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PRESENT STATUS OF GRAPE INDUSTRY IN INDIA AND FUTURE SCOPE : A REVIEW

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ABSTRACT

Grape is export oriented fruit crop which has gained significance in India due to location specific suitable modifications. Now grape growing is being practiced in almost all climatic conditions from tropical to temperate and spread over different states. Grape cultivation on a commercial scale is about seven decades old in the country and now considered as most remunerative amongst all fruit cultivation. In India, around 78-80% of grape is produced for fresh consumption. If we look 50 years before, the country has shown tremendous progress in grape production. Innovative grape growers in respect of varietal development, adoption of grape rootstocks and modification of grape cultivation practices pertinent to Indian climatic conditions has made India prominent table grape producing country. To lead global market of table grapes, India needs indigenous grape cultivars with better quality, wider availability, climate resilience and inherited tolerance against biotic and abiotic stresses. Besides widening of varietal base and development of abiotic stress tolerant rootstocks, some more important areas need to be investigated like adoption of protected cultivation, off-season availability to enhance the export potential of the country. Use of advanced technologies such as Decision Support System (DSS), digital technologies like use of multispectral images to identify the location specific problems in a vineyard and to know the harvesting period to avoid glut in the market, use of moisture sensors to save irrigation water, robotic to know the problems in each row, etc. will help to reduce the production cost as well as bring the accuracy in the viticulture

Keywords **:** Export, grape, productivity, rootstock, varieties.

Introduction

Grape (*Vitis vinifera* L.) is one of the major important fruit crops of the country. Worldwide it is being grown mostly for wine, fresh consumption, raisins, and juice. Primarily, it is a crop of temperate region, however, it has been widely adopted in tropical and subtropical conditions. Indian viticulture is unique as it is now being practiced in almost all climatic conditions from tropical to temperate. Grape is a high value export-oriented fruit crop which has gained significance in tropical climatic condition due to location specific suitable modifications in the existing practice. Choice of specific rootstock for establishment of vineyard is difficult due to wider options. *Vitis* species, such as *V. champinii*, *V. rupestris*, *V. berlandierii*, *V. longii*, *V. parviflora*, etc. has capacity to synthesize biochemical constituent modulating scion physiology, root morphology, development, and distribution. To overcome the abiotic stresses like drought and salinity, Dogridge rootstock become popular among the grape growers, however in long run it induces high vigour on scion which reduces bud fruitfulness (Satisha *et al.,* 2010). Considering the

problems associated with present Dogridge, 110R rootstock was recommended for hot semi-arid tropical climate (Somkuwar *et al.,* 2006a). Under Indian conditions, various studies have been conducted to check the performance of available rootstocks in the country especially in relation to table grape varieties in respect of yield and quality attributes (Somkuwar and Ramteke, 2006b); dry matter partitioning and nutrient uptake (Somkuwar *et al.,* 2008); comparative performance of own rooted and grafted grapevines (Somkuwar and Adsule, 2009); raisin recovery and its biochemical parameters (Somkuwar *et al*., 2013; biochemical content and disease incidence (Somkuwar *et al.,* 2014); vegetative and photosynthesis (Somkuwar *et al.,* 2015) etc. These studies revealed that Dogridge rootstock performed better in respect of drought tolerance, graft success and dry matter distribution in roots.

History of grape growing

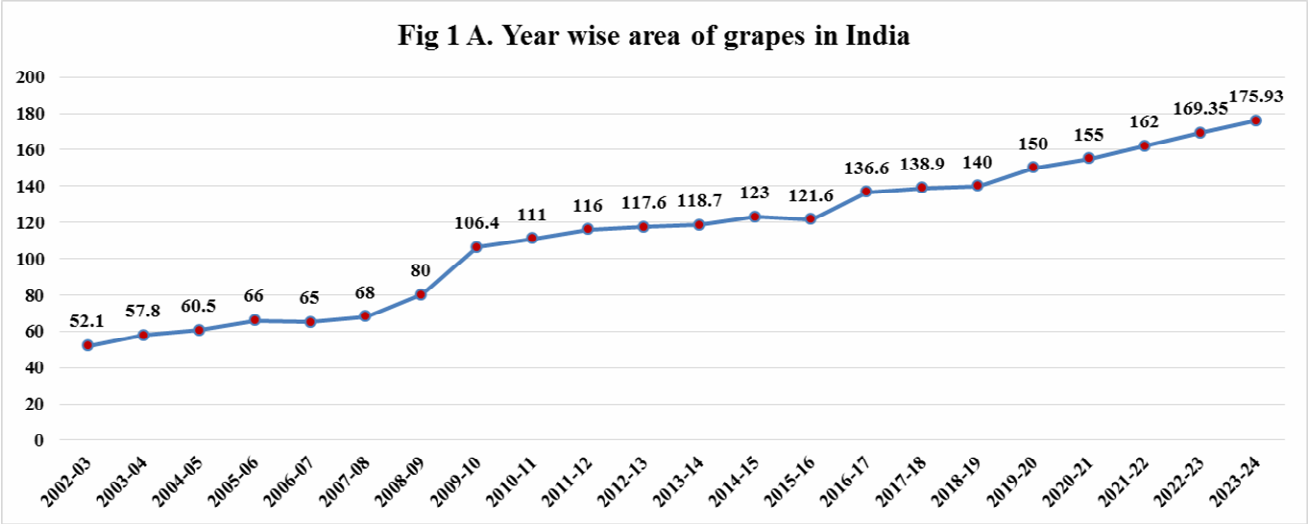
The grape cultivation began in Asia Minor between the south of the Black and Caspian Seas. From there, the Phoenicians carried the vine varieties to Greece, Rome, and Southern France before 600 B.C. At the end of the second century A.D the Romans took the vine varieties to Germany. Then it spread eastward through Turkey, Iran and to be the undivided India. As per the historical evidence, the existence of grapes in India dates back about 4000 years ago. Medical treatise of India like Charak Samhita and Shushrut Samhita written between 1356-1220BC had mentioned grapes and their utilization in the preparation of medicines. Aryans were well versed with grapes and knew its cultivation and processing into different kinds of beverages. A Buddhist pilgrim from China who visited India during 629-645 A.D. reported that grapes were found in the country. Cultivated grapes are believed to have been introduced into the north of India by the Persian invaders somewhere in 1300 A.D (Olmo, 1970). In the 14th century, Mohamed-Bin-Tughlak brought grapes to the southern parts of the country when he shifted his capital from Delhi to Daulatabad. From Daulatabad, grape cultivation spread to Hyderabad in Deccan during the Nizam's period. Nizam of Hyderabad had also introduced some grape varieties into Hyderabad from Persia in the early 20th century. The introduction of grapes into South India seems to have yet another course. The grape was introduced at Melapatti (Salem district of Tamil Nadu) by a French priest in 1832 (Shanmuga Velu, 1998). Later in the 19th century, a French Jesuit priest Rev. Fr. Larney in Michel Patti village in Madurai district introduced it (Ayyanger, 1930). From Daulatabad, Hyderabad, Salem and Madurai, the grape cultivation spread to the states of Maharashtra. Andhra Pradesh, Karnataka, and Tamil Nadu (Chadha and Shikhamany, 1999).

