pattern often develops on the surface of the berry.

Survival and spread:

- The powdery mildew fungus overwinters in dormant buds or as specialized structures on the surface of the vines. When conditions are favorable for growth of the fungus in spring, spores are produced, released, and cause new infections. Secondary spread of the disease can occur if spores are produced in these new infections.

Favourable conditions:

- High humidity and moist weather favours the development of disease.



1.

2.

3.

Disease symptoms on leaves and fruits

1,2,3:

https://www.google.co.in/search?q=powdery+mildew+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=a20MU4ybOcuprA

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

3. Anthracnose:

Disease symptoms:

- Anthracnose, caused by the fungus *Elsinoe ampelina*, is also known as bird's-eye rot from its appearance on the fruit.
- The disease appears first as dark red spots on the berry. Later, these spots are circular, sunken, ashy-gray and in late stages these spots are surrounded by a dark margin which gives it the "bird's-eye rot" appearance. The spots vary in size from 1/4 inch in diameter to about half the fruit.
- The fungus also attacks shoots, tendrils, petioles, leaf veins, and fruit stems. Numerous spots sometimes occur on the young shoots. These spots may unite and girdle the stem, causing death of the tips. Spots on petioles and leaves cause them to curl or become distorted.

Survival and spread:

- The primary infection by diseased vines and secondary infection by wind-borne conidia.

Favourable conditions:

- Continuous/intermittent rains and high humidity are responsible for the development of disease.



1.

2.

3.

4.

Disease symptoms on fruits and leaves

1,2,3,4:

[http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape Anthracnose Disease Cycle.jpg](http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape_Anthraco...)

%252FGrape_Anthraco...%3Bhttp%253A%252F%252Fen.wikipedia.org%252Fwiki%252FElsino%2525C3%2525AB_...%3B800%3B800

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

4. Greenaria bitter rot:

Disease symptoms:

- This fungus can infect all green parts of the vine including leaves, tendrils, new shoots, as well as berries. However, mature leaves and ripe fruit are not susceptible. Infections of leaves first appear as red spots on the upper leaf surface in late spring.
- These circular spots enlarge and become tan to light brown with distinct, dark borders. Small, pinpoint black fruiting structures of the fungus often develop in the centers of these spots.
- Most serious damage usually occurs on the berries. On the fruit, infections first appear as whitish spots which enlarge to sunken areas with dark borders. Significant infections usually occur when the grape is pea-size or larger. As infection progresses, the fruit becomes black, wrinkled, mummified, and look like raisins. Infected grapes often shatter,

leaving only the stem.

Survival and spread:

- The fungus overwinters on mummified berries on the soil or in old clusters still hanging in the vines. Secondary infections can occur when additional spores are produced on the newly infected tissues.

Favourable conditions:

- Moisture and temperature above 20-25 °C favours the development of disease.



1.

2.

Disease symptoms

1,2: [http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape bitter rot.jpg](http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape_bitter_rot.jpg)

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

5. Bacterial leaf spot:

Disease symptoms:

- The young growing shoots are affected first. Disease infects leaves, shoots and berries. The symptoms appear as minute water soaked spots on the lower surface of the leaves along the main and lateral veins.
- Later on these spots coalesce and form larger patches. Brownish black lesions are formed on the berries, which later become small and shriveled.

Survival and spread:

- The pathogen survives in infected plant residue in soil and seed borne.

Favourable conditions:

- The disease is more prevalent during June-August and again in February-March.
- Temperature range of 25-30 °C and relative humidity of 80-90% is favourable for the development of the disease.



1.

2.

Disease symptoms

1,2: https://www.google.co.in/search?q=bacterial+leaf+spot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=mnAMU6ThJMKlrQeum4HIAQ&ved=0CAkQ_AU

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

6. *Alternaria* blight:

Disease symptoms:

- The disease attacks both leaves and fruits. Small yellowish spots first appear along the leaf margins, which gradually enlarge and turn into brownish patches with concentric rings. Severe infection leads to drying and defoliation of leaves.
- Symptoms in the form of dark brown-purplish patches appear on the infected berries, rachis and bunch stalk just below its attachment with the shoots.

