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Training and Pruning in Grapes

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PREFACE

Grape is an important fruit crop of India from employment generation point of vie. grown on variety of soils. It is grown on area of approx. 62,000 ha with annual production 1.6 million tones. Presently, Maharashtra occupies prominent position with regard to area and production in the country and cultivation is mainly concentrated in Nasik, Sangli, Solapur and Pune districts. By and large, the grapevine is trained on telephone, 'T' System and extended 'Y' system globally. However, in India initially the training for grapevines started using sticks of Pangara and single wire system and with the advancement in the viticulture bower training system became popular in the grape cultivation. Due to various difficulties being faced in this system, other training systems are being explored to train the grapevines keeping in view the light exposure, ventilation and the total cost involved in setting up of the system. The training system depending upon the various factors like weather condition of the region, soil type, class of grape and vigour of the variety. Further, the training system should be such that it should be technically feasible and economically viable keeping the maintenance cost in long term. Pruning is also necessary in grapevines to develop and maintain the growth every year for appropriate fruiting and, therefore, the information on this aspect is also covered in the bulletin.

The bulletin covers in detail the various training systems followed in the country for grapevines and the pruning system and practices. This is covered in both the season, namely, foundation pruning taken in March-May and fruit pruning in July-October. All the information has been substantiated with the research data gathered so far and also the photographs wherever it is required.

The information given in the bulletin will serve as guidelines for the grape growers in the country to get an overview of the various training and pruning practices to be followed for better quality and production. In addition, this bulletin is also useful to the researchers and the students engaged in grape research and development activities.

Date : 1st Janury, 2008
Place : Pune

(P. G. Adsule)
Director

1. INTRODUCTION

Grape *(Vitis vinifera)* is one of the most favoured commercially grown fruit crops of the country. Major area under grape cultivation is concentrated in central and peninsular Indian states like Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu and a limited extent in the areas of North. At present, grape is cultivated in an area of about 62,000 ha with annual production of 1.6 million tones (Anon., 2005), which makes a share of 1.97 percent of total production of grapes in the world. India has achieved the distinction of having the highest productivity/unit area of grape in the world. The area under grape cultivation in the country has increased by 50 percent and its production has increased by 71 percent over the last decade owing to the economic importance of the crop. Inspite of the high yield obtained in grapes, the export to the international market is very low.

Earlier the vines grown on their own roots were performing well since the soil and water conditions were appropriate for their growth. With the onset of problems like soil salinity, bad quality water and shortage of irrigation water due to drought, the severe decline in the productivity of vines raised on their own roots in semi arid regions of Maharashtra and N. Karnataka was reported. Owing to the conditions of salinity and drought establishment of grape vineyards on rootstock were became mandatory. In addition to these, the production of exportable produce was recorded to be minimum since the grower could not harvest even optimum proportion of the exportable grapes from unit area allotted to each vine. This was mainly due to the faulty cultural practices like training, pruning, water and nutrient management practices followed in grapes.

2. PROBLEMS IN PRODUCTION OF QUALITY TABLE GRAPES

The quality in grape is referred as the eating quality of the berries, which predominantly judged by the people eating. The major quality parameters in grape are size in terms of diameter and length, shape of the cluster, cluster filling, total soluble solids, acidity, berry adherence for increased shelf life, etc.

There are various reasons for not achieving the quality in grapes is as below.

PHYSICAL COMPONENTS

SIZE AND SHAPE OF THE CLUSTER

The appearance of the cluster is determined by their shape and size. Bunches having conical shape are generally preferred in the market while the irregular shaped bunches are rejected. The cluster size is more important than the shape in the market (Chadha and Shikhamany, 2001). The weight of the cluster varies from 100 g to nearly 1.0 Kg depending upon the cultural practices followed after each pruning. Bunches weighing 350 - 500 g are generally preferred in the international market. The uneven size and shape of the bunch on a vine is mainly due to the uneven cane size obtained/ maintained after back pruning.

CLUSTER FILLING

This is referred as number of berries available per cm length of the rachis of a bunch. Generally, the consumer prefers well-filled bunch. The compact bunches are hard and rigid and are either damaged during the process of ripening or gets cracking during packing and transport. Hence, loose bunch having 80 - 100 berries should be considered as the important character. Many times it is not achieved mainly because improper and untimely thinning of berries in a cluster during the growth and development period.

QUALITY COMPONENTS

SUGAR : ACID RATIO AND OTHER BERRY CHARACTERS

The palatability of the grapes is determined by the ratio of sugars to the acids content in the berries. The requirement of total soluble solids in the international market is 18° Brix and above. However, from the quality point of view, the sugar : acid ratio should be between 35-40.

In the Indian condition, the growers achieve either high or less total soluble solids. This is mainly because of heavy crop load and shading effect results due to faulty training of shoots on the training system used. Other berry characters like physical condition is the primary requirement. The berries in a bunch must be free from scars by insect pest, bruises, dust and diseases. Size, shape and colour of the berries are also important for table grapes.