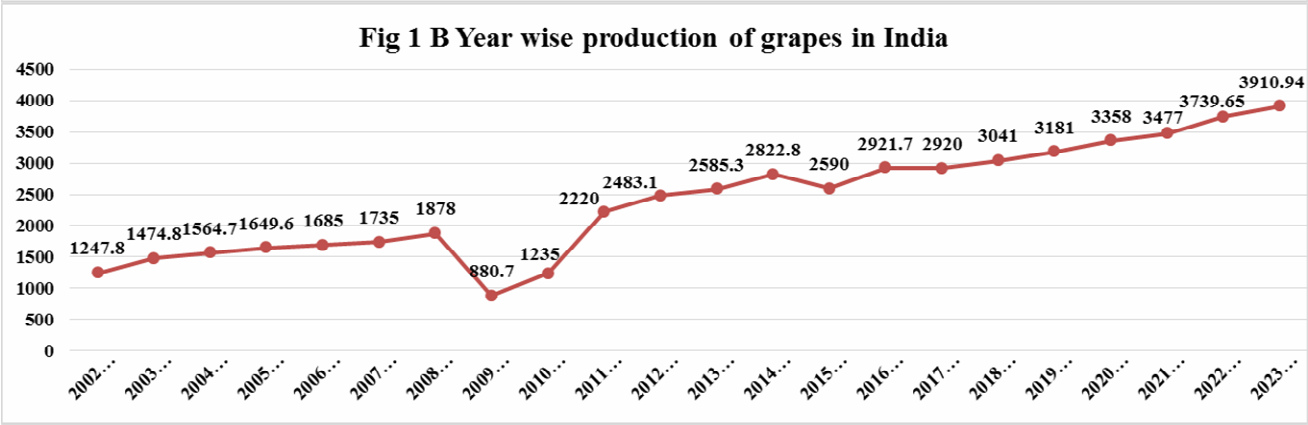
Tropical viticulture in India has a rich history with its origins in Nashik region of Maharashtra. As per the reports, in 1923, Raosaheb J.K. Gaikwad planted the first grape garden at Ozar, marking the beginning of grape cultivation in this tropical region. From Nashik, the grape cultivation spread to Satara, Pune and Solapur district of Maharashtra. Mr. Dadasaheb Shembekar, Mr. N.C. Barawake, Mr. Ganukaka Datey and Mr. Mamasaheb Tilekar were the pioneers who started grape growing around the year 1930 in the Baramati area of Pune district in Maharashtra (Chadha, 2008). Indian grape cultivation is unique in many ways like short productive span of grape orchard (15-20 years), highest productivity in the world, special pruning practices to regulate the fruiting and the absence of Phylloxera problem in the country.