Survival and spread:

- The disease is externally and internally seed borne. The pathogen survives through spores (conidia) or mycelium in diseased plant debris or weed.

Favourable conditions:

- Moist (More than 70% relative humidity) and warm weather (12-25 °C) and intermittent rains favours disease development.



1. 2.

Disease symptoms

1,2:

https://www.google.co.in/search?q=alternaria+leaf+spot+of+grapes&espv=210&es_sm=93&source=Inms&tbn=isch&sa=X&ei=mnAMU6ThJMKlrQeum4HIAQ&ved=0CAkQ_AU

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

7. Black rot:

Disease symptoms:

- The disease attacks the leaves, stem, flowers and berries. All the new growth on the vine is prone to attack during the growing season.
- The symptoms are in the form of irregularly shaped reddish brown spots on the leaves and a black scab on berries.
- Occasionally, small elliptical dark coloured canker lesions occur on the young stems and tendrils. Leaf, cane and tendril infection can occur only when the tissue is young, but berries can be infected until almost fully-grown if an active fungicide residue is not present.
- The affected berries shrivel and become hard black mummies.

Survival and spread:

- Pathogen survives in soil and plant debris.

Favourable conditions:

- Warm and moist climate with extended periods of rain and cloudy weather favours the development of the disease.



1.

2.

3.

Disease symptoms

1,2,3:

https://www.google.co.in/search?q=alternaria+black+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=mnAMU6ThJM KlrQeum4HIAQ&ved=0CAkQ_AU

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

8. Blue mould rot:

Disease symptoms:

- Scanty growth - white and turn bluish green are seen.
- Decay the berries.
- Infected tissues become soft and watery.
- Infected berries emit a mouldy flavor.
- The fungus covers whole berries and it looks like bluish green in colour.

Survival and spread:

- Spores of this fungus are very common in the air and soil which are the source of infection.

Favourable conditions:

- Blue mold is most common when temperatures are higher than 10-14°C.
- Free moisture for six hours or longer on the onion surface is necessary for infection to occur.



1.



2.

Disease symptoms

1,2:

https://www.google.co.in/search?q=blue+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=l3YMU9ri JM2nrge-

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

9. Black mould rot:

Disease symptoms:

- It is a post harvest disease. The fungus enters the berries through the injuries caused due to poor post harvest handling operations.
- The pulp of infected berries is reduced is reduced to watery consistency.

- Berries look black in colour.

Survival and spread:

- Spores of this fungus are very common in the air and soil which are the source of infection.

Favourable conditions:

- Black mold is most common when temperatures are higher than 30°C (86°F) in the field or 24 °C in storage.
- Free moisture for six hours or longer on the onion surface is necessary for infection to occur.



1.

2.

Disease symptoms

1,2:

https://www.google.co.in/search?q=blue+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=l3YMU9riJM2nrge-

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

10. Green mould rot:

Disease symptoms:

- It is a post harvest disease. The fungus enters the berries through the injuries caused due to poor post harvest handling operations.
- Infected berries are discolored yellowish green, and affected fruits shrivel.
- Masses of powdery green spores generally covered the bunch of grapes.

Survival and spread:

- Spores of this fungus are very common in the air and soil which are the source of infection.

Favourable conditions:

- Green mold is most common when temperatures are higher than 30°C in the field or 24°C in storage.
- Free moisture for six hours or longer on the surface is necessary for infection to occur.



Disease symptoms

https://www.google.co.in/search?q=green+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=I3YMU9riJM2nrge-

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

11. Rhizopus rot:

Disease symptoms:

- Round irregular, light brown and water soaked lesion appear on fruits.
- Decaying fruits emits fermented, mouldy smell.
- Conidia aseptate, small and globose
- It is a post harvest disease. Under warm and moist conditions the fungus grows rapidly producing a coarse grey mat of mycelium.
- Injury caused to the berries by tight packing and storage temperature help the fungus grow during storage. If the infected berries are trimmed at harvest, it does not occur after harvest under ideal storage conditions.

