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IPM Package of Practices for Grapes

(For Producing Quality Fruits for Export)

Government of India

Ministry of Agriculture & Farmer's Welfare

Department of Agriculture & Farmer's Welfare

Directorate of Plant Protection Quarantine & Storage

NH-IV, Faridabad

April, 2022

IPM Package of Practices for Grapes (For producing quality fruits for export) was compiled by the DPPQS technical team under the Chairmanship of **Dr. Ravi Prakash, Plant Protection Adviser, and guidance of Dr. Pramod Kumar Meherda, IAS, JS (PP). Dr. S.C. Dubey, ADG(PP), ICAR, New Delhi** provided review from crop specific ICAR institute - National Research Centre for Grapes, Pune.

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FOREWORD

Pests and disease menace cause significant crop losses to the farmers. At times, farmers apply large quantity of pesticides indiscriminately to control pests & diseases during various crop growth stages or on noticing damage symptoms in the crop. Indiscriminate use of chemical pesticides is a major cause of ecological imbalances, environmental pollution, pesticide resistance, pest resurgence and pesticide residues.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. IPM strategy has currently shifted to more ecologically sustainable Agro-Eco System Analysis (AESA) based decision making for selection of IPM technique. The AESA based decision making considers relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest build up. IPM approach advocates utilization of alternate pest management techniques like cultural, mechanical and biological, prior to use of chemical pesticides. Pesticide residues, apart from pest association in agricultural produce, have proved to be a major impediment in exports of our agricultural commodities, especially of fresh fruits and vegetables.

Grape is one of the important fruits with high export potential. It is grown in large areas of the country. Sincere efforts have been made by resource personnel of DPPQS & ICAR to incorporate all the aspects that will help in production of pest and pesticide residue free grapes that will not only help in facilitating exports, but also in providing healthy fruits to Indian citizens. I hope that the IPM Package of Practices for Grapes will be a handy document for Central and State government functionaries involved in extension, as well as for farmers, and will go a long way in production of residue-free quality grape fruits in the country.

18/07/2022

Dr. Pramod Kumar Meherda

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FOREWORD

IPM is a science-based, decision-making process that combines biological, cultural, physical and chemical tools to reduce damage from pests and pest management tactics in a way that minimizes overall economic, health and environmental risks.

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Experience in different countries have sine 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 DPPQS have made sincere efforts in IPM Package of Practices for Grapes (For producing quality fruits for export) by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques, other IPM options and post-harvest management for the pesticide residues free in grapes and to export of grapes with the crop based plant protection measures. I covey my sincere thanks to Dr. S.C. Dubey, ADG(PP), ICAR, New Delhi for providing review from crop specific ICAR institute - National Research Centre for Grapes, Pune.

I hope this IPM package will serve as a ready reference for extension functionaries of Central / State Governments, NGOs and farmers for producing exportable grapes fruits.

Ravi Prakash

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Plant Protection Adviser

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PREFACE

India is the largest producer of grapes in the world with the production of 31, 29,000 MT and share 16% of total world production. However, Phytosanitary and Sanitary compliance are major aspects for export of any fresh fruits. Indiscriminate use of chemical pesticides for management of pests/ diseases results in pesticides residue in fruits and fails meeting sanitary requirement of various importing countries. In recent time, most of the countries incorporating Maximum Residue Level (MRL) as major sanitary requirement for import of Agricultural commodities especially for fresh fruits & vegetables. So there is challenge to produce pest as well as pesticide free fruits for export. Adoption of Agro-ecosystem Analysis (AESA) based Integrated Pest Management (IPM) can promise production of pests as well as pesticide residue free fruits and comply with Phytosanitary and Sanitary requirements of most of the Grapes importing countries. In addition, AESA based IPM also conserves bio-diversity in agro-ecosystem, reduce environmental pollution and reduce cost of cultivation and thereby increase farmers' income.

I convey my sincere thanks to Joint Secretary (Plant Protection) & Plant Protection Adviser for encouragement and facilities for compilation of this PoP and also to ADG (PP), ICAR, New Delhi for review from crop specific ICAR institute - National Research Centre for Grapes, Pune.

This IPM Package of Practices for Grapes (For producing quality fruits for export) will prove an important guide for extension functionaries of Central / State Governments, NGOs and farmers for producing exportable grapes fruits.

Om Prakash Verma
Joint Director (IPM)

CONTENTS

1. INTRODUCTION

Grape (*Vitis vinifera* L.) belonging to Family *Vitaceae* is a commercially important fruit crop of India. It is a temperate crop which has got adapted to sub-tropical to tropical climate conditions of India. Grapes occupy a predominant position in terms of world fruit production, with approximately 16% share of the global fruit production. The average area, production and productivity of grape in India during year 2020-21 is 140 thousand hectare, 31, 29,000 MT and 22.35 MT/ha, respectively.

Grape is mainly cultivated in Maharashtra followed by Karnataka, Tamil Nadu, Mizoram and Andhra Pradesh. Some northern states viz.; Punjab, Himachal Pradesh and Jammu and Kashmir are also producing grapes. About 94%of total production comes from Maharashtra and Karnataka. From the total production, about 71 per cent is available for table purpose and nearly 27 per cent is dried for raisin making, 1.5 per cent for winemaking and 0.5 per cent is used for juice making.

2. CLIMATE AND SOIL REQUIREMENT

Grape is grown under a variety of soil and climatic conditions in distinct agro-climatic zones, namely, temperate, sub-tropical, hot tropical and mild tropical. However, Maharashtra is the major producer which amounts to 84% of the total production of the country.

Grapes are found growing on a variety of soil type. Best soil for grapes would be well drained loam to sandy loam with good organic matter and with soil depth of almost 1 m.

3. CULTIVARS AND VARIETIES

The grapes are grown for different purposes (wine, fresh consumption, raisin and juice purpose).

- **White Table Grapes -** Thompson Seedless, Tas-A-Ganesh, Sonaka, Super Sonaka, ManikChaman, Sudhakar Seedless, Manjari Naveen, etc.,
- **ColouredTable Grape-**Sharad Seedless, Nana saheb Purple Seedless, Flame Seedless, Red Globe, Crimson Seedless, Fantasy Seedless, ManjariShyama, etc.
- **Raisins Purpose-** Thompson Seedless, Clone 2A, ManjariKishmish, Tas-A-Ganesh, Sonaka, ManikChaman, etc.
- **Wine Purpose-** Merlot, Syrah, Zinfandel, Pinot Noir, Cabernet Franc, Cabernet Sauvignon, Pinot Noir, Sauvignon Blanc,Chenin Blanc, Chardonnay, Riesling etc.,

- **Juice Purpose -** : Bangalore Blue, Bangalore Purple, Manjari Medika, Muscat Hamburg (Gulabi), Ari-516, etc.

4. PROPAGATION AND PLANTING

Grapes are propagated by asexual method. While planting grapes on its own root, hardwood cuttings are used. However, with the onset of problems of soil and water quality the use of rootstock became mandatory. Rootstock cuttings are dipped in running water for about one day. This helps in leaching out the rooting inhibitors from the rootstock cutting and achieve early and uniform bud sprouts after planting. The cuttings are dipped in the solution of 2000-3000 ppm GA_3 for duration of 1 to 2 minutes. Generally, cuttings with 8-10 mm diameter having 4 nodes are selected for planting. The cuttings are planted in the polybags.

Planting of rootstock in the field should be completed during February- March month. Although more than 15 different types of rootstocks are available**,** Dogridge is the most commonly used rootstock followed by 110R and 1103P for grapes grown for table purpose. The rootstock plants are maintained in the field by following all recommended cultural practices. Grafting on rootstock is performed during August – September month. The grafting is done at one foot above the ground when rootstocks attained a diameter of 8-10 mm. In the condition of not achieving uniform shoot diameter at about one feet height above the ground, the fresh re-cut of rootstock is taken at the base. The recut is generally taken during first week of June. During this period, the relative humidity of more than 60%and less than 35 $^{\circ}$C should be maintained.

4.1 Grafting:

The grafting is generally done during the month of August –Sept. While grafting, the rootstock and scion (commercial varieties) should possess the following characters.

Rootstock:

i) The shoot of rootstock should have 8-10 mm diameter at one feet above the ground.
ii) The rootstock should be under sap flow condition.
iii) The rootstock should be straight growing and healthy
iv) The rootstock should be soft wood to semi-matured.

Scion:

i) The scion variety selected for grafting on rootstock should be from healthy, high yielding and disease-free vines.

ii) The shoot diameter of scion should be 8-10 mm.

iii) The scion selected for grafting should be completely matured with brown color pith.

iv) The scion should be round in shape with sufficient storage of food material.

Re- cut of Grafted Vines

The vines grafted during August-September are passing through disease incidence and nutrient deficiency. Due to continuous and heavy rainfall, the shoot growth will not be proper. Under such conditions, a fresh re-cut of the vine is taken during February when the minimum temperature starts rising above 15^0C. This helps in uniform and early bud sprouts. Re-cut are generally taken 4-5 buds above the graft joint. In case of uniform growth with thick shoot, re-cut can be taken one feet above the graft joint. Depending upon the growth status of grafted vine, the position of re-cut is decided. For uniform bud sprouting, bud swabbing with Hydrogen cyanamide @ 40 mL/L water is done.

4.2 Developing the Framework:

After the re-cut, the bud starts sprouting with 10-12 days. During this period, the temperature starts rising. This condition will help for early bud sprouts. Selection of shoot is important for disease-free vine.Since, the chances of disease infection on first sprouted shoot is more, it is pinched at 3-4 leaf and second shoot is selected for development of trunk. Growth of newly sprouted shoot will be much faster that needs to be managed properly so that without wasting this growth, framework development will be completed at the earliest possible. In this method, the newly growing shoot is cut at 6-7 leaf stage when it is at 8-9 leaf stage.

4.3 Trunk Development:

Trunk development is generally done following ‘stop n go’ method. When the shoot grows to a height of about one feet, it is pinched at about nine inch length (about 6-8 leaf). After the sprouting, top shoot is tied to the bamboo. The side shoots are allowed to grow and then pinched by retaining 3-4 leaves. The side shoot will support for storage of food material and formation of strong trunk.

4.4 Development of Cordons:

For cordon development, when the shoot grows three inch above the wire, the shoot grown for main trunk is pinched just 3 inches below the top wire (bower trained vine). In case

of Y trellis trained vines, the growing shoot is pinched at 3 inches below the cordon wire. The shoots after sprouting are turned on the wire for cordon development. The cordon development is done by "stop n go" method. When the shoot growth on cordon wire is at 8-9 leaf, the shoot is pinched at 6-7 leaf stage. After sprouting, the lateral growth is allowed to grow while the other side shoots are pinched at 3-4 leaf stage. This is called as short sub cane. Allowing the shoot growing using this method, will help to develop complete cordon during the first year only.