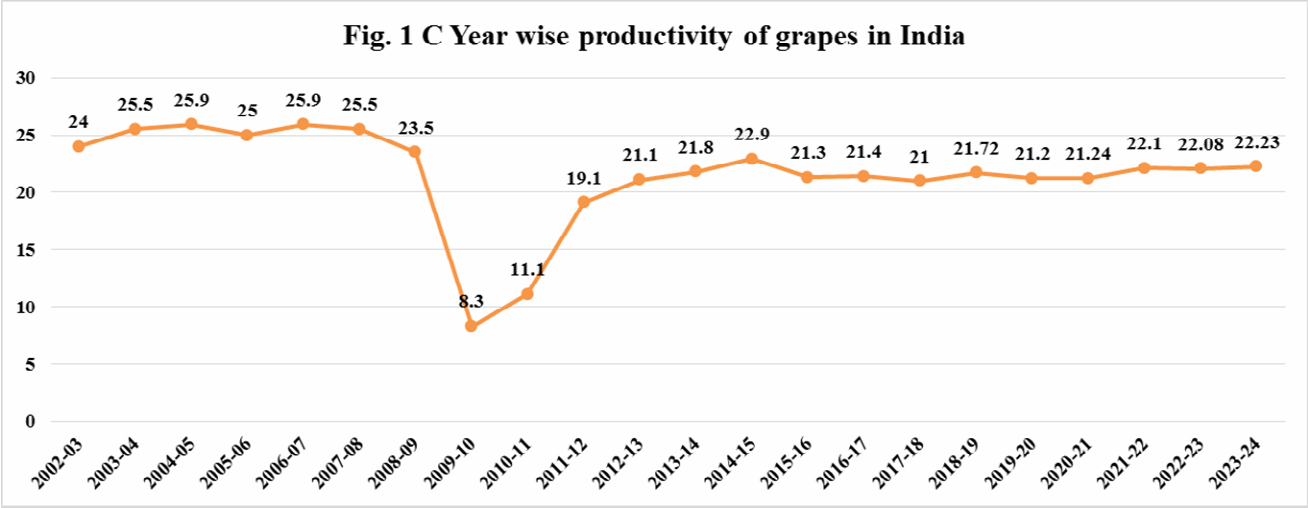
Area and Production of grapes

In India, area under grape cultivation has a major influence on productivity. During 2002-03, total area under grape cultivation was on 52.1 ha with a production of 1247.8 MT/ha and total productivity of 24.0 MT/ha. The trend was increased and the total productivity of 23.5 MT with a total area was 80.0 ha and production 1878.0 MT in 2008-2009 was achieved (Fig 1 A, B and C). Total area under grape cultivation in India during 2009-10 was estimated at 106.4 ha with a total annual production at 880.7 MT and productivity of 11.1 MT/ha. It has been increased after six years with total area of 1.21 lakh ha and production 2590 MT while the productivity of 21.3 MT/ha.

In the year 2016-17, total area of grape production was 136.6 ha with a production of 2921.7 MT/ha and total productivity of 21.4 MT/ha, whereas it has been increased up to the productivity 22.23 MT with a total area under cultivation was 1.75lakh ha and production 3910.94 MT in 2023-24.







Source: Ministry of Agriculture & Farmers Welfare, Govt. of India. (ON3854)

Fig. 1 : Year wise Area, Production, and productivity of grape production in India

Major states growing grapes in the country

Grapes are primarily grown in several states in India, with most of the grape production concentrated in specific regions known for their vineyards and wineries. Some of the major grape growing states in India as below.

Maharashtra

Maharashtra is the leading grape-growing state concentrating its cultivation in Nashik, Sangli, Solapur, Satara, Jalna, and Pune districts. Nashik is often referred to as the "Wine Capital of India" and is known for its high-quality wine production as well as to

produce export quality grapes. Maharashtra is leader in grape cultivation with almost 70 percent area and production in the state.

Karnataka

Next to Maharashtra, Karnataka is major important state growing grapes mainly for quality raisin and local market. The grapes are grown mainly in the districts of Bijapur and Bagalkot. The best quality raisin is produced from the grapes cultivated in Bijapur district. The state is known for its table grapes as well as quality raisin production.

Tamil Nadu

Tamil Nadu, particularly the districts of Theni, Krishnagiri and Dharmapuri is known for table grape cultivation.

Mizoram

Major grape variety grown in this area is Bangalore Blue, a juice variety. The state also has two wineries functioning.

Maharashtra continues as leader in grape growing states of India. By contributing an area of 123.79 ha (2023-24), the state produced over 2628.25 thousand metric tonnes (MT) of grapes during 2023-24 followed by Karnataka in 43.06 ha area with total production of 1093.20 thousand MT production. Tamil Nadu is India's third largest grape-producing state, with the production of around 50.73 thousand MT with 2.04 ha area of the total grapes production in the country. The changes in area and production in different states was at faster rate. Maharashtra was leading producer with 67.20% share in total grape production in India followed by Karnataka (27.95%), Tamil Nadu (1.29%), etc during 2023-24 (Table 1).

Table 1: Improvement in area and production

Sr. No	States	Area (000 ha)			Production (000 Tonnes)			Share (%)	
		2012-13	2021-22	2023-24	2012-13	2021-22	2023-24	2021-22	2023-24
1	Maharashtra	90	118.94	123.79	2050	2466.29	2628.25	70.67	67.2
2	Karnataka	19.7	36.58	43.06	320.9	854.66	1093.2	24.49	27.95
3	Tamil Nadu	2.68	2	2.04	43.38	50.01	50.73	1.43	1.29
4	Andhra Pradesh	1.58	2.37	3.38	31.51	46.82	101.25	1.34	2.58
5	Mizoram	2.38	2.35	2.38	20.8	17.3	17.23	0.5	0.44
6	others	1.3	0.01	1.28	16.51	--	20.28	--	0.51
	India	117.63	162.25	175.93	2483.09	3435.08	3910.94	97.09	99.97

Source: National Horticulture Board, 2023.