As per the Agmark standards fixed, the grape selected for export should fulfil the following requirements.

i) Bunches and berries of table grapes shall be
   a) Clean, sound, free of any visible foreign matter
   b) Free of pest, affecting the general appearance of the produce
   c) Free of damage caused by pest or diseases
   d) Free of abnormal external moisture
   e) Free of any foreign smell and / or taste
   f) Free of all visible trace of moulds

ii) Berries shall be intact, well formed and normally developed.

iii) Table grapes shall comply with the residue levels of heavy metals, pesticides and other food safety parameters as laid down by the Codex Alimentarius Commission for export.

iv) Table grapes shall have minimum soulable soilds of 16° Brix.

v) Table grapes shall have minimum sugar/acid ratio of 20:1.

3. CROPPING PATTERN IN THE COUNTRY

In peninsular India and other tropical region, the vine has evergreen growth habit. However, in the temperate parts of the country, the vine goes into dormancy during the winter. In addition to these, the climatic conditions are different in different parts that the growth habit and the pruning time cannot be same. Hence, the pruning practices needs to be followed differently during the year in different regions. The cropping pattern based on the pruning is as below.

I. SINGLE PRUNING AND SINGLE CROPPING

This practice is generally followed in temperate region of the grape growing areas. In this, the vine gets only one growing season to complete the physiological processes and the rest of the period it goes into dormancy. Since the physiological processes are not taken place due to the dormant nature of the vine, it is pruned at the end of winter season. The bud differentiation and fruit set takes place at the same time in this type of pruning. It is followed mostly in northern part of the country where Perlette variety is mainly grown.

II. DOUBLE PRUNING AND SINGLE CROPPING

In the subtropical and tropical region the vine grows vigorously. This system is followed mainly in Maharashtra, Andhra Pradesh and some parts of Karnataka state. After harvest of bunches, all the canes are pruned back by retaining one or two basal bud. This is called as back pruning. The shoots from these sprouted buds are allowed to grow and the food material is stored in it. Hence, it is also called foundation pruning. These shoots after maturity are called as canes, which are pruned after 5th bud position in table grapes and 3-4 bud in wine grapes during September-October for fruits. Hence this pruning is called as forward pruning or fruit pruning.

III. DOUBLE PRUNING AND DOUBLE CROPPING

The mature shoots (canes) are pruned to 7-8 buds in the forward pruning. The same canes are pruned back to 3-4 buds after harvesting the crop in summer. The mature shoots arising from these 3-4 buds along spurs are pruned for fruiting canes in the next winter (Chadha and Shikhamany, 2001). This is mainly followed in Tamil Nadu where the grape variety Gulabi is grown on a large scale. In this region, the pruning is done during November-December and the crop is harvested during March - April while the canes pruned during May - June, the crop becomes ready during August - September.

4. TRAINING THE VINES

Training, basically a potential tool in managing the canopy architecture in plants with weak stem, like grapevines. Training the perennial trees to open vase center is an age-old practice to harvest the light and provide proper aeration for fruit yield. Vigorous vineyards have the potential for higher yield if the vigor is properly exploited. Rather than reducing the vigour of vine to fit a standard trellis, we need to design more effective trellis system. We need to develop canopy management techniques that compliment the trellises and put the vines strength to work

producing fruit. Increase in the grape production per hectare depends on efficient management of canopy during the cropping season. For higher crop production, canopy management plays an important role. Since the grapevine has indeterminate growth having weak stem, it needs support not only to support the weight of its aerial parts and fruits but also to maintain the canopy architecture. Canopy architecture of vine is shaped by trellis and the system of training. The fabricated structure used for training the vine is called the trellis while process of shaping the canopy is called *"training"*.

