Grape Cultivation on Rootstock

भाकृअनुप
ICAR

National Research Centre for Grapes

(Indian Council of Agricultural Research)

P. B. No. 3, P. O. Manjri Farm, Solapur Road, Pune - 412 307

Correct Citation :
Somkuwar, R. G. and Adsule P. G. (2004)
Grape Cultivation on Rootstock

Technical contribution and compilation by :
R. G. Somkuwar
Senior Scientist (Horticulture)
Dr. P. G. Adsule
Principal Scientist (Horticulture) and Director (Acting)

Editors :
Dr. P. G. Adsule
Dr. Anuradha Upadhyay

Technical Bulletin No. : 5
November 2004

Price : Rs. 70/–

Published by :
Dr. P. G. Adsule, Director,
National Research Centre for Grapes
P. B. No. 3, P. O. Manjri Farm,
Solapur Road, Pune – 412 307.
Tel. : 020-2691 42 45, Fax : 020-2691 42 46

Printed at :
Flamingo Business Systems
19, Laxminagar Commercial Complex No. 1
Shahu College Road, Pune – 411 009.
Tel. : 020-2444 78312, 2444 0636
Email : flaminbs@vsnl.com

CONTENTS

LIST OF TABLES

LIST OF PHOTOPLATES

PREFACE

Grape is one of the important commercial fruit crop grown on a large variety of soil. Maharashtra occupies 60% of the total area under grape cultivation in the country. Earlier, grapevines were exclusively grown on their own roots, as most of the areas were considered free from soil and water borne problems. Commercial exploration of rootstocks was not known in India till recently. However, with the reports of declining yield in the states of Maharashtra and Northern Karnataka due to problems associated with the salinity of soil and water and severe drought, the interest on the rootstocks started growing. Rootstocks have not only potential for combating the soil and water problems, but also a potential tool for manipulating the vine growth and productivity. The bulletin covers in detail the conditions when the rootstock to be used, its choice, cultural practices right from preparation of land till it is grafted, and care of grafted vines. All this information has been substantiated with the research data in tabular forms and photographs etc.

The information given in the bulletin will serve as guidelines for the grape growers to imbibe this new technology under the various situations of soil and water. Further, the bulletin is also handy for the growers as well as for the researchers and the students engaged in the research and developmental activities of grape. I also take this opportunity to acknowledge the help received from all the concerned of this centre in bringing out this bulletin.

Place : Manjri, Pune
Date : November, 2004

P. G. ADSULE
(Director)

1. Introduction

Grape is one of the important commercial fruit grown on a large variety of soils. In India, it is grown on about 45,000 hectare area with annual production of 12,00,000 tonnes. Maharashtra is a leading state in area, production and also in quality. It accounts for 60% of the total area under the crop in the country. Till 1985, most of the grape vineyards were raised on their own roots, as there were no noticeable problems of soil and also of quality and availability of water used for irrigation. Subsequently, there were reports of reduction in yield due to the soil and water related problems. The water used for irrigating grapes was found with high reach of chlorides contributed mainly from the chemical fertilizers. Due to the drought during the last four years, the situation of irrigation water scarcity is becoming worst in grape growing regions of Maharashtra and other parts of country.

Based on the research carried out in other countries, the commercial harnessing of rootstocks in grape growing has gained importance and benefits.

A few species of genus *Vitis* are hardy in nature and able to sustain under adverse soil and water situations. Particularly species like *Vitis champini*, can grow well, develop large root system and provide required support to the table/raisin or wine grapes, making it commercially viable.

Rootstock is the lower portion of the graft, which develops into the root system of the grafted plant. The rootstock can originate through seed, rooted cuttings or a layered plant. Rootstocks are also a means to vegetatively propagate clonal cultivars. Many crop species or cultivars cannot be propagated on their own. Hence the only means of propagation is through grafting or budding. This is carried out generally on the rootstock of same or related species.

2. Considerations in the choice of rootstocks

Adoption to unfavorable soil condition - The rootstock are tolerant to saline soil conditions and poorly drained soil.