Survival and spread:

- Spores of this fungus are very common in the air and soil which are the source of infection.

Favourable conditions:

- Black mold is most common when temperatures are higher than 30°C in the field or 24°C in storage.
- Free moisture for six hours or longer on the surface is necessary for infection to occur.



Disease symptoms

https://www.google.co.in/search?q=rhizopus+rot+of+grapes&espv=210&es_sm=93&source=ln

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

12. Botrytis bunch rot or gray mold:

Disease symptoms:

- One or more berries of a cluster show signs of decay just before harvest. The decay may progress to include most of the berries in a cluster. The infected fruit may become covered with a grayish-tan powder containing the spores of the fungus.
- Berry stems and cluster stems may be invaded, causing them to shrivel.
- When the fungus decays berries low in sugar, the rotting berry has a sour odor and taste.
- If the berries are nearly mature and have a high sugar content, the decaying berry is quite firm, dry, and somewhat sweetish to the taste. Berries that have split or have been punctured often are attacked by other organisms, resulting in a sour or moldy decay.

Survival and spread:

- Fungus survives in all decaying vegetation. Its spores are present in the vine yard throughout the year.

Favorable conditions:

- Brown mold is most common when temperatures are higher than 30°C in the field or 24°C in storage.
- Free moisture for six hours or longer on the surface is necessary for infection to occur.



1. 2.

3.

Disease symptoms

1,2,3:https://www.google.co.in/search?q=botrytis+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=JXqMU6SXKoeMrQe3ilDoBw&ved=0CAkQ

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

13. Rust

Disease symptoms:

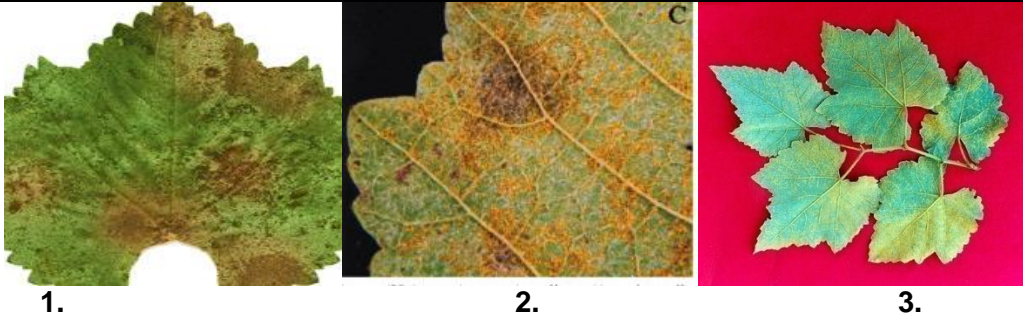
- The symptoms are in the form of numerous orange coloured pustules on the lower surface of the leaves. In case of severe infection such pustules cover the entire leaf surface leading to severe defoliation.

Survival and spread:

- The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris.

Favourable conditions:

- Moisture and temperature above 20° C favours the development of disease.



Disease symptoms

1,2,3:

https://www.google.co.in/search?q=rust+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=bnkMU8LVI4aYrgfQ8oGwAw&ved=0CAkQ_AUoAQ&biw=1280&bih=656#facrc=&imgdii=&img

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14. Foot rot:

Disease symptoms:

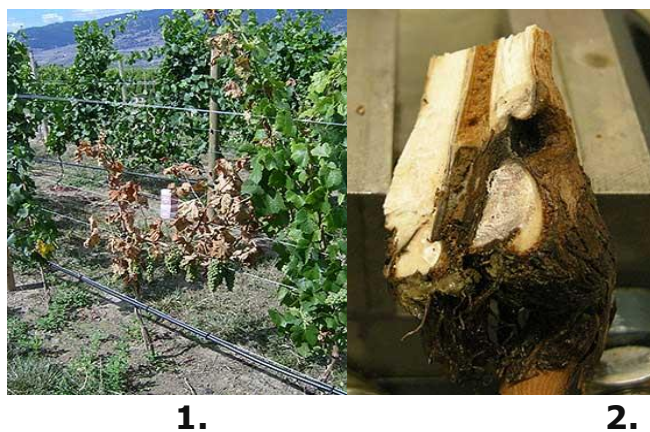
- Roots show black, sunken, necrotic lesions. In cross section, the base of the trunk appears necrotic and xylem vessels may be black in colour.
- Leaves may appear to be water stressed or scorched, and vines may be stunted and/or killed.
- *Cylindrocarpon* may occur in combination with other plant pathogens.

Survival and spread:

- *Cylindrocarpon* is a common soil-borne fungus which causes root rot in many plant species.
- It survives in soil as mycelium and also produces conidia (spores) and chlamydospores (spores that can survive adverse conditions).

Favourable conditions:

- Moderate humidity and moist conditions

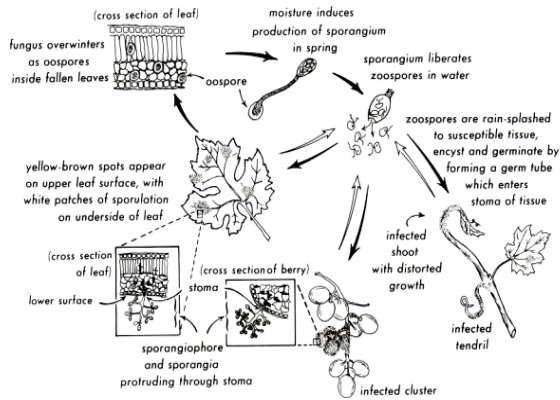


Disease symptoms

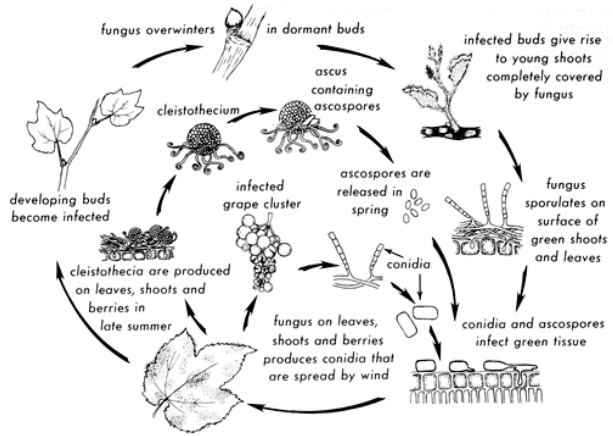
*For management refer to page number-----

Diseases cycles:

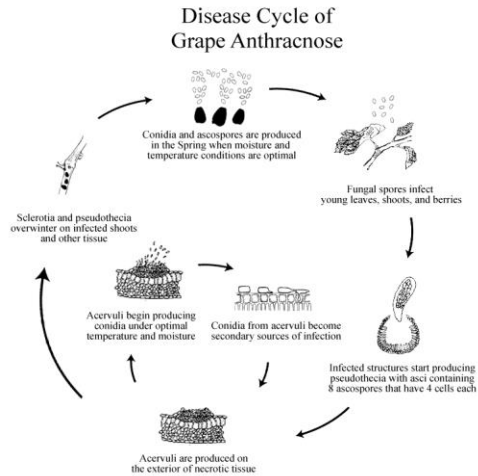
1. Downy mildew:



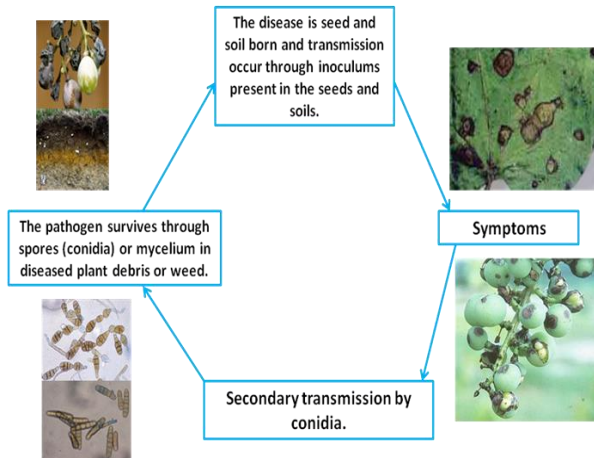
2. Powdery mildew:



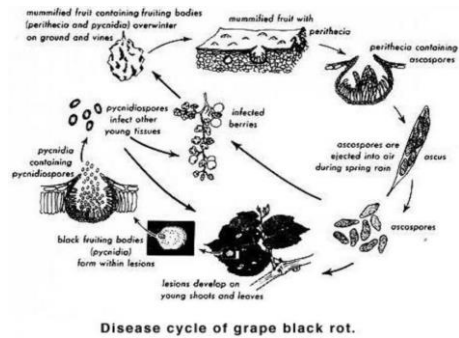
3. Anthracnose:



4. Bacterial leaf spot:



5. Black rot:



X. SAFETY MEASURES

A. At the time of pre-harvest:

The following harvesting care should be taken:

1. Maturity:

- As grape is a non-climacteric fruit, it should be harvested only when the berries are fully ripened on the vine itself.
- The optimum stage for harvesting of grape bunches is indicated by the characteristic colour of fruits, variety, change in colour of bunch stalk from green to yellow or brown, aroma/flavour, softening of berries, sweetness of pulp and thickening of juice. Stage of maturity at the time of harvesting determines the suitability of fruits for processing, domestic or export market.
- Generally, all bunches in the vineyard do not ripen evenly at the same time and all the berries in the same bunch do not ripen at the same time. Therefore, it is desirable to thin them out by removing small sized berries at the developing stage. It will bring uniformity in maturity and size of berries.

2. Harvesting seasons:

- The harvesting season of grapes in major producing areas of India differ considerably. Different harvesting seasons of grapes in India are as under:
 - 1) Southern India - May to June and December to April
 - 2) Western India - September to October and April
 - 3) Northern India - June
- Harvesting of grapes can be advanced or postponed for about 10 to 15 days depending on the market situation.
- In case of early pruning, grapes become ready for harvest in about 130 days, in case of late pruning in about 150 to 180 days.
- Ripening period may be enhanced by spray of ethephon at the rate of 100 to 500 ppm 10-20 days before harvesting.
- The spray of 1% calcium nitrate 10 days before harvest decreases post harvest loss. To bring uniform colour development in berries, treatment of Ethrel (500 ppm) is advised 7 days before harvesting.

3. Harvesting:

- Harvesting is the detachment of bunches from the vine at the proper level of maturity. Great care should be taken at time of harvesting. It should be performed without mechanical damage and product loss, as quickly as possible.
- The proper stage for harvesting the grapes is adjudged by the development of characteristic colour of a variety and also by touching the grapes from the apical portion of the bunch. In grapes three major colours, viz. white, red and black are found.
- The criteria used to judge ripening differ according to the use of the grapes. For making raisins, harvesting at a late stage is preferred, to get more sugar in grapes for increasing the weight of the dried product. For all other purposes, ripening is judged on the basis of sugar: acid ratio for getting proper blend required for table purpose or wine making. The correct blend of sugar acid ratio should be between 25-30.

For export market, the following parameters are considered during harvesting of grapes:

- Berry size- Berry size should be more than 16mm in diameter.
- TSS- TSS should be more than 17° Brix.
- Bunch weight- Bunch weight should be between 300-750 g.
- Bunch colour- Bunch colour should be milky green.
- The selected bunch should not be compact.
- All the berries should be of uniform colour and size in a bunch.
- Less than 2% sunburnt or sulphur bleached, bruised or crushed berries.
- Peduncle should be fresh and green.

