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Vision 2050

National Research Centre for Grapes

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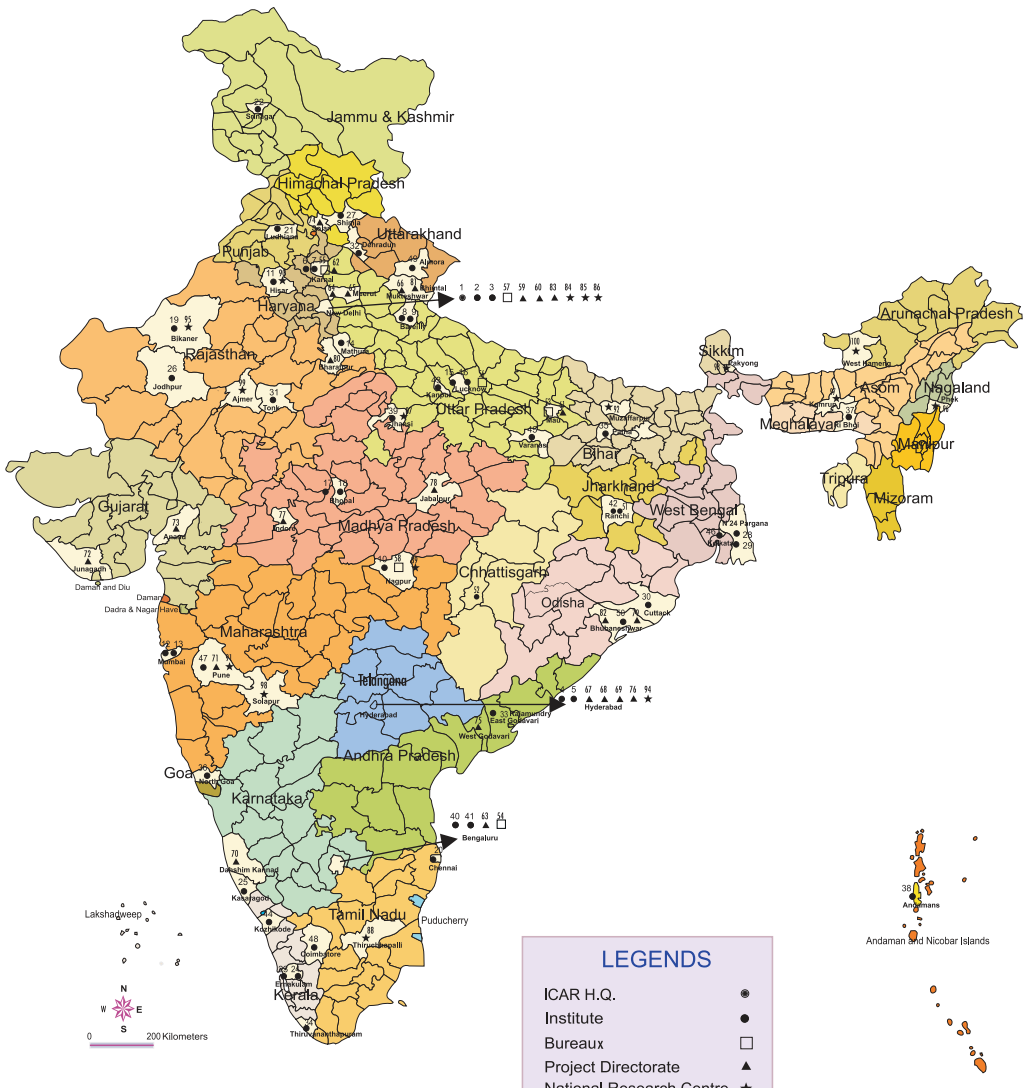

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Vision 2050

राअंअनु के
NRCG

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Printed : July 2015

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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)
केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-National Research Centre for Grapes (ICAR-NRCG), Pune has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

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Preface

Vision 2050 for Grapes in Nutshell

India has emerged as one of the major table grape growing countries in the world. About 2.59 million MT grapes are annually produced in the country most of which is table grapes. It is typically tropical viticulture as more than 95 per cent of vineyards, of 1.19 lakh ha, is in tropical climate in Maharashtra, Karnataka, Tamil Nadu, Telangana, and Andhra Pradesh. India is the only country in the world, where table grapes are available during in April-May. Exploiting this exclusive market window, table grapes are exported to Europe in international standard cold chain. About 8% of total production of grapes is exported, and value of the export is about Rs. 16000 million. Among the countries exporting grapes to Europe, Indian grapes have been rated above grapes from major competing countries like Chile, South Africa, Australia, by major importers. About 26 percent of Indian grapes are produced specially for raisin making and are sundried. Most of the raisins produced are consumed within country, however during last few years raisins are also being exported. Wine industry is also encouraged through state wine policies mostly in Maharashtra, and Karnataka. However, commercial wineries are also present in Mizoram and Madhya Pradesh.

