HISTORICAL INSIGHT INTO GRAPE INTRODUCTION, SPREAD, ESTABLISHMENT, STATUS, AND FUTURE PROSPECTS IN INDIA

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GRAPE INTRODUCTION IN INDIA

Grape is an important fruit crop with high commercial significance. Historical evidence suggest that the cultivation of grape in India dates back about 4000 years ago (Persaud, 1997). Charak Samhita and Shushrut Samhita, medical treatises of ancient India written between 1356 and 1220 BC mention about grapes. A description of land suitable for grape growing is given in Arthashastra, written by Kautilya (Chanakya) during 350-275 BC. A Chinese Buddhist pilgrim who traveled through India during 629-645 A.D. reported that “grapes were found here and there from Kashmir on”. 

North India

It is thought that Muslim conquerors from Iran and Afghanistan brought the grape to North India in the year 1300 A.D. As a result of the introduction of different varieties by the Mughal king Akbar and his son Jahangir; Kabul, Kandhar, Kashmir, Sindh, and Punjab became significant regions for grape cultivation. Subsequent Mughal emperors did not encourage grape cultivation as winemaking was considered as a sin in Islamic religion which led to viticulture’s demise.

The grape introduction was started in Punjab during the 1930s by Sardar Bahadur Sardar Lal Singh and led to a collection of numerous grape genotypes (Chadha, 2019). Genotypes such as Bedana, Khalili, Fosters Seedling, Waltham Cross, Black Prince, and others were found to be suitable for commercial production in Punjab (in undivided India). However, citrus cultivation overtook the grape expansion. To restore the grape research and development in North India during the middle of the 1980s, more than 350 grape varieties from the United States, the Soviet Union, Yugoslavia, Australia, etc. were collected by the Indian Agricultural Research Institute (IARI), New Delhi; Horticultural Research Institute, Saharanpur (U.P.) and Regional Fruit Research Station, Abohar (Punjab). Successful grape growing at these locations demonstrated the cultivation potential of early ripening genotypes in North India.

To promote commercial grape cultivation in Punjab, Mr B.M. Pansare from Andhra Pradesh was appointed as the Grape Extension Adviser for the region by the Chief Minister of Punjab, Shri. Pratap Singh Kairon during 1962. The program commenced with the introduction of the Anab-e-Shahi grape from Hyderabad and exposure visits of Punjab farmers to the grape cultivation practices in Andhra Pradesh. Although the variety adapted well to heavy yield in the Punjab region, inferior quality fruits with low TSS (12-16˚B) were obtained due to rains at fruit ripening. Therefore, the early ripening variety ‘Perlette’ was imported from California. Additionally, Thompson Seedless Pusa Seedless and Khalili were also introduced. Due to government initiatives, guidance from fruit specialist Dr. K.L. Chadha and farmers’ participation area under grapes grew significantly. Because of lack of achieving mature fruits and commercial yield, growers lost interest in growing grapes.

Western India

When the capital was moved from Delhi to Daulatabad during the rule of Mohammed-bin-Tughlak in the 14th century, it is said that the grape was brought to the Aurangabad area of Maharashtra. Bokhari, Fakiri, and Sahebi grape varieties were introduced. Subsequently, the variety Habshi was introduced by Baba Shah Musafir from Persia. Iban Batuta and Thevenot mentioned the
existence of vineyards all over the country, including Baluchistan and the North-West Frontier provinces, down in the Vindhya Mountains. The Portuguese provided the business with yet another boost. Also, funds were donated to the Christian Missions in Aurangabad in the year 1550 by the early Bijapur and Ahmednagar Kings. The fall of the Moghul Empire resulted in the collapse of grape cultivation in this region.

In Maharashtra, Nashik and Pune are two key regions for grape farming. Nashik is fortunate to have a plentiful supply of water from the Godavari River, which aided in the development of commercial viticulture in the region. These districts were known for cultivating grapes namely Bokhri, the Fakiri, Pandri Sahebi, and Kali Sahebi. The industry flourished well from 1717 to 1817 AD, the period of the Maratha Empire. Tropical viticulture was first practiced in India at Nashik, Maharashtra when Rao Saheb J.K. Gaekwad established the first grape garden at Azar in 1923.