5. NUTRIENT MANAGEMENT:

In India, grape is mainly grown in the semi-arid tropics with more than 90 % of the area concentrated in Maharashtra and North Karnataka. Majority of the vineyards are either raised on heavy soils or on marginal lands. Though grapes can be cultivated on varied soil conditions, deep and well-drained soils with pH range of 6.5 – 8.0 is ideal. The soil pH above or below this range is known to restrict availability of some nutrient elements and thus inhibit growth and development. The weather is mostly dry with less number of rainy days (30- 40 days) during the year. Once planted, it stays at the site for at least 10-15 years. Favourable rooting environment and proper understanding of the phenology is key to efficient water and nutrient management. Being double pruned and single cropped, the nutrient requirement differs between both the pruning seasons. However, this region suffers from abiotic stress namely moisture and salinity stress. Normally, potassium, magnesium, iron, zinc and sometimes boron deficiencies are observed in our vineyards. Apart from these, toxicity of sodium can also be observed due to saline irrigation water containing sodium more than 100ppm.

Nutritional requirement of vines differ with crop growth stages. The grapevines are drip irrigated and the same technique can be efficiently used for delivering nutrients based on crop growth stages at split intervals and on demand. Fertigation allows the application of nutrients precisely and uniformly to the wetted volume where active roots are concentrated. This improves the fertilizer use efficiency as compared to conventional practice of direct application of fertilizer to the soil. Studies carried out at ICAR-NRC Grapes on Thompson Seedless vines raised on Dogridge rootstock have clearly shown 60 % saving in the fertilizer when applied through drip over soil application. The nutrient doses given for fertigation should be modified according to the petiole nutrient status of the vines and soil as over the years' nutrient build up is there in the soil. For better results fertigation interval should not be

more than three days and nutrient doses should be applied in equal splits depending upon the number of days in a particular stage. Nutrient present in the irrigation water and the contribution of organic manures should also be taken into consideration. Generally, it is recommended to apply on per hectare basis, 25 T FYM/ suitable other organic sources every pruning season to improve the soil physico-chemical and biological properties. Grow a green manure crop in the rainy season. It also helps in suppressing the weeds. Plough the green manure crop when it is in flowering stage.Fertigation schedule for grapes are given in table 5.1. The quantity of nutrient given in tables 5.1 & 5.2 are guidelines for applying the NPK doses at different growth stages and may change based upon the site and climatic conditions.

Majority of the grape growing areas in Maharashtra and North Karnataka are alkaline in reaction and also calcareous. The grapevines are able to tolerate calcium carbonate level upto 5%. Calcium deficiency in calcareous soils is not common and do not require specific fertiliser application unless vineyard soil has high pH or sodium. Certain climatic conditions (cold or rainy) or nutrient imbalance in soils may cause Ca deficiency in fruits (berries) which can be corrected by two to three foliar applications or bunch dipping between fruit set and veraison stage @ 0.3 to 0.5% (calcium chloride or calcium nitrate). Magnesium application must be done only if needed based on petiole test value, since in many vineyards ground water irrigation source may add substantial quantities of Mg in soil. To maintain Magnesium level in soil, apply magnesium sulphate @ 100 kg per hectare per pruning season in four splits. Among the micronutrients, zinc and iron are the most commonly deficient nutrients. Due to large variation of calcium carbonate in soil, no specific recommendations are available. Apply sulphur at an average of 50 kg per acre and boron 2 kg per acre per season in nutrient deficient vineyard.

Plant tissue analysis is used as diagnostic tool for detecting nutrient deficiencies before the deficiency symptoms become visible. In grapevines, petioles are most sensitive to the changes in nutritional status and their nutrient composition helps in taking appropriate decisions for nutrient management.

For regular monitoring of nutrients status of vines, grape petioles are sampled twice under the condition of double pruning and single cropping season at stage-bud differentiation stage and at full bloom stage and once during full bloom stage in single pruning and single cropping system. The optimum level of petiole nutrient contents for Thompson Seedless vines grafted on Dogridge rootstock are given in Table 5.2.

Table 5.1: Fertigation Schedule for Thompson Seedless Vines raised on Dogridge Rootstock

Growth stages	Expected duration (days after pruning)	Nutrient application (kg/ha)		
		N	P_2O_5	K_2O
Foundation pruning season (April – October)				
Shoot growth	1-30	60	-	-
Shoot growth	31-40	20	35.5	-
Fruit bud differentiation	41-60	-	71	-
Cane maturity and Fruit bud development	61-120	-	-	80
121 days - fruit pruning	121 -	-	-	-
Fruit pruning season (October – March)				
Shoot growth	1-40	80	-	-
Bloom to Shatter	41-55	-	26.5	-
Berry growth and development	56-70	-	26.5	-
Berry growth and development	71-105	80	-	80
Ripening to Harvest	106- harvest	-	-	80
Rest period	Harvest to Foundation pruning (20 days)	26	18	26

Table 5.2: Optimum range of petiole nutrient contents for Thompson Seedless vines grafted on Dogridge rootstock

Nutrient	Bud differentiation stage	Full bloom stage
Macronutrients		
N (%)	1.20 – 1.53	1.44 – 1.80
P (%)	0.387 – 0.472	0.283 – 0.356
K (%)	0.590 – 0.680	1.61 – 2.95
Ca (%)	0.727 – 1.03	0.508 – 0.81
Mg (%)	0.877 – 1.28	0.579 – 0.870

6. IRRIGATION

Water is a critical input for grape production. Majority of the vineyards are located in the semi-arid areas of the country and are drip irrigated. As this region suffers from moisture

stress, water should be applied judiciously i.e. in right quantity and at right time to get good returns.

6.1 Growth Stage of Vine and Water Requirement

The water requirement varies with different growth stages of vine. At certain stages of the vine, moisture stress is beneficial (fruit bud differentiation) while moisture stress during more vegetative growth leads to less fruit bud which is harmful.

From foundation pruning to bud differentiation stage (normally mid-April to May) the water requirement is maximum. Vines should not be stressed in order to obtain canes of desired thickness (8-10 mm) and sufficient canopy. In the fruit bud differentiation stage, irrigation should be reduced to facilitate better bud differentiation. Shoot maturity and fruit bud development stages coincides with rainy season, but still there is a need to irrigate the vines as the rainfall is highly erratic, non-uniform distribution and gap between two rainy events are more.

In the fruit pruning or forward pruning season, the vines should be irrigated timely to promote strong shoot growth and adequate leaf area. Since fruit-set is not a problem in Indian vineyards, mild stress during berry set to shatter stage (berry dropping) helps in reducing berry set which are otherwise to be thinned. Berry growth to veraison period is most critical stage as cell division and elongation are occurring in the fruit. Water stress at this stage reduces the berry size and yield. During the period from veraison to harvest, the vines should not be over-irrigated in order to avoid berry cracking and delay in harvest. Moisture stress at this stage however results in berry drop. During resting period (after harvest) the vines can survive on available soil moisture in heavy soils. If the rest period is more than 15-20 days, the vineyard should be irrigated every week based upon the temperature but adequate care should be taken to discourage new growth.

Irrigation Scheduling

Water requirement of grapes varies with the atmospheric aridity and vine growth stages. The irrigation should be schedule based on the pan evaporation reading and growth stages.

Table 6.1: Irrigation schedule for Thompson Seedless vines raised on Dogridge rootstock

Growth Stage	Expected duration (days after pruning)	Water requirement (litres/day/hectare per mm of evaporation)	Month of operation	Expected Pan evaporation (mm)	Approximate water (L/ha/day)
Foundation Pruning					
Shoot growth	1-30	4200	April-May	8-12	33,600-50,400
Shoot growth	31-40	4200	April-May	8-12	33,600-50,400
Fruit bud differentiation	41-60	1400	May-June	8-10	11,200-14,000
Cane maturity and Fruit bud development	61-120	1400	June-August	0-6	0-8,400
121days - fruit pruning	121 -	1400	August- Fruit pruning	0-6	0-8,400
Fruit Pruning					
Shoot growth	1-40	4200	October-November	6-8	25,200-33,600
Bloom to Shatter	41-55	1400	November-December	4-6	5,600-8,400
Berry growth and development	56-70	4200	December - January	3-6	12,600-25,200
Berry growth and development	71-105	4200	December - January	3-6	12,600-25,200
Ripening to Harvest	106- harvest	4200	January - March	8-10	33,600-42,000
Rest period	Harvest to Foundation pruning	-	March-April	8-10	-*

These recommendations are for guidance purpose only and may change based on site conditions.

7. TRAINING, PRUNING AND OTHER INTERCULTURAL OPERATIONS

Training of Grapevine

To train grapevine, different training systems are used by the grape growers. Bower (Pandal System), Single wire, short arm T trellis, long arm T trellis, Telephone system, Kniffin, Small Y and Flat roof gable are generally adopted.

However, Y system/ Extended Y (Flat roof gable) system and bower are mainly followed in the grape growing areas.

Pruning

The prevailing pruning practices in India can be broadly grouped into the following three categories

i) **Single Pruning and single cropping:** This system is prevalent in North India. Since only one growing season is available, grapevines are pruned with the onset of spring or during late winter (mostly January-February) and the crop is harvested before onset of monsoon.

ii) **Double pruning and single cropping:** This system is predominantly followed in Maharashtra and Karnataka. After harvest of grape (harvesting complete during March-April), the vines are given rest for about a month, water is withheld to help concentrate the reserves in the mature parts of the vine. All the fruiting canes are pruned back retaining only one basal node. This is called as back pruning or foundation pruning. Buds on the shoots growing from these spurs differentiate into floral primordial and the shoots mature in about five months. These mature shoots are pruned for fruiting before the onset of winter (September- October). This pruning is called forward pruning or fruit pruning. All the mature shoots are subjected to fruit pruning. Thus, in this system of pruning, a cycle of two pruning resulting in one crop is practiced.

iii) **Double pruning and double cropping:** This system is followed in south interior Karnataka and Tamil Nadu. The varieties grown in these region are Anab-e-Shahi, Bangalore Blue and Gulabi. In this region, due to mild climate throughout the year, fruit

bud differentiation is not a problem. The grape growers are harvesting two crops in a year.

8. Regulation of Flowering

Flower cluster appears soon after the emergence of young shoots.In case of table grapes to set good size berries, limited berries has to be retained. For this purpose application of GA-3 @ 40 ppm at 50% flowering is commonly followed. As a results, 50 percent berries only set and avoids the compact of the bunch. If the rachis is well elongated, the use of GA may be avoided.