Adoption to unfavorable water quality conditions - high soluble salts, high chlorides.

Resistance or tolerance to the pest and diseases such as *phylloxera*.

Enhancing quality of the produce-The rootstocks eg. Dogridge B is found to increase the quality of the fruit.

Controlling the size of a plant - The tree size can be controlled by the use of rootstock eg. Dwarfing rootstock in apple and mango.

Higher input use efficiency -Rootstock by virtue of enlarged root system, provide higher rate of nutrient absorption, higher nutrient use efficiency. Due to deep penetration and contact with large volume of soil-rootstock can sustain water scarcity and produce crop with limited irrigation water.

2.1 Soils

Grapevines grow on a variety of soils of variable properties. However, long term performance is affected by the soil physico-chemical and microbial properties of soil, *viz.*, soil depth, texture, pH, EC, ESP, free $CaCO_3$, state of organic matter and types of microorganisms. The soil may be at least one meter deep. There should not be hard and impervious rock within 1 m depth. In shallow soils, due to poor drainage in rainy season the active root zone of the vines suffer from lack of aeration and therefore such soils are not suitable for grape growing. Shallow soils should be thoroughly ripped to 1 m depth before planting and engaging modern tillage machinery. Sandy soils have poor nutrient status and water holding capacity. Under such condition, clay soil should be mixed to improve their water holding. Loamy soils are the best for grape production. While selecting soil of specific site following consideration be made.

1. Away from river or water body like lake/tank to avoid high relative humidity.
2. Away from road, highway to reduce menace of mites and dust and heavy metal accumulation on the produce.
3. Slope to the extent of 3%.
4. At least a meter soil depth.
5. Soil be free from the sub surface hardpan or rocks.
6. Soil should be non saline or saline which can be tolerated by rootstock.
7. Soil to be free from water stagnation even in rainy season and have provision of drainage.

2.2 Water

Grape is irrigated crop and therefore cannot be grown successfully without irrigation. To provide adequate canopy and healthy canes, vines are given irrigation adequately. The situation, where the available irrigation water is less than the requirement, the use of rootstock is necessary, as it has well developed root system, exploring water from large volume of soil and at deeper depth. The quality of irrigation water also plays an important role in grape cultivation. Irrigation water

should be free from high concentration of soluble salts (EC>1.00 dsm^{-1}). With Bangalore Dogridge rootstock grape can grow up to EC 3.8 dsm^{-1} the safe limit of Cl is 3 miliequivalent (me) per litre and with rootstock up to 18 me/1.

3 When to use rootstocks ?

The following are the situations where rootstocks can be used.

3.1 In saline soils

The soils are said to be saline when the EC of its saturation extract is more than 2 ds/m, ESP less than 15% and pH less than 8.6. Excessive Cl^- in the soils causes leaf scorching and defoliation which leads to low yield and inferior quality produce. Marginal leaf burning, premature leaf fall, stunted and weak growth and reduced yield are the symptoms of salinity injury.

3.2 In sodic soils

Sodic injury due to high sodium status is problem in arid tropics. The soils are said to be alkaline when the EC of the saturation extract is less than 2 ds/m, ESP is more than 15% and pH between 8.6 and 10.0. Weak vine growth with slender shoots, small leaves and short internodes are symptoms of alkalinity injury. Such soils may be avoided for grapes.

3.3 In drought regions

In semi arid tropics, where evapotranspiration is high, vines suffer from soil moicture stress. This can result in weak growth and poor crop production. Excess moisture stress leads to reduction in the number of canes and its size, small berry size with dull fruit color. Bunches on such vines will be exposed directly to the sunlight. The color and appearance of such bunches are of inferior type for the sale.

Scion growth is vigorous on rootstock, which are capable of developing the larger feeder roots and also far away locations from the stem. Hence, the water and nutrient are utilized from a greater volume of the soil. This character of rootstock can be utilized to make best use of available soil moisture and reduce the water input.

Thus, one can minimize the quantities of applied nutrients to the soil by employing rootstocks. Dogridge rootstock was found to be an efficient user of available nitrate and potassium. Hence, this rootstock can be useful to get added advantage to the applied potassium.