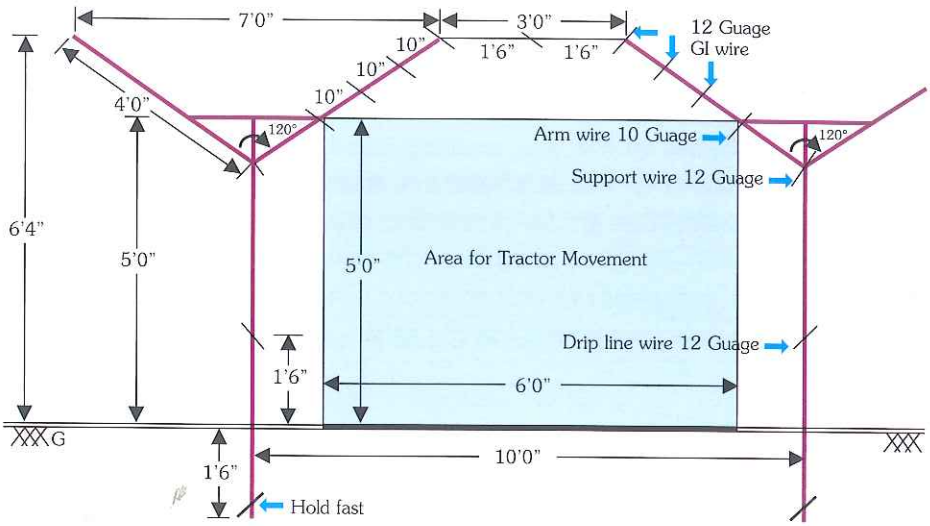
4.1 PURPOSE OF TRAINING

Proper training is essential for the production of a good yield of high-quality fruit and to maintain a balance between vegetative growth and fruiting. To be most productive, grapevine should be pruned and trained to a definite system. Two of the most popular trellis Flat roof Gable and bower (pandal) are both satisfactory for quality yield if managed well, however, each system has its own advantage and disadvantage. Distribution of vigour of the vine and storage of food material in different parts and development of adequate number of fruiting canes per unit area should be the main purpose of training. To achieve this, grapevine having indeterminate and weak stem needs support for its growth. This is possible when the vine is trained on a particular structure called trellis. Various structures are being used to support grapevines. One to two layers of leaves for any area on the canopy are best for flower bud and fruit development. Hence, training plays an important role in achieving the fruitfulness in a vine. Training of vine on any training system should fulfill the following.

1. The training should facilitate proper light and air penetration with optimum photosynthetic activity in the canopy.
2. It should provide separate fruit zone from canopy
3. It should encourage higher bud differentiation on the growing shoot.
4. Workers productivity and easy for working.

Since, the high yield depends on the canopy management through training system, an ideal training system should fulfill the following requirements.

1. It should give rise to adequate number of fruiting canes.
2. It should support heavy crop load of good quality per unit area of land.
3. It should allow good ventilation and light into vine canopy.
4. It should avoid microclimate congenial for growth and spread of diseases and insect pests.
5. It should be convenient for mechanization of cultural operations.
6. It should be convenient to carry out manual operations effectively and compatible with the equipment.
7. It should be simple and less expensive in establishment.
8. It should be economically viable.



Extended "Y" / Flat roof gable system
(Row to Row spacing 10 ft.)

Fig. 1 : An ideal training system

4.2 FACTORS RESPONSIBLE FOR TRAINING SYSTEMS USED

To increase the yield per unit area, the vines are trained on different training system. The use of training system depends on various factors like weather condition of the region, soil type, type of grapes grown and vigour of the variety. In addition, the training system selected should be economically viable for maintenance and cost of production. Defective training may lead to under utilization of available resources by the vine resulting into poor cropping. The factors responsible for use of training system are explained as below.

4.2.1 WEATHER CONDITION

In some areas the climate is very hot during April - June (vegetative growth phase of vine). During this period the temperature goes even up to 48° C with dry weather in the non-traditional grape growing areas of Buldhana (Chikhali, Amadapur, Ramnagar and Chinchkhed area) and Yawatmal districts. This leads to sun burning of the cordons resulting into reduction of the transportation of food material and ultimately the dead arm formation. The temperature during February also starts rising above the normal temperature prevailing in other grape growing area. This creates the condition of berry scorching, early ripening of the fruit and yellowing of bunches which are not accepted in the international market. To protect the vine from high temperature use of bower system of training (pandal) can be the good decision though it has few difficulties in following cultural operations.

4.2.2 SOIL TYPE

The vigour of the vine is directly related to the soil type where the grapes are grown. In black cotton soil the water holding capacity is more. This helps in the proper utilization of nutrients and irrigation water supplied to the vine resulting into high vigour. To avoid the losses of nutrients, the vigour needs to be well distributed in a training system that can sustain the load of the cordons and utilize the sunlight for proper bud differentiation. In this type of soil 'Y' or extended 'Y' can work well. However, in light soil the water holding capacity is less leading to leaching out of nutrients and water from the root zone. The vine under such situation does not produce more vigour. Hence, spacing and training system needs to be changed considering the vigour in the soil.

4.2.3 TYPE OF GRAPES

The grapes are grown for different purposes i.e., for table, raisin and wine. Based on the genetical make up, the vine imparts the vigour that decides the training system to be used to train the vine. The commercially grown table grapes i.e. Thompson Seedless and its mutants *viz.*, Tas-A-Ganesh, Sonaka, Clone 2A, etc are basically vigorous varieties and if grown on heavy soil becomes more vigorous. To adjust the vigour of the vine Y or flat roof gable system can be used. In addition to these, the wine varieties impart less vigour. Hence, for economic yield of the wine grapes the spacing also needs to be reduced and the training system like 'T. single wire, kniffin, etc. are to be used.

4.3 DIFFERENT SYSTEMS OF TRAINING

Canopy refers to the size and shape of the vine structure. The components of a vine canopy are its primary arms and secondary arms, which form the permanent framework of the vine, canes, shoots and leaves. While the size of the canopy is dependent on the number and length of primary and secondary arms, the number of canes, the number and length of the shoots and the number and size of the leaves, the shape of the canopy is determined by the length and orientation of the arms and the shoots. To increase the vine productivity through canopy management, different training systems being used at present are described below.

4.3.1 BOWER/PANDAL SYSTEM

During the past, this system of training was popular among the grape growers in the state owing to its high productive potential. It has the scope for producing canes @ 1 per sq. ft. It is highly suited for vigorous varieties in which vigour does not hamper the productivity. Other advantages associated with this system of training are protection of the bunches from sunburn. But in varieties like Thompson Seedless and Tas-A-Ganesh where vine vigour and excessive foliage density affects the productivity adversely, this system is not much beneficial to the growers due to the following reasons.