Grape cultivation spread from Nashik to Satara, Pune, and Solapur districts. Mr. Dadasaheb Shembekar, N.C. Barawake, Ganukaka Datey, and Mamasheb Tilekar were the pioneers, who started grape growing in the year 1930 in the Pune-Baramati area. Rao Bahadur Shembekar encouraged grape growers to improve their cultivation practices. His son Shri D.G. Shembekar perfected the techniques for successful cultivation of grapes and introduced new varieties like Kandhari, Gros Colman, Selection 94, and Thompson Seedless. The description of the viticulture industry of Maharashtra was published in the 'Punjab Horticulture Journal' (Bakshi and Chadha, 1968). The significant earnings of grape growers led to an increase in grapes in the local markets. As compared to other varieties, the Thompson Seedless grape variety gained favor because of its superior transportation and storage characteristics, consumer preference, etc. The area under this area rose significantly in Nashik, Ahmednagar, Pune, Satara Sangli, Solapur, Latur, and Osmanabad districts. Thompson Seedless, its mutants (Tas-a-Ganesh, Sonaka, Manik Chaman), and Sharad Seedless were cultivated at a commercial scale.

**South India**

**Andhra Pradesh (including Telangana)**

From Daulatabad and Aurangabad, grape cultivation spread to Hyderabad in Deccan during the Nizam period. Nawab Sirajyar Jung, Horticultural Advisor to Nizam, and Shankar Pillay, Horticulturist of Hyderabad helped in the revival of the grape industry in various parts of Marathwada. Anab-e-Shahi was the ruling variety in Hyderabad Deccan (Randhawa, 1969). Extremely high yield was achieved in the Andhra Pradesh area. After carving the state of Telangana, now 800 ha area remains in Andhra Pradesh under grape, while 750 ha in Telangana.

**Tamil Nadu**

Grape was introduced at Melpatti by a French priest in 1832 and afterward at Michaelpatti by a French missionary Rev. Fr. Larmey in Tamil Nadu. A variety of PachiDraksha (Green Grape) attracted the grape growers at Krishnagiri and Pattiviranpatti in the Madurai district of Tamil Nadu. Under the very congenial conditions of climate and soils, it was possible to obtain two crops in a year which was not possible in Deccan conditions. Later on, a variety of Thompson Seedless was also introduced.

**Karnataka**

Evidence of grape cultivation in Bellary (then in Madras Presidency, now in Karnataka) dates back to 1842. The Portuguese missionaries introduced grape in Goa, from where it spread to Dharwad and Bangalore. The variety “Isabella” from Portugal was well adapted to Bangalore conditions and became quite popular. Another variety, named “Bangalore Blue”, was introduced from Daulatabad. Anab-e-Shahi and its clone ‘Dilkush were introduced and became popular by virtue of their high yields, good quality, and amenability to two crops in a year. Currently, Sharad Seedless and Flame Seedless, two coloured seedless varieties have gained popularity around the Bangalore region. In Northern Karnataka districts, however, Thompson Seedless and its clones are popularly grown. Besides, certain wine varieties were also introduced in Bangalore by private wine industries, but those are grown on a limited scale.

**North-Eastern India**

Grape cultivation in North Eastern India is of recent origin and new plantations around Champhai district, Mizoram were taken up in 1992. Horticulture Department, Government of Mizoram initiated supporting farmers in 2005, as a result of which about 500 families from Hnahlahn and around 250 families in and around Champhai started...
grape plantations (Lalengkima, 2016) Initially, cultivation started with Bangalore Blue (Vitis labruscana) and later varieties, Pusa Navrang and Pusa Urvashi were introduced with the guidance of Horticulture Division, IARI, New Delhi. It also introduced ‘Tempranillo’, for processing as red wine which has been given for cultivation to 60 families at Mualkawi. Two more varieties that are under testing in the state are ‘Kyoho’ and ‘Muscat’ (Black Queen). A Mizoram Grape Growers’ Society (MGGA) was also been formed at Champhai town and Hnahlan village on 28th November 2006 for the promotion of grape growing. Presently about 2,450 ha area is covered under grape production mainly for wine making. Grape is also being cultivated in Nagaland on a limited scale (220 ha). A small area is also being developed in the states of Manipur and Arunachal Pradesh, which is still to pick up.

Non-traditional Areas

Efforts are also being made to identify pockets suitable for grape cultivation in non-traditional areas. In West Bengal, ICAR-National Research Centre for Grapes, Pune is making efforts to introduce the cultivation of seedless grape varieties namely Thompson Seedless, Fantasy Seedless, Manjari Medika, Manjari Naveen, and Manjari Shyama at Taldangra Horticulture R&D farms of Bankura district, West Bengal. This project is funded by the State Govt. of West Bengal. The institute is also assessing the scope of commercial cultivation in Rajnandgaon near Raipur, Chhattisgarh.

