GOOD AGRICULTURAL PRACTICES FOR PRODUCTION OF QUALITY TABLE GRAPES

भाकृअनुप
ICAR

राष्ट्रीय अंगूर अनुसंधान केन्द्र

NATIONAL RESEARCH CENTRE FOR GRAPES

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

MANJRI FARM POST, SOLAPUR ROAD, PUNE - 412 307, INDIA

राअंअनुके
NRCG

Published by:

P.G. Adsule, Director

National Research Centre for Grapes, Pune

Edited by:

P.G. Adsule, D. S. Yadav, Anuradha Upadhyay, J. Satisha and A. K. Sharma

Designed by:

D. S. Yadav, Indu S. Sawant and Shailaja Satam

Cover photo credits:

R. G. Somkuwar

DISCLAIMER:

All care has been taken to provide correct information in this document. However, in no case, the National Research Centre for Grapes or the Indian Council of Agricultural Research or the Government of India, will be liable for any expense, loss or damage, including, without limitation, indirect or consequential loss or damage whatsoever, arising from use, or loss of use, of information provided in this document.

Preface

At present, the area under grape cultivation in India is about 111,000 ha (NHB Stat 2011) with the production in the range of about 12,35,000 tonnes. Table grape cultivation is mainly concentrated in peninsular Indian states such as Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Grape is emerging as an important commercial fruit crop of India and the highest among fruit crops in earning foreign exchange. Further, it is receiving importance in creating jobs on and off the farm and other related sectors, thus improving economic status of farmers, farm labourers and other labourers.

Table grapes are mainly used for the fresh consumption of domestic market and very little (about 2 %) for export market mainly for Europe, Middle East, South East countries and Bangladesh. A big chunk of table grapes (> 30 %) are also used for making raisins. Considering the end use of grapes, Good Agricultural Practices (GAP) in terms of training, pruning, thinning, fertigation, irrigation, crop protection and appropriate method and stage of fruit for harvesting are important and therefore these practices in farm production and post-production processes have bearing for safe and healthy grapes for consumers while taking into account environmental sustainability. In this document, all these practices including selection of appropriate table grape varieties, the use of label claim chemicals for quality and safe end product are covered for the guidance of all stake holders particularly, growers, raisin makers and exporters keeping in view the food safety measures in the country and also for export market. The grape growers of India are highly dedicated and committed group, and are ready to make a mark in the world grape trade. It is mainly through their efforts that grape cultivation has slowly emerged from the unorganized to an organized sector. Not only the elite groups of grower- exporters but a large number of smaller growers, too, have become aware of the Good Agricultural Practices (GAP).

I hope all the stake holders in grape Industry will take advantage all the guidelines set in this document and comply with these requirements for quality production as required under the good viticulture practices. I also take this opportunity to thank all my fellow Scientists, technicians and others in bringing out this useful document for the benefit of grape Industry.

Place : Pune (P.G. Adsule)
Date :18.02.2013 Director

Contributors

Dr. P.G. Adsule
Director
Tel: +912026956001
Mobile: 09970987097
Email: dirnrcg@gmail.com

Dr. G.S. Karibasappa
Principal Scientist (Horticulture)
Tel: +912026956050
Mobile: 09823799584
Email: goudar.karibasappa@gmail.com

Dr. Indu S. Sawant
Principal Scientist
(Plant Pathology)
Tel: +912026956031
Mobile: 09373324010
Email: indulika18@yahoo.co.in

Dr. S.D. Sawant
Principal Scientist
(Plant Pathology)
Tel: +912026956032
Mobile: 09371008649
Email: ipmsawant@yahoo.co.in

Dr. R.G. Somkuwar
Principal Scientist
(Horticulture)
Tel: +912026956060
Mobile: 09422032988
Email: rgsomkuwar@yahoo.co.in

Dr. A.K. Upadhyay
Principal Scientist
(Soil Science)
Tel: +912026956040
Mobile: 09890077721
Email: ajayk_upadhyay@yahoo.com

Dr. K. Banerjee
Principal Scientist (Agricultural Chemistry) and National Fellow (ICAR)
Tel: +912026956091
Mobile: 09890940914
Email: kbgrape@yahoo.com

Dr. S.D. Ramteke
Principal Scientist
(Plant Physiology)
Tel: +912026956075
Mobile: 09422313166
Email: sdramteke@yahoo.com

Dr. J. Sharma
Senior Scientist
(Soil Science)
Tel: +912026956040
Mobile: 09423013611
Email: jsharmagrape@yahoo.co.in

Dr. A.K. Sharma
Senior Scientist
(Horticulture)
Tel: +912026956065
Email: sharmadrajay@gmail.com

Dr. J. Satisha
Senior Scientist
(Horticulture)
Tel: +912026956065
Email: satilata@gmail.com

Dr. D.S. Yadav
Scientist
(Entomology)
Tel: +912026956035
Mobile: 09272122858
Email: deependra81@gmail.com

Dr. Ahammed Shabeer T.P.
Scientist, (Agri. Chemistry)
Tel: +912026956091
Mobile: 08793393659;
E-mail: shabeertp2000@yahoo.co.in

Mrs. Amala U.
Scientist
(Entomology)
Tel: +912026956099
Email: amala.uday@gmail.com

Mr. Govind Hande
Inspecting Authority for Phytosanitory (Export)
Agriculture Department, Govt. of Maharashtra,
Email: govindhande@gmail.com

Contents

This page is left blank intentionally

Chapter 1

Major table grape varieties

G. S. KARIBASAPPA

Table grapes are those grapes which are meant for consumption while they are fresh, in contrast with the grapes grown for wine production, juice production or for drying into raisins. They should have attractive appearance, bold and elongated berries, and crisp pulp with thin and soft skin. Seedlessness is another desirable character for these grapes. The table grape varieties generally have lower sugar content as compared to wine grapes and are pulpier. The salient features of the major grapevine varieties grown for table purpose in India are described in this chapter.

1. Thompson Seedless and its clones

Worldwide, it is the major table grape variety. In India, it is being cultivated commercially for about last five decades. Thompson Seedless along with its clones have been successfully cultivated for table as well as for raisin making and presently occupy 70 per cent area approximately of the total 1.12 lakh hectares under grape cultivation in the country during 2011-12. Fruit yields of 20 tons of quality grapes per hectare can be obtained with this variety. Under peninsular Indian conditions the fruit is normally harvested after 120-150 days of forward pruning. The berries continue to ripen even in warm summer days and these cultivars are suited for staggered production. Some of the clonal selections from Thompson Seedless like Tas-A-Ganesh and

Fig. 1. Thompson Seedless

Sonaka from India, 2A clone from California, H-5 from Australia have become popular in India. Manik Chaman, Maruti Seedless, Ambe Seedless from India is also gaining popularity due to their high and distinctive responses to hormonal treatments and higher recovery of export quality fruits.

Salient features

Clusters are medium to large, cylindrical to conical shaped, heavily shouldered that ripen in about 130-140 days after pruning. The berries are seedless, small to medium sized, oval to ellipsoidal in shape, soft berry skin and greenish white to golden in colour with firm, juicy pulp. The majority of exported grapes from India consist of this variety.

2. Manjri Naveen

It is a clonal selection from Centennial Seedless made at NRCG, Pune and was released in December, 2009.

Salient features:

Fig. 2. Manjri Naveen

This variety ripens about 25 days early as compared to Thompson Seedless. It is a white seedless, naturally bold berry with mild muscat flavour table grape variety. It has uniform berries and clusters and do not require extensive thinning operations. Extended harvesting should be avoided, the ripe berries are less acidic and aromatic hence should be quickly packed for precooling and cold storage. Yield of 20-25 tons of exportable quality fruits can be obtained per hectare.

3. Red Globe

This variety developed at UC Davis, California, USA was introduced to India in 1985 and after multi-locational evaluation it was recommended for cultivation.

Salient features

Clusters are big, berries very bold (22-25 mm dia), red round, seeded with meaty pulp. It is a late ripening variety and takes more than 135 days from pruning. It has good keeping qualities and can be cold stored for at least 3 months. Fruit yield is about 20-25 tons per hectare.

Fig. 3. Red Globe

4. Fantasy Seedless

It is a complex hybrid derived from a cross between B36-27xP64-18 at USDA Fresno, California.

Salient features:

Vines are vigorous require high sunlight exposure for adequate fruitfulness. This variety does not require GA_3 for thinning/ sizing. Some

Fig. 4. Fantasy Seedless

clusters may require a manual thinning in rare case. Berries are medium bold, deep purple to black, seedless, thin skin and firm and obovate in shape. Clusters are medium in size, conical shape, and medium to loose in compactness with excellent flavour. It is mid late ripening variety and takes not less than 130 days from pruning. Late harvesting and excess soil moisture /humid conditions sometimes lead to berry cracking. Care must be taken not to over crop during first year of production. The fruits can be cold stored for 8 weeks.

5. Flame Seedless

Fig. 5. Flame Seedless

It was obtained as a result of complex 3 generation hybridization made at USDA, Fresno, California, USA.

Salient features:

The vines are very vigorous and the shoots tend to grow continuously under tropical conditions. The berries are bright red, large to medium in size, round and seedless. They have crisp skin, firm but juicy pulp with a distinctive muscat flavour. Bunches are medium to large, conical and well filled. It is an early variety and takes about 95-110 days to harvest from pruning. Therefore, it is advantageous to grow in northern states where grape growing period for fruit production is less as compared to southern peninsular states. For maturity, minimum 16° brix is required. Ripening should coincide with slight cool climate for uniform colour and muscat flavour retention, i.e., during late February or early March. The fruit yield ranges between 15-18 tons per hectare. Fruits can be cold stored for 8-10 weeks. Packing in punnet helps maintain quality during transport. However, there is a need to improve berry attachment for long distance markets.

6. Sharad Seedless and its clones

It is a clonal selection from the Russian variety Kishmish Chernyi (Black Sultana). Recently, 4 clonal

Fig. 6. Sharad Seedless

selections are made by farmers, those respond well to hormone applications

with attractive berries. These selections are Jumbo (Nath Seedless) and Nana Purple for extra bold elliptic berries, Sarita and Krishna with oblong/ elliptical shaped berries with attractive conical shaped bunches.

Salient features:

The berries are bluish black with crisp pulp, oblong to elliptical in shape and highly responsive to Gibberellin treatment for berry size. The fruit quality is better when ripening coincides during cool climate. It has a medium maturity and takes about 125 days from pruning for harvesting. Quality yields of 15-18 tons per hectare can be obtained with proper canopy management, bunch and berry thinning and berry sizing. However, the berries are susceptible to the bleaching as a result of SO_2 injury during storage in fruit boxes lined with grape guards. Hence the variety is not suitable for long duration storage/shipment, but can be exported to short distant/ quick accessible markets.

7. Crimson Seedless

It was obtained as a result of cross between Emperor x C33-199 at USDA, Fresno, California.

Fig. 7. Crimson Seedless

Salient features:

Vines are very vigorous. Crimson Seedless berries are bright red, large, cylindrical-oval and seedless. They have thick, tough skin, and firm crisp flesh with a neutral flavour. Bunches are medium in size, conical with a shoulder, and well filled to slightly compact. This variety does not require GA_3 for thinning/ sizing. Some clusters may require a manual thinning. It is a late ripening variety and takes not less than 130 days from pruning. The fruits are acidic and usually harvested at sugar: acid ratio of more than 25 for Indian markets. The fruits can be cold stored up to 18-20 weeks.

Newly introduced varieties

1. Autumn Royal

This variety was developed from a cross of Autumn Black x C74-1, at USDA, Fresno, California.

Salient features

The variety has bold berries, purple black to black in colour, ovoid to ellipsoidal in shape. The berry flesh is firm and translucent, skin medium thick. It is a late maturing variety. This variety does not require GA_3 for thinning/ sizing. Some clusters may require a manual thinning. Without

Fig. 8. Autumn Royal

gibberellin or girdling, berry weight can average more than 8 gram. However, to avoid post-harvest rachis drying, a spray of 6-BA to clusters at 4 mm stage of berry growth is advised. It is a late ripening variety, takes not less than 135 days from pruning. The fruits are harvested at sugar acid ratio of 25. Fruits can be cold stored up to 14-16 weeks.

2. Autumn Seedless

This variety was developed from a cross of Calmeria x (Muscat of Alexandria x Thompson Seedless) at USDA, Fresno, California.