Table 8.1 Growth Regulator for Berry Elongation and Development

Sr. No	State	Concentration of GA3	Purpose
1	10 % Flowing	GA3@10 ppm	Berry elongation
2	50% Flowing	GA3@15 ppm	Berry elongation
3	90% Flowing	GA3@20 ppm	Berry elongation

9. Use of Hormones

1) **For uniform bud sprouting:** In established vineyard, bud sprouting is a major problem which is achieved using hydrogen cyanamide. The dose of hydrogen cyanamide varies with pruning time, cane diameter and also the temperature in the vineyard. Apply hydrogen cynamide 50% SL after foundation pruning @ 25 to 30 ml/L and 40 to 50 ml/Litre after fruit pruning
2) **For fruit bud differentiation:** After the foundation pruning, achieving fruit bud differentiation requires judicious use of plant growth regulators. The cytokininlevel in the vine need to be increased. First spray of 6-BA @ 10 ppm is given at 3-4 leaves on the sub-cane while another spray is followed after 6-7 leaf stage. Generally, this stage comes after 40 and 50 days from foundation pruning.
3) **Bunch emergence:** After the fruit pruning, the changes in weather may lead to conversion of flower into the tendril. This condition is called as fillage. To control this condition, spay 6BA @10 ppm just at the time of bud sprouting. Use potash though soil and sprayed with minimum dose is effective.

4) **Cluster development:** Cluster development is important for producing export quality of a bunch. The spray schedule of GA3 is followed from the pre-bloom stage. The following schedule is followed for cluster development.

Table 9.1: Growth Regulator for Cluster Elongation During

Sr No	Stage	Concentration of GA3	Purpose
1	Parrot green color stage of a bunch	GA3@10 ppm	Rachis elongation
2	5 days after the first spray	GA3@15 ppm	Rachis elongation
3	5 days after second spray	GA3@20 ppm	Rachis elongation (If the elongation is not achieved)

Table 9.2 Growth Regulator for Bunch Development

Sr No	Days after fruit pruning	Growth stage	PGR used and concentration	Purpose
1	18-20 days	Parrot green color stage of a bunch	GA3@10 ppm	Rachis elongation
2	21-24 days	5 days after the first spray	GA3@15 ppm	Rachis elongation
3	25-27 days	3-4 days after second spray	GA3@20 ppm	Rachis elongation (If the elongation is not achieved)
4	45-50 days	3-4 mm berry size	GA3@ 40 ppm (bunch dip)	Increase in berry size
5	50-55 days	7-8 mm berry size	GA3@ 30 ppm + CPPU @1.0 ml/L water or 6BA @ 10 ppm (bunch dip)	Increase in berry size

Table 9.3 Use of Hydrogen Cyanamide after Foundation Pruning:

Type of Vineyard	Temperature in the Vineyard	
	30-40^{0}C	**More than 40^0 C**
New vineyard (1-3 years)	30 mL/L	25 mL/L
Old vineyard (4-8 years)	30 mL/L	25 mL/L
Old vineyard (more than 8 years)	25 mL/L	20 mL/L

Table 9.4 Use of Hydrogen Cyanamide after Forward Pruning:

Temperature	Concentration
35-40^{0}C	30 mL/L
30-35^{0}C	35 mL/L
25-30^{0}C	40 mL/L
Upto 25^{0}C	50 mL/L

Table 9.5 Use of Hydrogen Cyanamide based on Cane Diameter:

Cane diameter	Concentration
6-8 mm	30 mL/L
8-10 mm	35 mL/L
10-12 mm	40 mL/L
More than 12 mm	50 mL/Lor 40 mL/Ltwice

10. Physiological Disorder in Grapes

1) Pink berries

Due to variation of minimum and maximum temperature in the atmosphere, the green pigment changes into pink color. This syndrome is called as pink berry which develop when maximum temperature reaches above 35°C and minimum temperature below 7°C. To reduce the gap between maximum and minimum temperature, the bunches are covered with paper.

2) Berry cracking and rotting

Commonly observed in all the table grapes. The grape become more prone to berry cracking from the stage of veraision. Generally, berry cracking starts after the rainfall in the vineyard. To prevent the berry cracking, follow early pruning to avoid coincidence of berry ripening with normal rainfall.

3) Sun burn

Under the condition of reduced canopy, the bunches are exposed to direct sunlight. The cells of berries will be injured due to direct sunlight or UV rays of the sun on the berries. The chlorophyll in a berry will get disturbed. Fruits exposed to sunlight during its growth may also develop sun scald.

To protect the bunches from direct sunlight, canopy development before berry set, planting direction, covering the vineyard either with shade net or covering individual bunch with paper are to be followed.

4)Swelling of knot on a bunch

For berry development, the grape requires external application of plant growth regulators at different berry development stage. However, if the plant growth regulators used are in excess quantity, the peduncle as well as pedicel develops knot. This knot is visible after veraision stage. It is hollow in shape that may not support for sugar development in a bunch.

11. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED DECISION MAKING FOR PEST MANAGEMENT, ECOLOGICAL ENGINEERING

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

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

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

The basic components of AESA are:

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions

- Climatic factors
- Farmers past experience

Principles of AESA based IPM:

Grow a Healthy Crop

- Select a variety resistant/tolerant to major pests.
- Select healthy seeds/seedlings/ planting material.
- Treat the seed/seedlings/planting material with recommended pesticides especially bio-pesticides.
- Follow proper spacing.
- Improve the soil health by mulching and green manuring, whenever applicable.
- Nutrient management especially with organic manures and bio-fertilizers 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. Apply an adequate amount for nutrients for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Crop rotation

Observe the Vineyard Regularly (climatic factors, soil and biotic factors)

- Monitor the field situation at least once a week (soil, water, plants, pests, natural enemies, weather factors, etc.). Make decisions based on the field situation and Pest: Defender (P:D) Ratio. Take immediate action when needed (e.g. collection and destruction of egg masses, infested/infected parts/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 herbivore 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.

Pest: Defender (P: D) Ratio:

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts, etc. can be adopted to arrive at the number 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 can be divided into three categories like 1. Parasitoids; 2.Predators; and 3.Pathogens. The important natural enemies in grape are given in ecological engineering table.

Model Agro-ecosystem Analysis Chart

Decision Taken based ontThe Analysis of Field Situations:

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2:1. However, some of the parasitoids and predators will be able to control more than one pest. 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 biopesticides and botanicals, etc. can be relied upon before resorting to synthetic chemical pesticides.

Field scouting

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

For insect pests

- **Mealy bug:** Count and record the number of both nymphs and adults on randomly selected shoot leaves) per plant.
- **Spodoptera:** Count the number of young and grown up larvae on each plant and record.
- **Thrips:** Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).

For diseases

Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as

weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

A. **Root sampling** Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth). 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 pseudo stem infested/infected due to rot should be counted and incidence should be recorded.

B. **Leaf sampling** Examine all leaves and or sheaths on each plant for lesions and determine the area of leaf infection. Count the number of leaves (leaf area diameter)/plant infected due to disease and record.

C. **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.

Monitoring through pheromone trap catches:

Pest specific pheromone traps should be used for lepidopteran pests for monitoring. Change the lures once in 2-3 weeks regularly. Number of moths/trap should be counted and recorded.

A. Blue sticky traps

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

B. Light traps

Set up light traps @1 trap/acre for monitoring of insects. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm). Count the number of thrips on the traps daily and take the appropriate decision regarding management practices.

ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. The

cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops

Natural enemies may require

- Food in the form of pollen and nectar for adult natural enemies.
- Shelters such as overwintering sites, moderate microclimate, etc are needed.

Ecological Engineering Plants (Attractant plants)

Cow Pea 	**Carrot** 	**Sunflower** 
Buck Wheat 	**Alfa Alfa** 	**Mustard** 
Cosmos 	**Marigold** 	**Dill** 

Ecological Engineering Plants (Repellents plants)

	
Ocium	**Peppermint Spear Mint**

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 should be based on availability, agro-climatic conditions and soil types.

12. INTEGRATED PEST MANAGEMENT

12.1 Thrips: *Scirtothrips dorsalis*(Thysanoptera-Thripidae)

Thrips are the sucking pests which prefer to feed on all the above ground succulent and tender grapevine parts, like young leaves, leaf tips, leaf veins, stem, shoots, pre-flowering bunch, bunch peduncle, flowers, rachis, and young berries.

Scirtothrips dorsalis is the major species causing damage to table grapes in peninsular India at present. *Rhipiphorothrips cruentatus* incidence in grapes has reduced in last decade. A third thrips species, *Retithrips syriacus* is also reported in grapevine, however, it remains only on old leaves and does not cause any economic damage either to berries, flowers, or leaves.

	
Scirtothrips dorsalis	*Rhipiphorothrips cruentatus*

	
Thrips damage on leaf	Thrips damage on grape bunches
Photo Courtesy: NRC Grapes (Dr D.S. Yadav)	

Life Cycle

- **Egg**: The female thrips lays eggs about 50-100 on the underside of the leaves. Eggs are very small 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.

Nature of Damage and Symptoms

- Both nymphs and adults suck the vine sap, which result in the curling and cupping of young leaves.
- The damage after the foundation pruning is mainly confined to vegetative parts of the vine but after the fruit pruning, in addition to the damage on vegetative parts, they also damage the pre-flowering bunches, flowers and young berries.
- On pre-flowering stage bunch, the thrips damage can lead to necrotic spots on berries and the whole bunch may die if not controlled timely.
- Thrips suck the sap from the ovaries of flowers in the berry setting stage, which leads to flower shedding and loss in yield. This is the loss in terms of quantity; however, the loss in terms of quality is also profoundly serious as rasping and sucking of young berries by thrips results in the brownish net-like appearance on the berry surface called as berry scarring.
- Therefore, the new flush emergence stage, pre-flowering, flowering, berry setting and early berry development, stages are the critical stages for damage by thrips.

Integrated Management of Thrips

- Regular monitoring and timely management interventions are especially important for the effective management of thrips. To monitor thrips population, tap grapevine shoot on white paper and count the number of thrips fallen on the paper. It was observed that during fruit pruning season, higher thrips population is found on canopy during afternoon hours in comparison with morning or evening hours. Therefore, the monitoring for thrips should be done during afternoon.
- Deep ploughing in summer after April pruning or exposure / raking of soil in vineyards helps to destroy its pupal stages and minimizing the incidence.
- Sanitation is to be maintained for eliminating the sources of thrips infestation. Keep the garden clean by removing weeds. Plant debris from previous crops is also a source of both immature and adult thrips, and they should be destroyed.
- Removal of weeds and alternate host plants like hibiscus, okra, custard apple, guava etc. in and nearby vineyards.
- Spray of NSKE 5% @ 0.5 mL/L of water helps to manage thrips population
- Need based spray of insecticides given table no 11.

