Important Natural Enemies of Grape Insect Pests

Parasitoids

Trichogramma spp.  
Telenomus sp.  
Campoletis spp.

Bracon spp.  
Carcelia spp.  
Brachymeria euploeae

Predators

Robber fly  
Earwig  
Pentatomid bug

Reduviid bug  
Ground beetle  
Black drongo

Plants Suitable for Ecological Engineering in Grape Vineyard

Chrysanthemum sp  
Sunflower  
Ocimum spp.

Urdbean  
Spearmint  
Mustard

Marigold  
Carrot  
French bean

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

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Citation

Front cover picture
Model AESA chart for Grape

Back cover picture
Grape vineyard

Published by
National Institute of Plant Health Management, Rajendranagar, Hyderabad – 500 030

Copies:
1,000; November, 2014

For internal circulation only. Not for sale.

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Printed at
Balaji Scan Pvt. Ltd.,
A.C. Guards, Hyderabad.
Tel: 040-23303424
e-mail: bsplpress@gmail.com
www.balajiscan.com
FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of widespread 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

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FOREWORD

IPM as a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanical and chemical. Over the years IPM underwent several changes, shifting its focus from damage boundary, economic injury to economic threshold. Currently most stakeholders rely upon economic threshold levels (ETL) and tend to apply chemical pesticides at the first instance in the event of a pest attack, through 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 show 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)
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 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, through 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)
AESA BASED IPM PACKAGE FOR GRAPE

Grape - Plant description:

Grape (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.
I. PESTS

A. Pests of National Significance

1. Insect pests
   1.2 Flea beetle: *Scelodonta strigicollis* Olivier (Coleoptera: Chrysomelidae)
   1.3 Girdle beetle/grape cane girdler: *Ampelo glypterater* LeConte (Coleoptera: Curculionidae)
   1.4 Thrips: *Rhipiphorothrips cruentatus* Hood (Thysanoptera: Thripidae)
   1.5 Hoppers: *Empoasca fabae* Harris, *Erythroneura comes* Say (Hemiptera: Cicadellidae)
   1.6 Stem borer: *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
      2.8.1 Blue mould rot: *Penicillium digitatum* (Pers.) Sacc.
      2.8.2 Black mould rot: *Aspergillus niger* Van Tieghem
      2.8.3 Green mould: *Aspergillus flavus* Link.
      2.8.4 Rhizopus rot: *Rhizopus nigricans* Ehrenberg
      2.8.5 *Botrytis* bunch rot or gray mold of grape: *Botrytis cinerea* (De Bary) Whetzel

3. Nematode
   3.1 Root-knot nematode: *Meloidogyne* spp.

4. Weeds
   Broadleaf
   4.1 Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)
   4.2 Common purselane: *Portulaca oleracea* L. (Portulacaceae)
   4.3 False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)
   4.4 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
   4.5 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
   4.6 Coat buttons: *Tridax procumbens* L. (Asteraceae)
   4.7 Spanish needles: *Bidens pilosa* L. (Asteraceae)
   4.8 Silk leaf: *Lagascea mollis* Cav. (Asteraceae)
   4.9 Madras leaf-flower: *Phyllanthus madraspatensis* L. (Euphorbiaceae)
   Grasses
   4.10 Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)
   4.11 Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
Sedges

4.12 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
4.13 Flat sedge: *Cyperus iria* L. (Cyperaceae)

B. Pests of Regional Significance

1. Insect and mite pests

1.1 Red mite: *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 insect: *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 *Botryodiplodia* sp.

3. Nematodes

3.1 Reniform nematode: *Rotylenchulus reniformis* Linford and Oliveira (Andhra Pradesh, Maharashtra)
3.2 Dagger nematode: *Xiphinema americanum* Micol

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

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of vineyard observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

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

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

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience
Principles of AESA based IPM:
Grow a healthy crop:
- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/ planting material
- Treat the seeds/seedling/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring whenever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Crop rotation in inter free space.

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

Plant compensation ability:
Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

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

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

**Pest: Defender ratio (P: D ratio):**

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

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 of the vineyard continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

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

**AESA methodology:**

- Go to the vineyard in groups (about 5 farmers per group). Walk across the vineyard and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
  - Plant: Observe the plant 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 vineyard and their intensity.
  - Water: Observe the water situation of the vineyard.
  - Weather: Observe the weather condition.
- While walking in the vineyard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situations of the vineyard in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation of the vineyard. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what vineyard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

**Data recording:**
Farmers should record data in a notebook and drawing on a chart:

- Keep records of what has happened help us making an analysis and draw conclusions
Data to be recorded:

- **Plant growth (weekly):** Length of the plant, number of leaves.
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil conditions; irrigation; weather conditions
- **Input costs:** Seeds; fertilizer; pesticides; labour
- **Harvest:** Yield (Kg/acre); price of produce (Rs./Kg)

Some questions that can be used during the discussion:

- Summarize the present situation of the vineyard.
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the vineyard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL:

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

In ETL based IPM, natural enemies, plant compensation ability and abiotic factors are not considered. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P:D ratio.