Major export of grapes from India

India has made an impressive beginning in grape exports with 94377 MT valued at Rs. 973 crores during 2014-15. These exports have risen to 343, 982.34 MT valued at Rs. 3,460.70 crores in 2023-24 (APEDA, 2023-24). Thus, within a short time, the quantum of grape exports constituted more than 20 percent of the total fresh fruits export from India. The grape exports are being made to over 30 countries of which United Kingdom, Netherlands, UAE, Bangladesh, Germany, Belgium, Saudi Arabia, Kuwait, Sri Lanka, Bahrain constitute close to 98% of share of total exports. Top importing countries for Indian grape remain the Netherland (33%), Saudi Arabia (9.69%), Russia (6.65%), United Kingdom (6.92%), Bangladesh (5.63%), Malaysia (3.35%) and Germany (3.17%) as per agri-exchange.apeda.gov.in

The growth of exports since 2014 is given below

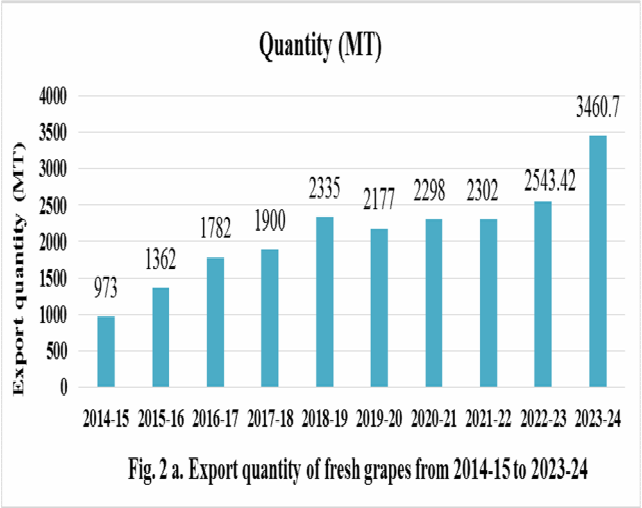


Fig. 2 a. Export quantity of fresh grapes from 2014-15 to 2023-24

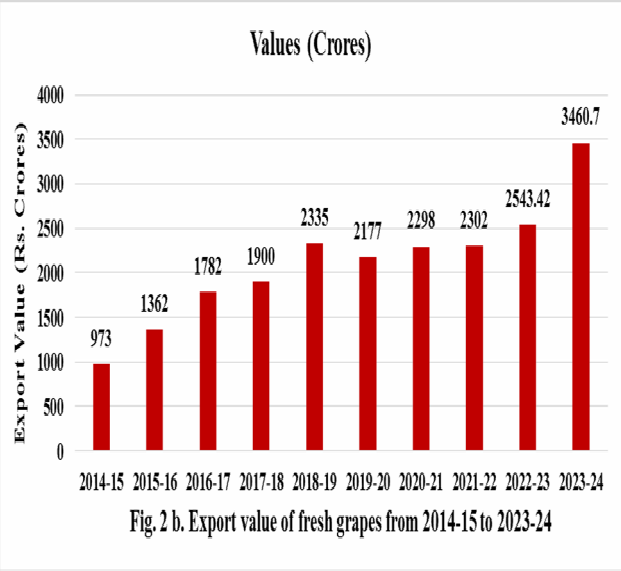


Fig. 2 b. Export value of fresh grapes from 2014-15 to 2023-24

Source: http://agriexchange.apeda.gov.in 2024

Grape exporting countries in world

Several countries around the world are known for exporting grapes to international markets. These countries have favorable climatic conditions for grape cultivation and often produce a wide variety of grape types. Some of the major grape-exporting countries is given below.

Table 2: Major grape-exporting countries in world

S. No.	Country	Major varieties exported
1	Spain	Table and wine grapes
2	Italy	Wine grapes
3	United States	Table, wine, and raisin grapes
4	Chile	Table and wine grapes
5	South Africa	Table and wine grapes
6	Australia	Wine grapes
7	Argentina	Wine grapes
8	Turkey	Table grapes
9	India	Table and raisin grapes
10	Mexico	Table grapes
11	Peru	Table grapes

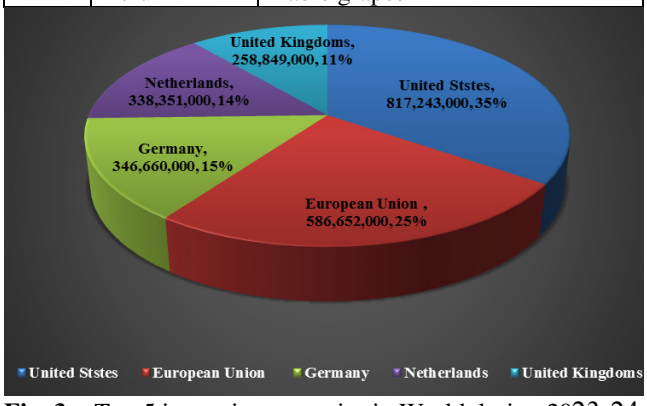


Fig. 3a: Top 5 importing countries in World during 2023-24 (Value in US$ Mill & % Share in total)

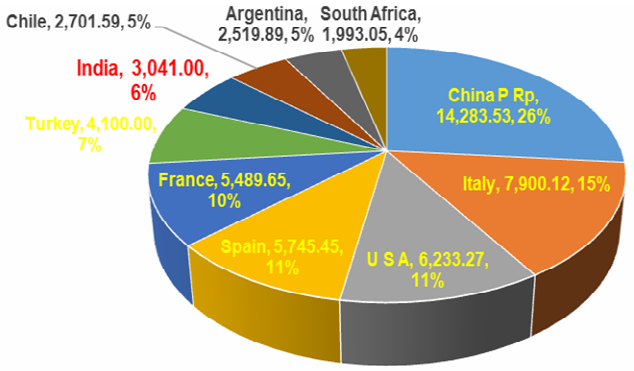


Fig. 3b: Major exporting countries in World during 2023-24 (Value in US$ Mill & % Share in total)

Source: http://agriexchange.apeda.gov.in 2024

These countries benefit from favorable climates, modern agricultural practices and established distribution networks that allow them to export grapes to various international markets. The types of grapes exported may vary from table grapes for direct consumption to wine grape for winemaking or processing into raisins. The specific grape varieties also depend on the region's strengths and consumer demand in target markets.