12.2 Mealy bugs: *Maconellicoccus hirsutus*(Hemiptera: Pseudococcidae)

Among about six different mealybug species infesting grapes, *Maconellicoccus hirsutus* is most important and widespread. The mealy bugs increase in numbers due to imbalance in the ecosystem. In a balanced agro-ecosystem, mealybug populations are usually kept under check by their natural enemies. Two prunings in grapes and use of broad-spectrum insecticides reduce natural enemy activity and upset the balance. Two prunings seem to be a necessity to ensure fruitfulness in semiarid tropics like Maharashtra, Karnataka, Telangana and Andhra Pradesh grape growing regions but by avoiding use of broad-spectrum insecticides, natural enemies can be conserved and pest populations can be kept under check naturally, which can ultimately lead to lesser insecticidal applications and less number of residue detections.

Life Cycle

- **Egg:** Eggs are minute, about 0.3-0.4 mm in length. The female mealybug lays around 500 eggs in ovisac of white wax in clusters which are generally deposited on growing under the bark, growing buds, shoots and ripening bunches of the vine. The eggs are oval and orange coloured which turn pinkish on maturity.They hatch in about 3-9 days.

- **Nymph:** Newly hatched first instar nymphs are very mobile and called as crawlers. Crawlers are pinkish in colour. They disperse over the host to different plant parts or be carried away by wind, man, equipments or animals. The nymphal stages may last for about 20-30 days.
- **Adult:** The female mealybug is about 3-5 mm long with soft, oval and flattened body which is pink in colour and covered with white waxy covering. Thorax and abdomen are not distinct. The adult males have two long waxy tails with a pair of wings and a pair of halteres. Males are capable of flight and are very rare. Mealybug completes the life cycle in about 30-40 days.

Nature of Damage and Symptoms

- Both the nymphs and adult females suck the plant sap from the phloem on different plant parts.
- At the time of forward pruning, majority of the mealy bugs remain hidden under the bark of main trunk and cordons. During the new flush emergence stage especially after fruit pruning, mealy bug feeding leads to the curling and malformation of growing shoot and thereby arresting its further growth.
- During veraison stage, mealybugs migrate from the main trunk, cordons and shoots to developing berries and produce profuse quantity of honeydew leading to sooty and sticky bunches which considerably reduces the quality and marketability of the fruits.
- Ants association with these pests will further aggravate the problem as they help the pest to migrate easily from one vine to another besides protecting from the natural enemies.

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Adult female mealy bugs and eggs mass</td><td>Mealybug and honeydews on bunches</td></tr>
<tr><td colspan="2">Courtesy Photo: NRC Grapes (Dr D.S. Yadav)</td></tr>
</table>

Management

- Broad-spectrum insecticides such as fipronil, lambda cyhalothrin, methomyl and imidacloprid should be used only sparingly and should be completely avoided when natural enemy activities are higher.
- For example, during rainy season due to high humidity conditions mealybug natural enemies such as *Anagyrus* spp. and *Scymnus* spp. increase in numbers and control mealybugs naturally. Therefore, use of such chemicals should be avoided during this period.
- Broad-spectrum insecticides such as should not be used in grapes for mealybug management.
- If insecticidal application becomes necessary to control mealy bugs, buprofezin 25 SC @ 1.25 mL/L water should be the preferred option as it is safer to natural enemies.
- Use of methomyl should be avoided and should never be used after flowering as it is broad spectrum and persistent in nature.
- Soil drenching of systemic chemical is beneficial as compared to spraying as it helps to conserve natural enemies thus should be preferred option.
- Need based spray of insecticides given in table no.11

12.3 Flea Beetle:*Scelodonta strigicollis*(Coleoptera: Chrysomelidae)

It is a regular pest of grapes and causes economical losses.

Life cycle

- **Egg:** Eggs of *S. strigicollis* are small and cylindrical in shape. They are blunt on both sides and the anterior end of the egg is a little broader than the tail end. They are whitish to slightly yellow in colour. The eggs are deposited singly or in groups mainly in the soil. Female lays about 15-20 eggs individually or groups. Incubation period is of 4 to 5 days.
- **Grub:** Grubs have five pairs of tiny legs with brisk movement. Last larval and pre pupal grubs become brownish in colour. The grubs feed on cortical portion of root and other organic matter in the soil. The grub stage is of about 15 days.

	
Flea beetle on sprouting bud	Young shoot damaged by flea beetle
Photo Courtesy: NRC Grape (Dr D.S. Yadav)	

- **Pupa:***S. strigicollis* pupae are small and shape of the pupa on one side is pointed, and another is blunt. The pupa is brown in colour with coconut type shape. It pupates up to 6-8 cm deep in the soil in earthen cells. The pupal period is of about 15-20 days and whole life cycle is completed in about 35-40 days.
- **Adult:** The adult of *S. strigicollis* is a small, oval-shaped beetle. They are metallic brown to metallic bronze with 6 dark spots on the elytra and small body hair. They have bloated femora which allow for the springing action of these insects when disturbed. *S. strigicollis* can also walk and fly.

Nature of Damage and Symptoms

- Flea beetles are active especially during the bud breaking stage of the vine after the pruning. Adults are damaging stage of the pest. Adults eat away the young buds and leaves. As a result, the shoot growth is arrested.
- Flea beetles can also feed on tender merging shoots, young stems, bunch peduncle and mature leaves. The tender shoots and young leaves may die due to the feeding.
- Linear and rectangular shaped holes on the leaves are the characteristic damage symptoms by this pest.
- Flea beetle grubs are seen in the soil but have not been reported causing any economic damage.
- The greatest economic loss occurs when beetles feed on buds from bud swell until the first leaf separates from the shoot tip stages.

Management

- Remove weeds from inside and around the vineyards. The cultivator may be used to rack up the soil in inter-row spaces to expose and kill immature stages.
- They remain hidden away from sunlight during the day and actively feed during night. Therefore, flea beetle management is better when sprayings are carried out during night.
- Need based spray of insecticides given table no 11.

12.4 Caterpillar: *Spodoptera litura* (Lepidoptera: Noctuidae)

Spodoptera litura is the major caterpillar species causing damage in two pruning single yield viticultural system of India. Sometimes, hornworms and hairy caterpillars may also be found infesting grapes.

Life cycle

- **Egg:** Mated female lays about 300 eggs in groups and cover them with brownish hair tufts and on lower side of leaves. Eggs are yellowish which turns blackish before hatching. Hatching takes place in 3-7 days.
- **Larva:** Fully mature caterpillar is about 35-40 mm in long with velvety black body colour, yellowish-green strips on dorsal sides and white bands on lateral sides.
- **Pupa:** The mature larvae generally curls into a C-shape prior to pupation. Pupae appeared pale yellowish initially after but later become dark reddish brown in colour Pupa of *S. litura* is of obtect type and pupation takes place under the litter, underside of loose bark or in the soil. The pupal periods last for about 4-7 days.
- **Adult:** The adult moth has golden and greyish brown patterns on fore wing and hind wings are whitish. The lifecycle of pest is completed in 32-60 days and several overlapping generations may complete in a year.

Spodoptera larvae

Leaf damage by Spodoptera larvae

Photo Courtesy: NRC Grape (Dr D.S. Yadav)

Nature of Damage and Symptoms

- Caterpillars are biting and chewing type of insects and feed on mainly grapevine sprouting buds and leaves. Whenever relative humidity increases due to rainfall, they may become serious pest. The highest damage in grapes is caused by *S. litura* during bud sprouting stage.
- First instar larvae of *S. litura* are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they spread to different plant parts and become voracious feeders making irregular holes on the leaves.
- In case of heavy damage, they can skeletonise leaves leaving only veins and petioles.
- During the later part of the crop growth stages, *S. litura* larvae can cause damage to the bunches by biting berries and peduncle and as a result affecting bunch appearance and quality.

Management

- Just after fruit pruning, there is no canopy on the grapevine. Therefore, *S. litura*larva remain hidden under loose bark of stem, in soil under leaf-litter or inside cracks in ground during daytime. They come out during night and feed, therefore, their presence in the vineyard goes undetected and they can cause huge damage during sprouting stage.
- They can be easily monitored by regular inspection of vineyards at night during bud sprouting stage. At this stage, application of insecticides is generally not effective and frequent applications of insecticides may be required to manage them. This will also increase the cost of cultivation.
- The economic way of managing this pest is to wrap the main trunk and supporting bamboo with polypropylene adhesive tape (about 2 inches width) at about 2-3 feet height from the ground. Keep the sticky side of the tape is towards the stem and the shiny slippery side is outwards. The *S. litura* larva who tries to climb the trunk during the night will not be able to climb due to the slippery surface and the damage can be managed very effectively. If the vineyard is old and has loose bark, then the loose bark should be removed before applying the adhesive tape otherwise the larva will remain hidden under the bark above the tape.
- Installation of light traps during rainy season is also very effective in controlling the moths of *S. litura*.
- Collection and destruction of egg masses, and neonates manually.

- Installation of pheromone trap 4-5 traps/acre.
- Need based spray of insecticides given table no 11.

12.5 Grapevine stem borers: *Celosterna scabrator,Stromatium barbatum* (Coleoptera:Cerambycidae),*Dervishiyacadambae*(Lepidoptera: Cossidae)

Celosterna scabrator,Stromatium barbatum and *Dervishiya cadambae* are the major stem borer species infesting grapevine in peninsular India. All three stem borer species cause extensive damage to the sapwood and heartwood of grapevine stem and reduce both vitality and productivity of the vines.

12.5.1 *Celosternascabrator*

Life cycle:

- **Egg:** The eggs are laid inside the stem by making a cut and covering with a substance which hardens after some time. Therefore, targeting adults and eggs for management is not feasible.
- **Larva:** The larva feed inside and make galleries.
- **Pupa:** Pupation takes place inside the gallery in the infested plant.
- **Adult:** The time of adult emergence and oviposition for *C. scabrator* is

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Adult Celosterna scabrator</td><td>Brass fallen near vine due to Colesterana scabrator</td></tr>
<tr><td colspan="2">Courtesy Photo: NRC Grape (Dr D.S. Yadav)</td></tr>
</table>

exceedingly long which starts with the initiation of monsoon and lasts for about 120-150 days.

Nature of Damage and Symptoms:

C. scabrator larva can feed only on live plants and make gallery inside. The characteristics symptoms of its damage are that it removes the frass out from hole which can

be noticed around the plant and the leaves of infested plant shows interveinalchlorosis at later stages.

Management:

The best way to manage *C. scabrator* is to tag infested plants, tear apart the gallery and remove and kill the larva.