PECULIARITIES OF INDIAN VITICULTURE

Viticulture in India is unique in many ways. Though grape cultivation originated in temperate regions, the vinifera grape is commercially grown in tropical areas. A special pruning system regulated the crop growth and fruiting. This ensured the two harvests a year and up to five harvests in two years in tropical regions which resulted in 6-8 months fresh grape availability in a year. Indian viticulture includes vulnerability to fungal diseases, a short productive life span of 15-20 years, and a high yield per hectare in the world (Chadha, 1992). Grapes are being grown in three types of climates:

Temperate Region: The grape is being cultivated in the sub-Himalayan regions, parts of Jammu & Kashmir, Ladakh, Kullu and Kangra valley, Kotgarh as Nahan in Himachal Pradesh, Kumaon Hills in Uttarakhand and northern Arunachal Pradesh. The climatic conditions of these regions are similar to the natural habitat of grape vines. Maharaja of Patiala introduced several vinifera and labrusca grape varieties in Kangadhath, now in Himachal Pradesh besides indigenous grape varieties in arid temperate regions of Kinnaur and Ladakh. Vinifera grapes are not successful in these regions due to the short period available for ripening, but labrusca grape varieties grew successfully for winemaking. Due to the availability of longer period for maturity, wine grapes are in cultivation in Ladakh and Kinnaur regions.

Sub-tropical Region: This region mimics the natural habitat of the grapevine which includes Punjab, Haryana, Rajasthan, Delhi and Western UP. Normally vines are pruned in December- January and only 100 days are available from bud break to harvest due to the coincidence of monsoon with harvest time in the normal varieties which takes more than 125 days to harvest. Variety Perlette successfully adapted in the region but bunch compactness was the major issue in its cultivation.

Hot tropical areas: Viticulture in hot tropical areas has been taken up in Mid-Maharashtra, North Karnataka, and Telangana region, where vines do not undergo dormancy. Vines express a high degree of apical dominance in the region. Double pruning and single cropping systems are followed in this region. The productive life span of vines is short.

Mild topical areas: In South Karnataka and Tamil Nadu, vines exhibit a high degree of apical dominance. In this region, temperatures seldom reach 40°C and atmospheric humidity is high. Vine growth is much higher than in subtropical regions. Vines are pruned twice and two crops in a year or 5 crops in 2 years are harvested. Double pruning and double cropping systems are followed in the region.

CHANGING STATUS OF VITICULTURE IN INDIA

Commercial viticulture in India is about only seven decades old. During 1960, the total area under grape cultivation in the country was only 800 ha, which increased at a growth rate (CAGR) of 8.94 percent to 1,63,000 ha in 2021-22.
Similarly, grape production started with a meager 10 thousand MT in 1960 and reached 3301 thousand MT in 2021-22 at 9.81 percent CAGR. Productivity increased from 12.5 MT/ha to 20.25 MT/ha during the above period registering an annual growth rate of 0.88 per cent. The productivity of Indian grapes used to be low until 1970 in the states. It was medium during 1975-1995 and reached a high level (25 MT/ha) during 2000-2015 (Table 1). However, Indian grape productivity is the highest in the world. India has reached at 7th position as far as world grape production is concerned.

Maharashtra occupies the largest area under grape cultivation and accounts for about 73 percent of the production of grapes in the country. The major areas are confined to four districts namely, Nashik, Sangli, Solapur, and Pune (Gawande, 2021). The area and production of grapes have considerably increased in Maharashtra followed by Karnataka and Tamil Nadu. In Andhra Pradesh, Punjab, and Haryana, grapes are cultivated only to a very limited extent. Although about 80 percent of the world's grape production is utilized for winemaking, about 78-80 percent of India's total grape production is only utilized for table purposes, 17-20 percent towards raisin making 1.5 percent for juice making, and only 0.5 percent is used for wine production.

**Table 1.** Changing status of grape area, production and productivity in India (1960-2022)

<table>
<thead>
<tr>
<th>Year</th>
<th>Area ('000 ha)</th>
<th>Production ('000 MT)</th>
<th>Productivity (t/ha)</th>
<th>CAGR in Area* (%)</th>
<th>CAGR in Prod* (%)</th>
<th>CAGR in Productivity* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>0.8</td>
<td>10.0</td>
<td>12.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1970</td>
<td>2.8</td>
<td>40.0</td>
<td>14.3</td>
<td>13.35</td>
<td>14.87</td>
<td>1.35</td>
</tr>
<tr>
<td>1980</td>
<td>4.0</td>
<td>80.0</td>
<td>20.0</td>
<td>3.63</td>
<td>7.18</td>
<td>3.41</td>
</tr>
<tr>
<td>1990</td>
<td>17.1</td>
<td>341.5</td>
<td>20.0</td>
<td>15.63</td>
<td>15.62</td>
<td>0.00</td>
</tr>
<tr>
<td>2000</td>
<td>30.2</td>
<td>789.6</td>
<td>26.1</td>
<td>5.85</td>
<td>8.74</td>
<td>2.70</td>
</tr>
<tr>
<td>2010</td>
<td>60.0</td>
<td>1600.0</td>
<td>26.7</td>
<td>7.11</td>
<td>7.32</td>
<td>0.23</td>
</tr>
<tr>
<td>2022</td>
<td>163.0</td>
<td>3301.0</td>
<td>21.54</td>
<td>8.69</td>
<td>6.22</td>
<td>-1.77</td>
</tr>
</tbody>
</table>