Grape varieties grown in major grape growing states

Grapes grown in different states and different regions are known for specific grape varieties. Here are some of the major grape varieties grown in different states.

1. Maharashtra

Nashik districts: Nashik is known for cultivation of grapes for export. The major grape varieties grown in the district are Thompson Seedless, Tas-A-Ganesh, Clone 2A, Crimson Seedless, Flame Seedless, etc. In addition, the district is also known for wine grape cultivation with Cabernet Sauvignon, Sauvignon Blanc, Syrah, Merlot, etc. being grown as major wine varieties. Nashik is also called as wine valley.

Pune regions: This region grow varieties like Thompson Seedless, Tas-A-Ganesh, Clone 2A, Manjari Naveen, Sharad Seedless and its clones (Sarita Seedless, Krishna Seedless, Nanasaheb Purple Seedless, etc), Sonaka, Manik Chaman, Super Sonaka, Flame Seedless, Manjari Shyama, etc.

Sangli district: Thompson Seedless, Sonaka, Manik Chaman, Super Sonaka, SSN, Jyoti Seedless, Manjari Shyama, etc. are the major grape varieties grown.

Solapur district: This district has warmer climate with high temperature and low humidity. This region

concentrates mainly for raisin making and local market. The major grape varieties grown are Thompson Seedless, Tas-A-Ganesh, Clone 2A, Nanasaheb Purple Seedless, Manjari Kishmish, Super Sonaka, Manik Chaman, etc.

Jalna district: Jalna district in Marathwada region is an emerging region for grape cultivation. The region experiences the hot and dry climate always thus reducing the cost of production mainly on disease management. Being hot and dry weather, there is a scope of raisin industry. The district grows mostly Thompson Seedless, Tas-A-Ganesh, Sonaka, Super Sonaka and Manik Chaman variety.

2. Karnataka

Karnataka is the second largest state growing grapes in the country. The weather is hot and humid in majority of the areas. Bijapur, Bagalkot and Gulbarga are the major grape-growing areas. Popular grape varieties include Thompson Seedless, Tas-A-Ganesh, Clone 2A, Manjari Kishmish, Bangalore Blue, Sonaka, Super Sonaka, SSN, etc. The best quality raisin is produced from the grapes cultivated in Bijapur district. The state is known for its table grapes as well as quality raisin production.

3. Andhra Pradesh

Anantapur, Chittoor and Kurnool districts are known for grape cultivation. Varieties like Thompson Seedless, Anab-E-Shahi and Manjari Naveen are grown.

4. Tamil Nadu

Krishnagiri and Dharmapuri districts are grape producing areas in the state with Thompson Seedless, Manjari Medika, Flame Seedless and Muscat as major grape varieties.

Table 3: State wise varieties grown with their characteristics

State growing grape varieties	Varieties grown	Characteristics	
		Colour	Seeded/ seedless
Maharashtra	Thompson Seedless and its clones (Tas-A-Ganesh, Clone 2A): Oblong type	White	Seedless
Maharashtra	Nanasaheb Purple Seedless (Oblong type), Fantasy Seedless (Elongated type)	Black	Seedless
Maharashtra	Krishna Seedless, Sarita Seedless, Jyoti Seedless (All are mutants from Sharad Seedless) - Elongated type	Black	Seedless
Maharashtra	Sharad Seedless	Black	Seedless
Maharashtra	Flame Seedless	Red	Seedless
Maharashtra, Karnataka	Crimson Seedless (Oblong type)	Red	Seedless
Maharashtra, Karnataka	Red Globe	Red	Seeded
Maharashtra and Karnataka	Sonaka, Manik Chaman, Super Sonaka, SSN, Anushka): Elongated type	White	Seedless
Karnataka	Bangalore Blue	Black	Seeded
Tamil Nadu	Gulabi	Purple	Seeded
Tamil Nadu	Muscat Hamburg	Purple	Seeded
Telangana and Andhra Pradesh	Anab-e-Shahi	White	Seeded
North India	Perlette, Pusa Seedless	White	Seedless
North India	Flame Seedless	Red	Seedless

Table 4 : Area distribution, cropping pattern and grape availability in different state

State	Approx area (ha)	Purpose	Cropping pattern	Grape availability (period)	Major varieties grown
Maharashtra	1,20,000	Table, raisin	Double pruning single cropping	December to May	TS, TAG, Clone 2A, Crimson Seedless, Nanasaheb Purple Seedless, Flame Seedless, Super Sonaka, Sonaka, Manik Chaman, Manjari Kishmish, Manjari Shyama, etc.
Karnataka	35,000	Table & raisin	Double pruning single cropping	December to April	TS, TAG, Clone 2A, Crimson Seedless, Nanasaheb Purple Seedless, Flame Seedless, Super Sonaka, Sonaka, Manik

					Chaman, Manjari Kishmish, etc.
Tamil Nadu	14,000	Table & Juice	Double pruning & double cropping	Throughout the year	Muscat Hamberg, Gulabi, Manjari Medika
Mizoram	5,000	Wine	Single pruning & single cropping	June- July	Bangalore Blue
Punjab, Haryana	2,000	Table	Single pruning & single cropping	May-June	Flame Seedless, Perlette, Early Perlette, Pusa Seedless, etc.