12.5.2 *Stromatium barbatum*

Life cycle

- **Egg:** The eggs are laid either singly or in group (60-140 eggs per female) under the loose bark. Eggs are creamish white in colour and pointed from both ends. Egg start hatching from
- **Larva:** The larva upon hatching directly bores into wood and feeds inside. The larval period is of about 9 months.
- **Pupa:** Pupation takes place inside the infested plant. This stem borer normally goes into pupation during second fortnight of March to mid-May. The pupal period is of about four weeks and the adult will remain inside the stem and wait for monsoonal rains to start.
- **Adult:** Adults of stem borer *Stromatiumbarbatum* may start emerging during the first week of June and by mid-June majority of adult emergence takes place. However, small numbers of stem borer adults may keep on emerging till September.

	
Adult Stromatiumbarbatum	Stromatium larva and powder inside the stem
Courtesy Photo: NRC Grape (Dr D.S. Yadav)	

Nature of Damage and Symptoms:

S. barbatum species of stem borer is pest of 6-7 years older vineyards. The grubs of this species feeds inside the stem and convert the stem wood into powder like termites. Primarily this is pest of dead wood, therefore, it prefers older vineyards in which deadwood

formation is there. There is no external symptom on the plant visible in the vineyards infected by this species.

During December to March months, when larva is feeding on the dead dry wood, the feeding sound can be heard in the old vineyards. More than 100 grubs of stem borer can be found in a single plant in case of high infestation. Two to three years of infestation can reduce the productivity of vineyards by 50%.

Management:

- Installation of light traps outside the vineyards is helpful in monitoring the initiation of emergence of stem borer adults so that timely management can be carried out.
- Adults of stem borer remains hidden under the loose bark of grapevine stem and cordons and majority of the eggs are also laid under this loose bark. Therefore, if this loose bark is removed just before the onset of monsoon, the adults will not find places to hide and lay in the vineyard and stem borer infestation will reduce.
- To protect the healthy vineyards of 6 years and older from infestation, it is important to hinder entry of adults inside by erecting shade netes vertically on that side of the vineyard where infested neighbouring vineyard is situated during May end to July end. The height of the shade net barrier should be minimum 12 feet from the ground and the lower portion of the shade net touching the ground should be buried under soil. Another way to reduce entry of adult beetles in the vineyard is to hang neem leaves inside and at the border of the vineyard.
- Frequent sprays of NSKE 5% may also be done 4-5 times targeting main trunk and cordons during first fortnight of June.

12. 5. 3 *Dervishiya cadambae*

Life cycle

- **Egg:** Eggs of *D. cadambae* are yellowish-white and round in shape. The egg chorion has a reticulate sculptured pattern resembling the bark which makes the eggs difficult to detect. The eggs are mainly laid in groups in cracks and crevices or under the loose bark of the main trunk and cordons of grapevines. Egg stage is of approximately 15-20 days.
- **Larva:** Larva are reddish in colour. Young larvae feed on sapwood under the bark and excreta mixed with webbings are usually seen under the bark. After about 2-3 months they bore inside the stem and plug the hole with excreta and webbings. They feed inside and make galleries in the direction along the length of the main trunk and

cordons. The young larvae remain under the bark and feed on sapwood in grapevines. As larvae feed under the bark, their presence goes undetected. Careful observation allows to detect, excreta entangled with webbings protruding outside bark. Larval stage is of about 200-220 days.

- **Pupa:** The pupa is brownish in colour with rows of spine-like processes on the dorsum of abdominal segments. Pupation takes place either in ground inside a pupal chamber lined with silken fibres or inside the gallery where the larva is feeding. The pupal stage lasts for about 10-15 days.
- **Adult:** The adult moths are medium-sized and dark coloured. The whole life cycle completes in about 250 days. The major adult emergence period is June-July months.

	
Dervishiya cadambae	***Dervishiya cadambae* larva**
Courtesy Photo: NRC Grape (Dr D.S. Yadav)	

Nature of Damage and Symptoms:

D. cadambae young larvae feed under the bark and later instars bore inside and make galleries. It reduces both vitality and productivity of the plants.

Management

- Regular monitoring under loose bark during months of July to September.
- Installation of light traps outside the vineyards to kill moths during months of July to September.
- Removal of loose bark at the beginning of rainy season to reduce site of oviposition.
- In case of infestation, when the young larvae are feeding under loose bark during July-September months, remove the loose bark and manually collect and kill the larva.

12.6 Girdle beetle/grape cane girdler: *Sthenias grisator*(Coleoptera: Cerambycidae)

Nature of Damage and Symptoms:

- Girdler beetle damage is generally noticed during September-October months in one- to two-year-old vineyards. The girdling results into injury and weakening of the plant.
- Sometimes, the beetle can cut the stem at girdling site so much that the plant portion above it dies.

Management of Girdle beetle/grape cane girdler

- Hand collection and destruction of beetles is the best strategy to manage it. The beetle generally becomes active at night around 9 pm and prefers to stay on the plant which it did cut previous night or the nearby plants. These plants may be observed at night with the help of torch and beetles can be hand collected and killed. Spraying of insecticides doesn't seem economically viable option as the number of damaged plants are generally 1-2% only.
- Where the plant stem has been completely cut, raise new shoot below this portion.

12.7. Mites:*Tetranychus* spp.(Trombidiformes: Tetranychidae)

Red spider mite,*Tetranychus spp.* is a major pest causing damage to grapes in peninsular India. They prefer high temperature and low relative humidity.

Nature of Damage and 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
- They prefer to feed on older leaves but increase in population leads to their migration to even bunches.

- Both nymphs and adults cause damage.
- Their feeding causes yellowing and discolouration of leaves affecting photosynthesis and sugar accumulation in berries.
- Serious infestation may lead to extensive defoliation especially during January to April which may reduce the TSS in the berries and resulting into poor quality fruits.
- Defoliation also results in direct exposure of berries to sunlight causing sun-burn.
- Red spider mite infestation becomes higher in vineyards nearing harvest.

	
Different life stages of red spider mites	Web formation on under surface of leaf due to mite infestation

Management:

- Best strategy for mite management is timely application of acaricide to reduce population build-up. Once majority of leaves show chlorosis and webbing due to mite incidence, the mite management will become difficult. Any vineyard with more than 50 days old canopy can easily become susceptible to mite incidence. Therefore, critical monitoring for mite population build-up is necessary.
- With the increase in temperature during mid-January or February, the mite incidence also increases and reaches peak levels during March-April months.
- If temperature is high, weekly water sprays @ 1000 L water per acre can help in washing dust from the leaf and decrease leaf temperature which can help in reducing mite population. Additionally, water sprays can also help in breaking webbings, thus increasing efficiency of insecticidal applications.
- Many alternate hosts plants such as *Parthenium* weed, etc. act as breeding grounds for mites, thus, they should be removed from the vicinity of the vineyards.
- Use of broad-spectrum insecticides such as imidacloprid, methomyl, fipronil, etc. should be avoided after 50 days of fruit pruning as they can kill mite natural enemies and increase the mite populations.
- Need based spray of insecticides given in table no 11.

Table No. 12 Use of Registered Insecticides on Management of Grape Pests:

Insect Name	Name of insecticide	Waiting Period (days)
Mealy bug	Buprofezin 25 % SC	07
	Spirotetramat 15.31 % OD	60
	Clothianidin 50 % WDG (soil drenching)	60
Mites	Abamectin 01.90% EC	03
	Hexythiazox 05.45 % EC	05
	Bifenazate 22.60 % SC	-
	Spirotetramat 15.31 % OD	60
Thrips (*Scirtothrips dorsalis)*	Cyantraniliprole 10.26 % OD	05
	Emamectin benzoate 05 % SG	05
	Fipronil 80 % WG	10
	Spinetoram 11.70 % SC	30
	Spinosad 45 % SC	15
Flea beetle (*Scelodonta strigicollis)*	Imidacloprid 17.80% SL	32
	Lambda-cyhalothrin 04.90% CS	07

- ***Refer Annexure 5 of Residue Monitoring Programme for export grapes**

13. INTEGRATED DISEASE MANAGEMENT

13.1 POWDERY MILDEW (*Uncinula necator*)

Powdery mildew is considered a dry weather disease.

Symptoms

- The symptoms develop as whitish powdery areas on both the surfaces of the leaves.
- Infected spurs, canes, tendrils, panicles and berries have a white powdery appearance.
- These whitish powdery patches consisting of conidia and conidiophores of the fungus may enlarge, coalesce and cover the whole area of the leaf.

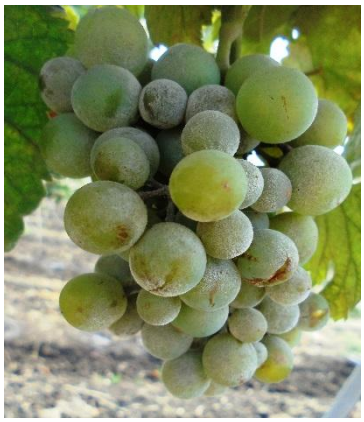
- The disease attacks the vines at any stage of their growth. Young leaves curl when severely infected and drop prematurely.
- Floral infection results in shedding of flowers and poor fruit set.
- Early berry infection results in shedding of affected berries. If severely attacked they are enveloped with a white powdery coating and crack eventually.
- Low, diffused light favors disease development. As a result, disease severity may be greater inside the canopy

Disease Development

- Pathogen can survive during off season as mycelium/ hyphae in dormant buds When conditions are favourable, the fungus is reactivated and shoots growing from infected buds become covered with white mycelium.
- Secondary infection takes place by wind which blows the conidia /oidia produced on the infected shoot developed from infected dormant bud
- The period between Decembers to January i.e. a warm winter, with a temperature range of 20 to 33.5°C is very favourable for disease development.

White powdary growth on upper surface of leaf

Powdery mildew on grape leaves



White powdary growth on upper surface on fruit

Photo courtesy- ICAR-NRC for Grapes, Pune

13.2 DOWNY MILDEW (*Plasmopara viticola*)

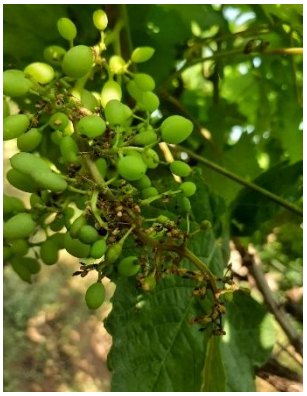
Symptoms

- The symptoms develop as irregular, yellowish, translucent spots on the upper surface of the leaves. Correspondingly on the lower surface, dirty white, powdery growth of fungus appears.
- Affected leaves become yellow and brown and gets dried due to necrosis.