(Source: Ministry of Agriculture and Farmers Welfare and *author’s own calculation)

Horticultural Research, Bengaluru took up research work on grape improvement, production technology, plant protection, and post-harvest management. Simultaneously, several public & private agencies were established and have been involved in promoting grape production, post-harvest management, and technology generation briefly given below:

**Maharashtra Rajya Draksha Bagaitdar Sangh (MRDBS)**

Maharashtra Rajya Draksha Bogaitdar Sangh (MRDBS) deserves credit for revolutionizing the grape industry in Maharashtra. It was established in 1960 under the patronage of the Agriculture Minister of Maharashtra, Late Vasantrao Naik. The organization has been involved in the overall development of grape crops, technical guidance, import of vineyard inputs, carrying out grape research, providing reliable grafts, better transportation, and planning of study tours of grape growers.

**All India Coordinated Research Project**

The ICAR-All India Coordinated Research Project (ICAR-AICRP), a landmark in the history of agricultural research, was extended to fruit crops by the Indian Council of Agricultural Research during the fourth Five Year plan on July 31, 1971. This project covered a large number of tropical, sub-tropical, and temperate fruits with headquarters at CMRS Lucknow and tropical fruits at IIHR Bengaluru. The two fruit projects were however merged in 2013 with headquarters of the Project Coordinator at IIHR Bengaluru. The technical coordination in Grape was however shifted to NRC Pune in 2001.
A number of centers were sponsored by ICAR on grape research under this project. These included the IARI, New Delhi, NRCGP, Pune; MACS (Agharkar Research Institute), Pune; IARI, Bengaluru; PAU, Ludhiana (1972); APAU, Rajendranagar (1975); MPKV, Rahuri (1989); MPAUT, Mandsaur (2009); Vijayapur, Karnataka (2014) and TNAU, Coimbatore were identified as centers for grape research.

**National Horticulture Board (NHB)**

National Horticulture Board (NHB) was set up by the Government of India in 1984 as an autonomous organization under the Ministry of Agriculture with its Headquarters at Gurgaon to promote the production, processing, and marketing of various fruits and vegetables in the country. NHB supports model projects on the development of commercial horticulture through production and post-harvest management of horticulture crops.

**Agricultural and Processed Food Products Export Development Authority (APEDA)**

It was established by the Government of India under the Agricultural and Processed Food Products Export Development Authority Act passed by the Parliament in December 1985. The role of authority was to develop industries relating to the various products for export by providing financial assistance or undertaking surveys and feasibility studies, participating and promoting of joint ventures and other reliefs and subsidy schemes. It also works on fixing standards and specifications for improving packaging, marketing, promotion of export-oriented production, and development of scheduled products.

**Mahagrapes**

It is a cooperative partnership firm established on 19th January 1991 with the help of the Maharashtra State Agricultural Marketing Board, Govt of Maharashtra, and NCDC, New Delhi with its headquarters at Pune. Sixteen grape grower cooperative societies are the member societies of Mahagrapes from Sangli, Solapur, Latur, Pune, Nasik, etc. It has boosted the export of grapes by developing worldwide markets, quality control in post-harvest activities, extension services to members of co-ops for production of export quality grapes, supply and supervision of branded packaging needed logistical support, and advance payment to farmers for their produce. Also, pre-cooling and cold storage facilities were created at each grape grower cooperative society. MAHAGRAPES has been an established brand in the EU and Middle East markets for more than a decade.

**ICAR-National Research Centre Grape, Pune**

The ICAR-National Research Centre for Grapes was established to take up strategic and applied research on safe grape produce and productivity; transfer of technology and capacity building of stakeholders for enhanced and sustainable production of grapes and act as a National Referral Laboratory for food safety and pesticide residue. The Centre has made significant achievements towards grape research by collecting large germplasm, identifying resistance sources, developing new varieties for various purposes (Manjri Naveen, Manjari Kishmish, Manjari Medika, and Manjari Shyama), standardizing production technology and production of zero pesticide grapes, post-harvest grape management, etc.