4. Trimming and handling:

Grapes used as table purpose must attract the consumer attention to fetch better price. The post harvest quality of the fruit depends fully on the proper care taken after harvesting of the crop.

- The removal of undesirable, diseased and injured berries at initial stage improves the appearance and reduces the infection at later stage.
- The clusters after thinning/trimming must be handled with utmost care.
- Rough handling promotes more dry stems, brown stems, more weight loss and soft berries. Careless handling reduces shine and attractiveness of the berries.

After harvesting, the bunches in some cases are put directly in CFB Boxes/Wooden Boxes/Bamboo Baskets at the field itself for transportation to markets. But, it is desirable that soon after harvesting the produce should be properly screened to sort out damaged, shrivelled and diseased berries taking care to keep the natural waxy bloom on the surface. Sometimes, the harvested produce is treated/fumigated with sulphur dioxide to sterilize the fruits. It prevents attack of bacteria and fungi from cuts/wounds.

5. Factors affecting grape berry ripening:

The berry's maturity period varies from variety to variety. Cultural practices such as pruning, pinching of shoots, training system, irrigation, nutrition, atmospheric temperature, spray of

growth regulators and other chemicals play important role in ripening period required by grape berries.

- The berry should be seedless.
 - The taste of the fruit should be a blend of sweet and sour with 18% - 20% sugar and 0.5 to 0.6% acidity. The sugar, acid ratio varies from one variety to another and on climatic conditions.
- The colour of berries should be uniform and turning green amber.
 - The skin of berry should be thin, crisp and should dissolve with pulp at the time of consumption.
- The berry should be fully developed, uniform and sound.
- The bloom on the skin of berries should be retained uniformly.
 - The stem and peduncle should look fresh and should be of medium thickness, greenish yellow in colour of moderate length.
- Berry drop is not preferred during handling and packing.
 - The fruit should be free from residual toxicity of pesticides, stains, diseases and pests.
 - Cracked berries, dried berries and off coloured berries are not preferred.

6. Management of Physiological Disorders:

To minimize post harvest losses, certain measures are adopted to check physiological disorders. The post-harvest control of certain physiological disorders is as under:-

- 1) **Stem browning:** the stem of grape bunches is important part of quality. It is essentially required for handling and trimming. It is the first part of the cluster to deteriorate. The stem turns brown early if temperature is high. The treatment of 10ppm N.A.A. 7 – 10 days before harvesting helps retention of stems green colour. The spray of calcium chloride (1 g/l of water) at the time of sugar conversion increases the strength of the stem, reduces berry drop and also keeps the stem green. Its spray given during last 20 days before harvesting also helps in retaining bloom and giving attractive appearance. Calcium orthophosphate 1.1 gram or Superphosphate 10 gram per 10 litre of water can also be used for this purpose.

- 2) **Water loss:** Humidity and temperature are the important factors which decide the degree of water loss. Low temperature and high relative humidity lower the water loss in grape berries. Due to water loss, the berries become soft shriveled and unattractive and quality deteriorates considerably. This water loss can be reduced and the quality can be maintained by quick movement of grape from the vineyard to pre-cooling after harvest. To minimize post-harvest loss, irrigation one day before harvesting should be avoided. It will reduce fungal infestation in packing also.
- 3) 3) **Berry cracking:** It results due to heavy rain fall or irrigation at the final stage of development of grape berries. Formation of high pressure in the berries on the un-stretchable skin results in berry cracking. The moisture should be controlled at the harvesting stage to reduce this problem.

B) During postharvest:

Post-harvest losses:

All fresh fruits including grapes are inherently perishable. During the process of distribution and marketing, substantial losses are incurred which ranges from a slight loss of quality to total spoilage. Post-harvest losses may occur at any point in the marketing process, from the initial harvest through assembling and distribution to the final consumer. The causes of losses are many: physical damage during handling and transport, physiological decay, water loss, or sometimes due to glut in the market and there is no buyer.