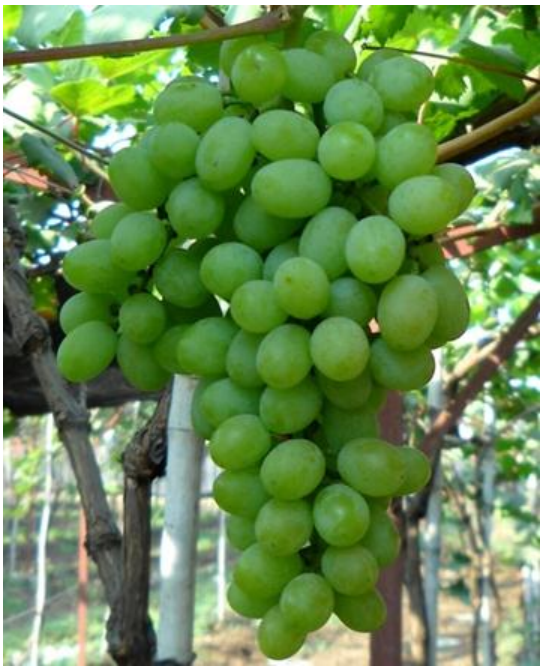

Fig. 9. Autumn Seedless

Salient features

Clusters are attractive, medium large, moderately compact to loose and conical to winged cylindrical in shape. Berries are naturally bold and hence do not require GA_3 for thinning/sizing. Some clusters may require a manual thinning. Berries are white seedless and attractive oval shaped. Berry skin is medium thick, crisp and tender. Pulp is firm and sweet and attains 21°brix. It is a late ripening variety and takes not less than 130 days from pruning for harvest. The fruits are harvested at sugar acid ratio of 25. Fruits can be cold stored up to 14-16 weeks.

3. Blush Seedless

It is a cross between Emperor and Davis Z 4-87 developed at UC Davis, California, USA.

Salient features

Vines are moderately vigorous. Bunches are medium, well-

Fig. 10. Blush Seedless

filled/compact, uniformly long, conical and symmetrical. Berries are red, oval and seedless. Berries may be uneven in size. The skin is tender and crisp with meaty flesh. It is a late ripening variety takes not less than 130 days from pruning. The fruits are harvested at sugar acid ratio of 25. Fruits can be cold stored up to 12 weeks.

Chapter 2

Vineyard establishment on rootstocks

J. SATISHA

Use of rootstocks in India is only two to three decade old practice. Prior to 1990's most of the vineyards were on own roots of commercial varieties. However occurrence of salinity build up and moisture stress in these regions contributed for decline in the productivity of own-rooted vineyards. This prompted some of the growers to use drought and salt tolerant rootstocks in their vineyards. The grafted vines outperformed the own rooted Thompson Seedless vines under the conditions of abiotic stresses such as soil and water salinity and water scarcity, which prompted other grape workers to use rootstocks to overcome these adverse situations.

During the initial years of establishing of vineyards on grape rootstocks in India, "Dogridge" was the only rootstock which was commercially accepted by most of the grape growers. Though this rootstock performed better during initial years of vineyard establishment, over the years few problems encountered with this rootstock such as more vigour on scions, reduced fruitfulness, accumulation of more sodium resulting in uneven bud sprouting and death of cordons etc. To overcome these problems associated with Dogridge under given soil and climatic condition, growers started establishing their vineyards on 110R rootstock based on the research findings of NRC Grapes, Pune. Rootstock 110R was known to induce less vigour on Thompson Seedless

Fig 1. Severity of moisture stress symptom in vines on own roots (left) than on grafted vines (right)

scions, quick and uniform bud sprouting, increased fruitfulness, reduced accumulation of sodium in leaf blades, cordons, petioles etc. Hence, rootstock 110R has thus find prominent place in Indian viticulture and most of new vineyards are being established on this rootstock. However, some of the Thompson Seedless vineyards grafted on Dogridge rootstock is performing better without facing any problems related to vine vigour, fruit bud differentiation, fruit yield, etc. which clearly indicates that the performance of particular rootstock is mostly depends on the soil and irrigation water quality in which it is grown and also the viticultural operations being followed. A rootstock which performs better in a particular soil and climatic condition may not perform similarly in other soils. Some of the vineyards on own rooted varieties are also performing better. Hence, it is necessary to consider soil and water analysis before choosing particular rootstock for establishing vineyards. A list of rootstocks recommended for different soil and irrigation water qualities is shown in Table 1.

If the grape growers intended to establish their vineyards on rootstocks, the following practices should be followed.

1. Purchase pure and true to type rooted cuttings of rootstocks from genuine nursery to avoid genetic mixture.
2. The best time for planting rootstocks in field is during February – March.
3. Open the trenches of 2.5' depth and 2.5' width in North – South direction of desired length. This should be done at least one month prior to planting. The recommended spacing between rows is about 9-10 ft.
4. Fill the trenches with top soil, FYM, green manure, super phosphate, etc. and irrigate copiously.
5. At the time of planting, open the pits at the desired planting distance (5-6 ft for table grapes).
6. Plant the rooted cuttings in the opened pits and irrigate immediately to avoid

Table 1. List of rootstocks recommended for different soil and irrigation water characteristics.

No.	Situation/problem	Rootstock
1.	Water shortage	1103 P, 140 RU, 110 R, 420 A, SO 4, 99 R, , Dogridge
2.	Soil EC more than 2 m mohs/cm and water EC more than 1 m mohs/cm	Ramsey, 140 RU, 99 R, 110 R.
3.	Soil ESP more than 15 per cent and/or water SAR more than 8.	140 RU, Ramsey, 110R, 1103 P
4.	Free calcium content of soil is more than 12 %	Fercal, 140 Ru, SO 4, 420 A.
5.	Chloride content of water is more than 4 meq/litre	Ramsey, Dogridge, 140 RU. Teleki 5-C, 110R, 99R
6.	Poor vigor of the variety without any soil/water problem	Dogridge, St. George, SO 4, 140 Ru.
7.	For increased nitrogen, potassium uptake.	Dogridge B, St. George, 34 EM, Ramsey.
8.	For increased bud break	1613, 110R

Fig 2. Rootstocks planted in pits opened on the trenches

transplanting shock and field mortality (Fig 2).

7. After 15 days of planting apply fertilizers such as 19:19:19 and urea alternately either through fertigation or soil application for good growth of rootstocks.
8. Allow all the shoots to grow for about 50 days. This will help in building up of sufficient food reserves in the plant. After 50 days remove the weak and thin shoots leaving only 2-3 strong and healthy shoots. To make straight growth of the retained shoots, erect bamboo sticks in each basin and tie the shoots to the bamboo sticks.
9. The best season for *in situ* grafting is during the month of September. Wedge grafting is the preferred method of grafting as it gives maximum success and is also simple method.
10. At the time of grafting the retained shoots of rootstocks are decapitated at about 1.5 ft above ground level. The grafting is performed by opening slit on the rootstock shoot and inserting wedge shaped scion and tying with polythene strips (Fig 3).

Fig 3. Grafting of scion variety

11. Irrigate the grafted plants immediately to maintain sap flow for better graft union.
12. Do not disturb graft union and irrigate the vines continuously to avoid desiccation. Care should be taken to remove suckers developed on rootstock portion as those shoots are strong competitors for water and nutrients with sprouted shoots on scion stick.
13. Once new shoots start developing, train the shoots straight by tying them to bamboo sticks.
14. As grafted plants start growing, simultaneously the girth of graft union also starts increasing. As a result the tied polythene strip may cause girdling in grafted region. To avoid this, the tied polythene strip should be removed carefully with sharp knife and retie the grafted region with new polythene strip.
15. Uniformity in growth of all the vines may be achieved by taking recut in the following January – February months.
16. The re-cut is done by retaining only two or three buds above graft region.
17. The sprouted shoots are further trained to trunk, primaries and secondary (cordons) as per the trellises employed in the vineyard

Chapter 3

Training, pruning and canopy management

R. G. SOMKUWAR

Grapevine is a climber. It has indeterminate growth with weak stem. It needs support not only for the weight of its aerial parts and fruits but also for maintaining the canopy architecture. The trellis and the system of training shape the canopy architecture of vines. The fabricated structure used for training the vines is called the trellis while the process of shaping the canopy is called training. The manner in which a grapevine is trained does not only influence the vine growth, productivity and quality but also brings about variation in microclimate. Canopy management starts out with the interaction of the cultivar, vineyard site, seasonal climate, inputs and the trellis system. Canopy management of grapevines deals with the development and maintenance of their structure in relation to size and shape for maximum productivity and quality. The basic concept in the canopy management of perennial vines is to make the best use of land and climatic factors for increased productivity. Tree vigour, sunlight, temperature and relative humidity of that region plays a great role in the production and quality of fruits.

1. Training

Grapevine is trained to achieve high quality production. There are number of training systems used worldwide, however, no single training system is appropriate for all situations. Based on the vine vigour, degree of vineyard mechanisation and availability of the skill workers the selection of training system is decided. The growth potential of grapevine and the condition under which the vine is grown are never uniform. The trellis used for training the vine is decided during the first year itself.

Fig. 1. Grafting of scion

Fig. 2. Training of rootstock

Fig. 3. Training after grafting

Training system used in vineyard should fulfil the following requirements.

1. The training system should be cheap and economical.
2. The training system should help to expose maximum leaf area to the sunlight for better photosynthesis.
3. The vine trained to any type of training system should promote maximum bud break.
4. The training system should offer a scope for mechanization with respect to efficient fungicide/ insecticide sprays, harvesting of maximum produce and pruning practices.
5. The training system should support the crop load to harvest good quality grapes.

The training of grapevine is performed to train different vine parts in the initial year. These are as below.

1.1 Training of rootstock

After the re-cut of rootstock in the field (before grafting), the selected shoots of rootstock are trained to the bamboo sticks so as to encourage straight growth of trunk after grafting. This helps in storage of required food material in the developing trunk.

1.2 Training the trunk of grafted vine

The grafted vine is tied with bamboo stick so as to train the trunk straight.

1.3 Training of primary arms on Y trellis

Fig. 4. Training of primary arm

Immediately after re-cut of grafted vines, the shoot grows vigorously. This shoot should be pinched six inch below the first wire so as to train the primary shoot in a slanting position. This will avoid the direct sunlight exposure of the primary arm.

1.4 Training of secondary arms (cordon)

The cordon development should be done based on the vigour of the vine. Due to the presence of prominent apical dominance in Thompson Seedless and its clones, the cordon development and training

Fig. 5. Training of secondary arms

should be done following 'stop and go' method. This will help to obtain complete cordon with desirable length during the first year.

2. Pruning

The pruning can be defined as removal of plant parts to obtain appropriate number of fruiting units. The objective of pruning includes-

1. Controlling the size and form of a vine.
2. To increase fruiting area on a vine.
3. Maintaining the balance between vegetative growth and fruiting.

Fig. 6. Back pruning in grapes

4. Optimize the production potential of vine.
5. To obtain better quality fruit from the vine.

The pruning is done based on the prevailing weather conditions in that region. Under central parts of India, the vine grows vigorously throughout the year. Hence, double pruning pattern is followed for grape cultivation. The vines are pruned during April by leaving basal single bud on the shoot proximal to the cordon. Since, the whole portion of cane is pruned; this pruning is called as back pruning. Fruit pruning is done during October for getting fruits, hence, it is also called as fruit pruning. During fruit pruning, the matured canes are pruned either after knot on the sub cane or at 6-7 bud position in case of straight canes. However, the pruning position varies with cane vigour and varieties.

3. Canopy Management

Canopy management refers to the practices followed to obtain the ideal characteristics in various canopy components to realize the maximum yield of quality grapes.

3.1 Canopy architecture

Canopy refers to the size and shape of vine structure. The size and

Fig. 7. Well trained vineyard

shape of the canopy is dependent on canopy components such as primary arms and cordons, canes, shoots and also on a given trellis/ training system.

The ideal canopy should fulfil the following requirements:

1. It should give the grapevine a desirable shape and support the crop load.
2. It should offer scope for convenient field operations and mechanization.
3. It should have adequate number of fruitful canes.
4. It should allow sufficient light and ventilation into the canopy during the growth season.
5. It should give maximum proportion of quality grapes per unit area.
6. It should have sufficient foliar coverage to nourish and protect bunches during the fruiting season (November-March).
7. It should avoid overlapping of the foliage to facilitate efficient photosynthesis by every leaf.
8. It should offer scope for effective spray coverage with pesticides and growth regulators.
9. It should not build up micro-climate that is congenial for disease development.

Fig. 8. Correct stage of sub cane

The requirement of canopy during each pruning under tropical region is as below.

3.2 Canopy management after foundation pruning

1. The ideal stage for shoot thinning is at 4-5 leaf stage. This helps in reducing the loss of nutrients from the vine.
2. The number of shoots retained on vine should be 0.70-1.0 per ft^2 for quality produce.
3. The canopy should be open during April – September to facilitate optimum sunlight harvesting required for efficient photosynthesis.
4. The shoots on each cordon should be vertically positioned to harvest maximum sunlight required for fruit bud differentiation.

Fig. 9. Vertical shoot position after back pruning for effective fruit bud differentiation

5. While removing the excess shoots from the cordon, remove both vigorous and weaker shoots so that all the shoots will be uniform in diameter. This will promote

Fig. 10. Fruit Pruning of vine

Fig. 11. Pre bloom stage of a bunch

uniform bunch development after fruit pruning.

6. Vines with vigorous shoots should follow sub cane system while straight cane is followed in less vigorous vines.
7. While making the sub cane, pinch the shoot to 7- leaves at 9- leaf stage so as to develop proper sub-canes.
8. Top the side shoot again at 5th leaf when it is at 7- leaf stage.
9. Impose soil moisture stress at 7+5 leaf stage. This helps in increasing the fruit bud differentiation.
10. Top the shoots to 15- leaves (7+8) when the shoots start maturing. This helps to store enough food material and advance cane maturity.