AESA and farmer 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
**B. Field scouting:**

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

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

**For insect pests:**

**Mite/mealybug:** Count and record the number of both nymphs and adults on randomly selected shoot leaves) per plant.

**Thrips:** Count and record the number of both nymphs and adults present on the five terminal leaves per plant.

**Spodoptera, Desmia:** 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. 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:**
Pheromone traps for *Spodoptera* @ 4-5 traps/acre have to be installed, if available. Install the traps separated by a distance of >75 feet in the vicinity of the selected vineyard. 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 traps. 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 foot above the crop canopy for monitoring and mass trapping of nocturnal insects. Light traps with exit option for natural enemies of smaller size should be installed and operated 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 cm$^3$ (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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004 a, b).

Ecological Engineering for Pest Management – Below Ground:

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

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of Trichoderma harzianum/viride and Pseudomonas fluorescens for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their vineyards, registration is not required).

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

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

In order to attract natural enemies following activities should be practiced:

- Raise the flowering plants / compatible cash crops along the vineyard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the vineyard
- Not to uproot weed plants those are growing naturally such as Tridax procumbens, Ageratum sp, Alternanthera sp etc. which act as a nectar source for natural enemies
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen and insects etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, lacewing, earwigs etc.
Plants Suitable for Ecological Engineering for Pest Management

Attractant plants

Cluster bean
Carrot
Desmodium
Buckwheat
French bean
Alfalfa
Mustard
Cosmos
Anise
Caraway
Dill
Chrysanthemum sp.
Urdbean
Maize
The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature, however, the actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types.
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders
**IV. RESISTANT/TOLERANT VARIETIES**

<table>
<thead>
<tr>
<th>Pests</th>
<th>Tolerant/ resistant variety*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nematode</td>
<td>Dogridge and 1613</td>
</tr>
<tr>
<td>Phylloxera</td>
<td>Dogridge and 1613</td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>Chholth Red, Skibba Red, Chholth white</td>
</tr>
<tr>
<td>Downy mildew</td>
<td>Amber Queen, Dogridge, Red Sultana</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Golden queen, Goldenmuscat, Bangalore blue, Pusa Navrang</td>
</tr>
<tr>
<td>Powdery mildew and downy mildew</td>
<td>Bangalore blue, Concord, Champion, Catawba</td>
</tr>
<tr>
<td>Anthracnose and <em>Cercospora</em> leaf spot</td>
<td>Bangalore blue, Convent large black</td>
</tr>
<tr>
<td>Grape diseases and pests</td>
<td>Berries yellow-green, Himrod</td>
</tr>
</tbody>
</table>

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

**V. CROP STAGE-WISE IPM**

<table>
<thead>
<tr>
<th>Management</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre sowing stage*</td>
<td></td>
</tr>
</tbody>
</table>
| **Common cultural practices:** | - Deep ploughing of vineyards during summer to control nematodes population, to expose pupae and propagules of soil borne pathogens.  
- Soil solarization can be done for sterilizing the nursery mixture  
- Timely sowing should be done.  
- Field sanitation.  
- Destroy the alternate host plants as well as crop debris  
- Crop rotation.  
- Adopt ecological engineering by growing the attractant, repellent, and trap crops around the vineyard bunds.  
| Nutrients             | - 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 in-situ in August and September.  
| Weeds                 | **Cultural control:**  
- Plough the vineyard in summer/ before planting to destroy existing weeds in the vineyard.  
- Grow the green manure crop to suppress weeds in rainy season.  
**Chemical control:**  
- 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 | **Cultural control:**  
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16)  
- Rabbing with paddy husk/ straw.  |
## Sowing stage*

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>At the time of planting, fill up the pits with well decomposed FYM @ 50 Kg per pit mixed with top soil, <em>Trichoderma</em> species and AM @ 50 g inoculum / plant.</th>
</tr>
</thead>
</table>
| Weeds     | Use weed free seedling for planting.  
Removal 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 | Follow common cultural, mechanical and biological practices (See page no. 14,15,16)  
**Cultural control:**  
Intercropping of marigold reduces nematode population  
Nursery should be raised in nematode free sites or fumigated or solarized beds  
Application of decomposed poultry manure @ 200 g / sq. m |
| Leaf blight, anthracnose | For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's.  
**Cultural control:**  
Irrigation by rose can.  
Use of resistant varieties such as angalore Blue, Beauty Seedless, Bharat Early, Golden queen, Large white.  
**Chemical control:**  
For anthracnose  
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 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 mancozeb 75% WP @ 0.6-0.8 Kg in 300 l of water/acre or ziram 80% WP @ 0.6-0.8 Kg in 300-400 l of water/acre. |