### TECHNOLOGICAL DEVELOPMENT

**Introduction of grape varieties**

In the initial phase, the introduction and evaluation of new varieties from exotic sources was taken up as a means for grape improvement in India. The beginning was made in 1938 when three varieties namely Abi or Bhokri, Fakhri, and Sahebi were introduced into Deccan.

A large number (116) of grape varieties were introduced from different grape-growing countries of the world at Lyallpur (now in Pakistan) in 1928 by S.B.S. Lal Singh (Singh and Singh, 1942) out of which, Black Hamburg, Black Prince, Dakh, Foster's Seedling, Kandhari, Khalili, Pandri Sahebi, Thompson Seedless and Waltham cross were identified as promising and selected materials were sent to other parts of the country like Aurangabad and Pune. IARI, New Delhi initiated grape introduction under the leadership of Dr. G.S. Randhawa in the late 1950s. As a result of these two efforts, 1,118 collections of grape varieties were made through indigenous and exotic collections. Based on the performance of grape varieties in different regions, many promising varieties were recommended for commercial cultivation in different regions (Table 2). However, the collection at present stands depleted considerably.
Table 2. Introduced varieties recommended during the 1960s for commercial cultivation

<table>
<thead>
<tr>
<th>Region/purpose</th>
<th>Varieties recommended</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hisar</td>
<td>Beauty Seedless, Delight, Kishmish Beli, Kishmish Chorni, Perlette, Pusa Seedless and Thompson Seedless</td>
<td>Singh and Singh (1972)</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>Andizns Kifcerniz, Black Hamburg, Coarna Rosie, Golden Queen, Kishmish Rozoviz, New Perlette, Monakka Sharbo and Surbakit Obeski</td>
<td>Chadha and Shikhamany, (1999)</td>
</tr>
</tbody>
</table>

Table 3. Varieties recommended for processing purposes

<table>
<thead>
<tr>
<th>Region/ purpose</th>
<th>Varieties recommended</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin making</td>
<td>Shundekhani, Perlette and Thompson Seedless, Pusa Seedless, Lughangia, New Perlette and Kishmish Rozoviz</td>
<td>Ambadan et al., (1971); Singh et al., (1973);</td>
</tr>
<tr>
<td>Wine Varieties</td>
<td>Seedless, Dakh, Foster's Seedling. Kandhari and Black Prince (Dry white); Dakh, Black Prince and Zinfandel (Dry Red); Seedless (Sweet wine), Black Prince (Sherry type wine), Foster's Seedling (Muscatel)</td>
<td>Johar (1956)</td>
</tr>
</tbody>
</table>

In recent years, some grape varieties developed through breeding programs in Australia and the United States of America and other countries also introduced such as Clone 2A, Red Globe, Crimson Seedless, Flame Seedless, Centennial Seedless, Dawn Seedless, Blush Seedless, etc (MRDBS, 2021).

Clonal Selection

Several superior clones were identified from the cultivated varieties. The earliest clonal selection from Thompson Seedless was named Pusa Seedless at IARI, New Delhi during the 1960s. Singh et al. (1974) identified 15 days early ripening clone from Perlette. Selection 7 was named Cheema Sehebi and Selection 94 was a male sterile variety obtained from the open-pollinated progeny of Pandri Sahebi. Dr. L. Venkataratanam identified a bud sport from Anab-e-Shahi and named Dilkush. 2A Clone a mutant of Thompson Seedless from California was introduced in India by the Maharashtra State Grape Growers Association and commercially cultivated in Maharashtra. Manjari Naveen is a clonal selection from Centennial Seedless developed by the National Research Centre for Grapes, Pune was released in 2008. Several innovative farmers also made selections (Chadha and Shikhamany, 1999 Gawande, 2021).

Clones identified by Grape Growers and commercialized


Sharad Seedless: Bud sport of Kishmish Chorni, identified by Shri. Nanasaheb Kale at Nanaj, Solapur district.

Sarita Seedless: Shri. Dattatraya Nanasaheb Kale from Nanaj, Solapur identified this selection from Sharad Seedless.

Nanasahab Purple Seedless: A selection made by Mr. Dattatraya Nanasaheb Kale of Nanaj, Solapur from buds on cordon of Sharad Seedless.

Nath Jambo Seedless: Mr. Vithal Nivrutti Thorat identified this selection from Sharad Seedless which was released in 2006.