3.3 Canopy management after fruit pruning

1. Before fruit pruning, collect the canes (about 40 canes/acre) of different thickness (6-8 mm, 8-10 mm and >10 mm diameter) and examine their buds under microscope for position of fruitful bud. This helps to decide pruning position to obtain maximum number of bunches.
2. The canes of 6 mm and less diameter are to be removed during fruit pruning.

Fig. 12. Stage of excess shoot removal after fruit pruning

3. Swab hydrogen cyanamide only to apical 2-3 buds on each cane. This helps in early and uniform bud break.
4. Based on the bud break and the bunch emergence, shoot thinning is to be performed at 4-5 leaf stage.
5. Bunches are to be retained based on vine spacing. Retain one bunch for every 1-1.5 ft^2 of canopy for quality grapes.
6. Excess shoot removal to be done at 4-5 leaf stage.
7. Bunch thinning should be followed at pre- bloom stage only.

Fig. 13. Stage of excess bunch removal

8. Retain only one or two bearing shoots on each cane. If the cane diameter is more than 8 mm, retain two bearing shoots and only

Fig. 14. Well filled bunch after berry thinning

one shoot if the diameter is less than 8 mm.

9. Encourage the shoot growth by applying more nitrogen and water until one month after fruit set.
10. Thin the berries and clip the clusters to reduce the number of berries in relation to the cane thickness. Retain 16 berries in a cluster per mm diameter of the cane.
11. Position the shoots appropriately to provide shade to the bunches on the South-West side of the canopy.
12. Retain only 100-120 berries in a bunch and remove all excess berries. This operation should be done immediately after berry setting. This helps in proper berry development and achieving the desirable berry size for quality produce.
13. Shoot topping is done at 10-12 leaf above bunch after fruit pruning to avoid competition for nutrients by the shoot and consolidate the food material in the developing bunches. This helps in increasing the berry size.

Fig. 15. The vine before harvest

14. To increase the berry size, girdling is one of the important operations beside use of growth regulators and cluster thinning. All these are complementary to each other. Therefore care should be taken to use these practices judiciously. Girdling helps in increasing the berry size at least by one mm diameter.
15. The time of girdling differs among varieties. In Thompson Seedless, the girdling is done at 4-6 mm berry size whereas in Sharad Seedless, it is done at 6-8 mm berry size.

Chapter 4

Nutrient and water management

J. SHARMA
A. K. UPADHYAY

Application of nutrients and irrigation to soil depends on the site selected for grape cultivation. Site selection in terms of soil and climatic condition is one of the important factors to be considered before establishing vineyard. Soil properties in terms of soil texture and structure, soil pH, depth, availability and quality of irrigation play a major role in successful viticulture. Similarly, climatic factors prevailing in the area with respect to rainfall pattern, temperature, light intensity, relative humidity also determine the success of grape cultivation. Though grapes can be cultivated on varied soil and climatic 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. Grapevines generally require hot and dry climate during its growth and fruiting period. Either very hot or very mild and cold climate during fruit ripening creates imbalance in sugar acid blend thus reducing fruit quality.

Grapevines once planted stays at the site for a period of about 15-20 years. Favourable rooting environment and proper understanding of the phenology of vine is key to efficient water and nutrient management. Nutrient availability to plants is dependent upon soil pH and its composition, amounts of nutrients in the soil and soil environment. Thus, regular soil testing can determine status and changes in its composition and any toxicity, which may impede nutritional balance. Further, grape roots being spread deep in the soils, vines may not respond to the fertilizer application as predicted by soil testing, hence, petiole testing also becomes very important. The petiole samples should be drawn during both foundation and fruit pruning seasons and sent for analysis to a recognized laboratory in order to know the nutrient status for vegetative growth and fruiting respectively.

Water is a critical input for grape production. Quality of water in terms of salinity, presence of specific ion (sodium, chloride, boron, nitrate etc.), carbonates and bicarbonates will have an impact on the quantum of water required for the vine cultivation as well as on the nutrient requirement based on vine phenology. Test the irrigation water and soil for presence of heavy metals *viz.* arsenic, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, lead, tin and thallium from the food safety point of view.

Before starting the foundation and fruit prunings, the grower should draw samples from the root zone of the soil to a depth of 30 cm from all sides of the point of application of drip water after harvest (during rest period). Simultaneously, they should also test the irrigation water quality.

Apply fertilizer based on soil and petiole test report. The nutrient input from organic manures and irrigation water should also be taken into consideration while deciding the quantity of nutrients to be applied at specific crop growth stage. The grower while procuring the fertilizer should also check the label details on the fertilizer bag and ensure from the dealer about its meeting the specifications as per Fertilizer Control Order (1985) of Government of India

and latest amendments. Similarly, the grower while procuring composts and organic materials must demand from the supplier or satisfy them about the product being free from heavy metals as stated above. Irrigation water particularly from groundwater sources can supply large quantities to meet crop needs of nutrients like nitrogen (nitrate-N), magnesium, calcium etc. For example- if irrigation water contains 20 ppm nitrate-N and about 20,00,000 liters of irrigation water is applied per acre in a year it will add 40 kg N as nitrate –N. Hence dose of nitrogenous fertilizers should be adjusted accordingly.

The nutrient and water requirement based on crop growth stages for Thompson Seedless vines raised on Dogridge rootstock are shown in table 1. This schedule can also be used for Thompson Seedless vines raised on 110R rootstock. The sprouting time of 10-12 days is considered for arriving at a given growth stage. The method of irrigation for vineyard is surface or drip system. These recommendations are for guidance purpose only and may change based on site conditions of vineyard. Further, The optimum range of petiole nutrient contents for Thompson Seedless vines grafted on Dogridge rootstock are given in table 2. For visual diagnosis of nutrient deficiencies refer figure 1.

1. Nutrient and water management after foundation pruning

1.1 0-40 days after foundation pruning

Apply recommended amendments and FYM at or before pruning. At the time of pruning apply FYM @ 25 ton/ha. Apply 30% nitrogen of the annual N needs during first 40 days after pruning and 20% of the annual P fertilizer dose between 31-40 days after pruning. Apply Zn and boron during 20-40 days to promote desired shoot growth. However, if the soil test value indicates deficiency, apply micronutrient (Zn, Fe, Mn and Boron) after bud swelling stage. Apply starter dose magnesium if the deficiency was indicated by the soil and petiole test during the previous fruiting season.

Apply proper quantity of irrigation water based on pan evaporation rates to achieve desired canopy. Expected pan evaporation during first 40 days may range from 8-12 mm per day. Accordingly the irrigation water needed will range from 33,600 to 50,400 litres per hectare per day.

1.2 40- 60 days after foundation pruning

Petiole testing: Collect the petiole from the fully mature leaf at 5th node position from the base of a cane at bud differentiation stage (33-35 days after bud sprouting) and send for analysis to a recognized laboratory. If the test report indicates the nutrient (s) as excess or very high, stop the application of that nutrient.

Apply 40% of the annual P dose during this period. If potassium deficiency symptoms such as inward leaf curling or shiny spot on leaves is noticed during the first month of growth (vegetative growth), start potassium application early. In case petiole test values indicate low magnesium content, apply magnesium by foliar spray not exceeding 0.5% concentration followed by soil application of 100 kg magnesium sulphate per hectare in four splits. Apply zinc and boron during 40- 60 days as per petiole test report preferably by foliar sprays.

Reduce the irrigation to 1/3rd compared to first 40 days to facilitate fruit bud differentiation. Expected pan evaporation during this stage may range from 8-10 mm. Accordingly 11,200 to 14,000 litres of irrigation water per hectare per day will be

needed. Excess irrigation or soil moisture at this stage will result in poor fruitfulness.

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.

1.3 60 to 120 days after foundation pruning

Apply 30% of annual potassium dose during 60 to 120 days after foundation pruning.

This stage also coincides with rainy season hence, irrigation may not be needed. If there are no rains continue irrigation as per the requirement.

2. Nutrient and water management after fruit pruning

2.1 0-40 days after fruit pruning

Apply recommended amendments and FYM at or before pruning. At the time of pruning apply FYM @ 25 ton/ha. Apply 30% of the annual nitrogen dose during first 40 days after pruning. Start micronutrient (Zn, Fe, Mn and Boron) and magnesium application after bud swelling stage if the soil test value indicates deficiency and deficiency was established after foundation pruning. Apply magnesium as foliar sprays @ 0.3 to 0.5% for quick correction of deficiency. In case of both P and Ca deficiency, application of superphosphate mixed with FYM/composts at the time of pruning will take care of both. Apply Zn and boron during 20-40 days to promote desired shoot growth preferably as foliar sprays. Take special care of potassium deficiency and start early application of potassium in case of deficiency. If the symptoms like inward leaf curling and or shiny spots are noticed on the leaves, apply 25 kg of sulphate of potash and spray potassium sulphate @ 3-5 g/L depending on leaf age.

Expected pan evaporation during first 40 days when vines are pruned in October may range from 6-8mm per day. Accordingly, the irrigation water needed will range from 25,200 to 33,600 litres per hectare per day.

2.2 40- 70 days after fruit pruning

Petiole testing: Test the petioles from the leaf opposite to cluster/bunch at full bloom stage. Modify the fertilizer doses accordingly. If the test report indicates the nutrient (s) as excess or very high stop the application of that nutrient.

Apply 30% of annual phosphorus dose during this period. If petiole test values indicate low magnesium content, apply magnesium by foliar spray not exceeding 0.5% concentration followed by soil application of 100 kg magnesium sulphate per hectare in four splits. If the potassium deficiency symptoms like inward leaf curling or shiny spots are noticed on the leaves, apply 25 kg of sulphate of potash and spray potassium sulphate @ 3-5 g/L depending on leaf age. Apply zinc and boron preferably by foliar sprays to overcome the deficiency fast. Boron may also be applied in soil via drip irrigation apart from foliar spays in case of sever deficiency.

Reduce the irrigation during 41-55 days in clayey soil to one-third compared to earlier stage to facilitate berry thinning. Expected pan evaporation during this stage may range from 4-6 mm. Accordingly 5,600 to 8,400 litres of irrigation water per hectare per day will be needed. Fifty five days after fruit pruning increase the amount of irrigation water. Expected pan evaporation during this stage may range from 3-6 mm. Accordingly,

12,600 to 25,200 litres of irrigation water per hectare per day will be needed. Light textured soil will need more irrigation and the irrigation should be reduced to 50% only compared to vegetative growth stage.

2.3 70 to 105 days after fruit pruning

Apply 30% each of nitrogen and potassium dose during this period. Apply magnesium preferably by foliar spray not exceeding 0.5% concentration. For overcoming calcium deficiency in developing berries due to unfavourable climatic conditions or nutrient imbalances in soil, apply preferably as foliar application. Two to three sprays may be needed.

Expected pan evaporation during this stage may range from 3-6 mm. Accordingly, 12,600 to 25,200 litres of irrigation water per hectare per day will be needed.

2.4 105 days after fruit pruning to Harvest

Apply 30% of potassium dose during this period. Apply magnesium by foliar sprays not exceeding 0.5 % concentration in case of suspected deficiency.

Expected pan evaporation during this stage may range from 8-10 mm. Accordingly, 33,600 to 42,000 litres of irrigation water per hectare per day will be needed. Do not over irrigate otherwise it may lead to problems like water berry and cracking.

3. Secondary and Micronutrients

- Sulphur deficiency is rarely observed in vineyards since considerable quantities are indirectly added by use of S containing fertilisers like SOP and S as fungicide
- 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)
- Apply magnesium sulphate @ 100 kg per hectare per pruning season in four splits for maintenance dose. However, the application must be done only if need is established based on petiole test value since in many vineyards ground water irrigation source may add substantial quantities of Mg in soil.
- Amongst the micronutrients, zinc and iron are the most commonly deficient nutrients.
- Due to large variation in the type and content of calcium carbonate in soil, no specific recommendations are available. However, under established deficient conditions, on an average 50 kg per hectare each of zinc sulphate, ferrous sulphate and manganese sulphate should be applied per season.
- Micronutrients are preferably applied as foliar application and based on petiole analysis. On an average, 3-4 sprays of 0.2–0.4 % of sulphate forms of Zn, Mn and Fe in a pruning season meet the crop needs.
- Boron is strictly applied on the basis of petiole analysis report.