3.4 In vineyards where yield is low and produce is poor

Yield and quality of grape can be increased by various canopy management practices. Rootstocks are considered as an important tool to alter the shoot vigor and bring equilibrium among the growth, yield and quality. Rootstock also increases the fruit bud differentiation, since they have the ability to synthesize excess cytokinins is in their roots.

Figure 1. Vines on own root (left) and on rootstock (right)

4. Choice of kind of rootstocks

Choice of rootstock has been suggested keeping in view the soil conditions, water quality and availability of water. However, it is advantageous to use rootstock in long term prospective looking at the history of the vineyard in the world, particularly the devastation by *phylloxera*. In Europe continent, it is a policy decision of the government to go for rootstock to overcome the *phylloxera* and other unfavorable soil and water quality situations.

It is within our choice to select the rootstocks from the available and also for the situations prevailing in the area and also in the field where actual planting is being done. The ultimate selection of the rootstocks for each location must, however, rest with the individual grower.

In Maharasthra, the situation is totally different in Nasik, Sangli, Pandharpur and Tasgaon. In these areas grape cultivation is facing the problem of saline and high content of chlorides in irrigation water. Under such conditions, selection of suitable rootstock is critical. Little research has been conducted so far on this aspect. Some of the rootstocks being used in grape cultivation are as below.

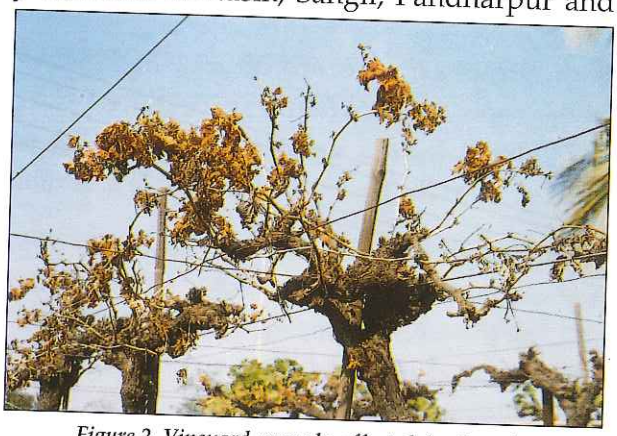

Figure 2. Vineyard severely affected by drought

1. 1103 Paulsen - Drought tolerant
2. 99 Ritcher - Drought tolerant
3. 110 Ritcher - Drought tolerant
4. SO_4 - Lime tolerant
5. Ramsey - Tolerant to saline soil
6. St. George - Drought tolerant
7. Dogridge - Can be used in all condition

5. Preparation of rootstock cuttings

5.1 Selection of cuttings from mother plant

The cuttings can be taken during September to October from mother plant. During this period, the mother plant of the rootstock will be in active phase as the temperature and humidity will be appropriate. Also, the required sap flow for bud sprout will be available. The cuttings will also get 3-4 month period for the root development till planting time of February-March.

5.2 Preparation of beds or polybags

The rooted cuttings in the nursery should be of at least 3-4 months old. The rooted cutting of this age generally develops the required root system. Before removing the rooted plants from the nursery bed (size 5' length and 2'6" width), they must have at least 4 to 5 mature buds on the shoots. The rooted plants are from nursery beds as well as from the polybags. The size of polybags for planting the cuttings should be large enough to supply the nutrients to the cuttings for the development of roots in bag. It should not be less than 7" x 4". The rooted plants in polybags are preferred for long distance transport.

5.3 Time of multiplication

The study conducted at the Centre for two years on the optimum concentration of IBA and season of planting revealed that the rooting of the cuttings was higher during October as compared to February month. Further, dipping the cuttings in 2000 ppm IBA had more success in rooting as compared to control.