Hybridization

Systematic grape improvement programs were started by many ICAR Institutes, e.g. IARI, New Delhi, IIHR, Bengaluru, and some other Agricultural Institutes and Universities, and as a result, several new hybrids were released by these institutions (Gawande, 2021). In 1980, four hybrids namely, Arkavati (Black Champa X Thompson Seedless), Arka Kanchan (Arab-e-Shahi X Queen of Vineyard), Arka Hans (Bangalore Blue x Anab-e-Shahi) and Arka Shyam (Bangalore Blue x Black Champa) were released from IIHR, Bangalore for commercial cultivation in the States of Karnataka, Maharashtra, Andhra Pradesh, and Tamil Nadu. Subsequently, 7 more varieties, namely Arka Chitra, Arka Krishna, Arka Majestic, Arka Neelamani, Arka Soma, Arka Trishna, and Arka Shweta were released from IIHR, Bangalore. IARI, New Delhi released five grape varieties, namely Pusa Urvashi, Pusa Navrang, Pusa Aditi, Pasa Trishar, and Pusa Swarnika. NRC for Grapes, Pune released two varieties developed through hybridization (Manjari Medika and Manjari Shyama).

Rootstocks

Over the period, the effect of rootstocks proved to be beneficial for domestication and increasing the productivity of fruit crops. The commercial exploitation of rootstocks in grapes was primarily aimed at the management of Phylloxera (Daktulosphaira vitifoliae Fitch.), a pest found in Europe that has devastated the grape industry based on V. vinifera cultivars. The use of North American grape species as rootstock, namely V. labrusca, V. riparia, V. rupestris, and V. berlandieri provided protection against Phylloxera, while V. berlandieri shows tolerance to chalky soil.

Considering the role of rootstocks in negating abiotic problems of salinity, drought, low vine vigor, poor fruiting, and nematodes, it has been commercially exploited. Based on the rootstock evaluation, Dogridge was found vigorous, Salt Creek showed tolerance to salinity and St George was drought tolerant (Chadha, 1992, Reddy et al., 1992). Commercial use of rootstocks in grapes was initiated in Maharashtra state, specifically for saline soil and water with excessive chloride. The use of rootstock has also contributed to better yield, bunch size and berry diameter, crispness, and sugar content under challenging abiotic conditions. Rootstock 1613, a nematode-resistant rootstock was found to be quite compatible with Anab-e-Shahi. Commercially rootstocks are multiplied by cutting and rooting is induced using Indole butyric acid (IBA) at the concentration of 1000-2000 ppm.

Viticulture practices

Canopy management: Manipulation of vine canopy is a critical component to achieving optimum productivity and quality produce, which is encouraged by better light penetration and interception (Somkuwar, 2008). Various training systems (Head, Bower, Telephone, Kniffin, V, Y, expanded Y, and Gable) were assessed for commercializing viticulture. Among these, the bower system is the most popular.

Nutrient management: Different trials were performed based on the fertilizer recommendations of different varieties in different states. However the fertilizer application should be based on petiole analysis at 45 days after spur pruning in south and west India and petiole opposite to cluster at full bloom in north India (Sharma and Upadhyay, 2012). It has been advocated that 40 percent nitrogen, 50 percent phosphorous, and 33 percent potassium to be given during the growing season and the rest of the fertilizers should be supplied during the fruiting season. Growth stage-wise fertilizer application through drip in grafted Thompson Seedless vines can save...
60 percent of fertilizer use over the conventional method of soil application.

**Water management:** An irrigation schedule based on pan evaporation (using 0.7 pan coefficient) and growth stages of grafted grape vines has been developed for optimum water use in grapes at ICAR-NRC Grapes, Pune. The schedule improved the water use efficiency by almost 141 percent. Inadequate or low soil moisture leads to weak growth, delayed cane maturity, and poor crop production. Excessive soil moisture, however, results in slow growth, poor bud burst, delayed maturity, poor quality, and rotting of roots. Excessive irrigation can increase salinity and disease incidences.

**Use of Bioregulators**

Bioregulators have an important role in the enhancement of yield, quality, and shelf life of grapes. The use of gibberellic acid (GA$_3$) for rachis elongation and berry sizing has been commercially adopted in seedless varieties for table grape production such as in Thompson Seedless. Hydrogen cyanamide @1.5 percent has been commercially used for induction of early and uniform bud break. Gibberellic acid application has revolutionized grape cultivation. Variety, stage, and end purpose should be considered for GA$_3$ application. The use of ethephon at colour break stage in coloured varieties can help in achieving uniform colour development.