Table 1. Irrigation schedule based upon pan evaporation and fertigation schedule for various growth stages of Thompson Seedless vines raised on Dogridge rootstock using saline irrigation water**

Growth Stage	Expected duration (days after pruning)	Water requirement (litres/day/hectare per mm of evaporation)	Month of operation	Expected monthly Pan evaporation (mm) in different grape growing regions	Approximate water (litres /hectare/ day)	Nutrient application (kg/ha)		
						N	P_2O_5	K_2O
Foundation Pruning								
Shoot growth	1-30	4200	April-May	8-12	33,600-50,400	60	-	-
Shoot growth	31-40	4200	April-May	8-12	33,600-50,400	20	35.5	-
Fruit bud differentiation	41-60	1400	May-June	8-10	11,200-14,000	-	71	-
Cane maturity and Fruit bud development*	61-120	1400	June-August	0-6	0-8,400	-	-	80
121 days - 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	80	-	-
Bloom to Shatter	41-55	1400	November-December	4-6	5,600-8,400	-	26.5	-
Berry growth and development	56-70	4200	December - January	3-6	12,600-25,200	-	26.5	-
Berry growth and development	71-105	4200	December - January	3-6	12,600-25,200	80	-	80
Ripening to Harvest	106-harvest	4200	January - March	8-10	33,600-42,000	-	-	80
Rest period	Harvest to Foundation pruning (20 days)	-	March-April	8-10	-	26	18	26

* The above growth stages generally coincide with rainy season and no irrigation may be required in heavy soils.

** The schedule has been worked based on experiment carried out in heavy and calcareous soils using saline irrigation water (EC ranging from 1.7-1.8 dS/m) and therefore this may be taken as guideline for stage wise irrigation for other soil types other than the one specified here.

Note:

- Depending on water quality, the amount of water needed may change. Irrigation should not be applied after the soil has reached field capacity after rain.

- Irrigation requirement will be less by 20% compared to above given schedule if low salinity water (EC less than 1.0 dS/m) is used.
- By application of organic mulch (3″ thick layer of Bagasse and covering the 3 feet wide vine root zone strip) @ 10 t per acre or plastic mulch in combination with spraying of Anti-stress (permitted biodegradable acrylic polymer) @ 4-6 ml/ L at 30, 60 and 90 days after foundation pruning and 30 and 60 days after fruit pruning, the irrigation water quantity could be reduced by 25%. Mulching also reduces weed incidence.
- The irrigation water requirement can be reduced by 25 % in the existing surface drip irrigated system by applying irrigation directly in the root zone at 9 inches depth in heavy soils and at 4 inches depth in light soil. Any hollow pipe of 2.5 inches diameter open on both sides (PVC pipes, earthen pipes, discarded plastic bottles) with holes on lower side and microtubes can be used for delivering irrigation water in the root zone in heavy soils. This irrigation technique also reduces weed incidence.
- This experiment was conducted in a row to row and vine to vine spacing of 10′ × 6′. Irrigation and fertigation schedules can be suitably applied up to a row to row and vine to vine spacing of 8′ × 5′.
- The nutrient quantity given are guidelines for distributing the NPK doses at different growth stages and may change based on the site and climatic conditions.
- One kg P=2.29 kg P_2O_5 and one kg K=1.21 kg K_2O
- Under normal climatic conditions generally, it takes 10-12 days for sprouting.
- The nutrient applications should necessarily take into account soil, petiole and water testing report.
- Contribution of nutrients from other sources like composts, FYM, green manuring irrigation water, etc. should also be taken into consideration for adjusting the nutrient dose. All the manures and fertilizers, irrigation water and other inputs should be tested for presence of heavy metals (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl) before use.

Table 2. Optimum range of petiole nutrient contents for Thompson Seedless vines grafted on Dogridge rootstock

Nutrient	Bud differentiation stage (BDS)	Full bloom stage (FBS)
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
Micronutrients**		
Fe (ppm)	54 – 80	32 – 80
Mn (ppm)	42 – 209	76 – 174
Zn (ppm)	30 - 88	51 – 130
Cu (ppm)	5 – 10	5 – 10
B (ppm)	30 – 50	30 – 50

* Even though the above mentioned petiole K content (0.59 – 0.68%) at bud differentiation stage is sufficient in soils high in available K content, nevertheless there are chances of leaf curling, which could affect management of disease and pests due to inadequate spray coverage. It is therefore, advisable to maintain petiole K levels at bud differentiation stage above 1.5%.

** Source: Bhargava, B.S. and Chadha K.L. 1993. Leaf nutrient guide for fruit crops. Pp. 973-1030. In: K.L. Chadha and O.P. Pareek (eds.). Advances in Horticultural Fruit Crops 2. Malhotra Publishing House, New Delhi.

a. Excess nitrogen

b. Excess nitrogen

c. Fe deficiency

d. Mn deficiency

e. Mg deficiency

f. N deficiency

Fig. 1(a-f). Visual diagnosis of nutrient deficiencies/imbalances

g. Boron deficiency

h. Inward leaf curling and shiny spots on leaves caused by potassium deficiency

i. Leaf blackening and necrosis caused by potassium deficiency and sodium toxicity

j. Interveinal chlorosis and reduced internode length and leaf size caused by Zinc

k. Chloride toxicity

Fig. 1(g-k). Visual diagnosis of nutrient deficiencies/imbalances

Chapter 5

Use of bioregulators for quality grape production

S. D. RAMTEKE

Hormonal balance in any plant system is as delicately interwoven and as distinct as a spider web. Any imbalance created in the hormonal system by injudicious usage of the growth regulators will collapse the entire plant system. So, one has to use growth regulators very judiciously in order to maintain the balance of endogenous hormones and physiology of the vine.

Quality improvement in grapes is aimed at the production of loose bunches, increasing berry size, sugar content and firmness. While using growth regulators for quality improvement, it is to be borne in mind that growth regulators bring out improvement in quality through changing the growth or diverting the flow of metabolites into the berries, but do not increase the quality parameters by themselves directly. They are the mediators. The basic requirements are the metabolites, i.e. the carbohydrates or proteins in the plant system. In the absence of these metabolites in the plant system, use of growth regulators cannot bring about the desired effect.

Bio-regulators are used in grape for various purposes viz. increasing fruitfulness, inducing bud break apart from increasing rachis elongation for production of well filled bunch, berry setting and also for increase in berry size besides quality improvement & increase in shelf life.

Application of bioregulators with their doses, stage of application is summarized in table 1.

1. Budbreak

Fig. 1. Budbreak

After fruit pruning, hydrogen cyanamide 50 SL @ 30-40ml/L (based on cane thickness) is applied on apical 2-3 buds within 2 days of pruning to increase uniform budbreak.

2. Cluster Elongation

Fig. 2. Rachis / cluster elongation

Clusters are treated with Gibberellic acid (GA_3) for cluster elongation, thinning and to increase berry size.

Table 1: Application of bioregulators at different stages after fruit pruning

Sr. No.	Days after pruning	Growth Stage		Chemical	Concentration /dose
1	1-2	After pruning		Hydrogen cyanamide 50 SL	30-40 ml/l
2	21-24	Parrot green (Prebloom) spray		Gibberelic acid (GA_3) technical	10 ppm
3	23-27	2nd prebloom dip		GA3 technical	15 ppm
				Urea phosphate	1000 ppm
4	48-50	After berry set 3-4 mm		GA3 technical	40 ppm
		for white seedless		Forchlorfenuron (CPPU) 0.1% L	2 ppm
		for color seedless			0.5 ppm
5	60-62	After berry set 6-7 mm		GA3 technical	30 ppm
6	50-70	Once before or at veraison		Calcium nitrate	5000 - 10000 ppm

GA_3 @ 10 ppm is used as foliar spray when the cluster is at parrot green stage. After 4-5 days, GA_3 @ 15 ppm can be given as a dip for rachis elongation and cluster growth. If the cluster is still small then GA_3 @ 20 ppm can be used as a foliar spray. The pH of the solution at every time of growth regulator usage should be acidic (pH 5.5 – 6.5).

3. Berry thinning

If required, GA_3 is sprayed @ 40 ppm at 50 percent flowering stage. This reduces the berry set and results in berry thinning. To enhance the efficacy of GA_3, the pH of the spray solution should be acidic (5.5 to 6.5).

4. Berry elongation

Treatment of GA_3 after berry set

Fig. 3. 50% flowering and berry thinning

will increase their size by elongation. Treat the clusters with GA_3 for berry elongation at 3-4 mm berry size.

5. Increasing berry diameter

For quality grape, berry diameter is more important than the berry length or the overall size of the berries. GA_3 (@ 40 ppm) along with CPPU (forechlorofenuron) 0.1%L (@1-2 ppm) is used at 3-4 mm berry size and second dip of GA_3 @ 30 ppm + CPPU @ 1 or 2 ppm at 6-8 berry stage.

Fig. 4. Berry elongation

Fig. 5 Berry size of 6-7 mm diameter

The use of CPPU at these two stages also helps to retain the green colour of berries.

The above schedule has to be followed according to leaf / fruit ratio as mentioned in chapter 3.

6. Improving shelf life

Shelf life may be improved by dipping the clusters with calcium nitrate @ 1 % aqueous solution at 75 to 105 days after fruit pruning or by treating the clusters with NAA @ 100 ppm in 2 split doses ten days prior to harvest.

7. Do's and Don'ts for application of bioregulators

7.1 Cluster and berry thinning

7.1.1 Do's

1. Spray GA_3 @ 10 ppm at parrot green stage of cluster and 15 ppm GA_3 after 4-5 days of 1st spray.
2. GA_3 spray solution should be acidic (pH 5.5 - 6.5). Use citric or phosphoric acid or urea phosphate as a adjuvant to lower down the pH of spray solution.
3. Dip the clusters with 40 ppm GA_3 at 50% flowering if necessary. Treat individual cluster selectively.
4. Cut the tips of clusters immediately after set by retaining 8-10 apical branches depending on the number of leaves available for a bunch.
5. Thin the berries manually before 3-4 mm berry size stage.
6. If thinning is inadequate remove the alternate branch of the rachis to retain 5-6 branches and clip the tip of the bunch 8 days after set.
7. Use sufficient spray solution to have optimum coverage of foliage as well as clusters.

7.1.2 Don'ts

1. Do not use the solvent (acetone / methanol) more than 30 ml per g of GA_3.
2. Do not spray GA_3 at pre-bloom stage without fungicide if the weather is cloudy and humid, particularly if it is likely to rain, to avoid excessive flower drop.
3. Do not spray GA_3 at full bloom or immediately after berry set to avoid berry shatter and formation of shot berries.
4. Do not girdle the vines before 3-4 mm berry size stage.
5. Avoid injury to the berries while thinning mechanically by scissors.
6. Do not use IAA along with GA_3 for cluster elongation.

7.2 Berry size

7.2.1 Do's

1. 1-2 ppm CPPU to 30-40 ppm GA_3 and dip the clusters in the mixed solution once at 3-4 mm stage and again at 6-7 mm berry size stage. Selection of concentration of growth regulators for dipping should depend on the number of leaves available per bunch.
2. Clip off the tip of the cluster by 1/3rd or 1/4th of its length, since the under developed berries are mostly formed in the lower half of the bunch.
3. Ensure that all berries in a cluster receive all GA_3 treatments uniformly.
4. Ensure adequate leaf/fruit ratio for a developing bunch (6-8 berries / leaf).

7.2.2 Don'ts

1. Do not induce more bud break than required per cane. Three buds on canes thicker than 10 mm, two on canes with thickness of 8-10 mm and one on the canes

with thickness ranging between 6-8 mm.

2. Do not allow the clusters to develop on a shoot having less than 8 leaves.
3. Do not treat the clusters with CPPU when the bearing shoot has inadequate leaf area, and the shoots are less vigorous.
4. Do not delay berry thinning beyond 8-10 mm stage of berries.
5. Do not treat the berries with GA_3 nor girdle the vines from berry set to shatter stage. Since this may lead to more shot berries in a bunch.

Chapter 6

Disease management

S.D. SAWANT
INDU S. SAWANT

Downy mildew, powdery mildew and anthracnose are the three important diseases caused by fungal pathogens and require warm and wet / humid conditions for causing infections. During monsoon, downy mildew and anthracnose are the major diseases noticed on the leaves, while powdery mildew appears when there is a long gap of rain with cloudy conditions. Sometimes, rust infection also occurs on old leaves especially during September.

From April to first week of June usually the climate is hot with temperature ranging from 35-40^{o}C and dry with relative humidity > 40%, hence there is least possibility of development of any disease. However diseases occur during monsoon period when rains are received any time from second week of June till middle of October. In most grape growing areas 300 to 500 mm rain is received annually and there are about 30-45 days recording more than 4 mm rain per day from June to October.

Fig. 1. Grape leaves showing oily spot symptoms of downy mildew

By the time monsoon sets in, majority of the canes would have developed more than 12 leaves and shoot growth is normally brought under control. In the absence of growing shoots, application of non-systemic fungicides can give equally good results. Copper fungicides in general are broad spectrum and have good rain fastness, thus show good results during wet conditions. During September, it rains in most of the grape growing areas and as a result of this diseased leaves drop off early. Accumulation of chlorides and salts, in general, in saline areas also lead to early leaf drop. After leaves are dropped off the new shoots start growing which not only attracts infection of downy mildew and anthracnose but also reduces stored food resources of the cane. Strategy of disease management after back pruning is, therefore, aims at providing protection during wet weather, to reduce the disease on the first 12 leaves of the canes and to make them stronger to resist drop till fruit pruning.