1. The canopy is horizontal where all the shoots fall on each other reducing fruitfulness.

2. The spraying can control the disease inoculums from one side only whereas the inoculums left in reverse side of the leaf get activated thus increasing number of sprays.

3. The system builds up microclimate in the canopy congenial for the easy spread of disease.

4. Bunches exposed to the sun becomes yellow and thus has more TSS than the shaded bunches. Such type of bunches are not accepted in the international market.

5. Mechanization is not possible.

6. Efficiency of the labour gets reduced due to its height.

4.3.2 SINGLE WIRE

In this system, single wire is pulled from the distal end of the pole. The height of 4' and 6" is maintained from the ground surface to stretch the wire. The cordons are developed on both sides of the trunk. In this training system the canes or foliage do not get any support and hence bunches are hanged on the wire. The proportion of bunches that comes under direct contact of sunlight is more. Since there is no support for the canes, the cane bearing bunches more than one break at the base due to the load. However, in case of vigorous variety the shoot touches the ground that may lead to disease spread during the rainy season. In heavy soil with grafted vines this system may not work well due to more vigour.

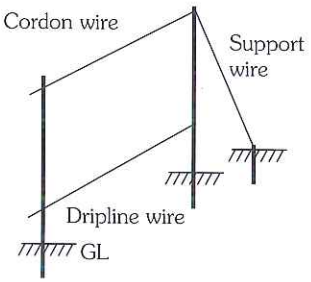


Fig. 2 : Single wire

4.3.3 SHORT ARM 'T' TRELLIS

This system is suitable for moderately vigorous varieties having slightly more apical dominance (Chadha and Shikhamany, 2001). Light in the canopy, which is an important aspect for fruit bud differentiation is more. Bunches and cordon comes under direct exposure of sunlight and chances of berry scorching and formation of dead wood during hot summer are more. Since the developing canes do not get enough space for support, the possibility of getting higher yield in such type of training system becomes difficult. The cordon development is similar to that of single wire training. The length of each arm provided is less due to which the canopy starts drooping and the appearance of umbrella is experienced.


Fig. 3 : Vine trained on T system

4.3.4 LONG ARM 'T' TRELLIS

This training system is similar to the short arm 'T' except that the length of arm, which is considered as improvement over short arm 'T' trellis. In this system the provision of foliage wire is made to support the canopy. Since the cordon is placed below the foliage wires the cordons during the hot summer are protected from the direct sunlight and the sun scorching, cracking and formation of dead wood is reduced. The canopy gets the 'V' shape. This system has the provision of longer shoot length and more leaf/fruit ratio when the shoots at the ground level are trimmed (Chadha and Shikhamany, 2001).

4.3.5 TATURA SYSTEM

This system is developed at Tatura in Australia. In this system of training the vines are trained to wires across the two sides of 'V' shape trellis. Training of secondary arm (cordons) is similar to that of kniffin system. This system provides good ventilation, aeration and sunlight in the vine canopy. This helps in reducing the relative humidity in the vine canopy and hence the reduced disease incidence. However, spraying in the inner side of the V- shaped canopy structure becomes difficult. Higher fruitful canes per unit area can be achieved in this system. In Maharashtra, the grape growers are not using this system at present.

4.3.6 KNIFFIN SYSTEM

Williams Kniffin developed this system in the year 1850 in New York. This system is suitable for the varieties having moderate vigour with less apical dominance. In the foreign countries, this system is followed for training the wine varieties. Since the varieties used are medium in vigour, the canopy receive maximum sunlight required for fruit bud differentiation. The cordons developed are like a multi-storeyed due to which the row-to-row and plant-to-plant spacing maintained is less accommodating more number of plant population per acre. Two wires are stretched at a height of 2'6" from the ground. The growing shoot is pinched 3" below the first wire and two shoots from the lateral growth is trained on the wire. The terminal shoot is allowed to grow in the vertical direction, which is again pinched 3" below the second wire. Similarly a pair of lateral shoot is also developed on the second wire. It is observed that the canes developed on the codons of the lower wire are less fruitful due to the shading effect.

Fig. 4 : Kniffin system

4.3.7 SMALL 'Y'

This system is similar to that of flat roof gable except the length of each arm and the use of variety for training. Since the majority of the wine varieties have less vigour, this system is being used to train the wine grapes. Length of each arm is maintained as 2 feet and the numbers of

wires are also restricted to two or three depending on the type of vigour and soil available in the field where the wine variety is grown. The development of cordons and canes on each arm is similar like former system. The distance between two poles is maintained based on the yielding capacity of the vine.