* Application of *Trichoderma harzianum/viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field 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

| Common cultural practices: | Collect and destroy crop debris  
Provide irrigation at the critical stages of the crop  
Avoid water logging  
Avoid water stress during flowering stage  
Follow judicious use of fertilizers  
Enhance parasitic activity by avoiding chemical pesticide spray, when 1-2 larval parasitoids are observed in the crops field. |
| Common mechanical practices: | Collect and destroy disease infected and insect infested plant parts.  
Collect and destroy eggs and early stage larvae  
Handpick the older larvae during early stages  
Hand pick the gregarious caterpillars and cocoons which are found on stem/branches and destroy them in kerosene mixed water.  
Use blue sticky trap @ 4-5 traps/acre and operate between 6 pm and 10 pm.  
Use light trap @ 1/acre and operate between 6 pm and 10 pm  
Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) |
- Set up bonfire during evening hours at 7-8 pm.

**Common biological practices:**
- Conserve natural enemies through ecological engineering
- Augmentative release of natural enemies

### Nutrients

<table>
<thead>
<tr>
<th>Variety</th>
<th>Region</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>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></td>
<td>175</td>
<td>122</td>
<td>315</td>
</tr>
<tr>
<td>South interior Karnataka</td>
<td></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>Thompson Seedless</td>
<td>North India</td>
<td>180-440</td>
<td>530</td>
<td>530</td>
</tr>
<tr>
<td></td>
<td>Maharashtra</td>
<td>265-400</td>
<td>200-350</td>
<td>265-320</td>
</tr>
<tr>
<td></td>
<td>South interior Karnataka</td>
<td>120</td>
<td>200</td>
<td>400</td>
</tr>
</tbody>
</table>


- 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

- 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) @ 1 l 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 parquat 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.


### Leaf eating caterpillar

- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Growing of castor as trap crop all around the vineyard for oviposition.

**Biological control:**
- Spraying NSKE 5% against eggs and first instar larva

### Stem borer/cane borer

- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- 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.
### AESA based IPM – Grape

<table>
<thead>
<tr>
<th>Insect</th>
<th>Cultural Control</th>
<th>Mechanical Control</th>
<th>Biological Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hopper</strong></td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).&lt;br&gt;- Plant tall border crops such as maize, sorghum or pearl millet to reduce hopper infestations.&lt;br&gt;- Keep the nursery area clean, free of weeds and grasses to keep away the grass hoppers.&lt;br&gt;- Removal of weeds and alternate hosts plants such as hibiscus, okra, custard apple, guava etc.&lt;br&gt;&lt;strong&gt;Cultural control&lt;/strong&gt;:&lt;br&gt;- Spray oxydemeton–methyl 25% EC @ 400 ml in 200-400 l of water/acre.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mealybug</strong></td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).&lt;br&gt;- Removal of weeds and alternate host plants like hibiscus, okra, custard apple, guava etc in and nearby vineyards throughout the year.&lt;br&gt;- Deep ploughing in summer or raking of soil in vineyards helps to destroy its nymphal stages and minimizing the incidence.&lt;br&gt;&lt;strong&gt;Mechanical control&lt;/strong&gt;:&lt;br&gt;- Remove and destroy the loose bark.&lt;br&gt;&lt;strong&gt;Biological control&lt;/strong&gt;: &lt;br&gt;- Release exotic predator, Cryptolaemus montrouzieri @ 10 beetles/vine &lt;br&gt;- Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations viz., 50000 ppm formulation is sprayed at 1 ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml/l, respectively. &lt;br&gt;&lt;strong&gt;Chemical control&lt;/strong&gt;:&lt;br&gt;- 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</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flea beetle</strong></td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).&lt;br&gt;- Remove the loose bark at the time of pruning to prevent egg laying.&lt;br&gt;- Shake vines to dislodge adult beetles, collect into trays containing kerosenated water (1 kerosene: 9 water) and destroy them.&lt;br&gt;- 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.&lt;br&gt;- Use high quality, large, vigorous seed- the quicker a seedling can establish itself the more damage it can withstand from flea beetles.&lt;br&gt;- Seed early - a plant that establishes quickly can ward off flea beetles more effectively. Caution advised if high populations are seen early in vineyards when planting. Crops must be monitored daily upon emergence for damage.&lt;br&gt;- Crop rotation - flea beetles over-winter along vineyard 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, planting canola again will contribute to high populations once again.&lt;br&gt;- Direct seeding - provides a microclimate that warms slower than a conventionally seeded crop. Cooler temperatures slow flea beetle activity, reducing damage.&lt;br&gt;- Increase seeding rates - increased plant populations means less damage to each specific plant.&lt;br&gt;- Wider row spacing - reduces the attractiveness to the flea beetles&lt;br&gt;&lt;strong&gt;Mechanical control&lt;/strong&gt;:&lt;br&gt;- Setting up of light trap @ 1/acre (6-10 pm).&lt;br&gt;&lt;strong&gt;Botanical control&lt;/strong&gt;: &lt;br&gt;- Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations viz., 50000 ppm formulation is sprayed at 1 ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml/l dose, respectively. &lt;br&gt;&lt;strong&gt;Chemical control&lt;/strong&gt;:&lt;br&gt;- 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 malathion50% EC @ 400 ml in 600-800 l of water/acre</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Chafer beetle**
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Eliminate hibernating site