In most grape growing areas of Maharashtra, Andhra Pradesh and Karnataka, normal time of fruit pruning is around 15th of October, but it can range from first week of July to last week of November. From disease management point of view, fruit pruning taken before 15th of October has greater risk of downy mildew, as there are more chances of rains and temperature is warmer. After fruit pruning, about 8-10 days are needed for sprouting of buds. Thereafter on

Fig. 2. Growth of downy mildew on lower surface of the leaf

an average every three days interval new leaf is developed. At fifth leaf there will be a bunch, which takes about 35 to 45 days from fruit pruning to develop to flowering stage and by 50 to 55 days fruits set in. First 50 to 55 days after pruning, risk of damages due to downy mildew infection on bunches is very high. Rains and heavy dew during this period helps development of downy mildew on bunches. Leaf wetness for continuous period of three hours after sunrise is favourable for new infection. If such conditions prevail during first 55 days of pruning, sprays of fungicides are needed at shorter intervals for effective control of downy mildew. Berries develop to 10 to 12 mm size within first 70-75 days after fruit pruning and thereafter the risk of downy mildew gradually reduces. Rains during November and December are rare, but in years when it rains during November or thereafter, heavy losses due to downy mildew are observed. Normally, 5 to 6 sprays of fungicides are required during first 55 days of pruning for effective management of downy mildew. This number of sprays may be increased to 9 in the event of rains during November- December, while it can be reduced to 3-4 when wet weather is absent after fruit pruning.

Details of chemicals, their doses, PHI, MRLs are given in Annexure I.

Fig. 3. Powdery mildew symptoms on leaves showing shiny chlorotic spots

1. How to take decision on "what to spray?" and "when to spray?"

1.1 When new infection of downy mildew occurs?

Infection of downy mildew takes place when leaf, bunch or cane is wet during day time at least for 2.5 to 3.0 hours. Such condition is present when it rains or RH is very high after rains and fog or dew remains for long time in the morning.

1.2 Preventive spray is needed when new infection is likely

The vineyard needs to be protected when new infection of downy mildew is likely to take place. Therefore, 10 days onwards, after fruit pruning the grower is expected to watch the vineyard for presence of dew on leaves and bunches, every morning. If the, temperature is above 10 ^{o}C, and dew is present on leaves after 9.0 am, the resultant leaf wetness period is sufficient to complete the process of new infection. Under such situation, decision to spray will depend on the following observations.

- Whether the last spray of systemic

Fig. 4. Powdery mildew symptoms on berries - pigmented web-like appearance on surface

fungicide for control of downy mildew was given within 3-4 days?

- ✓ If not, spray is required.
- ✓ If the spray was given within last 3-4 days, even though leaf wetness is present, spray may not be required till about 4 days have passed after this spray.
- ✓ The following other factors may also be considered for making decision to spray Weather forecast: if it is likely to rain within a day or two, spray can be preponed.
- ✓ Presence of active inoculum of downy mildew in close vicinity: if the oily spots (Photo 1) of downy mildew are seen in same or in nearby vineyard immediate spray may be needed.

1.3 Weather forecast helps in scheduling sprays

Location specific weather forecast for next 5 to 7 days is available on internet nowadays. Information on forecast of rain is often useful in scheduling sprays, especially during critical stages of growth. In most cases rainy condition lasts for 2 to 3 days. Preventive spray given before rains often protects vineyard from downy mildew for 2 to 3 days of rainy condition. Even if new downy mildew infection takes place, its establishment and appearance of first symptom such as oily spots and subsequent sporulation needs at least 3 days after infection. This means if the preventive spray is given just before rains, the grower can safely wait for 3 to 4 days of rainy weather and give subsequent spray only after rains have stopped. However, this can be effectively done when location specific weather forecast is available.

NRC for Grapes, Pune gives summary of weather forecast of 7 days, for major grape growing areas on its web site http://nrcgrapes.nic.in/.

On this website click on menu "**Weather forecast based grape advice**" to get the weather forecast and related advice on plant protection. To know more details on weather at location of your interest one can see different links given on this page.

Note: Above weather information is summary of weather forecasting given on the following websites http://www.weather.nic.in/current.htm , http://www.imd.gov.in/section/nhac/wch/todaywch.htm ,http://www.imd.gov.in/section/nhac/distforecast/INDIA.htm http://wxmaps.org/pix/prec6.html , http://www.accuweather.com/world-forecast.asp?partner=accuweather&traveler=0&locCode=ASI|IN|IN021|JUNNAR&metric=1 ,http://fallingrain.com

Fig. 5. Characteristics symptom of anthracnose on leaf showing shot hole

Fig. 6. Rust infection on leaf of Thompson seedless

1.4 Important risk periods for downy mildew

While taking decision on sprays for downy mildew, growth stage related risk needs to be taken in to consideration.

First 10-50 days after fruit pruning are important for management of downy mildew.

1.4.1 10 to 25 days after pruning

At this stage, new shoot is slowly growing. To protect new shoots, two preventive sprays of systemic fungicides for downy mildew, preferably belonging to low risk group as per Fungicide Resistance Action Committee (FRAC) classification**,** are required.

1.4.2 26 to 35 days after pruning

At this stage, young light green coloured bunch is just visible and rapid elongation of cane is visible. Application of GA3 as spray or bunch dip, for bunch rachis elongation, is given during this period. GA3 application makes shoots and bunch more succulent and more sensitive to downy mildew. Two more preventive sprays of systemic fungicides for downy mildew are required during this period.

36 to 50 days after pruning: At this stage, the flowers in the bunch start opening. When flower cap starts separating, it allows dew water to accumulate and remain on bunch for longer period. This leads to bunch infection of downy mildew even when weather is not very suitable for downy mildew. In case of mild infection, losses could occur due to flower drop or by drying off of bunchlets. Hence, during this period 1 or 2 additional preventive sprays of systemic fungicides for downy mildew are required.

1.5 Care needed if it rains during December

By December, most vineyards will have progressed beyond flowering and berry setting stage. In the event of normal weather, it rarely rains during December. Most grape growing areas in Maharashtra, Andhra Pradesh, and Karnataka will have considerably reduced temperature and night temperature will be close to 10°C.

Whenever, wet weather and young growing shoots are present there is a risk of downy mildew and anthracnose. High humidity, moderate temperature, and low light intensity due to crowded canopy or due to cloudy conditions increase the risk of powdery mildew.

Table 1: Disease management guideline after foundation pruning (April to October)

Days after pruning or growth stage	Control measure for disease
Pre-pruning period	**Downy mildew** Collect all downy mildew infected and dried bunches, leaves and canes from the vineyards before back pruning and burn them. Such operation may be essentially needed in vineyards with known attack of downy mildew during previous fruiting season. **General** Dead, dried wood present on arms, and dried bunches hanging on vine, should be removed and cut surfaces are pasted with Bordeaux paste.

Days after pruning or growth stage	Control measure for disease
Within 1-2 days after pruning	Spray vineyard with 1 % Bordeaux mixture within 1-2 days of pruning.
(During April – May or 15 to 50 days of back pruning)	**Anthracnose** Spray Carbendazim 50 WP, 1.0 g / L (1Kg / ha) at emergence of bud or immediately after rains for control of anthracnose. Add 25 to 30 g citric acid per 100 L of spray water before adding above fungicides to ensure that the pH of the spraying liquid is in acidic range. Spray Ziram 27 SL @ 4.0 ml / L or Chloronthalonil @ 2.0 g / L or COC @ 3.0 g / L or Copper hydroxide 77WP @ 2.0 g / L, 7 -10 days after the spray of systemic fungicide. Spray of such non-systemic fungicide is needed when it rains after first spray. If any anthracnose infected new shoot is noticed, manually remove the shoot.
	Powdery mildew Spray Sulphur 80 WDG 2.0 g / L or Potassium bi-carbonate @ 10.0 g / L Use of spreaders (Silwet or Sure-shot) @ 0.1 to 0.2 ml / L will improve the efficacy of above mentioned non-systemic compounds Ziram 27 SL 4.0 ml / L can be mixed with sulphur if anthracnose is present along with powdery mildew.
After the onset of the monsoon (During June and July)	**Anthracnose / Bacterial leaf spot or stem canker / Downy mildew** Maintain about 12 leaves from the base. Spray copper fungicides COC 50WP @ 3.0 g / L., or Copper hydroxide 77WP @ 1.5 g /L or 0.5 % Bordeaux mixture to control all or any one of the three diseases. Alternatively, spray of any non-systemic fungicide recommended for control of both downy mildew and anthracnose in Annexure I eg. ziram, mancozeb, captan, chlorenthalonil etc. Repeat after 10-15 days interval, during breaks in rain. By the end of July, if 2 to 3 sprays of copper fungicides are given depending up on rainfall pattern, outbreak of downy mildew or anthracnose is effectively controlled. In late pruned vineyards, where shoot growth up to first 10 to 12 leaves is still continuing, spray Carbendazim 50WP @ 1.0 g/L alone or in combination with COC 50WP @ 2.5 to 3.0 g / L to control only anthracnose.
	Powdery mildew Spray sulphur 80WDG @ 2.0 g / L or Dinocap 48EC @

Days after pruning or growth stage	Control measure for disease
	0.25 to 0.30 ml / L or Potassium bi carbonate @ 10 g/L . Use spreaders (Silwet or Sure-shot) @ 0.1 to 0.2 ml / L for better efficiency of above fungicides Do not spray Dinocap if tender shoots are present in canopy. At the end of July especially after the onset of monsoon downy mildew and powdery mildew can be present together in vineyards. In such situations, mixture of sulphur 80WDG @ 2.0 g / L and 0.5 % Bordeaux mixture can be sprayed. The pH of the Bordeaux mixture should be adjusted after the mixing of sulphur. In case of potassium deficiency, spray of mono-potassium sulphate (0:52:34 grade of soluble fertilizers), or sulphate of potash (SOP) @ 2-3 g / L could give considerable reduction in powdery mildew incidence. In continuously cloudy climate spray any systemic fungicide belonging to triazole groups (eg. hexaconazole, penconazole, flusilazole, myclobutanil, tetraconazole etc.) at regular recommended dose (Annexure-I) along-with potassium bicarbonate 5.0 g/L.
August to October	**Downy mildew, Anthracnose, Rust & Powdery Mildew.** Rub off new sprouts emerging after rains. Prefer spraying non-systemic fungicides (Bordeaux Mixture, copper hydroxide, COC etc.) for the control of downy mildew, rust and anthracnose if disease is present on old leaves. Spray Sulphur 80 WDG @ 2 g/L. plus Bordeaux mixture 0.5%, if both downy mildew and powdery mildew infection is present Use of copper fungicides mentioned above should control rust disease also. In case if the disease is found to increase, spray systemic fungicides such as, flusilazole 40EC @ 0.025 ml / L. Spray mineral oil formulation such as HP grape spray oil @ 5.0 to 10 ml/L. Such spray oils are not compatible with sulphur and copper fungicides, and captan. Hence ensure that al-least 20 days have passed after the spray of such fungicides, before the spray of mineral oil formulations.

Table 2: Disease management guideline after fruit pruning (October to March)

Days after pruning or growth stage	Control measure for disease
Immediately after pruning	**Clean cultivation** All diseased vine parts, dead woods, removed barks,

Days after pruning or growth stage	Control measure for disease
	pruned remaining of vine and weeds should be removed Spray 1 % Bordeaux Mixture within 1-2 days of pruning on canes and arms to kill left over disease inoculums. Mix mancozeb 75 WP, 5 to 7 g/L with hydrogen cyanamide solution for swabbing canes. This will help in killing pathogen inoculums (of downy mildew and anthracnose) if present on canes. If mancozeb is mixed with hydrogen cyanamide, use of red colour can be avoided as yellowish colour of mancozeb will help identifying treated cane in vineyard. If the un-pruned block is in close vicinity of pruned block, and the pruning in that block is not likely to take place within 5-8 days, it will be essential to spray 0.5 % bordeaux mixture in un-pruned block to avoid movement of inoculums from unpruned block to young shoots in pruned block. Sporangia of downy mildew can travel through air up to 100 m distance, while conidia of powdery mildew can be disseminated through air up to long distances. While staggering pruning in vineyards direction of air also should be taken in to consideration. Normally during October wind direction is East to west, hence early pruned blocks in the vineyard should be preferably in the eastern side so that there will be the least possibility of movement of airborne inoculums from unpruned blocks to new shoots in pruned block.
8 days after forward pruning	**Anthracnose, *Xanthomonas*** Spray systemic fungicides such as carbendazim @ 1.0 g / L or difenconazole 25 EC @ 0.5 g/L, followed by non-systemic fungicides COC @ 3 g / L or copper hydroxide 77 WP @ 1.25 g/L after 2-3 days. Sprays of copper based fungicides can restrict the infection of bacterium *Xanthomonas*, and are useful in avoiding development of resistance in anthracnose pathogen against systemic fungicides.
10 days onwards	**Downy mildew** Sprays for downy mildew control are needed when new shoots remain wet due to dew up to 8 to 9 am in the morning or it rains during the day. Sprays of systemic fungicides are needed at every three days interval after 10 days of pruning. However, in the absence of rainy condition, and if morning dew is not very heavy, spray interval can be extended up to 5 days. One additional spray of non-systemic fungicides can be given between two systemic fungicides to reduce the risk of the disease. List of recommended systemic and non-systemic