- Symptoms are more prominent on leaves, young shoots and immature berries.
- Dwarfing of tender shoots.
- Infected leaves, shoots and tendrils are covered by whitish growth of the fungus.
- White growth of fungus on berries which subsequently becomes leathery and shrivels. Infected berries turn hard, bluish green and then brown.
- Later infection of berries results in soft rot symptoms. Normally, the fully grown or maturing berries do not contact fresh infection as stomata turn non-functional.

Disease Development

- This disease spreads in warm and moist weather. Downy mildew begins with primary infection when spores are splashed from the soil to leaves.
- The fungus overwinters mainly in the fallen leaves which are the source of primary infection. Secondary infection occurs by motile zoospores by splashing rain.
- After October Pruning particularly during periods of rain, heavy dew and persistent fog at temperature above 11°C favour disease development.

 a light yellow lesion on upper side of leaf	 b. dirty white growth on lower side of leaf	 c. shrivelling of berries
Photo courtesy- ICAR-NRC for Grapes, Pune		

13.3 Anthracnose(*Elsinoe ampelina*)

Symptoms

- **Leaves-**At early stage pathogen cause infection to leave and develop small round spots and as the disease progress, it produce small holes at the centre of lesion (leaving a 'shot-hole' appearance). During severe infections, the leaves shrivel up and drop off.

- **Shoots-** Deep elongated cankers, greyish in the centre with a black edge
- **Inflorescences-** Inflorescences are highly susceptible. During severe infections, they can turn yellow, brown, then dry out completely. On berries, characteristic round, brown sunken spots resembling “Birds Eye” can be seen.

Disease Development

- The pathogen survives during off season in cankers formed on the canes and in infected berries on the ground and on berries left in the trellis. In spring, small fruiting bodies, called acervuli, form and produce spores (conidia). The spores are covered with a mucilaginous substance that enables them to stick to the site of infection. They are dispersed by rain.
- The longer the leaves and stems remain wet (>12 hours), more the severe infection.
- The disease develops at temperatures of 10 to 35°C; the optimum temperatures for disease development are between 20 and 26°C. Symptoms appear 4 to 12 days after infection.

a

b

c

Anthracnose Symptom On stem (a) grape leaves (b) and grape berries (c)

Photo courtesy- ICAR-NRC for Grapes, Pune

13.4 Bacterial Leaf Spot (*Xanthomonas campestris pv. viticola*)

Symptoms

- 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.

- The young growing shoots are affected first. Disease infects leaves, shoots and berries Brownish black lesions are formed on the berries, which later become small and shrivelled.

Disease Development

The pathogen survives in infected plant residue in soil and transmitted through propagative material.

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



Bacterial leaf spot symptoms of leaf

Photo courtesy- ICAR-NRC for Grapes, Pune

13.5 Leaf Blight and Bunch Necrosis (*Alternaria alternata*)

Symptoms

- 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.

Disease development

- The pathogen survives through spore (conidia) or mycelium in disease plant debris or weed. It appears in the month of June and December.

13.6 Leaf Rust (*Phakopsora vitis*)

- This disease is generally not reported on commercial table and wine grape varieties of grapes in Maharashtra state. This seen on rootstock varieties esp. Dogridge, 1103P, 110R, Ramsey, and SO4 etc.

Yellowish pustules on lower surface of grape leaf

Photo courtesy- ICAR-NRC for Grapes, Pune

Symptoms

- Small angular yellow to brown spots on the upper surface of grapevine leaves
- Yellow to orange, powdery spores form on the underside of the leaves
- Affected leaves can turn yellow and die, resulting in premature leaf fall

Disease development

- The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris. Secondary infection through Urediniospre continuously re-infect grapevines.
- Moisture and temperature above 20° C favours the development of disease.

Disease Management During Foundation Pruning

Fruit Bud Differentiation Stage (40 to 70 days from pruning)

As the monsoon commences during this period, the vines are susceptible to downy mildew, anthracnose and bacterial spot infection. In case of downy mildew,all shoots emerging from the crown near ground level should be removed. Shoots hanging from trellises towards ground should be tied on trellises or can be removed as the situation demands. This is done to avoid proximity of tender leaves and shoots to soil as downy mildew inoculum in soil becomes active after few major rains in June-July. Preventive application of Mancozeb 75WP@ 2g/L or Copper hydroxide @ 2.0 g/l or Copper oxychloride @ 3.0 g/l at 15-20 days interval may help in controlling downy mildew.

Cane Maturity Stage (61-90 days)

Anthracnose is extremely severe during this period as the vines receive intermittent showers and drizzles. Pruned material should not be dumped near the vines because if they are retained close to vineyard and open on soil surface, it may get wet with rain and air borne spores of the pathogens such as *Elsinoe/Colletotrichum* will again infect new shoots. Typical 'shot hole' symptoms are seen on the leaves. Spores overwintering in the cordons and infected canes form the primary source of infection and will spread in the vineyard with the rain. Application of Thiophanate methyl 70WP or Carbendazim 50 WP @ 1g/L twice at weekly intervals gives a good control of this disease. Sprays of copper fungicides suggested for control of downy mildew will also control anthracnose.

The combined effect of humidity and warm temperature predisposes the vines also to bacterial spot disease and minute water-soaked lesions are seen on the lower surface of the leaf, which enlarge and become angular. In severe cases, it causes complete defoliation of leaves. Mancozeb applied for downy mildew infection will simultaneously control bacterial spot as well. Copper oxychloride/hydroxide can also control the disease effectively. Many-a-times mixed infection of anthracnose and bacterial spot occurs simultaneously and in such cases application of Kasugamycin 5% + Copper oxychloride 45% @ 0.75 g/L yields good result.

Once there is a break in the rain, but the cloud cover along with high relative humidity prevails, there is a probability of a powdery mildew attack. The canopy growth, being dense during this time, further predisposes the vines to the disease. Efforts should be made to allow air and sunlight to enter the vines. Application of sulphur 80WDG @ 2.5 g/L can control the disease effectively. However, sulphur should not be sprayed if temperatures are very high (35-40 ^{o}C) as in high temperature it may cause phytotoxicity.

Table 13.1 Disease Management during Fruit Pruning

Days after pruning	Crop stage	Disease / Pest risk	Management strategy	Remarks
Pre- pruning period	1 week before pruning	Powdery mildew	• Soil application of *Bacillus* @ 1 L or kg / acre	• To reduce pathogen inoculum, present in thevineyard • For ISR & reduce inoculum in soil
	1-2 days before pruning	Downy and powdery mildew, anthracnose inoculum	• Downy mildew infected leaves shouldbecollected and dispose in compostpit	• To minimize carry overinoculum
After fruit pruning				
1-2	Dormant buds	Downy and powdery mildew, anthracnose	• Diseased canes and dead wood shouldberemoved • Mix Mancozeb 75 WP (5 g / L) with Hydrogen Cynamide (30-40 mL / L) paste for caneswabbing. • If the un-pruned block is in closevicinity of pruned block, and the pruning in that block is not likely to take place within 5- 8 days, it will be essential tospray *Trichoderma*in un-pruned block.	Preventive measure This will help in killing pathogen inoculum if present on canes.
4-5	Dormant to swollen bud	Downy mildew and powdery mildew	*Bacillus* @ 1 L or kg / acre	For ISR
8-10	Initiation of sprouting	Anthracnose	Carbendazim 50 WP @ 1.0 g/L or Thiophanate methyl 70 WP @ 0.75 g/L	In the event of rains to protect young growing tips
		Downy mildew and bacterial spot	Spraying of mancozeb 75 WP @ 2 g /L or Dusting of mancozeb 75 WP @ 2.5 kg per acre	Preventive application If the conditions are wet (rains or heavy dew)
11-15	At three leaf stage	Downy mildew	Spray (Iprovalicarb 5.5 + Propineb +61.25)- 66.75WP @ 2.25 g/L or Mandipropamid 23.4% SC @ 0.8 mL/L or (Ametoctradin27+ Dimethomorph 20.27)-47.27 SC @ 0.8- 1 mL/Lor(Cymoxanil 8 + Mancozeb 64)-72 WP @ 2g/L or Amisulbrom 20SC @0.375 mL/L or Cyazofamid @ 0.2 mL/L	Preventive

			Fosetyl-Al 80WP@ 4 g/L as a tank mix with mancozeb 75WP @ 2 g/L or propineb 70WP @ 3 g/L can be preferred if weather conditions are wet because these are better systemic fungicides under wet conditions	
15 to 35 days after pruning	Early shoot growth – 3 leaf stage to flowering	Downy mildew	Spray (Iprovalicarb 5.5 + Propineb +61.25)- 66.75WP @ 2.25 g/L or Mandipropamid 23.4% SC @ 0.8 mL/L or (Ametoctradin27 + Dimethomorph 20.27)-47.27 SC @ 0.8- 1ml/Lor(Cymoxanil 8 + Mancozeb 64)-72 WP @ 2 g/L or Amisulbrom 20SC @0.375 mL/L or Cyazofamid @ 0.2 mL/L	Preventive based on weather risk
			Total number of sprays of should not exceed three in a season. Applications of these fungicides should be taken up before and after the rainy spell when the humidity is relatively low and should be avoided in high humidity conditions during the rainy spell. Fosetyl-Al80WP@4g/Las a tank mix with Mancozeb 75WP @ 2 g/L or Propineb 70WP @ 3 g/L can be preferred if weather conditions are wet because these arebetter systemic fungicides under wet conditions.	Preventive based on weather risk
			If wet conditions continue for more than three days continuously, use of non- systemic fungicides such as Dithiocarbamates e.g. Mancozeb 75WP @ 2 g/L or Propineb 70WP @ 3 g/L, should be preferred for spray to avoid sporulation and secondary infection. It is very critical to repeat systemic fungicide applications after rainy spell stops.	Wet conditions for more than three days willlead to sporulation and initiate secondary infection.
			Fungicides may get washed off during long rainy spell, use of bioagents such as *Trichoderma*or *Bacillus* will help in reducing disease incidences.	