**Grape growing under cover**

Protected cultivation of grapes was initiated in Italy during the late 1950s with table varieties for obtaining early bud-break and fruit ripening (Novello and Palma, 2008). The first protected commercial vineyard was established in Central and Southern Italy using Cardinal variety, which gave promising results for early ripening, attractive clusters, and tasty berries (Morettini, 1974). In Maharashtra, protected cultivation of grapes was initiated for taking early crops and for protection from adverse weather conditions. Protected structures have plastic covers. It also helps in keeping day temperature below outside temperature and retaining heat energy at night time to keep warm condition. It also helps in the reduction of plant protection costs related to the control of downy mildew and other diseases.

**Disease and pest management:** Many diseases affect the grapevine, of which downy mildew, powdery mildew, anthracnose, and fruit rot are the most important and cause severe losses in yield. Of these, downy mildew is the most devastating in peninsular India. Among the disease control measures, weather forecasting and integrated disease management have a significant role in efficient disease management and safe fruit production. Stem borers, mealy bugs, thrips, and mites are important pests of the grapes. The use of biocontrol agents and integrated pest management strategies are important considerations for quality and safe grape production.

**POST-HARVEST MANAGEMENT, UTILIZATION AND TRADE**

**Post-Harvest Management**

Grape being a non-climacteric fruit has to be harvested at its full maturity. On account of the perishable nature of grapes and to avoid a glut in the market, post-harvest technologies (handling, storage, and processing) have a substantial role in Indian viticulture. Pre-cooling after harvest at 1-2 °C within 6 hours of harvest is pre-requisite. The storage is done at 0°C and 95% humidity. Refrigerated transport facilities are available from the farm to the destination market. Progressive growers use Grapeguard, pads in the cartons for extension of shelf life (Chadha and Shikhamany, 1999).

The processed products of grapes include raisins, wine, and juice. The present status of various products is discussed below.

**Raisin production**

Raisins are dried mature grapes. It is believed that the raisins were produced for the first time by the Egyptians as early as 6000 B.C. and were used for eating, treating illnesses, and even paying taxes. The traditional air-drying shelter of grapes has been used for thousands of years in Asia and other places around the world. Asia Minor was the center of the raisin industry about the time of Christ. Raisins were also promoted by sages and rishis of ancient India with the everyday diet.

However, it was only in the 1980s that the commercial production of raisins was taken up mainly in the Sangli, Solapur, and Nashik districts of Maharashtra. The raisin production is also taken up in the Bijapur district of Karnataka state for Thompson Seedless, Tas-A-Ganesh, Sonaka, and Manik Chaman. About 80 percent of raisins in the country are produced from these varieties.
Presently, raisins are produced by dipping the grape bunches in an emulsion having 2.5 percent potassium carbonate and 15 percent ethyl oleate for a duration of 2-4 minutes, and subsequent shade drying in open tier system (Adsule et al., 2012) which meets the Codex requirement of physicochemical, microbiological and organoleptic parameters except for some factors. The total production of raisins is about 1,85,000 tonnes (Wadke, 2019) which is next to the USA and Turkey. About 17-20 percent of total Indian grapes are processed raisins. Besides, a small segment of 'Munakka' (seeded raisins) has also grown since its demand is increasing.

**Wine production**

Production and consumption of wine is an age-old practice worldwide since antiquity. Literature mentioning wine production and consumption is available for modern Georgia (8000 years ago), ancient Greece (8th-4th BC), and classical Rome (up to 500 AD). Wine making is also an age-old practice in India though the exact date of wine production is not available. During the late 1960s, research on wine grapes was initiated in the country. In the year 1967, Mr. Shaw Wallace commissioned India's first winery in 1967 Hyderabad, with the help of an Australian winemaker, and produced Golconda wine, which was not of good quality. During the 1970s, Mr Vittal Mallya started producing Cinzano vermouths at Baramati with the support of Dr. Rossi. Varieties as well as technologies for wine production and standardization were initiated by a group of scientists in Delhi (Dan, et al. 1972), Hisar (Vyas, 1937, Relan and Vyas, 1971; Vyas and Gandhi, 1972), Bangalore (Negi, et al. 1972), (Chandra 2013), Mysore (Rao, 1972) etc.

Mr. Sham Chougule established Chateau Indage winery in 1985 and started making genuine wines from *vinifera* grape and launched Marquise de Pompadour sparkling wine in 1986, which was named as 'Champagne' with the support of Dr. K.L. Chadha who supported the establishment of 100 percent export wine units in Maharashtra. It also started imports of fine wine *vinifera* grapes like Cabernet Sauvignon, Chardonnay, Pinot Noir and Ugni Blanc and started making still and sparkling wines.