Soil condition in the grape growing region

The grapes are grown on variety of soils ranging from light soil to black cotton soil. The soil condition in different grape growing areas is different. In Maharashtra where around 70% grape cultivation is concentrated, the grapes are grown mainly on light to murum type of soils. In many of the places, the hilly areas are preferred for grape planting. The stones are broken with the help of ripper, the trench is opened and the soil collected from tank is filled to plant the grapevine. Hence, it is difficult to generalize the soil characters of any grape growing region of India, since these vary from vineyard to vineyard in a region. However, the range of values of certain important characters of soils in different grape-growing areas of India are given in Table 5.

Table 5: Soil characters of major grape growing region of India

Region	pH	EC (mmhos per cm)	ESP (per cent)	Organic carbon (per cent)	CEC (me/100 g)
Indo-Gangetic plains of North India	8.0 to 9.2	0.3 to 0.9	8-10	0.1 to 0.8	0.8 to 18.5
Telangana region of Andhra Pradesh	6.5 to 7.8	0.3 to 0.7	6-8	0.1 to 0.2	4.0 to 7.0
Rayalaseema region of Andhra Pradesh	6.7 to 8.1	0.4 to 0.8	7-10	0.2 to 0.3	4.0 to 10.0
North interior Karnataka	7.8 to 9.0	0.8 to 6.2	10-40	0.30 to 0.46	13.0 to 50.0
Maharashtra	7.0 to 9.0	0.3 to 4.0	12-48	0.4 to 1.2	20.0 to 48.0
South interior Karnataka	6.5 to 7.2	0.3 to 0.9	8-12	0.2 to 0.5	6.0 to 18.0
Tamil Nadu	6.5 to 8.5	0.4 to 1.8	8-16	0.2 to 0.8	6.0 to 18.0

Source: NBSSLUP, 2004

The soil conditions in grape growing regions varies depending on the specific location and grape variety being cultivated. However, grapes generally grow in well drained soils that can promote white roots for healthy canopy and fruit production. Majority of the soils under grape cultivation are saline in nature with pH ranging from 7.5 to 8.5. Grapes are sensitive to soil conditions and the right soil type can contribute significantly to the flavour, aroma, and overall quality of the grapes. Growers often chose grape varieties and rootstocks that are well-suited to the specific soil conditions in their region.

Some of the common soil conditions found in grape-growing regions are as below.

1. **Sandy loam soil:** Sandy loam soils are considered one of the best soils for grape cultivation. This type of soil has good drainage that can prevent waterlogging and retain sufficient moisture to support grapevine growth. These soils are rich in organic matter and nutrients providing a good foundation for grapevines.
2. **Loamy Soils:** Loam soils which are a mixture of sand, silt and clay can also be suitable for grape cultivation. They provide a balance between drainage and water retention and often have good fertility.
3. **Calcareous Soils:** Majority of the soils in grape growing region are calcareous in nature. The calcium carbonate content in these soil ranges from 5 to 22%. However, with the modification in cultural practices and using certain amendments these soils are being managed and the grapes are cultivated.
4. **Alluvial Soils:** These soils are common in near rivers. These soils are fertile and well-drained, making them suitable for grape cultivation.
5. **Clay Soils:** In majority of the area grape cultivation is done in black cotton soils. These are heavy soils with more water holding. However, after some time, these soils shrink resulting into development of cracks. These soil needs adequate soil management practices.

Use of rootstocks in grape cultivation

Grape being major important perennial fruit crops requires huge investment in the initial stage. Hence, proper planning before establishing the vineyard is the

first step to a successful grape cultivation. Before establishing a new vineyard, major problems in that area should be considered and steps to be taken. Grapevine rootstocks used in grape cultivation comes from a different species and are being used for different condition of soil and water. Growers select grapevine rootstocks based on drought resistance, pest resistance, or even tolerance for certain soil conditions, like high pH. Rootstocks are commonly used in grape cultivation to influence various aspects of grapevine growth and grape quality. The choice of rootstock can impact factors such as vine vigor, fruitfulness, drought tolerance, adaptation to saline soil, grape quality, disease resistance, and better shelf life. Here are some factors to consider when selecting rootstocks in grape cultivation.

1. **Vigor control:** Rootstocks can be used to manage vine vigor. Excessive vigor of any grape variety leads to reduced fruitfulness in the next season thereby reduction in yield. Reduced vigor also leads to reduction in grape berry quality and shelf life. Some rootstocks are known for controlling the growth of a grapevines which. Rootstocks can help to achieve a balanced vine canopy. Under Indian condition, the rootstock Dogridge is known for imparting the vigor under black soil while the rootstock 110-R controls the vigor thereby improving the fruitfulness (Somkuwar *et al.,* 2006a).
2. **Graft compatibility:** The grape being perennial in nature, will last for about 15-years in the filed after planting. Due to the problems associated with soil and water, the use of rootstock became mandatory in grape cultivation. However, the graft compatibility is a major concern in producing the sustainable yield. Graft compatibility between the rootstock and scion decides the efficient utilization of nutrient and water. The graft union must get healed up within 40 days after grafting. This ensures long term success of grape cultivation. Red Globe, a table grape variety (seeded type) was commercially grown on Dogridge rootstock had an issue of graft compatibility. The graft joint does not heal up immediately and this results into reduced vigor (canopy) as the nutrient and water supply gets restricted. However, the result obtained at ICAR- NRC Grapes, Pune proved Salt Creek rootstock the better choice for Red Globe.
3. **Soil adaptation:** While establishing any vineyard, the grape growers select rootstocks that are resistant/tolerant to soil problems (texture, depth, and fertility, pH, salinity, lime content, drainage, etc.). Majority of the grape vineyards are established on light to medium soil with well-drain soil property. In the recent years, climate change has made direct impact on grape cultivation. The scarcity of irrigation water resources emphasizes the importance of using water more efficiently in the grape vineyards. In Sangli district of Maharashtra, the grape growers are forced to buy water tankers for irrigating the grape vineyards as most grape-growing talukas experience drought. Under the condition of shortage of irrigation water, the rootstock 110-R can be considered suitable as it possesses the properties of drought tolerance. Although several approaches can be employed to mitigate the drought problem, however, using drought tolerant rootstocks can be one of the most sustainable solutions. By utilizing drought-tolerant rootstocks, grape growers can adapt to the effects of climate change and ensure the longevity and productivity of their vineyards in face of water scarcity and changing environmental conditions (Miras-Avalos and Araujo, 2021).