			Soil application of *Trichoderma* @ 2 L or kg / acre or *Bacillus* @ 1 L or kg / acre	For ISR & reduce inoculum in soil. Can be applied throughdrip irrigation system.
15-35		Anthracnose	Dithiocarbamate fungicides used for downy mildew control will be effective for anthracnose control and no separate application may be required. In case of incidence, application of difenoconazole 25EC@ 0.5 mL/L should be given which will also help in reducing shoot vigour and reduce downy mildew risk.	
15-35		Powdery mildew	Spray Hexaconazole 5EC @ 1 mL/L or difenoconazole 25EC@ 0.5 mL/L or (Fluopyram 200+Tebuconazole 200)-400SC @ 0.5 mL/L or Myclobutanil 10 WP @ 0.4 g/L or Tetraconazole 3.8EW @ 0.75 mL/L	Fungicide coverage to the inner canopy is very essential for powdery mildew management and this is the correct stage to ensure that inner canopy iscovered.
15-35		PM	Spray *Bacillus subtilis*2.0 ml or g /L	
36 to 50 days after pruning	Flowering to fruit set	Powdery mildew	Spray Hexaconazole 5EC @ 1 mL/L or difenoconazole 25EC @ 0.5 mL/L or (Fluopyram 200+Tebuconazole 200)- 400SC @ 0.5 mL/L or Myclobutanil 10 WP @ 0.4 g/L or Tetraconazole 3.8EW @ 0.75 mL/L or (Pyraclostrobin 25+Fluxapyroxad 25)-50SC @ 0.2 mL/L or Metrafenone 50SC @ 0.25 mL/L or Cyflufenamid 5% EW @0.5 mL/L	
		Downymildew	Spray Fosetyl AL 80 WP @ 3.0 g/L Mancozeb 75WP @ 2 g/L or Propineb 70WP @ 3 g/L	
			In the event of possibility of heavy rains and dew, application of spray oil (mineral oil) will help in reducing the retention of water in cluster at flowering stage and thereby	
			Application of mono potassium phosphate or SOP 2-3 g/L is known to help in reducing vigour as well as development of downy and powdery mildews. Curling due to Potassium deficiency reduces coverage of	

			fungicides and provides favourable micro-climate for powdery mildew development.	
		DM/ PM/ AN	Spray *Bacillus subtilis*2.0 ml or g /L	
50-60 days after pruning	Berry growth and development	Powdery mildew	Spray*Bacillussubtilis*2.0 ml or g /L If minimum temperature is above 10 ^{0}C and RH is more than 60 per cent.	
60 to 90 days after pruning	Berry growth to veraison	Powdery mildew	Spray sulphur 80 WG @ 2.0 g/L or difenoconazole 25EC@ 0.5 mL/L (PHI 45 days) or (Fluopyram 200+Tebuconazole 200)-400SC @ 0.5 mL/L or Myclobutanil 10 WP @ 0.4 g/L or Tetraconazole 3.8EW @ 0.75 mL/L or Pyraclostrobin 25+Fluxapyroxad 25-50SC@ 0.2 mL/L or Metrafenone 50SC @ 0.25 mL/L or Cyflufenamid 5% EW @0.5 mL/L. Use of *Bacillus* alternatively with fungicides should be done (gap between two sprays of 48 to 72 hrs).	Use the fungicides based on PHI mentioned in Annexure V of RMP
	Berry growth to veraison		Soil application of *Trichoderma* @ 2 L or kg / acre or *Bacillus* @ 1 L or kg / acre	For ISR & reduce inoculum in soil
After 90 days after pruning	Post veraison up to harvesting	Postharvest disease	Spray *Trichoderma*sp. 5 ml or g /L.	To control powdery mildew and may help to enhance degradation of pesticide residues
		Powdery mildew	Sulphur 80 WG @ 2.0 g/Lwater; or Spray *Bacillus subtilis*2.0 ml or g /L	*Bacillus* will also help in biodegradation of surface residues of pesticides
			Low residue risk options such as silver complex of Hydrogen peroxide or chlorine dioxide may be used if the active growth of powdery mildew is noticed.	Kindly note that it will kill the biocontrol agents also.
	20 days before harvest	Postharvest disease	Spray *Trichoderma*sp. 5 ml or g /L.	To control powdery mildew, post-harvest decay, and may help to enhance degradation of pesticide residues
	10 days before harvest	PM / Postharvest decay/pesticide residues	Spray *Bacillus subtilis*2.0 ml or g /L or *Trichoderma*sp. 5 ml or g /L.	To control powdery mildew, post-harvest decay, and may help to enhance degradation of pesticide residues

List of Fungicides Register UnderCIBRC for Management of Disease of Grape

Table 13.2 FungicidesSingle Product Formulations Use for Management of Grape Diseases

Name of disease	Fungicides	Waiting period from last application to harvest (in days)
Powdery mildew	Azoxystrobin 23% SC	7
	Carbendazim 46.27% SC	30
	Cyflufenamid 5% EW	25
	Difenoconazole25% EC	10
	Hexaconazole2%SC	14
	Hexaconazole 5% EC	14
	Hexaconazole 5% SC	14
	Kresoxim-methyl 44.3% SC	7
	Lime Sulphur 22% SC	
	Myclobutanil 10% WP	15
	Metrafenone 500 g/l SC	22
	MeptylDinocap 35.7% EC	30
	Penconazole 10% EC	30
	Picoxystrobin 22.52% w/w SC	7
	Sulphur 55.16% SC	10
	Sulphur 80% WP	-
	Sulphur85%DP	-
	Sulphur80%WDG	-
	ThiophanateMethyl70%WP	7
	Tetraconazole 3.8% w/w EW	30
	Triadimefon 25% WP	25
Downy mildew	Amisulbrom 20% SC	59
	Azoxystrobin 23% SC	07
	Aureofungin 46.15% w/v SP	15
	Azoxystrobin 23% SC	7
	Captan 50% WP	-
	Captan 75% WP	8
	Copper Oxychloride 50% WG	30
	Copper oxychloride 50% WP	-

	Copper Hydroxide 53.8% DF	12
	Copper Sulphate 2.62% SC	03
	Chlorothalonil 75% WP	60
	Cymoxanil50%WP	15
	Cyazofamid 34.5% SC	7
	Dimethomorph50%WP	25
	Kresoxim-methyl 44.3% SC	7
	Fosetyl-AL 80% WP	30
	Mancozeb75%WP	-
	Metiram70%WG	07
	Mandipropamid23.4% SC	5
	Oxathiapiprolin 10.1% OD	5 days
	Picoxystrobin 22.52% w/w SC	7
	Propineb70%WP	40
	Zineb75%WP	
	Ziram80%WP	--
Anthracnose	Aureofungin 46.15% w/v SP	15
	Carbendazim 50%WP	-
	Difenoconazole25% EC	10
	Mancozeb75%WP	-
	Iprodione 50% WP	20
	Kitazin 48% EC	15
	ThiophanateMethyl70%WP	7
	Ziram80%WP	--
	Chlorothalonil 75% WP	60
Angular leafspot	Mancozeb75%WP	-
Rust	Thiophanate Methyl 70%WP	7

Table 13.3Fungicides Combination Uses

Name of disease	Fungicides	Waiting period (in days)
Downey mildew	Ametoctradin 27%+ Dimethomorph 20.27% w/w SC	34
	Azoxystrobin 8.3% + Mancozeb 66.7% WG	21
	Azoxystrobin 11% + Tebuconazole 18.3% w/w SC	10
	Carbendazim12%+ Mancozeb63%WP	7
	Copper Sulphate 47.15% + Mancozeb 30% WDG	10

	Cymoxanil8%+ Mancozeb64%WP	10days
	Boscalid25.2%+Pyraclostrobin12.8%WG	34
	Benalaxyl-M 4% + Mancozeb 65% WP	48
	Dimethomorph 12% + Pyraclostrobin 6.7% WG	34
	Famoxadone16.6%+Cymoxanil22.1%SC	27
	Fenamidone4.44%+Fosetyl-AL 66.7%WDG	90days
	Fenamidone10%+ Mancozeb50%WG	85
	Fluopicolide 4.44% + Fosetyl aluminium 66.67%WG	32
	Kresoxim-methyl 18% + Mancozeb 54% WP	5
	MetalaxylM4%+ Mancozeb64%WP	8
	Metiram 55% + Pyraclostrobin 5% WG	34
	Metiram 44% + Dimethomorph 9% WG	10
	Metalaxyl8%+ Mancozeb64%WP	Not less than 7 weeks
Powdery mildew	Azoxystrobin 8.3% + Mancozeb 66.7% WG	21
	Boscalid25.2%+Pyraclostrobin12.8%WG	34
	Azoxystrobin 11% + Tebuconazole 18.3% w/w SC	10
	Copper Sulphate 47.15% + Mancozeb 30% WDG	10
	Kresoxim-methyl 18% + Mancozeb 54% WP	5
	Carbendazim12%+ Mancozeb63%WP	7
	Fluopyram17.7% w/w+Tebuconazole 17.7%w/w SC	10
	Fluxapyroxad 75g/l + Difenoconazole 50 g/l SC	32
	Fluxapyroxad 250g/l + Pyraclostrobin 250g/l SC	10
	Tebuconazole 50% + Trifloxystrobin 25% WG	34
Disease-Anthracnose	Azoxystrobin 8.3% + Mancozeb 66.7% WG	21
	Copper Sulphate 47.15% + Mancozeb 30% WDG	10
	Carbendazim 12%+ Mancozeb 63% WP	07
	Kasugamycin5% + copper oxychloride 45% WP	37 days
	Kresoxim-methyl 18% + Mancozeb 54% WP	5
	Fluopyram17.7% w/w+Tebuconazole 17.7%w/w SC	10
Disease-Bacterial leaf spot	Kasugamycin5% + copper oxychloride 45% WP	37 days

14.INTEGRATED WEED MANAGEMENT IN GRAPE VINEYARD

The grapes are grown on different training systems depending upon the varieties and the purpose for which they are grown. These different systems allow the growth of various types of weeds. In Bower system, soon after pruning of grapes, there is lot of sunshine underneath which allows the growth of *Cyperus rotundus* and *Oxalis corniculata*. After sometime, the vegetative growth of grape increases and shades the underneath space with result *Polygon plebejum, Euphorbia geniculata, Amaranthus viridis, Portiula caoleracea, Oxalis* sp. and *Mullugopentaphylla* among dicots and *Digitaria marginata, Eleusine indica,* and *Setariaglauca* among monocots come up.

Weed Infestation in Grape Vineyard

Weed Management in Grape Vineyard

Weed Management

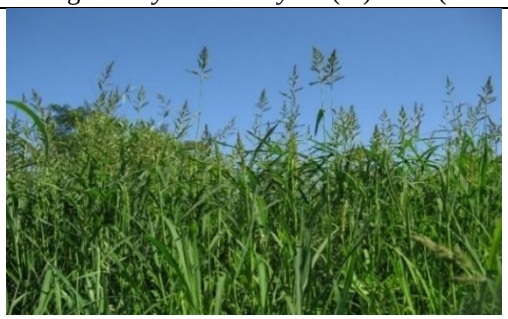
Weed menace has been considered one of the major constraints in grape production. Hand weeding, though an efficient method, it is laborious, costly, time consuming and unsuitable for large grape vineyards. This necessitates the use of herbicides for weed management in developing countries like India.