**Chemical control**
- Malathion 50% EC @ 400 ml in 600-800 l of water/acre

### Girdle beetle/Grape cane girdler
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Cutting of infested shoot bellow 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.

**Chemical control**
- Malathion 50% EC @ 400 ml in 600-800 l of water/acre

### Thrips
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Install 4-20 blue coloured sticky 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.

**Chemical control**
- 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**
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Proper irrigation scheduling reduces the water stress and also increases the humidity thereby reducing the mite population

**Biological control:**
- Several predatory insects and spiders feed on mites but the most efficient natural predators of mite pests are predatory mites.

### Leaf folder/Leaf roller**
- Follow common cultural, mechanical and biological practices (See page no. 14,15,16).

**Cultural control:**
- Simple method to control the pest population is to collect and burn the infested leaves.

### Powdery mildew
- For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's.

**Cultural control:**
- 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 under vine irrigation system and manage it carefully, excess water can favour the disease

**Chemical control**
- Benomyl 50 % WP @ 120 g in 250-280 l of water/acre or carbendazim 46.27% SC @ 0.1% or 100 ml, 100 l/acre or hexaconazole 2% SC @ 0.6-1.2 l in 200-300 l of water/acre or hexaconazole 5% EC @ 200-400 ml
### Downy mildew

- **For resistant / tolerant varieties** consult ICAR Institute / KVK's / SAU's.

#### Cultural control:
- 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.

#### Chemical control:
- 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 copper oxychloride 50% WG @ 0.24% or 240 g /100 l water or copper oxy chloride 50% WP @ 1 Kg in 300-400 l of water/acre or cymoxanil 50% WP @ 0.24% or 240 g/100 l water as required depending upon the crop stage and equipment used or cyazafamid 34.5% SC@ 80 ml in 200 l of water/acre or dimethomorph 50% WP @ 400 g in 300 l of water/acre or fosetyl-AL 80% WP @ 560-800 g in 300-400 l of water/acre or kresoxim-methyl 44.3% SC@ 240-280 ml in 200 l of water/acre or mancozeb 75% WP @ 0.6-0.8 Kg in 300 l of water/acre or propineb 70% WP @ 0.30% or 300 g/100 l water as required depending upon crop stage and plant protection equipment used or zineb 75% WP @ 0.6-0.8 Kg in 300-400 l of water/acre or ziram 80 % WP @ 0.6-0.8 Kg in 300-400 l of water/acre or cymoxanil 8% + mancozeb 64% WP @ 600-800 g in 200-400 l of water/acre or famoxadone 16.6% + Cymoxanil 22.1% SC @ 200 ml in 200-300 l of water/acre or fenamidone 4.44 %+ fosetyl Al 66.7% WG @ 800-1000 g in 200-300l of water/acre or fenamidone 10%+ mancozeb 50% 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 metalaxyl 8%+ mancozeb 64% WP @ 200 l/acre of 0.5% or metiram 55% + pyraclostrobin 5% WG @ 600-700 g in 300 l of water/acre.

### Anthracnose, blight

- **For resistant / tolerant varieties** consult ICAR Institute / KVK's / SAU's.

#### Cultural control:
- 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.

#### Chemical control:
- Same as in sowing stage.

### Bitter rot and bacterial leaf spot, rust**

- **For resistant / tolerant varieties** consult ICAR Institute / KVK's / SAU's.