   The soil where sugarcane was grown earlier are facing salinity issues. Mizoram soils are acidic in nature with low base saturation. The rootstock Salt Creek (Ramsey) is a highly vigorous rootstock. It has very good drought tolerance and high-water use efficiency. It has high lime tolerance and performs well in mildly acid soils. In addition, Salt Creek is also known for resistance to nematode salt tolerance. In Theni district of Tamil Nadu, Sandy Loam, clayey and alluvial soil is found. However, in Bijapur district of Karnataka state, black soils, red sandy soils, and mixed soils is observed. Certain rootstocks are better suited to specific soil types.
4. **Flavor and quality:** In a vineyard, weather (temperature, relative humidity, and precipitation), sunlight, etc. decides the quality of grape berries. Many of the times, wine varieties are being talked for flavor, however, the eating quality of grapes also becomes an important factor. In addition to these factors, use of grape rootstock also plays an important role in deciding the grape quality as well as wine quality including the flavor (Markovic and Atanackovic, 2013). The choice of rootstocks can influence the flavor and quality of the grapes produced. Different rootstocks can impart unique characteristics to the grapes including minerality and flavor profiles. Production of uniform size grape bunches and grape berries with 18 mm and above diameter is generally considered as quality grapes meant for export. Flavor in a grape berry is achieved through canopy management practices followed during berry development period after the fruit pruning. The flavor in grape berry is achieved

through exposure of grape bunch to sunlight (through training) and judicious use of nutrient and irrigation.

5. **Disease resistance:** Phylloxera disease on grape was first detected in France in the middle of 1860s and then across Europe and eventually devastated most of Europe's vineyards. However, grape cultivation in India does not have any threat of this disease. Fungal diseases like downy mildew, powdery mildew, anthracnose, and bacterial blight are major problems in grape cultivation in the country. These diseases can well be controlled using copper-based fungicides and Sulphur. Different rootstocks have varying levels of resistance to common grapevine pests and fungal diseases. By grafting desirable grapevine scion onto rootstock, growers can protect their vines from these threats (Cander *et al*., 2022). In addition, following canopy management practices can reduce the disease spread to the larger extent. The grapevine with erect shoot can be more helpful. However, training the shoots with vertical shoot positioning on the cordon can reduce microclimate thereby reducing the disease spread in the vineyard. The grapevine also suffers with virus infection. In wine grape variety mainly the virus infection leads to reduction in wine quality. Major viruses affecting wine grapes are grapevine leafroll virus, stem pitting, fan leaf roll virus, etc. However, in our condition, major grape cultivation is restricted to table and raisin grape only.

Challenges in producing the quality grapes

Grape is basically a more technical crop than any other fruit crops. It needs constant attention in both the pruning. Weather available during the fruit bud differentiation period, availability of skilled manpower for various operations (shoot thinning, shoot pinching, etc.), nutrient and irrigation management decides the crop yield during the year. Hence, it has a complex problem associated with production of quality grapes. Many of the times, excess production or even harvesting the maximum produce in a single year also affect the grape quality required for marketing.

Some of the common problems faced by grape growers and strategies to overcome them are as below.

Climate and grape production

In tropical condition, pruning is done twice (foundation and forward pruning) in a year. Foundation pruning is done after the harvest of crop. The new growth is considered as foundation for coming season. During this period, temperature plays an important role. Fruit bud differentiation takes place during 30 to 60 days after the foundation pruning. If the temperature reaches above 42^0C, the fruit-bud-differentiation gets affected. After fruit pruning, the period of bunch development (50 to 90 days after fruit pruning) is crucial that need special attention. Temperature plays an important role in berry development with below 10^0C during this period affects berry development.

High temperature during both pruning removes water from the canopy through transpiration and evaporation through soil thus demanding more water. Under such situation, management practices like use of anti-transpirants, mulching on bunds, irrigation during either morning or evening, spread of irrigation pipes (laterals) on the ground, etc. will help to use available water very efficiently.

Frost is another major problem in Nashik district facing during berry development stage. Frost injury is seen on the leaf and berries. In severe condition, the chlorophyll from leaf gets destroyed thereby reducing the canopy required for bunch development and maintaining the uniform green color.

Unseasonal rains with hailstorm during the period of berry development and harvest time becomes the major threat in grape production in majority of the grape growing areas. During the berry development stage, berry cracking and berry rot is experienced thereby leading the complete loss of crop. Use of plastic cover during fruit development stage, changing the pruning time, etc. are some of the major remedies can be taken by the grape growers.