Days after pruning or growth stage	Control measure for disease
	fungicides is given in Annexure The list is updated every year during October and is available on website of NRC for Grapes (http://nrcgrapes.nic.in) Spray anyone of the systemic fungicides from the list at 3 leaf stage, 5 leaf stage or 7 leaf stage as mandatory sprays, while maintaining spray interval at 5 days. Avoid using fungicides such as azoxystrobin, kresoxim methyl during first 18 to 20 days growth after forward pruning. Spray for downy mildew should be preventive and should be given before the start of rainy days or after the rainy days are over. If the rainy days are extended beyond 3 days, or when spray before the start of rainy days could not be given, or presence of downy mildew symptoms is observed in the vineyard or adjacent vineyard, spray non-systemic fungicides available as wettable powders (WP) can be applied as dusting.
25 to 35 days	**Downy mildew and anthracnose** Mix fosetyl Al @ 3 g / L in solution of GA prepared for spray. Normally 2 to 3 sprays of GA are given. Only one of these sprays, preferably first or second, spray may be given along with fosetyl Al. Time of spray may be decided considering, the time of spray of systemic fungicide for downy mildew given before the start of GA sprays. pH of spray solution of fosetyl al is acidic and hence helps better absorption of GA. However, if wet weather prevails during GA applications, spray of non-systemic fungicides other than copper fungicides is given after spray of fosetyl al and /or subsiquant spray of systemic fungicide is given at 3 days interval instead of 5 days.
	Powdery mildew If cloudy climate prevails there will be increase in morning temperature and morning dew may remain for less time. Under such situation powdery mildew can develop sporadically in vineyards leading to development of inoculum. Spray sulphur 80 WDG @ 2.0 g / L. If the cloudy climate persists for long period one spray of systemic fungicides recommended for powdery mildew (Annexure I) may be needed. Fungicide such as flusilazole has long PHI and is not recommended after fruit set due to residue problems can be preferred during this period.
35 to 50 days	**Downy mildew** It is most deceptive period, as even if there is no much dew

Days after pruning or growth stage	Control measure for disease
	in the morning hours, downy mildew may appear only on bunches, and cause flower drop, or complete destruction of bunch. Infection on leaves under such situation may be nil or minimum. About two preventive sprays of systemic fungicides for the control of downy mildew, at 5 days interval are essentially needed during this period. **Powdery mildew** Cloudy conditions will start the development of powdery mildew during this period. As most growers are more worried about downy mildew infection during this period, light infections of powdery mildew could be un-noticed. The worldwide it is observed that if powdery mildew infection is developed on bunches during flowering to fruit-set period, it becomes very difficult to control the disease on bunches during later stages. Especially it could lead to rachis infection of powdery mildew after veraison stage. Therefore at least one spray of systemic fungicide for the control of powdery mildew is needed during flowering stage. It is an ideal time for sprays of strabularin fungicides such as azoxystrobin 23SC or kresoxim methyl 44.3 SC, as it will provide protection against both downy mildew and powdery mildew.
50 days onwards	**Powdery mildew** Ensure that vines do not suffer from potassium deficiency. In case deficiency is observed give sprays of potassium nitrates / Potassium sulphate / monopotassium phosphate, are suggested. Follow the guidelines given under chapter on nutrient and water management. Spray any one of the recommended systemic fungicides at 7 to 10 days interval starting immediately after fruit set i.e. about 50 days of pruning. Spray interval can be decided on the basis of weather conditions or actual presence or absence of disease in vineyards. Whenever powdery mildew infection is seen in vineyard spray of tank mix of regular dose of systemic fungicide and potassium bi carbonate 5 kg / ha is useful to eradicate left over powdery infections. Between two sprays of systemic fungicides non-systemic fungicide dinocap 48 EC @ 25 ml/100 lit water can be sprayed up to 65-70 days after pruning. Most of the fungicides for the control of powdery mildew are given after fruit set. To avoid the residue of these fungicides in berries at harvest, recommended pre harvest intervals (PHI) and maximum residue levels (MRL) should be considered while selecting fungicide for spray at different growth stages. Normally, fungicides with long PHI and low MRL are selected for spray at early fruit growth

Days after pruning or growth stage	Control measure for disease
	stages. Use of flusilazole should be avoided after fruit set, while fungicides such as penconazole, and tridemefon should be selected up to first 80 days of pruning and hexaconazole or myclobutanil should be preferred close to veraison stage.
75 to 90 days	**Powdery mildew on bunches or rachis** Spray of strabularin fungicides such as azoxystrobin, which has PHI as low as 7 days, and MRL as high as 2.0 ppm. Hence such fungicide can be used for control of powdery mildew on bunches during last 30 days of berry maturity. Spray of sulphur 80 WDG @ 1.0 to 1.5 g / L can be given during last 20 to 30 days of berry maturity for the control of powdery mildew. Such sprays can be given alongwith good quality spreaders (Silwet or Sure-shot @ 0.05 to 0.1 ml / L) to avoid stains on berries. If less than 30 days are left application of mineral oils (HP Grape Spray oil 5 – 7 ml / L) can be used as spray on bunches for the control of powdery mildew without the risk of objectionable residue. Before application of any formulation few days before harvest it is advised to try the formulation first on few plants and if any spot or similar abnormality is not seen on berries the formulation can be used for spraying entire vineyard.

Chapter 7

Insect and mite pest management

D. S. YADAV
AMALA U.

Grapevines in peninsular India remain available for the pest development all the year round which leads to high pest infestation. Last two decades of viticulture in India witnessed sea-change in arthropod pest scenario. Girdler beetle which was major pest became minor, and minor pests such as thrips, mealybug, and red spider mite became major. More recently, an outbreak of leafhopper, *Amrasca biguttula biguttula* Ishida which was pest of only minor importance in grapes, was reported in Maharashtra state of India in 2011. Similarly, red spider mite, *Tetranychus urticae* has also attained a serious pest status only after 2006. Presently, thrips, leafhopper, mealy bug, stem borer and red spider mite are very important and cause considerable damage to the grapes almost every year. Before taking decisions on pest management interventions, the knowledge of identification characteristics of different pests and their biology is very important.

1. Biology

1.1 Thrips

Thrips are the sucking pests which prefer to feed on the succulent and juicy tender parts of the vine, like young growing shoots and appear after both the prunings. This insect enjoys the warm, bright sunlight combined with slightly higher temperature and low relative humidity. It disperses very easily in the vineyard as they are very active

Fig. 1. *Scirtothrips dorsalis*

Fig. 2. *Rhipiphorothrips cruentatus*

insects. Mainly two thrips species, viz., *Scirtothrips dorsalis* (Figure 1) and *Rhipiphorothrips cruentatus* (Figure 2) cause damage to growing shoots, flowers and berries of table grapes in India. A third thrips species, *Retithrips syriacus* (Figure 3) is also reported in grapevine, however, it remains only on old leaves and does

Fig. 3. *Retithrips syriacus*

not cause any economic damage either to berries, flowers or leaves. Nymphal stage of *Retithrips* is reddish in colour and farmers often confuse it with red spider mites, therefore, correct identification is important (Figure 4). Both nymphs and adults

Fig. 4. *Retithrips* nymphs on leaf

suck the vine sap, which result in the curling and cupping of young leaves (Figure 5). The damage after the

Fig. 5. Leaf cupping due to *Scirtothrips* damage

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 flowers and young berries. 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 very serious as rasping and sucking of young berries by thrips results in the brownish net-like appearance on the berry surface as well as scab formation (Figure 6). Therefore, the new flush emergence stage, flowering and berry setting

Fig. 6. Fruit scarring by thrips

stages are the critical stages for damage by thrips.

1.2 Leafhopper

Leafhopper, *Amrasca biguttula biguttula* (Figure 7) mainly appears during October and November months

Fig. 7. *Amrasca biguttula biguttula*

of the calendar year and the grapevines upto 40 days after pruning are highly susceptible for its damage. They suck the sap from young leaves

which results in leaf curling (Figure 8).

Fig. 8. Leafhopper damage

1.3 Mealybug

Pink mealybug, *Maconellicoccus hirsutus* (Figure 9) is the major mealybug species infesting grapes in

Fig. 9. *Maconellicoccus hirsutus*

India. Mealybugs are the major group of sucking pests affecting the grapevine. These insects prefer high temperature and comparatively less relative humidity. Population of mealybugs is usually low from June to November and starts increasing from mid-December onwards. Both the adults and nymphs suck the plant sap from the tender vine parts during the new flush emergence stage especially after fruit pruning, which leads to the curling and malformation of vine parts and thereby arresting further growth of the shoot. During veraison stage, they migrate from the trunk, cordons and shoots to developing berries and produce profuse quantity of honeydew leading to sooty and sticky bunches (Figure 10) which considerably reduces the

Fig. 10. Mealybug infested bunch

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.

1.4 Flea beetle

Scelodonta strigicollis (Figure 11) is the major species of flea beetle infesting grapes in India. These are metallic brown beetles with black spots on the dorsal side. They 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. Linear and rectangular shaped holes on the

Fig.11. Flea beetle

leaves are the characteristic damage symptoms by this pest (Figure 12).

Fig. 12. Characteristic linear leaf damage by flea beetle

Flea beetle grubs are seen in the soil feeding on the roots but do not cause economical damage.

1.5 Caterpillar

Caterpillars are biting and chewing type of insects and are not very serious pests of grapevine, even though occasionally they emerge as a serious pest. During the flowering and fruiting stage if relative humidity increases due to rainfall, *Spodoptera litura* (Figure 13) may become a

Fig. 13. *Spodoptera litura* larva

serious pest. They can be easily monitored by regular inspection of vineyards.

1.6 Mite

Tetranychus urticae (Figure 14) is the major species causing damage to grapes in India. Mites are important group of non-insect pest attacking grapevine. They are also sucking pests and prefer high temperature and low

Fig. 14. *Tetranychus urticae*

relative humidity. Their population starts increasing from second week of December and reaches to a peak during February-April. They prefer to feed on older leaves but increase in population leads to their migration to even bunches. Both nymphs and adults suck the vine sap and weaken the vine. Serious infestation leads to extensive defoliation especially during January to April and reduces the TSS in the berries and resulting into poor quality fruits.

1.7 Stem Borer

Stem borer has recently attained the status of major pest of grapevine in India. *Stromatium barbatum* (Figure 15) and *Celosterna*

Fig. 15. *Stromatium barbatum*

scrabrator are the major species infesting grapevine. These are the group of pests which can kill the whole vine compared to other pests in grapes. Adult emergence coincides with the onset of monsoon during May-June. Soon after mating, the females lay the eggs in the crevices of bark. After hatching, the grubs bore into the vine and the remaining part of their life cycle is completed inside the vine. In the later stage of infestation, bore holes and leaves with interveinal chlorosis can be observed (Figure 16). More than one borer can

Fig. 16. Interveinal chlorosis

infest single vine and parts like trunk, cordons and also branches having more than 1.5-2 cm diameter are preferred. Bored holes, heaps of excreta (either in pellet or in powder form) in and around the vines (Figure 17), general weakness of the vine, chlorotic leaves etc. are the symptoms

Fig. 17. Stem borer frass around plant

of stem borer infestation in vineyards. Severe infestation leads to vine death (Figure 18).

Fig. 18. Dead plant due to stem borer damage

2. Management

2.1 General practices

For insect and mite pest management, many common management strategies need to be followed. Field sanitation like removal and burning of pruned vine parts, dried branches, weeds, etc. should be followed throughout the year in order to bring down the inoculum of pests. During off season, pests like mealybugs hide under the bark of the vine, under the mulches near the root zone of the vine, and on the weed plants like *Cyprus* sp., *Parthenium* etc. Summer ploughing at inter and intra row spaces of the vine is recommended to expose the hidden stages of different pests. Ants help in the dispersion of mealybugs from one vine to another. So monitor the vineyards for ant movement and manage them.

Regular scouting and monitoring is necessary to detect early infestations and to take right management decisions at right time. Observe 20 vines/acre randomly on daily basis.

Chemical sprays should properly cover both sides of the leaf especially underside in the case of mite. In case of mealybugs, the sprays should be more concentrated towards the trunks, cordons, young buds and bunches rather than only on the foliage. For thrips, whole foliage spray especially on young shoots, flowers and bunches gives effective management.

The details of chemicals recommended for management of insect and mite pests with their doses, pre harvest interval (PHI), maximaum residue limits (MRL), etc. are given in Annexure I of this document.

Table 1: Pest management after foundation pruning (April to October)

Days after pruning or growth stage	Control measure for insect pest
Pre-Pruning Period	**Mealybug** If about 5 per cent of vines are found infested with mealybugs in the vineyard then the pre-pruning spot application on infested vines with methomyl 40 SP @ 1 g/L is effective. **Mite** In the case of severe infestation, one jet spray of water before the acaricidal spray will reduce the webbings and improves efficacy of subsequent spray of acaricide. One spray of sulphur 80 WDG @ 1.5-2.0 g/L to reduce the pest population. **Stem borer** The infested vines need to be treated individually. Check the bored holes, and if found plugged with excreta or wood powder, clean them using sharp tools like thin iron rod or wire. Try to make the holes wider as possible and hook out the larva and kill them.
8-12 days after pruning (bud swelling stage)	**Flea beetle** Preventive spray of lambda-cyhalothrin 5 CS @ 0.5 ml/ L or imidacloprid 17.8 SL @ 0.30 ml/L is effective.