The following points should be kept in view to minimize post harvest losses and to get high quality berries:

- Grape berries which contain more pulp percentage have longer shelf life.
- Glucose sugar helps in better storage than fructose sugar. The sugar content of berries is related directly with postharvest life. If it is more, the shelf life is more and vice-versa.
- The berry obtained from low nitrogen applied vines show better shelf life.
- Grape berries which retain shining for more time have better storage life.
- Green stemmed bunches of berries last longer.
- Healthy grape berries last longer in storage.
- Grapes harvested at low temperature and kept at low metabolic/physiological activities have more shelf life.
- By using grape guards, the freshness of berries can be retained which ultimately prolongs shelf life.

1. Storage:

Fresh grapes can be stored in cold stores for a period of about 6 weeks. Grapes should be pre-cooled promptly after harvest in separate rooms with large refrigeration capacity, high air velocity and high relative humidity. They are normally pre-cooled at 1-2° C within 6 hours of harvest. After pre-cooling, the dual releasing Sulphur dioxide pads (Grape guard) are placed with their coated surfaces downwards on the filled plastic pouches and covered with the polythene liner. The boxes with sufficient air circulation are closed and shifted to cold storage rooms where the temperature and humidity are maintained at 0-2° C and 90-95% respectively. In the cold storage ensure uniform cooling within a box and it's surroundings.

Cool chain: Cool chain is essential during the transport of export quality commodity all the way from the farm to the customer. This helps in maintaining the temperature inside the box at the same low level as in the cold storage.

The various stages of the cool chain are:

1. Cold storage at the farm.
2. Refrigerated truck from farm to the airport
3. Cold store at the airport.
4. Building up of the pallet in a cold store at the airport.
5. Loading the aircrafts directly from the cold store in a short time.
6. Cargo aircraft maintains cold store temperature in hold.
7. Off loading direct into a cold store in the receiving country.
8. Refrigerated truck to the customers.

Optimum temperature: Grapes can be stored at 0.0 to 2° C. The highest freezing point for berries is -2.1° C, but freezing point varies depending on SSC.

Optimum relative humidity: 90-95% RH and an air velocity of approximately 6-10 meter per minute (MPM) is suggested during storage




Source: <http://agmarknet.nic.in/preface-grapes.pdf>


XI. DO'S AND DON'TS IN IPM




S. No.	Do's	Don'ts
1	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
2	Always treat the seedlings with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seedlings without seed treatment with biocides/chemicals.
3.	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.
4.	Maintain optimum and healthy orchid 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.
5.	Use micronutrient mixture based on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
6.	Conduct weekly AESA 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
7	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
8	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
10	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.
11.	Diseases like downy mildew and powdery mildew are obligate parasites and active inoculum of disease comes from living tissues of host. Pruning of adjacent blocks if done keeping more than 9 days gap, pruned block provides inoculum on new growth emerged from pruned block.	Hence time gap between two adjacent blocks should not be more than 9 days. If unavoidable, fungicide should be sprayed on un-pruned block .

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules Colour of toxicity triangle	WHO classification of hazard	Symptoms poisoning	First aid measures; Treatment of poisoning	Harvesting intervals (days)
Organophosphate insecticides					
1	Dimethoate Highly toxic 	Class II Moderately hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	Treatment of poisoning: For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	--
Carbamate insecticides					
2	Carbofuran Extremely toxic 	Class I b highly hazardous	Constriction of pupils, salivation, profuse sweating, muscle incoordination, nausea, vomiting, diarrhea, epigastric pain, tightness in chest	Treatment of poisoning: Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation-good sign, more atropine needed	--
Neonicotinoids					
3	Imidacloprid Highly toxic 	-	Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.	First aid measures: Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious Person Treatment of poisoning: No specific antidote. Treatment is	3

				essentially symptomatic.	
4	Thiamethoxam	-	Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious	Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic.	5
Insect growth regulators					
5	Novaluron		Causes substantial but temporary eye injury.	First aid measures: Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic.	1-3
Anthranilic diamides					
6	Flubendiamide Slightly toxic 	Unlikely produce acute hazard	-----	Treatment of poisoning: Treat symptomatically as there is no known specific antidote	5
Other classes insecticides					
7	Indoxacarb		Altered blood chemistry Abnormal decrease in number of red blood cells (anaemia) which could produce tiredness, rapid heartbeat, dizziness, pale	First aid measures: Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious	5