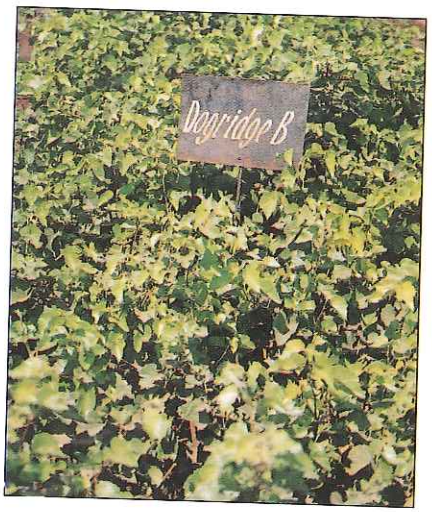

Figure 3. Dogridge B rootstock in nursery bed

6. Land preparation for vineyard establishment

Land should be levelled by the tractor. The major weeds like *Cyanadon dactilon* and nutgrass *(Cyprus rotundus)* should be completely controlled with the aid of herbicides like Glyphosate @5-6 ml/lit for Cyanadon and 12-15 ml/lit for nutgrass or manually. If the weeds are not controlled before the vineyard establishment, it competes with the grapevines for fertilizers as well as for water, Repeated 2-3 sprays of herbicides are required for complete removal of these weeds.

6.1 Trench opening, filling and direction

Trench opening is done before planting of grape rootstocks in the field. This operation of trench opening and filling makes the soil loose, friable and permeable to water, which is congenial for good aeration and since rootstocks produces huge mass of feeder and deeper roots. This helps in the better root penetration and distribution into the deeper layers of the soil. Land preparation and trench opening should be started during the month of December to January in a year. During this period, the rainless days helps in carrying out the trench opening and filling operations easily.

The size of trench should be about 75 cm deep and 75 cm width at a desired spacing depending upon the soil type. The depth and width of the trench can help in easy spread of the roots in the trench after planting. The length of the trench should be preferably 200 to 250 ft. This helps in carrying out cultural operations conveniently after the vineyard is established. While opening trenches, top 30 cm layer of the soil should be kept at one side of the trench and bottom soil at the other side. The opened trench should be allowed to expose to the sun for about 10 to 15 days before filling operation. While filling the trench, the topsoil should be filled in the bottom upto 2' depth. Above which the green manure crop like Sunhemp and Dhaincha should be spread. Well decomposed Farm yard Manure (1 basket or 20 kg) and the mixture of 500 g single super phosphate (granulated or powder) with 100 g urea, 100g SOP, 200 g $MgSO_4$ and 10 g micronutrient mixture are added per running foot of the trench. The remaining trench should be covered with the down surface soil and level. Make a light furrow in the covered trench for flood irrigation so that the trench will get full irrigation and the soil will also sink by filling the pore spaces.

Figure 4. Trench opening

The direction of the trench is not important when the vines are proposed to train on bower system. However, this should be taken into consideration if the proposed planting is to be trained on Y system of training. The trench should be in North - South direction under such cases. This helps in equal harvest of sunlight on both sides of the vine. This can also minimize the sunburn of bunches under the hot regions. The planting done in East - West direction is exposed to the sun throughout the day resulting in increased scorching of the berries of that side.

6.2 Ripping

Ripping is done in rocky and semi rocky soil to loosen the upper soil strata for easy penetration of water and thereby in-situ conservation of rainwater. This will also help the roots to go deeper in search of water and nutrient. This operation has become essential in light and rocky soils where grape cultivation is being taken.

6.3 Season of planting

The planting of rooted cuttings of the rootstock should be done from February to March in a year because the temperature starts rising above 15 °C, since then which is congenial for growth of plants. The planting carried out during this period will help in development of the root system in the field and also get the desired thickness of shoot for grafting during September.