The grape sector in India thus, includes various stakeholders such as grape growers, wineries and allied industries like cold storage, cold chain transport, packaging, manufacturers and suppliers of agrochemicals, drip irrigation systems, trellises fabricators, exporters, and hospitability industry in case of wine. Excellent infrastructure such as integrated pack houses and cold storages have been developed in Nasik district in Maharashtra from where table grapes are exported. Similarly grape drying shades, integrated cleaning, washing, size and colour grading machines and cold storages for raisins have been developed in Sangli and Bijapur districts in Maharashtra and Karnataka states. National Residue Monitoring Plan is in force to comply with stringent food safety requirements of European Union. Under this plan several private analytical laboratories of international standards and recognized by APEDA are working for pesticide residue analysis. Functioning of these laboratories is monitored and technically supported by National Referral Laboratory established with APEDA support at ICAR-National Research

Centre for Grapes, Pune. The entire activity of grape export is controlled through first of its kind, online e-governance software called Grapenet.

The grape cultivation needs high investment right from the establishment of new vineyard. For successful cultivation of grapes with sustained quality and productivity, a great deal of technical information is needed. Thus, grape industry will need constant research support. Until 1997 ICAR-Indian Institute of Horticulture Research, Bangalore, and ICAR-Indian Agriculture Research Institute, New Delhi had provided such support. Now ICAR-National Research Centre for Grapes, Pune is fulfilling the research needs of all stakeholders. The State Agriculture Universities in Maharashtra (Rahuri), Karnataka (Bijapur), Tamil Nadu (Cumbum), Madhya Pradesh (Mandsaur), and Punjab (Ludhiyana) are contributing through hosting AICRP centers. Development of package of practices including selection of varieties, use of rootstocks for water stress and salinity management, canopy architecture for different end uses, integrated nutrient and irrigation management, use of growth regulators, integrated insect and mite pest management, integrated disease management, agrochemical residue management, and post-harvest management have been developed and are being continuously fine-tuned to suit the national and international requirements and for different end uses of grapes. Good Agricultural Practices (GAP) routinely emphasized for management of resources such as soil and water, and for plant protection will be relevant for grapes too.

Loose bunch, bold and crispy berries, and long shelf life in cold storage are important desired characters of table grapes worldwide. In India Thompson Seedless and Sharad Seedless varieties and their clonal selections are grown and technologies to achieve above mentioned characters in these grapes involving application of growth regulators at different stages, manual thinning of bunches and berries have been developed and are being practiced. In many situations excess use of growth regulators achieve physical parameters but treated grapes have reduced shelflife and palatability is inferior for consumer preference. But new varieties in which these characters are naturally present have been developed outside the country where cost on application of growth regulators and other manual operations are saved. Widespread popularization of these varieties in other countries will put India in economic disadvantage in terms of cost of production and consumer preference in international market. Many of these varieties have 6 to 9 months shelf life in cold storage, thus advantage of exclusive market window in Europe can be easily neutralized by the competing countries. Such varieties should be introduced in India as early as possible. The

germplasm collections should be enriched with entries having such characters and breeding programs should be initiated to develop varieties with similar characters and suitable for Indian conditions. Varieties suitable for raisin production should also be identified especially which are black and seeded.

In tropical conditions, among various biotic stresses, downy mildew is the major factor affecting productivity and cost of production. Thus its management through incorporating resistance in popular cultivated varieties will be the most practical approach. Understanding molecular genetics of resistance in various germplasm sources and its use in breeding programs should be a research priority. Similarly, majority of grape growing areas among abiotic stresses, soil salinity, mainly aggravated due to quality of irrigation water and methods of irrigation is affecting the longevity of vines and quality of berries. To mitigate the problem understanding of genetics of salinity tolerance and use of this knowledge for developing soil type and variety specific rootstocks is essential.