Days after pruning or growth stage	Control measure for insect pest
15 to 50 days after pruning	**Flea beetle** If required, spray of lambda-cyhalothrin 5 CS @ 0.5 ml/ L or imidacloprid 17.8 SL @ 0.30 ml/L can be given. **Mealybug** If mealybug infestation is observed on less than 5% of vines, then spot application, otherwise if infestation is more, whole vineyard needs to be sprayed. Two sprays of buprofezin 25 SC @ 1.25 ml/L at an interval of 10 days are effective. **Thrips and leafhopper** If thrips population is above 3 per shoot, then spraying with fipronil 80 WG @ 0.05g/L or lambda-cyhalothrin 5 CS @ 0.5 ml/ L or imidacloprid 17.8 SL @0.30 ml/L is effective. This application will take care of leafhoppers also. **Stem Borer** As the adults are attracted to light, installation of Fine Light Trap @ 1 trap per hectare helps to trap and kill the adults especially soon after rain. The traps should be installed atleast 15 feet away from vineyard at three feet above ground level.
During June to October	**Chaffer beetle** If infestation is noticed, spray of lambda-cyhalothrin 5 CS @ 0.5 ml/ L is helpful for killing the adult chaffer beetles. The light traps installed for attracting stem borer adults are also effective in trapping chafer beetles and kill them. **Mealybug** Swabbing/washing of the trunk and cordons with methomyl 40 SP @ 1.0g/L after the bark removal, will help in management of mealybugs. Check for the ant movement and manage them. **Caterpillar** Light traps installed for the stem borer will reduce the insect population by trapping moths. *Spodoptera litura* pheromone traps @ 6 numbers/ha can also be installed to trap and kill adult moths. In case of caterpillar infestation, spray of methomyl 40 SP @ 1 g/L or emamectin benzoate 5 SG @ 0.22 g/L or lambda cyhalothrin 5 CS @ 0.5 ml/L water is effective.

Table 2: Pest management after fruit pruning (October to March)

Days after pruning or growth stage	Control measure for insect pest
Initiation of sprouting	**Flea beetle** Preventive spray of lambda-cyhalothrin 5 CS @ 0.5 ml/ L or imidacloprid 17.8 SL @ 0.30 ml/L is effective.

Days after pruning or growth stage	Control measure for insect pest
12-30 days after pruning	**Thrips** If thrips population is above 2 per shoot, then spraying with fipronil 80 WG @ 0.05g/L or lambda-cyhalothrin 5 CS @ 0.5 ml/ L or imidacloprid 17.8 SL @0.30 ml/L is effective. **Leafhopper** Install light Trap @ 1 trap per hectare during October and November months to trap and kill the adults. The traps should be installed atleast 15 feet away from vineyard at three feet above ground level.
31 to 50 days	**Thrips** If 2 thrips per shoot are observed then spray with fipronil 80 WG @0.05 g/l or lambda cyhalothrin 5 CS @ 0.5 ml/L or emamectin benzoate 5 SG @ 0.22g/L or Imidacloprid 17.8 SL @ 0.3 ml/L is effective. **Leafhopper** The chemicals (mentioned before in the table for management of thrips) which are using for thrips will also take care of the leafhoppers. **Mealy bugs** Drenching of imidacloprid 17.8 SL @ 1.5ml/L/vine is effective in providing preventive management of mealy bugs. **Caterpillars** Follow the management practices mentioned after the onset of the monsoon during June and July.
50-75 days	**Mealy bugs** If mealy bugs are found in more than 5 % of vines, two sprays at an interval of 10 days using buprofezin 25 SC @ 1.25 ml/L is effective in managing the pest. **Thrips** Spraying of emamectin benzoate 5 SG @ 0.22 g/L is effective at this stage for managing thrips if pest population reaches 2 thrips per bunch or shoot. If active shoot growth is observed during this period then stop it by shoot tipping. This practice helps in reducing thrips population in the vineyard. **Mites** Give adequate irrigation as water stressed vines are more prone to mite infestation. In the case of severe infestation, one jet spray of water before the acaricidal spray will reduce the webbings and improves efficacy of subsequent spray of acaricide. Spraying of sulphur 80 WDG @ 1.5-2.0g/L is effective in managing this pest.

Days after pruning or growth stage	Control measure for insect pest
75 to 90 days	**Mealy bugs** See the management practices which were mentioned in the text as well as in the table. Concentrate on managing the mealybug before veraison stage as if mealybug starts infesting bunches after veraison the effective control is difficult. **Mites** See the management practices which were mentioned above (from 50 days onwards) **Thrips** See the management practices which were mentioned above (from 50 days onwards)
> 90 days	Maintain pre harvest interval (PHI) as mentioned in Annexure 1 of this document and do not spray single chemical more than two times in a season. **Mites** Spray of sulphur 80 WDG @ 1.5-2.0 g/L water is effective. Jet spray of water with water volume 1000 litres per acre should be given for mechanical removal of mites and webbing before spray during morning hours.

Chapter 8

Maturity indices, harvesting and post-harvest quality management

A. K. SHARMA
P. G. ADSULE

Harvesting and post-harvest management practices have prime importance in maintaining the quality of table grapes. Harvesting of grapes at right maturity, gentle handling during harvesting, sorting, grading enhance the overall quality and enable to increase in shelf life and fetch more price in the market.

1. Maturity indices

Grape being non-climacteric fruit, it should be harvested after ripening. The minimum TSS of 16°B and sugar acid ratio of 20 has been fixed under the AGMARK as maturity standards of quality grapes. Characteristic uniform colour development is a reliable index of ripening in coloured varieties. In white varieties, uniform green colour is preferred.

2. Harvesting

Only attractive bunches fulfilling minimum AGMARK quality requirement should be harvested. Harvesting should be done by skilled workers wearing soft rubber gloves and using sharp secatures / scissors for cutting.

Careful handling of grapes during harvesting, transporting, cleaning and packing is very essential to prevent injury and abrasion. The bunch should always be held by stem/ peduncle. Rough handling results in loss of bloom (thin wax coating on berry surface) making the berries susceptible to decay (Fig 1).

Fig. 1. Lost bloom from berries

3. Time of harvesting

Bunches should be harvested during early morning hours before the berry temperature rises above 20°C, so that the berry temperature can be brought down to 4°C by pre-cooling within four - six hours. In case of dew, harvesting should be delayed till the dew has dried. If rainfall has occurred

Fig. 2. Damaged berries

the fruit should not be picked for at least 3-4 days. At harvest, the berries with visual symptoms of decay and damage (Fig 2) should be removed. These grapes should be cold stored separately and monitored for any development of decay.

4. Bunch collection

Harvested bunches are placed gently in clean perforated plastic crates and left in the shade of the vines for subsequent transfer to pack-house. The crates should be lined with food grade bubble sheets for cushioning and kept over newspapers spread on the ground to avoid contamination with vineyard dust. The bunches are kept in such a way that their stalks should not injure berries of other bunches.

5. Bunch cleaning and sorting

Trimming to remove immature, diseased, shrivelled, undersized, off-colour (Fig 3) or under developed and uneven sized (Fig 4) berries or side branches of the rachis should be done very carefully with sharp long nosed

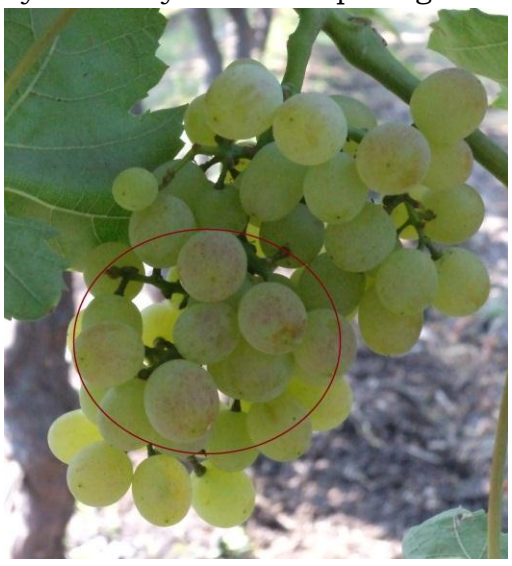

Fig. 3. Remove coloured berries

scissors to avoid injuries to the side berries. The berries should never be pulled out by hand as the portion of the pedicle along with pulp from the berry that remains attached to the bunch (wet brush) is a hot spot for the

Fig. 4. Remove uneven sized berries

development of decay causing organisms. Bunches which are too compact or too straggly or are damaged by sun scorching, diseases and insects should be removed before grading and packing.

6. Grading

Quality parameters of bunch, in terms of bunch weight and berry appearance (shape, colour, visible traces of moulds, skin blemishes) and fruit composition parameters like TSS, acidity and sugar : acid ratio has to comply AGMARK standards. Food safety standards like agrochemical residues in table grapes particularly the maximum residue limits (MRLs) are also to be complied as per regulations.

Detailed quality specifications are outlined below:

6.1 AGMARK Quality parameters

The following minimum weight requirements per bunch are laid down as per AGMARK standards.

Table 1: Bunch weight in gram

Grade	Large-berry (wt in g)	Small-berry (wt. in g)
'Extra Class'	200	150
I	150	100
II	100	75

The table grapes are graded into three classes defined below:

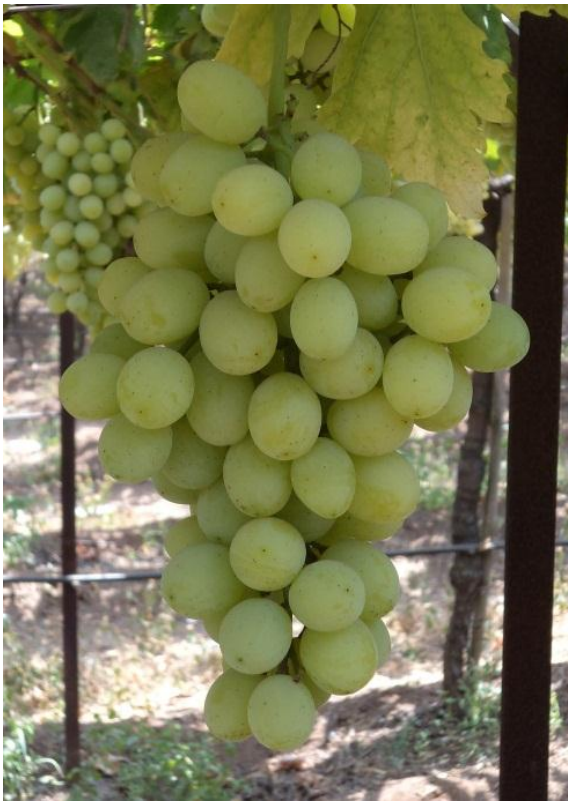

Fig. 5. Bunch without any defect having even coloured berries

6.1.1 Extra Class: Grapes must be of superior quality (Fig 7). The bunches must be typical of variety in shape and colour and have no defects (Fig 5). Berries must be firm, firmly attached to the stalk, evenly spaced along the stalk and have their bloom virtually intact (Fig 6).

Fig. 6. Bloom intact with berries

6.1.2 Class I: Grapes must be of good quality. The bunches must be typical to the variety in shape and colour. Berries must be firm, firmly attached to the stalk and, as far as possible, have their bloom intact. They may, however, be less evenly spaced along the stalk than in the extra class (Fig 8). Following slight defects may be accepted, provided these do not affect the general appearance of the produce and keeping quality of the package.

- a slight defect in shape,
- a slight defect in colouring

6.1.3 Class II: The bunch may show defects in shape and colour provided these do not impair the essential characteristics of the variety. The berries must be sufficiently firm and sufficiently attached. They may be less evenly spaced along the stalk than Class I grade. Following defects may be accepted, provided these do not affect the general appearance of the produce and keeping quality of the package.

- defects in shape,
- defects in colour,
- slight sun scorch affecting the skin only,
- slight bruising,
- slight skin defects.


Fig. 7. Extra class Manjri Naveen and Autumn Royal

7. Storage

7.1 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 less than 4°C within six to eight hours in the pre-cooling chambers. If the pre-cooling units are away from the production sites and packing houses, mobile pre-cooling units are to be used. The filled boxes without closing the polyethylene liner are placed in the pre-cooling chambers.

Fig. 8. Autumn Royal Class-I

7.2 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^{0}C and 93 ± 2% respectively. Temperature of 0°C and humidity of 95% are the best for maintaining freshness and preventing decay.

8. 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.

Chapter 9

Safe use of agrochemicals

KAUSHIK BANERJEE
AHAMMED SHABEER T.P.
GOVIND HANDE

Agrochemicals are basically organic or inorganic compounds which degrade with time to non-toxic metabolites on exposure to physio-chemical factors e.g. sunlight, heat, humidity, chemical agents in atmosphere, etc., and biological factors viz. enzymes, microbes, etc.