6.4 Planting of rootstock

Depending on the soil conditions and the temperature prevailing during the season, the field comes in 'Wapsa' condition after flood irrigation in three to five days. While planting rootstock in the field, the pits of 1′ x 1′ x 1′ (30 cm x 30 cm x 30 cm) should be opened. The distance between each pit in a row depends on the spacing already decided while planning the layout in the beginning. The distance in general should be based on the soil type. In heavy soil, it can be 6 ft (2m) while in light soil 5 ft (1.5 m) is sufficient. Before placing the rooted plant in the pit, 100 g FYM, 500 g sand and 5 g Chlorpyriphos should be added to the pit. Addition of FYM and sand helps the young fibrous roots to penetrate in the soil easily. Application of Chlorpyriphos helps in controlling the termites when the

Figure 5. Rootstock planted in main field

temperature rises during Match-April. The plant should be kept in center of the pit and pressed with the soil firmly. In case of polybag plants, care should be taken while removing the plant from the polybags that the roots are not cut with the sharp blade. If the rooted plants are taken from the nursery beds, the green portion of the shoot and the leaf should be removed before planting. The irrigation should be given immediately after planting.

7. Care of planted rootstocks till grafting

Once the rootstock is planted in the field, the new growth starts after 10 to 15 days of planting. The plants in the field should be reared properly to attain its appropriate size for grafting and also for its root development.

7.1 Irrigation

Irrigation should be given to plants before it shows symptoms of moisture stress. Since the feeder roots will be only on the top layer of soil, light irrigation is required everyday up to 30 days after the planting. During this period, the roots establish in the soil. Once roots are established, alternate day irrigation is adequate in heavy soil and everyday in light soil. Irrigation system in the field should be laid in such a way that all the plants in the vineyard get the same quantity of water.

Figure 6. Equal discharge of irrigation water

7.2 Manuring

The manures and chemical fertilizers should be applied to the young rootstock plants as given below.

Table 1. **Manure and fertilizers applied to young rootstock plant.**

Period after planting (days)	Nutrient / fertilizer formulation	Quantity (Kg/acre/day)
0 to 15	--	--
16 to 30	Urea	0.5
31 to 45	19 : 19 : 19	1.0
46 to 60	Urea	0.5
61 to 75	19 : 19 : 19	1.0
76 to 90	Urea	1.0
91 to 105	19 : 19 : 19	1.0
106 to 120	Urea	1.0
121 to 150	13 : 00 : 46	1.0
151 to 180	0: 00 : 51	1.0

7.3 Plant protection of young rootstocks

The rootstock plants are resistant to the common grape diseases like anthracnose, powdery mildew and downy mildew. However, they are more susceptible to rust and alternaria diseases. Therefore, care should be taken to prevent them from rust and alternaria. The incidence of these diseases occurs mostly on the older leaves. The diseases are not of much importance in the rootstock as all the leaves are to be removed before grafting. However, the rust can be controlled by spraying Kavach (Chlorothalonil) 1g/litre, Baylaton (Tridemefon) @1g/litre and *Alterneria* by spraying Blue Copper (Copper oxychloride) @2g/litre. Among the pest, chaffer beetle is serious and could be controlled by spray of Sevin (Carbaryl) @2g/litre.

Figure 7. Rootstock affected by rust

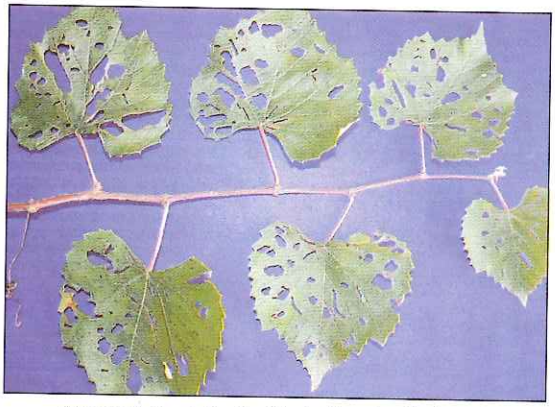

Figure 8. Rootstock affected by chaffer beetle

8. Selection of shoots and training

All the shoots of rootstock should be allowed to grow for about 50 days. This helps in building up of the sufficient food reserves in the plant. After 50 days, weak and thin shoots are removed leaving 2-3 strong and healthy shoots. For successful grafting, generally two shoots are grafted on one rootstock and therefore retention of three shoots initially allows selection of best two shoots on the rootstock plant. Bamboo sticks are erected in each basin and shoots are tied to it to grow them straight. This avoids the formation of dead wood on stem during the process of vine growth after a few years of planting.