Diseases and grape production:

Grapevine faces the problem of major diseases like downy mildew, powdery mildew, anthracnose, and bacterial blight while the insect pest like stem borer, flea beetle, thrips, mealy bugs become serious problem. Though every day weather advisory specific to problem faced is being provided to the grape growers, the higher cost of inputs is increasing the production cost. Hence, varieties resistant to major pest and diseases can help in increasing the quality grape production with reduction in production cost. In addition, promoting the biodiversity in vineyards can also support multiplication of natural predators of pests.

Availability of manpower

Grape cultivation is more expensive than other fruit crops due to the need for experienced labour, complex trellis systems, and advanced crop protection methods. Grape needs constant attention during growth and development stage. It requires around 1.5 manpower per day per acre area. During the fruit

pruning stage, the grapevine needs constant attention for retention of bunches per vine, berry thinning and dipping of grape bunches in plant growth regulators, disease management, etc. The shortage of skilled labours at critical stages of grape production is a source of concern for producers. Labor shortages cause delay in viticulture practices resulting in poor grape quality and lower market value. The shortages of manpower during these stages can be a major challenge. Hence, exploring the possibilities of implementation of options like mechanization, use of self-thinned grape varieties, rain tolerant/resistant varieties, etc, can be thought of.

Availability of varieties and grape production

At present, Thompson Seedless, a white seedless table grape variety is still dominating with about 70% area under cultivation. This variety requires plant growth regulator to produce loose bunch or it requires berry thinning to make the grape bunch for export. The grape varieties developed by the research institute are still not in the grower's field for commercial cultivation indicating that these varieties either do not fulfill the requirement of international market or not reached to the grape growers due to lack of extension activities. To fulfill the demand of international market, the varieties possessing self-thinning, bold berries characters, resistant to major diseases, rain resistant, etc. will be preferred. Intensifying the research on breeding the market driven varieties for specific purpose (raisin, juice, export purpose) and also for specific region including rootstock in the country could solve the present problem of dependency on single variety.

Consideration of market demand and exploring other avenues

The grape cultivation based on market demand can be the best option. Many of the international market demands thin skinned grape varieties. The varieties that are to be exported should also have better shelf life. Plant growth regulators at different berry development stages decides the berry quality. Efficient utilization of inputs including use of judicious use of plant growth regulators should be the priority to produce quality grapes. Establishing a strong market link for procurement of produce and distribution is necessary. Exploring the unexplored markets can supports to sell the produce and increase the area under cultivation. Standardization of package of practices and evaluation of grape varieties in a specific region can save the transport cost if the same grapes are brought from other state.

During the period of glut in the market, the producer does not get sufficient price to the produce. Hence, exploration of other avenues like raisin production, juice and wine production can support the grape industry.

Grape quality and export

Though India shares good position in the export of grapes in European market, the proportion of grapes from one acre area still varies from 2.0 to 8.0 tones with a total export of about 8 to 10 percent. The proportion of quality grapes fulfilling the requirement of international market need to be improved. The quality control measures during grape productions for ensuring uniformity in size, color and taste will fetch good price in the market.

Impact of extension activities on grape production

The high value crop like grape requires updating the recent information regarding new varieties, use of rootstocks, weather information, market requirement, fungicides availability and requirement for the control of diseases, etc. This is possible through extension activities by organizing workshops, conferences and training programs related to grape cultivation and marketing.

Opportunities in Grape Cultivation

Precision Viticulture

Digital technologies have its own applications in viticulture for soil property and quality assessment, nutritional status, canopy architecture, pest, and disease prediction, fruit composition and crop forecasting. Non-invasive sensor technologies such as thermography, X-ray spectroscopy, chlorophyll fluorescence, multispectral, and hyperspectral imaging have high applicability potential in disease and pest detection as well as in smart viticulture applications (Tardaguila *et al*., 2021).

Soil less Cultivation Technique

The latest developments on the Table-Grape Soil Less Cultivation (TGSC) system open pathways for high-level cultivation. A number of advantages of TGSC include easier manipulability of crop production cycle, flexibility over diverse varieties, control over high-quality and yield in extra-seasonal production, control over efficient use of water and fertilizer, reduction in pesticides, and pesticide residual components. TGSC also offers solutions to soil and rootstock related issues (Pisciotta *et al*., 2022).

Future strategy

India maintains its position as a major producer of table grapes. Production is currently much higher than demand in the domestic market. There is a need to promote the export of grape and its products to sustain

current production trend. Till recently, export of grapes from India was primarily limited to neighboring countries due to inadequate pre-cooling facilities and consciousness about quality. Development of pesticide residue laboratory at ICAR- National Research Centre for Grapes funded by APEDA has helped to reduce the failure of grape samples from 24% to less than 4% and thus helped to increase the export. To increase exports, regular guidance is being given to the grape growers on different aspects (pre-harvest, proper use of pesticides, post-harvest, packaging, cold storage, and transportation). However, still there is a need to increase the share of Indian grape in the international market where higher prices can be fetched. Breeding the varieties based on the market demand can support the Indian grape industry to sustain with higher returns. Use of advanced technologies such as Decision Support System (DSS), digital technologies like use of multispectral images to identify the location specific problems in a vineyard and to know the harvesting period to avoid glut in the market, use of moisture sensors to save irrigation water, robotic to know the problems in each row, etc. will help to reduce the production cost as well as bring the accuracy in the viticulture. Exploration of new international markets will also help to increase the area under grape cultivation. In addition, growing grapes in non-traditional areas will support the consumer to get the grapes available with minimum price as the transportation cost will be saved.

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