1. Sources of agrochemical residues in table grapes

In table grapes, the agrochemical residues may appear from the following sources:

1.1 Direct Source:

When agrochemicals are applied directly on the plants, a fraction of it gets adsorbed on the surface or absorbed by the fruits. The time required for degradation of a toxic molecule to harmless metabolites may vary from hours to years depending on the chemical nature of the compound and its susceptibility to the degrading factors. If a crop is harvested before such period, then analysis of the samples results in detection of the residues and consumption of such contaminated food may result in acute toxicity.

1.2 Indirect source:

Spray drift from adjoining crop fields, contaminated soil and irrigation water, contaminated agro-inputs like manures, fertilizers etc. can be source of pesticide residue.

2. Maximum residue limit (MRL) and its relationship with the GAP

MRL is the legally permitted maximum concentration of the pesticide residues in or on food when offered for consumption. It is derived by taking into account good agricultural practices (GAP). MRLs are the trade standards that are set in a way that there are no concerns for public health, especially with regard to vulnerable subpopulation groups (as children and the unborn). GAP takes into account the application of minimum quantities of pesticides necessary to achieve adequate pest control in such a manner that the amount of residues in the food is smallest possible. At the international level, the Codex Alimentarius Commission of the FAO/WHO decides MRL. The Codex Committee on pesticide residues (CCPR) was formed by United Nations with primary mandate to establish MRL for pesticides in food. In India, the MRL of pesticide are prescribed under the Food Safety Act, 2006. MRL of pesticides are specific for crop or food item.

Although the Codex MRLs are applicable to all the nations, individual countries may have their own MRL regulations. For agro-export, it is thus essential that the commodities should comply with the latest MRL regulations of the importing country. For example, the MRLs set by the European Union (EU) have to be complied for export of the fruits and vegetables to any EU member country. Earlier, individual EU countries used to have their own MRLs. Since September 2008, the MRLs have been harmonized across the 27 member countries of the European Union.

Terminal residue load of an agrochemical in grape or any other

commodity mainly depends upon its environment-stability and dissipation pattern. The rate of dissipation again largely depends upon the amount and concentration applied, initial deposit and the prevailing environmental conditions during fruit development stage.

The knowledge on MRL acts as a valuable guide to the growers and phyto-sanitary certificate issuing authorities of the Government. It alarms a grower for the fact that if he does not follow the recommended package of practices, the terminal residue levels of pesticides may exceed the permissible MRLs and he might face marketing set back along with legal hazards. The regulatory bodies at the National and International levels may use this information to decide whether a commodity is fit for sale in domestic and international markets.

3. Pre-harvest interval

It is the concept to minimize pesticide residues. On the basis of the MRL, the pre-harvest intervals (PHI) of pesticides are calculated. PHI is the safe waiting period, which is the minimum time in days that must be provided between last application of a pesticide and harvesting of the produce so that its residue level at harvest reaches below the MRL. Estimating PHI of a pesticide ideally involves multi-location field trails wherein the pesticides are applied following the guidelines of GAP. Representative samples are collected from the treated plants and analysed for the residues. The sampling is initiated on the day of the final application and continued at regular time interval till harvest. After precise estimation of the residues in each sample, the residue data are statistically processed to correlate the dissipation with progress of time. The dissipation rate is faster at the beginning and gets slowed down with the passage of time. This indicates a non-linear pattern of degradation and often implies that simple first order kinetics might not be adequate to explain the dissipation behaviour of most of the pesticides and predict the PHI.

4. Precautions for safe use of pesticide

4.1 Purchase

1. Purchase only required quantity for single application in specified area.
2. Do not purchase leaking containers, loose, unsealed or torn bags.
3. Do not purchase pesticides without proper / approved labels.

4.2 Storage

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

4.3 Handling

1. Never carry / transport pesticides along with food material
2. Avoid carrying bulk – pesticide (dust/granules) on head, shoulder or on the back

4.4 Preparation of solution

1. Use clean water
2. Always protect your NOSE, EYES, MOUTH, EARS and HANDS
3. Use hand gloves, face mask and cover your head with cap

4. Read the label on the container before preparing spray solution
5. Prepare spray solution as per requirement
6. Do not mix granules with water
7. Concentrated pesticides must not fall on hands etc. while opening sealed containers. Do not smell the sprayer tank
8. Avoid spilling of pesticide solution while filling the sprayer tank
9. Do not eat, drink ,smoke or chew while preparing solution
10. The operator should protect his bare feet and hands with polyethylene bags

4.5 Equipment

1. Select right kind of equipment.
2. Do not use leaky, defective equipment.
3. Select right kind of nozzle.
4. Don't blow /clean clogged –nozzle with mouth. Use old tooth-brush tied with the sprayer and clean with water.
5. Do not use some sprayer for weedicide and insecticide.

4.6 Application

1. Apply only at recommended dose and dilution.
2. Do not apply on hot sunny day or strong windy condition.
3. Do not apply just before the rains and also after the rains.
4. Do not apply against the wind direction.
5. Wash the sprayer and bucket etc. with soap water after spraying.
6. Containers, bucket, etc. used for mixing pesticides should not be used for domestic purposes.
7. Avoid entry of materials and workers in the fields immediately after the spraying.

4.7 Disposal

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

राष्ट्रीय अंगूर अनुसंधान केन्द्र
(भारतीय कृषि अनुसंधान परिषद)
डाक पेटी नं. 3, मांजरी फार्म डाकघर, सोलापूर रोड, पुणे – 412307, भारत
NATIONAL RESEARCH CENTRE FOR GRAPES
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
P.B. NO. 3, MANJRI FARM POST, SOLAPUR ROAD,
PUNE - 412 307, INDIA
Tel: +91-20-26956000 (EPABX), Fax: +91-20-26956099
E-Mail: nrcgrapes@gmail.com; Website: http://nrcgrapes.nic.in

Annexure-1
Revision date: 17th October, 2012

List of chemicals with CIB&RC label claim for use in grapes

Sr. No.	Chemical recommended for major disease & pest	Nature of chemical	Dose on formulation basis	EU MRL (mg/kg)	Pre-harvest Interval (PHI in days)
I	**Downy Mildew**				
1.	Mancozeb 75 WP	NS	1.5-2.0 g/L	5.0	35 (avoid using after fruit set)
2.	Propineb 70 WP	NS	3.0 g/L	1.0	40 (avoid using after fruit set)
3.	COC 50 WP	NS	2.5 g/L, 2.4 g/L	50.0	42 (avoid using after fruit set)
4.	Chlorothalonil 75 WP	NS	2.0 g/L	3.0	60
5.	Fosetyl Al 80 WP	S	1.4-2.0 g/L	100.0	7
6.	Metalaxyl + Mancozeb 8+64 WP	S+NS	2.5 g/L	2.0 + 5.0	66
6a.	Metalaxyl-M + Mancozeb 4+64 WP	S+NS	2.5 g/L	2.0 + 5.0	66
7.	Cymoxanil + Mancozeb 8+64 WP	S+NS	2.0 g/L	0.2 + 5.0	66
8.	Dimethomorph 50 WP + Mancozeb 75WP as tank mixture	S+NS	0.5 to 0.75 g/L + 2.0 g/L	3.0 + 5.0	66
9.	Fenamidone + Mancozeb 10+50 WG	S+NS	2.5 to 3 g/L	0.5 + 5.0	66
10.	Azoxystrobin 23 SC	S	494 mL/ha	2.0	7
11.	Iprovalicarb + Propineb 5.5+61.25WP	S+NS	2.25 g/L	2.0 + 1.0	55
12.	Famoxadone 16.6 % + Cymoxanil 22.1 % SC	S+NS	500 mL/ha	2.0 + 0.2	27

Sr. No.	Chemical recommended for major disease & pest	Nature of chemical	Dose on formulation basis	EU MRL (mg/kg)	Pre-harvest Interval (PHI in days)
13.	Kresoxim methyl 44.3 SC	S	600-700 mL/ha	1.0	30
14.	Fenamidone 4.44% + Fosetyl-Al 66.66% WDG	S	2 to 2.5 kg/ha	0.5 + 100	27
15.	Pyraclostrobin 5% + Metiram 55% 60WG	S+NS	1.5-1.75 kg/ha	1+5	15
16.	Mandipropamid 23.4% SC	NS	0.8 mL/L	2.0	5
II	**Powdery Mildew**				
17.	Penconazole 10 EC	S	0.50 mL/L	0.2	50
18.	Triadimefon 25 WP	S	0.50-1.0 g/L	2.0	45
19.	Hexaconazole 5EC	S	1.0 mL/L	0.01	60
20.	Myclobutanil 10 WP	S	0.40 g/L	1.0	30
21.	Flusilazole 40 EC	S	25 mL / 200 L	0.05	50
22.	Fenarimol 10 EC	S	0.40 mL / L	0.3	30
23.	Difenoconazole 25EC	S	0.50 mL / L	0.5	45
10a.	Azoxystrobin 23 SC	S	494 mL / ha	2.0	7
13a.	Kresoxim methyl 44.3 SC	S	600-700 mL/ha	1.0	30
24.	Dinocap 48 EC	NS	0.30 - 0.35 mL/L	0.05	50 (avoid application when tender shoots are present in canopy)
25.	Sulfur 40 SC, 55.16 SC, 80 WP, 80 WDG, 85 WP	NS	3.0 mL, 3.0 mL, 2.50 g, 1.87-2.50 g, 1.50-2.0 g/L, respectively	50.0	15
26.	Tetraconazole 3.8EW	S	0.75 mL/L	0.5	30
III	**Anthracnose**				
2a	Propineb 70 WP	NS	3.0 g/L	1.0	40
3a.	COC 50 WP	NS	2.5 g/L, 2.40 g/L	50.0	42 (avoid using after fruit set)
27.	Carbendazim 50 WP, 46.27 SC	S	1.0 g/L, 1.0 mL/L	0.30	50
IV	**Flea beetles**				
28.	Imidacloprid 17.8 SL	S	0.30 mL/L	1.0	60
29.	Lambda-cyhalothrin 05 CS	NS	0.50 mL/L	0.2	30
V	**Thrips**				
30.	Emamectin benzoate 05 SG	NS	0.22 g/L	0.05	25
31.	Fipronil 80 WG	NS	0.05 g/L	0.005	60

Sr. No.	Chemical recommended for major disease & pest	Nature of chemical	Dose on formulation basis	EU MRL (mg/kg)	Pre-harvest Interval (PHI in days)
28a.	Imidacloprid 17.8 SL	S	0.30 mL/L	1.0	60
29a.	Lambda-cyhalothrin 05 CS	NS	0.50 mL/L	0.2	30
VI	**Jassids**				
28b.	Imidacloprid 17.8 SL	S	0.30 mL/L	1.0	60
29b.	Lambda-cyhalothrin 05 CS	NS	0.50 mL/L	0.2	30
VII	**Mealy bugs**				
32.	Buprofezin 25 SC	NS	1.25 mL/L	1.0	40
33.	Methomyl 40 SP	S	1.0 g/L	0.02	61 (one application only at pre-flowering stage)
VIII	**Caterpillars (*Helicoverpa armigera* and *Spodoptera litura*)**				
29c.	Lambda-cyhalothrin 05 CS	NS	0.50 mL/L	0.2	30
30a.	Emamectin benzoate 05 SG	NS	0.22 g/L	0.05	25
IX	**Mites**				
25a.	Sulphur 80 WDG	NS	1.50-2.0 g/L	50.00	15
X	**Plant Growth Regulators**				
34.	Hydrogen cyanamide 50 SL	S	30-40 mL/L	0.05	90-120
35.	Forchlorfenuron (CPPU) 0.1% L	S	1-2 ppm	0.05	22 (for 1 ppm dose) 30 (for 2 ppm dose)
36.	Gibberellic acid (GA3) Technical	S	100 ppm (Cumulative Usage)	5.00	7
37.	1-Naphthyl acetic acid 4.5% L	S	100 ppm	0.05	PHI data not available
38.	Chlormequat chloride 50 SL	S	250 ppm	0.05	PHI data not available
XI	**Herbicides**				
39.	Paraquat dichloride 24 SL	NS	5 mL/L	0.02	PHI data not available

NS = Non-systemic, S = Systemic

Note

- All the doses mentioned above are for high volume sprayers, where normal spray volume is 1000 L/ha. Spray volume can however be changed as per the efficiency of sprayers used. However, the amount of each pesticide based on its active ingredient recommended for 1 ha area on the basis of 1000 L spray solution should be strictly maintained to minimize pesticide residues.

- Recommended PHI will be valid only if two applications of an agrochemical are given per fruiting season at the interval of 7-15 days at recommended dose except in case of Flusilazole and Methomyl.

  The PHI of the fungicide Flusilazole and insecticide Methomyl pertains to one application by foliar spray only.
- Imidacloprid (17.8 SL) application (spraying or soil drenching) should not exceed more than two times per fruiting season.
- The responsibility of usage of chemicals for the management of any of the above pests and diseases will rest with the growers in compliance with the requirements of the importers / EU and, in the minimum; all chemicals listed in Annexure 9 should be tested.