On the retained shoots, leaves are removed in batches. Initially, 2 to 3 leaves are removed and then at every 15 days interval. This allows retention of sufficient food reserve in the shoot and also the straight growth. The growth of straight shoot will not be affected by dead wood of the shoots.

Figure 9. Shoots ready for grafting

9. Period of grafting

The February or March planted rooted cuttings will attain the graftable size of about 8 mm thickness with good food reserves by September to October in the year which is the best season for grafting. During this period, the shoots of the rootstock will be in full sap flow condition as required for the callous formation and success of the graft. A temperature of about 30 to 35 °C and relative humidity above 80% has been found the best for successful grafting based on the experiments at this institute. The success of grafting also depends on the skill of the person carrying out the grafting operation. If the grafting done during September or October fails due to one or the other reason, it is better to go for green grafting during next May or June months. To avoid the mixture of the varieties in the same block, some of the shoots are to be retained on a vine so as to use during grafting on the grafts, which has failed.

9.1 Selection of scion and Pre-grafting treatment

The scion should be selected from the disease free and high yielding choice variety from the vineyard. The canes selected for grafting should be mature and have healthy buds and short internodes. Generally one season old cane fulfills the requirement of scion for grafting. There should be at least two buds retained on each selected scion stick. The selected scion stick are then kept in the solution of Carbendazim @1g/litre for about 2 to 3 hours or even more time to avoid the incidences of the diseases like *Botrydiplodia* in a vineyard. If the inoculums of the disease is not killed before grafting, the dark blackening on above graft joint starts appearing after one-month period and the infection continues to move upward resulting in the drying of vine. This kind of symptoms has been observed at the Research farm of this Institute in case of Sharad Seedless variety. The selected cuttings for grafting should be kept in moist cotton or gunny bag. Preferably, fresh cuttings should be taken for grafting everyday to achieve the higher success rate.

9.2 Grafting

Grafting is done by the following two methods.

i) *In situ* grafting.

ii) Grafting in the nursery beds.

9.2.1 In situ grafting

The grafting is carried out on matured shoots of rootstock planted in the field. Since the root system is well developed and shoots have attained the desired thickness, the success rate is higher in this type of grafting. This system is more popular among the growers and has the following advantages.

1. The rootstock can be planted in the field as per the availability.
2. Rootstock establishes faster in the field and can attain the graftable size in 4 to 5 months.
3. The roots develop much faster in the ground as it receives more rooting media.
4. The graft success rate is higher.
5. It avoids the transplanting shock as in the case of grafted plants.

The shoots are separated from bamboo by removing the twin tied earlier. The selected shoots are then cut at about 1½ ft. (45 cm) height from the ground surface. With the help of grafting knife, make vertical slit cut (V notch) of about 4 to 5 cm downward from the cut end of the stock. At the basal end of the scion, the bark on two opposite sides should be removed with sharp knife and make it into a wedge shape of 3 to 4 cm without damaging cambium layer. The pith of the basal portion of

the scion should be exposed. The wedge shaped scion be inserted into the vertical slit on the rootstock and tied the stock and scion firmly with polythene strips. The wedge shaped scion should be inserted firmly in the stock leaving no space in between. There should not be any air space left while tying the graft joint by plastic strip. If the plastic is not tied properly, the graft joint exposed to air and raindrop may leads to the drying or infection by pathogen leading to the failure of graft.

Figure 10. Scion prepared for grafting

Figure 11. 'V' notch made during grafting

The stock and scion selected for grafting should be of same thickness for good union. If this is strictly followed, there will always success of the grafting. Grafting should be done at the height of 1½ ft. (50 cm) above ground level. If the grafting is done very close to the ground level, it may lead to rooting at graft union due to soil contact. In a vineyard, there is a practice to make earthing up every season to develop feeder roots. Under such situations, the grafting joint comes in direct contact with soil and starts rooting from scion part. The grafted vine if develops root at the joint, it becomes the own rooted vine and the purpose of use of rootstock under adverse situation gets defeated. If the grafting is done above 1½ ft. (50 cm) height, the stem does not get enough length to store the food reserve.