4.3.8 FLAT ROOF GABLE

Fig. 5 : Flat roof gable system

This system of training is more popular among the grape growers next to the bower system. After realizing the difficulties faced by the growers in bower system, various systems were tried to train the vines from which 'Y' system was introduced. In this system of training, double cordons are placed horizontally on the wire. The shoots arising from the cordons are generally erect during the bud differentiation stage after back pruning. Each bud on the shoot harvest uniform sunlight that helps in maximum fruitfulness of individual cane on the vine. Vertical canopies which envisage at the best utilization of light and minimization of building up of high humidity in the vine canopy gives the good quality of bunches. The best way to manage the canopy in grapevines is to train the vines on flat roof gable system of training. Once the vine is trained on this system the canopy becomes open and well divided that helps in proper aeration in the canopy. With this system, the fruiting canes are trained upwards from the trunk, and it is thus also known as vertical shoot positioning (VSP). The studies conducted at the centre on effect of shoot positioning on fruitfulness in Thompson Seedless grapes have revealed that the upward positioned shoots are more fruitful than the horizontal and downward positioned shoots (Table 1). This is because of the vertical position of shoot that helps the individual bud to receive maximum sunlight required for fruitfulness. The canes are supported by securing them to a number of trellis wires running the length of the row of vines. After forward pruning, bunches are protected by direct sunlight while the shoots receive sunlight for photosynthesis. While surveying the vineyards for "effect of training system on production of exportable quality grapes", it was observed that uniform green colour bunches were less and bunches were exposed to sunlight when the angle of 'Y' was less than 120° in case of 'Y' system. Hence, for the production of exportable quality grapes, the degree angle needs to be given priority while establishing the vineyard. This training system is generally preferred for vigorous varieties.

Table 1 : Effect of shoot orientation on bud fruitfulness at different bud position in Thompson Seedless grapes (after back pruning).

Shoot position	Bud Position				
	3	4	5	6	7
Downward	32.40	42.60	36.00	42.50	38.20
Horizontal	35.50	36.70	48.50	48.60	36.0
Upward	36.60	56.00	76.01	80.41	74.0

4.4 ADVANTAGES OF TRAINING

Grapevine stem being weak, it needs support in the early years. Grape bunches are produced on the new shoots emerging from mature growth. Therefore, vine training is required to sustain the load of a developing bunch. Training of vines has the following advantages.

1. The vine gets supports for growth.
2. The trunk, which is called as storage wood becomes erect which can support the cordons, canes, shoots and bunches, etc.
3. It helps in achieving adequate number of canes, which are the fruiting units.
4. It allows sufficient light and ventilation into the canopy during the growth season.
5. It avoids overlapping of the foliage to facilitate efficient photosynthesis by every leaf.
6. It offers scope for effective coverage of sprays with pesticides and growth regulators.
7. It avoids build up of microclimate that is congenial for disease development.

4.5 TRAINING THE NEW VINES

4.5.1 TRAINING ROOTSTOCK

For efficient utilization of the available resources by the vine resulting into quality grape production, training needs to be given priority right from the beginning. Once the rootstock is planted in the field there will be many shoots arising from the base. For success of one graft we perform grafting on two shoots for which retention of three shoots of rootstock plants are generally recommended to the growers for selection of healthy and straight shoots. Hence, after removal of excess shoots of the rootstock plant, the selected shoots are trained to bamboo with the help of sutali. Bamboo should be placed near the shoots for training. Many of the time it is observed that while training, the plants are taken near the bamboo. The bent portion of the plant comes in direct contact with the hot sun and the portion becomes woody resulting into dead wood of the trunk. After few years the portion on the trunk cannot supply the food material since the xylem vessels gets killed. Hence, proper training at this stage is important.

Fig. 6 : Properly trained rootstock

Fig. 7 : Deadwood formed due to faulty training

4.5.2 TRAINING PRIMARY ARM

The commercial variety is grafted on rootstock in the month of August-September. The grafted vines are allowed to grow till February. Since the cuttings of the commercial variety used for grafting will not be of same size, sprouting and growth of the vine is not uniform. Hence, re cut is taken leaving 2-3 buds above the graft joint during February. The growing shoot is tipped below the first wire for developing the primary arms. The shoot should be cut 3-4 inches below the first wire. Cutting at this place will help the shoot to get proper direction for its growth. The arms developed by this method will be slanting to the main trunk, which will avoid direct sunlight during the hot sun. If the shoot is tipped at the level of wire, it will receive direct sunlight. During the first year after back pruning, the primary arm will come in direct contact of hot sun in the month of April - May leading to formation of dead arm.

Fig. 8 : Correct stage of arm development

Fig. 9 : Faulty developed primary arm

4.5.3 SINGLE-TRUNK VS. TWO-TRUNK TRAINING

For success of one graft, grafting is performed on two growing shoots of rootstock. One successful and healthy graft is retained while the other is removed by cutting from the base. In majority of the cases, both the grafts are successful and healthy with the same vigour. Commercial grape growers often train two parallel trunks in the systems. In essence, each trunk

Fig. 10 : Training of double stem

makes up for half the canopy. For instance, in case of four-arm Kniffin, one trunk might produce the canes for the right side lower wire and the left side upper wire, and vice versa for the other trunk. In other countries, the growers follow this as a hedge against stress, particularly winter damage, if one trunk is killed; production from that plant is not completely lost. Two trunks also allows for renewing a trunk without losing production from the plant. The research conducted at the farm of National Research Centre for Grapes, Pune on effect of stems on yield and quality of Tas-A-Ganesh grapes resulted into higher yield than single stem. Developing double trunk at a time is difficult due to the apical dominance phenomena in Thompson Seedless grapes. Hence, while training the vine double stem should be maintained only when both the trunk/ stems are growing with the same vigour.