#### Cultural control:
- 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
- Collect about 200 random petiole samples (fifth leaf 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               | • Remove weeds around the plants.  
|                    | • Use straw or plastic mulch to avoid weed growth and to maintain soil moisture for longer period. |
| Insects            | • Same as in vegetative stage. |
| Powdery mildew, downy mildew | • For resistant / tolerant varieties consult ICAR Institute / KVK’s / SAU’s.  
|                    | **Cultural control:**  
|                    | • 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. |
|                    | **Chemical control:**  
|                    | • Same as in vegetative stage. |
| Blight, anthracnose, bitter rot and bacterial leaf spot | • For resistant / tolerant varieties consult ICAR Institute / KVK’s / SAU’s.  
|                    | **Cultural control:**  
|                    | • 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       | • For resistant / tolerant varieties consult ICAR Institute / KVK’s / SAU’s.  
|                    | **Cultural control:**  
|                    | • Careful handling in the vineyard, pre-cooling and refrigeration helps in controlling the disease.  
|                    | • Pruning and thinning of the vineyard reduces disease incidence  
|                    | • Humidity around the clusters. |
| Blue rot           | • For resistant / tolerant varieties consult ICAR Institute / KVK’s / SAU’s.  
|                    | **Cultural control:**  
|                    | • Avoiding injuries to the ripe berries helps to reduce soft rot.  
|                    | • Use clean planting stock; remove disease wood and burn immediatly; fungicide application at shoot extension and later if temperatures are cool. |
| Birds, bats        | **Cultural:**  
|                    | • 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 vineyards  
|                    | • Noise makers: propane canons, electronic scare devices  
|                    | • Nets: Still the best option for full protection  
|                    | • Use traps, tape, balloons, kites, etc. |
| Postharvest        | **Cultural control:**  
| Black mould rot, blue mould rot, green mould rot, Botrytis rot | • Careful handling and prompt refrigeration to 1-2 °C or below prevents the disease in storage.  
|                    | • Inclusion of SO$_2$ releasing pads in the boxes while packing helps to control the disease. |
**Rhizopus rot**

**Cultural control:**
- 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.

**Physical control:**
- Maintaining cold storage temperature between 4-10 °C prevents fungal growth.

**Note:** The pesticides dosage and spray fluid volumes are based on high volume sprayer. The recommended pesticides' name are as per CIBRC updated on 31.10.2014.

**VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT**

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

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

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

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

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

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

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

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

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

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

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

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 K₂O /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

3. Calcium:

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

**Management:**
- Soil application of quicklime slaked lime, dolomite, calcium carbonate (0.02-0.6 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

**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).

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 N source (11-52-0)

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 P₂O₅

7. Boron:

**Deficiency symptoms:**
- Shoot tip death and short inter-nodes, 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 leaf development stage

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 l 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 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 tertaborate) 12-16 Kg/acre
- Foliar sprays of zinc sulphate (.5-1.0%) neutralized with calcium carbonate, 3 weeks before flowering.

Source: [http://afghanag.ucdavis.edu/a_horticulture/fruitstrees/grapes/presentations powerpoint/PPT_NUTRI_REQUIRE_FOR_GRAPEVINES.ppt](http://afghanag.ucdavis.edu/a_horticulture/fruitstrees/grapes/presentations powerpoint/PPT_NUTRI_REQUIRE_FOR_GRAPEVINES.ppt)
VIII. PHYSIOLOGICAL DISORDERS

1) 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.

2) 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.

3) Shot berries:
   **Symptoms:**
   - 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.

4) Pink berry:
   **Symptoms:**
   - 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.

5) Bud and flower drop:
   **Symptoms:**
   - 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.
   - This phenomenon is prevalent in North India in the states of Punjab, Haryana and Rajasthan.

6) Poor cane maturity:
   **Symptoms:**
   - 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.
IX. COMMON WEEDS

2. Common purselane: *Portulaca oleracea* L. (Portulacaceae)
3. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
4. Goat weed: *Ageratum conyzoides* L. (Asteraceae)
5. Spanish needles: *Bidens pilosa* L. (Asteraceae)
7. Silk leaf: *Lagascea mollis* Cav. (Asteraceae)
8. Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)
10. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
11. Flat sedge: *Cyperus iria* L. (Cyperaceae)
12. Coat buttons: *Tridax procumbens* L. (Asteraceae)
X. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1) Leaf eating caterpillar:

**Biology:**

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.

**Life cycle:**

1. Eggs
2. Larva
3. Pupae
4. Adult

**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.

**Natural enemies of leaf eating caterpillars:**

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

**Predators:** Chrysoperla zastrowi sillemi, C. crassinervis, King crow, braconid wasps, dragon flies, spider, praying mantids, Harpactor costalis, Rhyncoris fuscipes, R. squalis, Polistes stigma, Coranus spiniscutis etc.

*For management refer to page number 16.
2) Mealybug:

**Biology:**

**Egg:** 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 parthenogenetically throughout the year.

**Life cycle:**

<table>
<thead>
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<th>1.</th>
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<tr>
<td>Damage symptoms</td>
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- 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.