Many times it becomes difficult to get both matured scion as well as stock. Research studies conducted at this institute on the maturity of scion and stock on success of graft union revealed that mature stock + mature scion and immature stock + mature scion give good success of the grafting. The data is presented in the table 2.

Table 2. Standardization of level of maturity of stock and scion for success of grafting in TAS-A-Ganesh (scion) grapes.

Level of maturity of stock and scion	Sucessful graft (%)	Stock : scion ratio	Shoot length (cm)	Days taken for bud sprout
1. Mature stock + Mature scion	95.00	0.79	85.41	16.93
2. Mature stock + Immature scion	92.00	0.90	105.40	17.60
3. Immature stock + Mature scion	74.00	0.87	114.34	16.84
4. Immature stock + Immature scion	53.00	0.86	82.97	17.06

9.2.2 Grafting in Poly bag and transplanting in the main field

In this system, the cuttings are to be planted well in advance in the poly bag. The success rate in this method is less compared to the *in situ* grafting and requires more attention for the maintenance of the plants. This method has the following disadvantages.

1. The roots do not develop as required for well-established plant in the field.
2. The shoot diameter of rootstocks does not attain 8 mm thickness at the graftable height of 1½ ft. even after one year in the polybags.
3. It takes more time for the grafted plant to establish in the main field after transplanting as the roots receive shock at the time of removing from the polybags.

Because of these disadvantages, this method is not popular among the farmers and *in situ* grafting is preferred.

After considering the effectiveness of the grafting, it is always better to plant the rootstock in the main field and perform *in situ* grafting.

Figure 12. Mature scion and immature stock

10. Graft performance of commercial varieties on different rootstocks

Selection of rootstock depends on the condition of the soil and water in the proposed grape vineyard. The study was conducted at the farm of NRC Grapes with the objectives to study the graft success of Thompson Seedless and also Flame Seedless on different rootstocks. Data on the compatibility with rootstock is presented in table 3. It was observed that the rootstock 110 R, Dogridge B and 1103 P recorded maximum successful graft percentage with Thompson Seedless whereas Flame Seedless recorded maximum success on 110 R rootstock.

Figure 13. Comparison of nursery grafted and in situ grafted vine

Table 3. Graft performance of Thompson Seedless and Flame Seedless scion on different rootstocks.

Rootstock	Stock : scion ratio		Shoot length (cm)		Days taken for bud sprout		Successful grafts (%)	
	T.S.	F.S.	T.S.	F.S.	T.S.	F.S.	T.S.	F.S.
110 R	0.92	1.04	80.02	103.60	17.01	17.20	90.0	92.5
99-R	0.86	1.15	61.10	68.08	18.07	18.43	84.91	83.33
St. George	1.02	0.91	58.33	55.00	18.86	17.36	75.01	85.00
Dogridge-B	1.12	0.85	111.32	109.7	16.60	16.34	91.66	83.33
1103 P	0.91	-	66.30	-	17.37	-	91.66	-
SO4	0.82	-	58.81	-	16.94	-	73.88	-
Salt Creek	0.84	-	94.50	-	19.16	-	83.33	-
1613 C	0.79	-	55.66	-	19.44	-	58.33	-

T.S. = Thompson Seedless, F. S. = Flame Seedless.

11. Care of grafted vines

Generally irrigation is given 2 days before the grafting to make the rootstock plant active by increasing the sap flow required for success of grafting. The bud starts sprouting after 10th day of grafting. Bud sprouting also depends on the local weather conditions. The graft joint starts bulging with the callous formation at the union. During this period, loosening and again tieing the polythene strip around the joint is required to avoid the constriction. The cultural operations should be followed from sprouting onwards. The doses of fertilizers followed for grafted vines up to February month (re cut time) are given below.

Table 4. Fertilizer schedule for grafted vines up to re-cut.