In the past, majority of workers have tried either pre-emergent or post-emergent application of weedicides for the control of weeds in the grape vineyard. No single weedicide either as pre-emergence or post-emergence can offer a long lasting control of weeds in vineyards since grape vines are irrigated and the soil moisture is maintained throughout the year, which helps the weeds to grow almost throughout the year.

- **Hand weeding:** *Euphorbia geniculate* and *Euphorbia hirta,* which appear as major weeds, carry fungal and insect pests and act as alternative hosts. The usual method of weed control is manual by employing women labour.
- **Mulching**: Mulching with inorganic materials like black polythene film and organic materials like wheat and rice straw, sugar cane trash, dried leaves and saw dust have been advocated for conserving soil moisture and fostering rapid growth of plants.

- **Cover cropping**: The general cover crops grown in grape orchards are cowpea, French beans, cucurbits, sun hemp and mung.

COMMON WEEDS IN GRAPE VINEYARDS:

<table>
<tr>
<td> 
Pigweed: AmaranthusviridisL.(Amaranthacea)</td>
<td> 
Common purselane: Portulacaoleracea</td>
</tr>
<tr>
<td> 
Goat weed: Ageratum conyzoides L. (Asteraceae)</td>
<td> 
Carrot grass: Partheniumhysterophorus L. (Asteraceae)</td>
</tr>
<tr>
<td> 
Spanish needles: Bidenspilosa L. (Asteraceae)</td>
<td> 
Bermuda grass: Cynodondactylon (L.) Pers. (Poaceae)</td>
</tr>
<tr>
<td> 
Flat sedge: Cyperusiria L. (Cypraceae)</td>
<td> 
Barnyard grass: Echinochloacrusgalli (L.) Beauv. (Poaceae)</td>
</tr>
</table>

Chemical weed control:

Table 14.CIBRC Approved Herbicides for Weed Control in Grape Vineyard

Herbicide Name	Weed Species	Waiting period
2,4-D Sodium salt Technical (having 2,4-D acid 80 % w/w) (Earlier Registered as 80%WP)	*Convolvulus spp.* *Tridaxprocumbens*	> 90 days
Paraquat Dichloride 24% SL (Post-emergence directed inter row application at 2-3 leaf stage of weeds)	*Cyperusrotundus,* *Cynodondactylon* *Convolvulus sp.* *Portulaca sp.* *Tridax sp.*	90
Diuron 80% WP	*Cleome viscose, Chenopodium album. Cyperusiria, Euphorbia hirta, Alternantheraechinata, Amaranthusspp, Argemonemaxicana, Ipomoea spp, Xanthium strumerium, Fumeriaparviflora, Asphodelustenuifolius, Medicagodenticulata, Eleusineaegyptia*.	-

15. POST HARVEST HANDLING

Pre-cooling

- The grapes should be transported to Pre-cooling units within 4-6 hours of harvest. The temperature of harvested grapes should be brought down to 1 to 3°C in the pre-cooling chambers.
- If the pre-cooling units are away from the production sites and packing houses, frequent movement of grapes from field to pre-cooling chambers is needed or mobile pre- cooling units are to be used.

Cold storage

- After Pre-cooling, the dual releasing Sulphur dioxide pads (Grape guard) are placed with their coated surfaces facing downwards on the filled plastic pouches and covered with the plastic sheet lining.
- The boxes are closed and shifted to cold storage rooms where the temperature and humidity are maintained at 0 ± 0.5 $^{\circ}$C and 93 ± 2%, respectively. Temperature of 0

°Cand humidity of 95% are the best for maintaining freshness and preventing decay in the berries.

Transport

- Conveyances and/or containers used for transporting food stuffs shall be kept clean and maintained in good conditions in order to protect foodstuffs from contamination and dust.
- These containers must be capable of maintaining appropriate temperatures which should be monitored at regular intervals.

Post-harvest losses

- Grapes fruits are highly sensitive to temperature. The harvesting of grape is generally done early morning and stop grape harvesting before temperature reaches 20 °C. Light coloured and clean crates capable to place only two layers of bunches are suitable. Cover the filled crates and place in the shade. After harvesting grapes are transported under semi covered vehicle to avoid losses from direct contact with sun. Grading and packing process is performed under control temperature of about 15-17 °C at packhouse. The packed grapes are immediately shifted to precooling chambers to achieve the temperature upto 1 to 3 °C and thereafter the grapes are stored in cold storages at 0 ± 0.5 °C and 93 ± 2% till either exported or send to market. Under cold storages the table grape can keep upto 2 to 3 months.
- However at any stages if the cold chain in broken, then there is deterioration in quality due to water loss and post-harvest diseases. During the process of distribution and marketing, substantial losses are incurred which ranges from a slight loss of quality to total spoilage which depends on prevailing supply chain conditions. 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.

16. DO'S AND DON'TS IN IPM

Sl. No.	DO'S	DON'TS
1	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
2	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
3	Maintain optimum and healthy orchid stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
4	Use micronutrient mixture based on soil test recommendations.	Do not apply any micronutrient mixture after sowing without soil test recommendations.
5	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only	Do not apply any micronutrient mixture after sowing without test recommendations.
6	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per vineyard observation	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
7	Follow the recommended procedure of trap crop technology	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies
8	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.	Hence time gap between two adjacent blocks should not be more than 9 days. If unavoidable, fungicide should be sprayed on un-pruned block.

17. EXPORT PROCEDURE

The grape export from India was started in the year 1991 after economic liberalization. There is a phenomenal rise in export of grapes from India, as only 14,606 tons were exported during 2001-2002 which has increased to 1,93,690.54 MT tons in 2019-2020. In current scenario there is export of table grapes and raisin to more than 50 Countries like Netherlands, Russia, U.K, Bangladesh, Germany Thailand, Hong Kong, Malaysia, Canada, Oman, China, Denmark, Nepal, Finland, SriLanka etc.,

Constraints in Export

- **Maximum Pesticide Residue Level**: For export of grapes to European union and other country, it is mandatory that grape consignment should meet the Maximum Pesticide Residue Level of importing country (Codex).
- **Cold Chain**: After precooling, grape need to be stored at 0 to 1°C, it is very sensitive to temperature fluctuation hence need to maintain cold chain during transit of container.
- **Cost of production is very high**: Due to high skilled labour intensive intercultural operation, training, pruning, hormone application, there is high the cost of production in grapes.

Grape Orchard and Grower Registration

- Farmers willing to export the grapes need to register their plots to State Agriculture Department/Horticulture
- Physical verification of grape orchards by State Agriculture officer/ Agriculture assistant (Form 4B)
- Unique Grape orchard plot registration number will be given by state department for traceability of farm
- Each registered farmer shall maintain the registration and application records of all chemicals
- The farms registered/intended to get registered shall not use chemicals, which are under developmental trials and not registered with CIB&RC.
- The plot registration certificate shall be issued only through the Grape Net under the signature of Registration Authority.
- Each farmer, at the time of harvest, shall give a declaration to the exporter in Annexure-3 stating those chemicals viz. insecticides, fungicides, herbicides, plant growth regulators, bio-product formulations or any other.

- Document verification Annexure -4B by laboratory purpose for pesticides residue analysis

Grape Pesticide Residue Sample

- The representative grapes sample of orchid will be tested as per norm for pesticides residue analysis by APEDA approved laboratory
- Sample Fail - The orchard will be rejected, no permission for export of grapes from such plots
- Sample Pass - Famers and exporter will planning for harvesting schedule

PackhouseRequirement

For export of grape, there is need of Pack house which should be register with APEDA/NPPO

Unidirectional products flow chart

- Raw Material from farm
- Arrival of Raw Material at packhouse
- Primary Inspection & Weighing in pre Inspection Area
- Raw Material held in Holding Area
- Shorting, Grading in Processing Area
- Packaging the produce
- Final produce stacked in stacking Area
- Inspection by Plant Quarantine Authority
- Pre Cooling/ Cold Storage as per requirement
- Dispatch through loading dock

Farmer Registration:

Each farmer, who intends to export directly or supply fresh grapes to an exporter, shall apply for registration/renewal of its farm and plot(s) to the concerned District Superintending Agriculture/ Horticulture Officer, as per application form for registration/renewal of grape farms given in Annexure-1.

Responsibilities of farmers, growers and exporters

- The farmers/growers/exporters and any other stake holders of fresh table grapes to the EU market shall comply with the EU MRLs of chemicals based on EU Regulations.
- All farmers shall maintain a record of package of practices followed by them in a prescribed register to be provided by the respective State Horticulture/ Agriculture Departments.
- Samples of soil and water from the registered farms containing banned/restricted chemicals in the previous season shall be drawn for testing by the authorized laboratories and the NRL.

Field Inspection

- Each Inspection Authority (Agriculture/Horticulture Officer) shall visit the farm/plot(s) at least twice to inspect the farm/plot prior to harvesting of the grapes.

Method of Sampling from Grape Farms/Plots

- Farmers/exporters shall provide a schedule to the laboratories and Inspecting Authority/Registration Authority well in advance for drawl of samples for pesticide residue analysis to enable them to plan their sampling arrangements

Accreditation/Recognition Requirements and Responsibility of Authorized Laboratories- Pesticide Residue Laboratory

- The authorized laboratories shall test the grape sample for MRL.
- In case, the test results exceed the MRLs, the nominated laboratory shall immediately bring the matter to the notice of NRL, PSC issuing Authority, Inspection Authority (Horticulture/Agriculture Officer), exporter/farmer and APEDA along with a copy of the test report giving details of the plots and the chemicals exceeding the levels.
- The laboratories shall, in case of failed samples, also send the chromatograms, etc. to the NRL through GrapeNet.

Procedure for Issue Phyto Sanitary Certificate (PSC)

Arrival of Grapes at Packhouse

- Harvesting of grapes should be done early in the morning
- On arrival of grape in packhouse, the Document related to backward linkages will be verify by PQ official

Primary Inspection

- Plant quarantine inspector will do primary inspection of grapes at the arrival point in packhouse (primary inspection area).

Plant Quarantine Inspection of Consignment

- Plant Quarantine inspector will draw the boxes from each consignment as per SOP for export& requirement of importing countries and will inspect the consignment in dedicated plant quarantine laboratory in pack house.

Precooling and Cold Storage

- Once the consignment is passed in plant quarantine inspection, the palletised grapes are immediately shifted in pre-cooling chamber to maintain 1 to 3 °C and later on in cold storage at 1 °C till the dispatch of container.

Dispatch of Container

- The container should be referred container and should maintain the temperature 0 to 1°C throughout the transit period.

18. REFERENCES

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