**Natural enemies of mealybug:**

**Parasitoids:** *Coccidoxenoides peregrina, Anagyris dactylopii, Allotropa citri, Leptomastix dactylopii* etc.

**Predators:** *Coccinellid (Cryptolaemus montrouzieri), Symnus coccivora, Mallada boninensis, Spalgis epeus* etc.

*For management refer to page number 17.*
3) **Mite:**

**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.

**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)

*For management refer to page number 18.*
4) Thrips:

**Biology:**

**Egg:** Eggs are hyaline, globular laid in mass and 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 polyphagus pest. Besides, it also infests brinjal, cotton, groundnut, castor, bottlegourd, guava and tea.

**Life cycle:**

![Life cycle diagram of thrips]

**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.

**Natural enemies of thrips:**

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

*For management refer to page number 18*

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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 wing spread 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.

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*For management refer to page number 18*
**Life cycle:**

- 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, *Ampeloglypter 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 overwintering 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.

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**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.

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**Natural enemies of leaf folder:**

- **Parasitoid:** *Bracon cushmani, Cardiochiles spp.* etc.

- **Predators:** Lacewing, spider etc.

*For management refer to page number 18.*

### 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, *Ampeloglypter 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 overwintering 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.
**AESA based IPM – Grape**

Life cycle:

1. **Egg:** Yellow to orange, cylindrical in shape, rounded on one end and 1mm in length and 0.4 mm in width. Eggs are laid near the buds or loose cane.

2. **Larva:** Newly hatched larvae is dark brown in colour but late turns light brown, 7-9 mm in length, and whole body is cover with back shiny and rectangular plates of varius sizes which gives the spotted appearance of larave

3. **Pupa:** Pupae bright yellow, 4-6 mm long, and with conspicuous reddish brown eyes. Wings and legs are off white colour.

4. **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 enlarge and enabling the adult to jump quickly when disturbed.

**Damage 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

*For management refer to page number 18.

**7) Flea beetle:**

**Biology:**

**Egg:** Yellow to orange, cylindrical in shape, rounded on one 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 late turns light brown, 7-9 mm in length, and whole body is cover with back shiny and rectangular plates of varius sizes which gives the spotted appearance of larave

**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 enlarge and enabling the adult to jump quickly when disturbed.

**Life cycle:**

1. **Egg:**
2. **Larva:**
3. **Pupa:**
4. **Adult:**

**Damage symptoms:**

- The adult beetles scrap 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.

1,2,3,4: http://www.nysipm.cornell.edu/factsheets/grapes/pests/gfb/gfb.asp
*For management refer to page number 17.

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.

*For management refer to page number 18.

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  

**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.

**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 16.*

**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. Eggs
2. Larvae (Infective (J2) juveniles)
3. Adults
   - Male (longer): 16-22 days
   - Female (bulged): 25-30 days

**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 the day, especially under dry conditions and are often stunted
- Nematode infection predisposes plants to fungal and bacterial root pathogens

**Survival and spread:**

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

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

**Favourable conditions:** Loamy light soils.

*For management refer to page number 15.*

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Damage symptom

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


5. Ichneumon spp.

6. Carcelia spp

7. Campoletis spp.

Pupal parasitoid

8. Brachymeria euploeae
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Predators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Lacewing</td>
<td>2. Ladybird beetle</td>
<td>3. Reduviid bug</td>
</tr>
</tbody>
</table>
16. Predatory thrips
17. Oligota spp.
18. Orius spp.
19. Hover fly
20. Mirid bug

XI. 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.

![Disease symptoms](http://www.google.co.in/search?q=downy+mildew+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=a20MU4ybOcuprAew4IBQ&ved=0CAkQ_A) 1, 2

*For management refer to page number 19

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.
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.

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.

![Disease symptoms](http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape_bitter_rot.jpg)

1,2: http://upload.wikimedia.org/wikipedia/commons/2/2a/Grape_bitter_rot.jpg

*For management refer to page numbers 19-20.

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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.

![Disease symptoms](https://www.google.co.in/search?q=bacterial+leaf+spot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=mnAMU6ThJMKVQzr cleanup=0CATQ_AU)

1,2:https://www.google.co.in/search?q=bacterial+leaf+spot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=mnAMU6ThJMKVQzr cleanup=0CATQ_AU

*For management refer to page number 19.
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 ºC) and intermittent rains favours disease development.

![Disease symptoms](https://www.google.co.in/search?q=alternaria+leaf+spot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=mnAMU6ThJMKlrQeum4HIAQ&ved=0CAkQ_AU)

*For management refer to page number 15.