			skin, leg cramps, shortness of breath, Central nervous system effects	person Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic.	
Fungicides					
8	Captan Moderately toxic 	Class III slightly hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic	6
9	Mancozeb Slightly toxic 	Unlikely produce acute hazard	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic	10
10	Copper oxychloride Moderately toxic 	Class III slightly hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic	--

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; 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; expose to sunlight or rain water; 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. Read the label on the container before preparing spray solution.
7. Prepare the spray solution as per requirement
8. Do not: mix granules with water; eat, drink, smoke or chew while preparing solution.
9. Concentrated pesticides must not fall on hands etc. while opening sealed container. Do not smell pesticides.
10. Avoid spilling of pesticides while filling the sprayer tank.
11. 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. Don't 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; apply just before the rains and after the rains; 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 field immediately after spraying
7. Avoid tank mixing of different pesticides





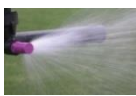

G. Disposal

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.


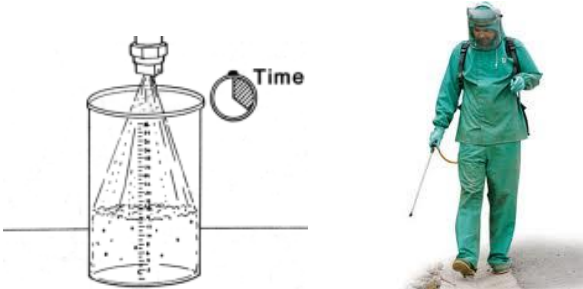
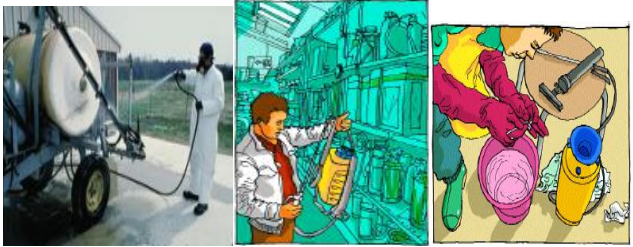
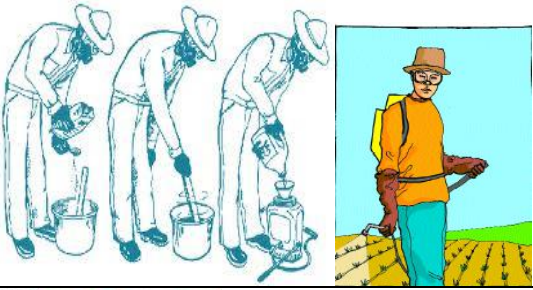

XIV. PESTICIDE APPLICATION TECHNIQUES


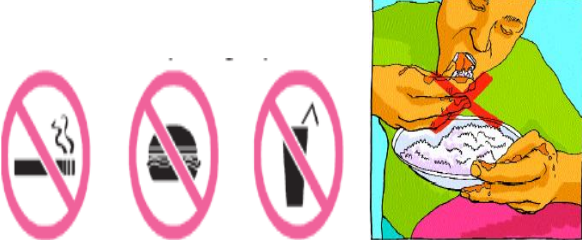


Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
		<p>or</p> <ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle 	
ii) for small sucking leaf borne pests			

Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
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Category B: Field flying pest/airborne pest			
Vegetative stage	Insecticides and fungicides	<ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle <p>Or</p> <ul style="list-style-type: none"> • Battery operated low volume sprayer (Droplets of small size) • Spinning disc nozzle 	 
Reproductive stage (Field Pests)			
Mosquito/locust and spatial application (migratory Pests)	Insecticides and fungicides	<ul style="list-style-type: none"> • Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle 	
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.	

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