4.5.4 CORDON TRAINING

What is being described as cordon system training here goes by a variety of names, including single cordon, double cordon and four cordon. But the basic principles among these specific systems remain constant. Single and double cordon training helps in receiving the uniform sunlight required for bud differentiation. This system allows for excellent light and spray penetration, yields high-quality fruit and easy to prune. On the other hand, the multiple cordons due to overcrowding of the shoots become less fruitful. Hence, this system is not considered suitable for quality yield production in training vigorous varieties like Thompson Seedless and its clones. The double cordon training is the most commonly used. A significant advantage of cordon training is its suitability to cultural operations like thinning of bunches and dipping in growth regulator solution.

4.5.5 SHOOT TRAINING

While developing the framework during the first year, the cordons are developed by 'stop and go' method. In this method the shoot selected for cordon development is cut at 5-6 leaf positions when the total number of leaves are 8-9. This helps in sprouting of all buds on pinched shoot. The sprouted shoots are then trained to the wire.

Fig. 12 : Faulty training invites disease incidence

Fig. 11 : Proper training harvest maximum sunlight

4.6 TRAINING OLD VINES

Since the vine is trained right from the grafting in the field from the first year, training in old vines is not much required. In case of dead arm on the old cordon, the process of rectification can be undertaken. Once the dead arm is removed, the sprouting of buds takes place. The shoot then can be taken for developing the new arm where the process is same as that of the cordon development in new vine. Training of shoot is more important during both the pruning in grapes.

During the growth stage after foundation pruning, there would be 70-75 shoots/vine.

Fig. 13 : Proper training minimizes the risk of diseases.

After April pruning number of shoots/sq. ft requirement is 0.5 to 0.7 which accounts for 32-35 shoots/vine spaced at 10'x6'. If all the 70-75 shoots are retained, there will be heavy competition of nutrient, water and also sunlight. During the growth stages if dry weather persist, inoculums of powdery mildew will spread at fast rate. In crowded vines, most of the shoots do not receive the spray effectively leading to multiplication of the disease. The number of sprays required to control powdery mildew will also increase thus leading to increase in the cost of diseases control. Due to heavy crowing of shoots, the relative humidity in the canopy will increase, which creates the congenial environment for downy mildew diseases. During the rainfall period if the new growth continues, there will be a fast spread of anthracnose disease. Hence, to avoid these problems during the growth stages, retention of required shoots per vine can help in avoiding the spread of powdery mildew and Downey mildew diseases. Removal of new growth by maintaining the proportion of leaves/shoot can also avoid the spread of anthracnose.

5. PRUNING

Pruning is necessary to develop the plant and to maintain it on the support provided. Regular, purposeful pruning is essential for controlling the number, position and vigor of fruiting canes and the yield and quality of the fruit. Correct and proper pruning is an absolute if table grapevines are to be kept productive and healthy over the life of the vine. The procedure allows for the development of good vegetative growth and optimum yields. It also allows for proper distribution of the food within the vine canopy, which has a big influence on berry quality. Incorrect pruning, on the other hand, can seriously damage vines, limit fruit production and shorten the life of the plant. Unpruned table grapevines soon become unproductive and overgrown since basically it is a creeper. Pruning is the removal of vegetative portions of the vine, including leaves, shoots and canes. If the vines are too vegetative, the crop will be short

and fruit quality will be low due to shading year after year. On the other hand, if over-cropping is allowed to occur, the fruit will be of low quality, harvest will be late, and in extreme cases, the vine can die. Unfortunately, there is no simple rule for pruning table grapes; each vine needs to be pruned to maintain the delicate balance between vine vigor and fruit production. Different vines require different choices when deciding which canes to cut and which to retain. In addition, the amount of wood left is highly dependent upon the strength and health of the vine.

5.1 TYPE OF PRUNING

Fig. 14a : Plant at beginning

Fig. 14b : Plant after forward prunning

5.1.1 SUB CANE PRUNING

After foundation pruning, the growing shoot is cut at 7th leaf position when it is at 9-leaf stage. The side shoot arises from the cut end forming a knot. The inter nodal distance on the shoots arising laterally is less at the beginning. Pruning 1 or 2 buds after the knot is an indication of the presence of fruitful bud on the sub cane. However, on the knot the presence of strong bud indicates the strong and healthy bunch. The growers do not utilize this bud many times. Due to apical dominance phenomena the top bud gets sprouted and the basal buds becomes dormant at later stage. Pruning just near the knot on the sub cane can help in getting strong bunch on the cane.