7) *Black rot*:

**Disease symptoms:**
- The disease attacks the leaves, stem, flowers and berries. All the new growth on the vines 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 darkcoloured canker lesions occur on the young stems and tendrils. Leaf, cane and tendrill infection can occur only when the tissue is young, but berries can be infected until almost fully-grown if an activefungicide 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.

![Disease symptoms](https://www.google.co.in/search?q=alternaria+black+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=mnAMU6ThJMKlrQeum4HIAQ&ved=0CAkQ_AU)

*For management refer to page number 20.*
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 is necessary for infection to occur.

![Disease symptoms](https://www.google.co.in/search?q=blue+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=I3YMU9riJM2nrge-

*For management refer to page number 20.

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 is necessary for infection to occur.

![Disease symptoms](https://www.google.co.in/search?q=blue+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=I3YMU9riJM2nrge-

*For management refer to page number 20.
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.

https://www.google.co.in/search?q=green+mould+rot+of+grapes&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=I3YMU9RtM2rnege-

*For management refer to page number 20.*

11) **Rhizopus rot:**

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

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

*For management refer to page number 21.*
### 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.

*For management refer to page number 20.*

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

Survival and spread:

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

Favourable conditions:

1. Moderate humidity and moist conditions

*For management refer to page number 19.*
**Diseases cycles:**

1. **Downy mildew:**
   - Fungus overwinters as conidia on the surface of the vine or in soil.
   - Sporangia are released in spring.
   - Sporangia liberate zoospores in water.
   - Zoospores are优选 to susceptible tissue, forming an infection site.
   - Fungal growth is visible as a white, powdery film on the leaves.

2. **Powdery mildew:**
   - Fungus overwinters as dormant buds on the grape cluster.
   - Pink salt continues on the surface of the leaves in the spring.
   - Conidiophores and conidia produced on leaves, shoots, and berries.
   - Conidia are spread by the wind.

3. **Anthracnose:**
   - Conidia and conidiophores are produced in the spring when warm and humid conditions are optimal.
   - Fungal spores infect young leaves, shoots, and berries.
   - Secondary growth occurs on the tissue of infected leaves.

4. **Bacterial leaf spot:**
   - The disease is seed and soil-borne, and transmission occurs through inoculum present in the seeds and soils.
   - The pathogen survives through spores (conidia) or mycelium in diseased plant debris or weeds.
   - Secondary transmission by conidia.

5. **Black rot:**
   - Disease occurs on diseased plant debris or weeds.
   - Conidia are produced on the surface of infected tissue.
XII. SAFETY MEASURES

A. At the time of 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 ripe 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. 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 storage:

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.

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
### XIII. DO’S AND DON’TS IN IPM

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Do’s</th>
<th>Don’ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grow only recommended varieties.</td>
<td>Do not grow varieties not suitable for the season or the region.</td>
</tr>
<tr>
<td>2</td>
<td>Always treat the seedlings with approved chemicals/bio products for the control of seed borne diseases/pests.</td>
<td>Do not use seedlings without seed treatment with biopesticide/chemicals.</td>
</tr>
<tr>
<td>3</td>
<td>Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.</td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Maintain optimum and healthy orchid stand which would be capable of competing with weeds at a critical stage of crop weed competition</td>
<td>Crops should not be exposed to moisture deficit stress at their critical growth stages.</td>
</tr>
<tr>
<td>5</td>
<td>Use micronutrient mixture based on soil test recommendations.</td>
<td>Do not apply any micronutrient mixture after sowing without soil test recommendations.</td>
</tr>
<tr>
<td>6</td>
<td>Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.</td>
<td>Do not apply any micronutrient mixture after sowing without test recommendations.</td>
</tr>
<tr>
<td>7</td>
<td>Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per vineyard observation</td>
<td>Do not store the pheromone lures at normal room temperature (keep them in refrigerator).</td>
</tr>
<tr>
<td>8</td>
<td>Apply short persistent pesticides to avoid pesticide residue in the soil and produce.</td>
<td>Do not apply pesticides during preceding 7 days before harvest.</td>
</tr>
<tr>
<td>9</td>
<td>Follow the recommended procedure of trap crop technology.</td>
<td>Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.</td>
</tr>
<tr>
<td>10</td>
<td>Diseases like downy mildew and powdery mildew are caused by 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.</td>
<td>Hence time gap between two adjacent blocks should not be more than 9 days. If unavoidable, fungicide should be sprayed on un-pruned block.</td>
</tr>
</tbody>
</table>
## XIV. SAFETY PARAMETERS IN PESTICIDE USAGE