Further, Mr. Kanwal Grover in Karnataka is credited with producing eponymous wines in 1992 and International Distillers India by restarting Cinzano in 1996 at Indage's winery at Narayangaon provided a leadership role in the establishment of wineries in India. Mr. Rajeev Samant launched Sula Wine. Grapes are grown mostly in Nashik, followed by Pune and Sangli districts. Cabernet Sauvignon, Shiraz, Merlot, Pinot Noir, Zinfandel, and Carignan are popular for red wine while Sauvignon Blanc, Chenin Blanc, Ugni Blanc, and Chardonnay are grown for white wine production.

Central and state governments also took initiatives to promote winery and wine production by forming the “Indian Grape Processing Board' in 2009 in Pune by MoFP and state policies such as ‘The Maharashtra Grape Processing Policy 2001 that helped in rising production of wines from 712 kl in 2002-03 to over nearly 20 million liters in 2018-2019. Later, the formulation of ‘The Karnataka Wine Policy 2008 helped the industry by giving ease in winery licenses, wine Tavens, and Wine Boutiques. As a result, wineries were established in Bijapur, Bidar, and Belgaum (apart from Bangalore) districts. At present, the wine market has been growing at 25-30 percent a year, however, per capita consumption is only 0.07 liters/person/year. Major consumption is limited to a few cities including Mumbai (39%), Delhi (23%), Goa (9%), Bangalore (9%) and rest of India (20%). Nearly 74 wine-producing units exist in India.

**Juice production**

Grape processing for juice-making grapes is very new to India with the introduction of tetra packs. Bangalore Blue variety grown in Karnataka state is being utilized for juice making. Other varieties such as Pusa Navrang, Manjari Medika, and MACS 516 are also suitable for juice making. However, juice extraction through the membrane method and pasteurization and storage in hermetically sealed containers are recommended on a commercial scale. Many companies are now processing and marketing tetrapack grape juices.

**Trade**

Grape is one of the largest traded fruits in the world, either as fresh grapes or processed products (raisins, juice, and wine). Major exporters of grapes are Chile, Italy and USA, while, USA and Germany are the major importers of grapes in the world. So far, India's efforts have been mainly on exports to European countries. Indian fresh grape exports have increased from 20,647 tonnes in 2000-01 to 2,46,134 MT in 2018-19 at a value of Rs 2,33,525.08 lakh (US $ 334.8 million) (APEDA, 2019). Indian grape is
being exported to more than 63 countries with maximum exports by volume to the Netherlands followed by Russia, UK, and Bangladesh. During 2018-19, 299 MT of grapes valued at 8616 lakh rupees were imported from 12 different countries such as China, USA, Peru, Chile, Afghanistan, Australia, etc.

The harvesting period of major grape-producing and exporting countries is from May onwards to November. Whereas, grape production in India of major exported varieties is mainly from January to March. Other grape-growing countries, which produced grapes during this period are Chile, South Africa, and Israel. Europe is the biggest market for grapes, as monthly imports of grapes are about 90,000 tonnes in winter and around 40,000 tonnes in summer (February-May). Thus India has the potential to meet the requirements of European markets provided maintenance of quality produce and MRL compliance.

Considerations

- In India, grapes are being grown all over the country under variable climatic conditions. Its peculiarities and uniqueness necessitate research to evolve suitable varieties and techniques for growing vines under different agro-climatic conditions considering the vine physiology.
- Improvement work needs to be focused on specific objectives like abiotic and biotic stresses, climate change, etc. Collection of trait-specific germplasm and its utilization in breeding programs supported by advanced biotechnological interventions (marker-assisted selection, genome-wide association mapping, CRISPER/Cas9, etc.) should be given priority.
- Rootstocks should be identified for saline and drought-prone areas, promotion of fruitfulness, and variety specific.
- Attention should be given to canopy management as per the training system to harness optimum light, ventilation, and protection measures. Crop load management should be taken care of for quality produce as per market demand and to manage uneven ripening and colour development.
- Ways need to be devised for increasing fertilizer use efficiency by placing them in close proximity to the high root zone activity and use of micro-organisms. Overuse of fertilizers in grapes is a matter of concern and should be discouraged. Stage-specific water and fertilizer requirements will save on the cost of fertilizer and soil health.
- Protected cultivation need to be popularized for expanding viticulture in non-traditional areas and for the production of off-season crop in traditional areas.
- Integrated pest and disease management strategies should be taken up on priority for quality and safe grape production.
- Wine research should incorporate the identification of wine purpose varieties, wine-making techniques, quality winemaking, and use of different yeast strains in wine making.

ACKNOWLEDGEMENTS

I am thankful to Dr. V.B. Patel, ADG (Fruits and Plantation Crops), ICAR, New Delhi for his assistance in the compilation of relevant information for the article and Dr. R.K. Pal for proofreading the manuscript.

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