5.1.2 STRAIGHT CANE PRUNING

The shoot is not cut at 7th leaf as it is done in case of sub cane but is allowed to grow till 12-13 leaves. It is then pinched to stop the growth. By pinching the shoot at later stage the shoot grows slowly and the requirement of 16- 17 leaves per shoot gets fulfilled. Straight cane is generally recommended when enough irrigation water is not available in the vineyard during the period of vegetative growth. During forward pruning, the straight cane is pruned depending on the fruitful bud available on the cane. The pruning position differs from variety and shoot length.

However, reduction in inter nodal length is proper indication for fruit pruning in straight canes. While conducting the experiment on straight vs. sub canes it was observed that the straight canes had more thick canes than in sub canes. The bunch size was also more leading to the better quality grapes.

5.1.3 SPUR PRUNING

Spur pruning is done in case of wine grapes. This is the simple method that requires little or no decision on what to select for fruiting wood. A difference between spur and cane pruning is the bud number taken into consideration for pruning. The pruning is done at two or three bud position. The buds on the spur should be 4 to 6 cm apart. If more than one shoot grew from a node on the cordon, select the strongest one and cut off the others. Generally basal buds are not fruitful in case of table grapes. Hence the spur pruning is not followed. Even in some of the wine cultivars, the basal buds of canes aren't fruitful; the shoots that grow from these buds do not produce fruit. Hence, instead of spur pruning of these cultivars cane pruning is followed.

5.1.4 PRUNING LEVEL

Pruning level in grapes refers to the pruning intensity. Retention of number of canes on each vine refers to the intensity of pruning the vine whereas the retention of number of buds on each cane refers as intensity of cane pruning.

5.1.5 INTENSITY OF PRUNING

Intensity of pruning a cane refers to number of buds left on the cane. This depends on the following :

1. **Cane vigor and thickness :** More vigorous canes (thick with long internodes) have fruitful buds at distal ends while less vigorous canes (thin and short internodes) have fruitful buds at basal nodes.

2. **Climate :** Position of fruitful buds again depends on climate. In mild climate, the fruitful buds are on distal end, in moderate climate at middle region and severe climate at basal ends.

3. **Genotype :** The position of fruitful bud varies with variety / genotype. e.g. Anab-e-Shahi : 4-6, Bangalore Blue : 3-4 and Thompson Seedless : 5-12

The most fruitful canes are those that were exposed to light during the growing season, are not less than pencil width in diameter, and have an average inter node length (long internodes indicate too much vigor). If we are uncertain as to whether the basal buds of a cultivars are fruitful, it's best to cane-prune. However, it is easy to convert from one system of pruning to the other.

While training the vines, remember the following :

1. **Stem :** Height should be more than 135 cm from the ground to the point of primary branching. This helps in storage of enough food material required by the vine.

2. **Primary arms :** Possibly two arms should be maintained having proper thickness with 30-35 cm length. The arms developed should be in East-West direction.

3. **Secondary arms :** The arms developed should be four placed horizontally facing North-South direction. Length of each arm should depend on the distance allotted to each vine on one side. At least six-inch gap should be maintained between two arms. Since these arms are the basic unit of food storage for canes developed, the thickness should be 10 - 15 cm.

4. **Shoots :** The shoot is the basic unit developed on the cordon after back pruning. On each vine at least 75 to 80 shoots are sprouted after back pruning. Retention of all shoots affects the quality. Hence retain 0.60 to 0.65 shoot per square feet spacing of the vine. The shoot length is also restricted to 95 - 100 cm during back pruning. The orientation of shoot should be in such a way that the shoots are positioned vertically for proper fruit bud differentiation. For proper bunch development after forward pruning, the cane should be 8 - 10 mm in diameter.

5. **Leaf :** For proper nourishment of the bunch, the leaf having 150 to 180 cm^2 leaf area should be maintained on each shoot. There should be 16-17 leaves per shoot.

6. SUMMARY

Grape *(Vitis vinifera)* is one of the most important commercially grown crops of the country. Major area under grape cultivation is concentrated in central and peninsular Indian states like Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu and a limited extent in the areas of North. At present, grape is cultivated in an area of about 62,000 ha with annual production of 1.6 million tonnes, which makes a share of 1.97 percent of total production of grapes in the world.

The major quality parameters in grape are size in terms of diameter and length, shape of the cluster, cluster filling, total soluble solids, acidity, berry adherence for increased shelf life, etc.

Training, basically a potential tool in managing the canopy architecture in plants with weak stem, like grapevines. Vigorous vineyards have the potential for higher yield if the vigor is properly exploited. Rather than reducing the vigour of vine to fit a standard trellis, we need to design more effective trellis system.

Appropriate training is essential for the production of a optimum yield with high quality fruit and to maintain a balance between vegetative growth and fruiting. In peninsular India and other tropical region, the vine has evergreen growth habit. The climatic conditions are different in different parts and therefore the growth habit and the pruning time cannot be same. Hence, the pruning practices needs to be followed, as the growth habit of the plant is different in different regions.

To be most productive, grapevine should be trained and pruned to a definite system keeping in view more productivity.

The use of training system depends on various factors like weather condition of the region, soil type, type of grapes grown and vigour of the variety. In addition, the training system selected should be economically viable for maintenance and cost of production.