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Pesticide Classification as per insecticide rules</th>
<th>WHO classification of hazard</th>
<th>Symptoms of poisoning</th>
<th>First aid measures and treatment of poisoning</th>
<th>Harvesting intervals (days)</th>
</tr>
</thead>
</table>
| 1      | Malathion, Moderately toxic,                  | Class III slightly hazardous  | Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity | **First aid measures:** Rush to the nearest physician.  
**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. | –                           |
| 2      | 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 essentially symptomatic. | 3                           |
| 8      | Captan Moderately toxic                       | Class III slightly hazardous  | Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc. | **First aid measures:** Rush to the nearest physician.  
**Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic | 6                           |

**Fungicides**

<p>| | | | | | |
|  |  |  |  |  |  |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>Toxicity Level</th>
<th>Hazardous Symptoms</th>
<th>First Aid Measures</th>
<th>Treatment of Poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Mancozeb</td>
<td>Slightly toxic</td>
<td>Unlikely produce acute hazard</td>
<td><strong>First aid measures:</strong> Rush to the nearest physician.</td>
<td><strong>Treatment of poisoning:</strong> No specific antidote. Treatment is essentially symptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.</td>
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<td></td>
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<tr>
<td>10</td>
<td>Copper oxychloride</td>
<td>Moderately toxic</td>
<td>Class III slightly hazardous</td>
<td><strong>First aid measures:</strong> Rush to the nearest physician.</td>
<td><strong>Treatment of poisoning:</strong> No specific antidote. Treatment is essentially symptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.</td>
<td></td>
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</tr>
</tbody>
</table>
XV. BASIC PRECAUTIONS IN PESTICIDE USAGE

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

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

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

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

E. Equipments
1. Select right kind of equipment.
2. Do not use leaky and defective equipments
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; Do not apply just before the rains and after the rains; Do not apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the 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.
## XVI. PESTICIDE APPLICATION TECHNIQUES

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category A: Stationary, crawling pest/disease</strong></td>
</tr>
<tr>
<td><strong>Vegetative stage</strong></td>
</tr>
<tr>
<td>i) For crawling and soil borne pests</td>
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<tr>
<td>ii) For small sucking leaf borne pests</td>
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<td></td>
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<tr>
<td><strong>Reproductive stage</strong></td>
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</tbody>
</table>

| **Category B: Field flying pest/airborne pest** |
| **Vegetative stage** |
|  | Insecticides and fungicides |
|  | • Motorized knapsack sprayer or mist blower (droplets of small size) |
|  | • Airblast nozzle |
|  | • Operating speed: 2/3rd throttle |
|  | • Battery operated low volume sprayer (droplets of small size) |
|  | • Spinning disc nozzle |
| **Reproductive stage (Field Pests)** |
|  | Insecticides and fungicides |
|  | • Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) |
|  | • Hot tube nozzle |

<p>| <strong>Category C: Weeds</strong> |
| <strong>Post-emergence application</strong> |
|  | Weedicide |
|  | • Lever operated knapsack sprayer (droplets of big size) |
|  | • Flat fan or floodjet nozzle @ 15 to 20 psi |
|  | • Lever operating speed = 7 to 10 strokes/min |
| <strong>Pre-emergence application</strong> |
|  | Weedicide |
|  | • Trolley mounted low volume sprayer (droplets of small size) |
|  | • Battery operated low volume sprayer (droplets of small size) |</p>
<table>
<thead>
<tr>
<th></th>
<th>XVII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td>For application rate and dosage see the label and leaflet of the particular pesticide.</td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.</td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>Clean and wash the machines and nozzles and store in dry place after use.</td>
</tr>
<tr>
<td><strong>4.</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>5.</strong></td>
<td>Do not apply in hot or windy conditions.</td>
</tr>
<tr>
<td><strong>6.</strong></td>
<td>Operator should maintain normal walking speed while undertaking application.</td>
</tr>
<tr>
<td><strong>7.</strong></td>
<td>Do not smoke, chew or eat while undertaking the spraying operation</td>
</tr>
<tr>
<td><strong>8.</strong></td>
<td>Operator should take proper bath with soap after completing spraying</td>
</tr>
<tr>
<td><strong>9.</strong></td>
<td>Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.</td>
</tr>
</tbody>
</table>
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Important Natural Enemies of Grape Insect Pests

**Parasitoids**

- *Trichogramma* spp.
- *Telenomus* sp
- *Campoletis* spp.
- *Bracon* spp.
- *Carcelia* spp.
- *Brachymeria euploeae*

**Predators**

- Robber fly
- Earwig
- Pentatomid bug
- Reduviid bug
- Ground beetle
- Black drongo

**Plants Suitable for Ecological Engineering in Grape Vineyard**

- *Chrysanthemum* sp
- Sunflower
- *Ocimum* spp.
- Urdbean
- Spearmint
- Mustard
- Marigold
- Carrot
- French bean
- Cowpea
- Buckwheat
- Maize
AESA BASED IPM PACKAGE
GRAPE

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

National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Pests

Defenders