Period after planting (days)	Fertilizer and their formulation	Quantity (Kg/acre/day)
0-15	Urea	0.5
16 - 30	19 : 19 : 19	1.0
31 - 45	Urea	1.0
46 - 60	19 : 19 : 19	1.0
61 - 75	Urea	1.0
76 - 90	19 : 19 : 19	1.0
91 - 105	13 : 00 : 46	1.0
106 - 120	0 : 0 : 51	1.0

11.1 Selection of Shoots after sprouting

Both the buds retained on the scion sprout after grafting. However, due to the apical dominance the first bud grows faster than the later. Chances of occurrences of disease infection at the first bud position are more than the later and hence the shoot from the second bud is selected for training. There is a practice of taking two shoots at a time for training. In such cases, two shoots should be selected only when the growth of both shoots is uniform for the appropriate development of framework of the canopy.

Figure 14. Selection of shoot for training

Figure 15. Selection of shoot for double stem

11.2 Plant protection of grafted vines

The major pest and diseases of grafted vine are flea beetle, powdery and Downey mildew and anthracnose respectively.

Flea beetle infestation is serious threat during bud sprouting. The beetles damage the sprouting bud by sucking the sap. Hence spray of Carbaryl @3g/litre is recommended to avoid the damage. Rain at shoot development stage, results in building up of moisture which may lead to Downey mildew infection. Spray of Copper Oxychloride @2g/litre or M 45@2g/litre or Ridomil @2g/litre is recommended to control the disease. Under dry and cloudy weather condition, powdery mildew infection appears. Spraying of fungicides like Baylaton @1g/litre, M 45 @2g/litre will effectively control the powdery mildew. Wettable Sulphur @2g/litre also give good control of the disease. Continuous rain for 2 to 3 days increases the probability of appearance of brownish tinge of anthracnose on the newly growing leaf. Prophylactic spraying of Bavistin @1g/litre or blue copper @2g/litre water is recommended to protect the new shoots.

12. Summary

Grape is one of the important commercial fruit grown on a large variety of soils. It is grown on about 45,000 ha area with an annual production of 12,00,000 tonnes. Maharashtra has the major share in area and production in the total area of country followed by Karnataka, Andhra Pradesh. Till recently, the grape vineyards were

raised on their own roots as there were no problems noticed in relation to the salinity of soil and water and also severe drought. But, as the yield started declining, the importance of use of rootstock in grape cultivation realized by the grape growers.

Rootstock is the lower portion of the graft, which develops into the root system of the grafted plant. The rootstock can be used under the various conditions of soil and water quality, drought, and where there is a problem of phylloxera and nematodes and vigorousness and quality of fruits is reduced. It is the choice of rootstock can be suggested keeping in view the soil type and water quality.

The cuttings can be taken during September - October when a mother plant of rootstock is in active sap flow condition. The cuttings should be planted in the nursery beds of 5' x 2'6" or in polybags of 7" x 4" for multiplication. The basal portion of the cuttings is dipped in 2000 ppm IBA solution for fast root initiation.

Trench opening for planting the rootstock in main field is done during December - January. The size of trench should be 2'6" x 2'.6" with required length. The direction of trench should be always North-South to harvest sunlight by the canopy.

The rootstock can be planted in February - March so that the graftable size will attain till September - October, an appropriate time for grafting. Irrigation is required everyday in light soil and alternate days in heavy soil. To control rust disease the plants should be sprayed with Chlorothalonil (Kavach) @1g/lit.

All the shoots should be allowed to grow up to 50 days from planting. Afterwords, retain 2-3 strong and healthy shoots for training. Grafting is done during September-October during when there are congenial condition of high relative humidity and temperature for the success of grafting. Grafting is done by two methods - *in situ* and in nursery beds. When the grafting is failed, mature scion and immature stock method of grafting could be used to fill up the gaps.

Both the buds retained on scion sprouts after grafting. However, due to apical dominance, the first bud grows faster than the later one and therefore, there are more chances of infection by diseases. Therefore the second bud should be chosen for training.

Flea beetle infestation is serious threat during the bud sprouting period and could be controlled by spray of Carbaryl@3g/litre water. The diseases like downy mildew and anthracnose may occur during rainy days. These could be controlled by suitable fungicides recommended.