To increase the vine productivity through canopy management, different training systems are being used. Wine varieties by and large impart less vigour. Hence, for optimum yield of the wine grapes the spacing also needs to be reduced and the training system like 'T', single wire, kniffin, etc. has to be followed.

Training of vines has the advantages *viz*., the vine gets supports for growth, the trunk, which is called as storage wood becomes erect which can support the cordons, canes, shoots and bunches, etc., it helps in achieving adequate number of canes, which are the fruiting units, it allows sufficient light and ventilation into the canopy during the growth season, it avoids overlapping of the foliage to facilitate efficient photosynthesis by every leaf, it offers scope for effective coverage of sprays with pesticides and growth regulators, it avoids build up microclimate that is congenial for disease development, etc.

For efficient utilization of the available resources by the vine resulting into quality grape production, training needs to be given priority right from the beginning.

Single and double cordon training helps in receiving the uniform sunlight required for bud differentiation. This system allows for excellent light and spray penetration, yields high-quality fruit and easy to prune. On the other hand, the multiple cordons due to overcrowding of the shoots become less fruitful. A significant advantage of cordon training is its suitability to cultural operations like thinning of bunches and dipping in growth regulator solution.

While developing the framework during the first year, the cordons are developed by *"stop and go"* method. In this method, the shoot selected for cordon development is cut at 5-6 leaf positions when the total number of leaves are 8-9. This helps in sprouting of all buds on pinched shoot.

Since the vine is trained right from the grafting in the field from the first year, training in old vines is not much required. In case of dead arm on the old cordon, the process of rectification can be undertaken.

Pruning is necessary to develop the plant and to maintain it on the support provided. Regular, purposeful pruning is essential for controlling the number, position and vigor of fruiting canes and the yield and quality of the fruit. Correct and proper pruning is an absolute if table grapevines are to be kept productive and healthy over the life of the vine.

The procedure allows for the development of good vegetative growth and optimum yields. It also allows for proper distribution of the food within the vine canopy, which has a big influence on berry quality. Incorrect pruning, on the other hand, can seriously damage vines, limit fruit production and shorten the life of the plant.

Sub cane pruning, straight cane pruning and spur pruning is generally followed in grape.

Intensity of pruning a cane refers to number of buds left on the cane. This depends on cane vigor and thickness, climate and genotype.

7. DO'S AND DON'TS IN TRAINING THE VINE

DO'S

i. Train the sprouted shoots on bamboo initially and tie with wire. This will help in achieving the straight trunk and avoid formation of dead wood.

ii. When the shoot grows 3 inches above the first wire, cut 3 inches below the wire. Follow the same while cutting at second wire. This gives proper direction to the sprouting of side shoots for the formation of primary and secondary arm.

iii. Develop the cordon in installments by using *"Stop and Go"* method.

iv. Develop limited canes during the first year to maintain the health of the vine.

v. Make sub canes only when enough irrigation is available that results into more vigor of the vine.

vi. The shoot orientation for harvest of maximum sunlight should be 90° after April pruning and 45° after October pruning for protection of bunches from sunlight.

vii. Retention of 0.67 shoot for every square feet during April pruning can help in production of exportable quality bunches after October pruning.

DON'TS

i. Avoid hard pinching for developing the cordons.

ii. Avoid developing canes on the trunk during the first year. By doing this, the trunk may get exhausted leading to weakening the vines.

iii. Avoid over-crowding of shoots and natural shading of leaves.

iv. Do not reduce the angle of the shoot less than 45° when the shoot orientation is in vertical direction after October pruning.

vii. Restrict the shoot growth by maintaining 16-17 leaves per shoot.

8. DO'S AND DON'TS IN PRUNING THE VINE

DO'S

i. The vines should be pruned based on the time of selling the produce in local or international market.

ii. The leaf removal should be done 7-8 days before October pruning in case of grafted vines and 3-4 days in own rooted vines.

iii. The canes should be swabbed with bud-sprouting chemical twice in case of thick canes having diameter more than 10 mm.

iv. The pruned material (disease free) can be buried in the trench for composting after treating with fungicide to control from the disease.

v. The vineyard should be irrigated 2-3 days before the pruning is done.

DON'TS

i. Avoid retaining the canes having less than 6 mm diameter.

ii. Avoid delay forward pruning under the situation of complete leaf fall due to heavy rainfall or disease incidence.

ANNEXURE - I

Some knowledge of grapevine parts is helpful in understanding pruning details.

TRUNK

This is the main and permanent stem of the plant.

ARMS

These are the side extensions of the main stem. The primary and secondary arms are the major constituents of the vine. They are the basal portions of former canes that were left after pruning.

SHOOTS

Immature, soft stem growths of the current growing season are shoots. Shoots arise from buds on wood one or more years old and bear leaves, flowers and fruit.

CANES

These are the mature shoots, those that have become woody after growth has ceased. Fruiting cane merely refers to a one-season-old cane that is capable and suitable for bearing fruit.

SPURS

These are also one season old matured shoots called spurs. The shoot pruned at 3-4-bud position in case of wine grapes are called spur-pruned canes.

SUCKER

This shoot usually arises from the ground at the lower part of the trunk.

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