Change of climate has resulted in higher frequency of untimely rains, thunderstorms, hailstorms in grape growing area. During last few years such events have caused heavy losses in grapes in major grape growing areas, bringing in element of uncertainty in viticulture. Under similar situations in European countries like Italy and Spain, a low cost, and cost effective technology on protected cultivation in grapes has been developed. In this technology vineyards are raised under special quality plastic cover. The technology has changed world table grape scenario, and countries like Italy and Spain where there were no table grapes until last 15-20 years now produce table grapes more than that in India. The heart of technology is in low cost method of erection of supports for laying plastic cover. Even plastic is also innovative having properties that helps in keeping day temperature below outside temperature, and retaining heat energy at night time to keep temperature warmer than outside and protect from frosts. Introduction of such a technology may change the scenario of viticulture in India. In tropical belt it will be possible to produce grapes throughout the year. In case of early pruned vineyards it will protect early vegetative growth and mature grapes from rains. Pressure of downy mildew and related cost of protection will be reduced to minimum. Main season crop can be protected from cold waves, while late season crop at maturity will be protected from rains and hailstorms. More importantly it will remove the element of uncertainty of profitability in viticulture. Staggering in fruit pruning will be possible with less risk and market gluts can be avoided. This

technology may also increase viticulture in subtropical climate in north and central India. In northern India fruits are taken on shoots growing after winter. About 120 days after pruning are needed to produce quality grapes even with short duration varieties. In northern India this many days are seldom available between pruning in February-March when minimum temperatures start rising above 10°C and beginning of monsoon rains in June. Thus, mature grapes often face rains and reduce its market value drastically. In central India, fruit pruning is taken during October, but often vineyards suffer from frost during winters. Both these situations can be effectively managed under plastic cover.

The elevated CO2 levels due to climate change potentially can increase yields in grapes in arid or semi-arid zones. However, appropriate understanding of irrigation requirements under high temperatures to avoid moisture stress in the event of higher evaporative losses will be essential. In arid and semi-arid zones water availability and its quality both will be limiting factors. Thus technologies improving water use efficiency, in such situations, will be crucial to reap the benefits of higher CO2 levels and increase the productivity.

Availability of skilled labor has been major constrain in increasing area under table grapes in traditional area. Profitability in grapes in general and table grapes in particular is largely dependant on production of quality grapes. Implementation of package of practices for production of quality grapes, timely availability of skilled labour is indispensible. If skilled labours are not available, even resource rich grower will not expand his area under grapes. Urban construction industry around grape growing area, whether near cities or rural areas, takes away labours from vineyards. The trend is likely to continue and intensify with time. Mechanisation of major labour consuming activities in vineyards such as pruning, weeding, compost applications, crushing of pruned waste for its recycling, harvesting of green manuring plants and putting them in rootzones etc. is possible. Application of growth regulators through bunch dipping requires large number of skilled labours. Introduction of new varieties may reduce its need in future. But presently bunch dipping operation is recommended to ensure thorough coverage of the bunch with desired growth regulator. Recently, use of high tech low volume sprayers with electrostatic technology has shown that it can achieve required coverage and replace the dipping operations. Developed western world is facing labour shortage since years. Hence, technologies for mechanizations have been very well developed in those countries. Some of the relevant technologies can be easily introduced in our country through adoptive trials. In western world farm holdings are very large

and hence machineries developed are usually suitable for large holdings, hence modifications of machines to suit small holdings in India are essential. Enthusiastic and innovative grape growers have already started importing various machines for mechanization in vineyards. But to put their efforts on right track, research programs with adaptive trials are needed. Technology on unconventional energy sources such as power generation using wind and solar energy is becoming cost effective. While introducing mechanization, possibility of use of such energy sources should be considered to restrict cost of production. Use of robotics based and GPS, and remote sensing may make it fully mechanical.

Diversification for value addition is exploited very minimum in Indian grapes industry. Some of the red grape varieties are exceptionally rich in chemicals having medicinal properties, such as resveratrol and anthocyanins. These compounds have been reported to have antioxidant properties and can prevent heart diseases, cancers and even diabetes through reduced insulin resistance. Research work on breeding varieties for higher amount of such compounds and developing technologies for large scale cultivation of these varieties to produce functional foods will add new dimension in viticulture. ICAR-NRCG has already shortlisted one such variety which may be useful in developing new industry on functional foods. Grape leaves on inducing biotic stress under humid conditions can produce higher quantity of resveratrol. Thus there is a possibility of extraction of resveratrol from leaves during vegetative phase of tropical viticulture making it more profitable. Seeds of grape in general are known to have more anti-cancerous properties. Extraction of grape seed oil especially from varieties having more medicinal properties should be aimed for developing functional foods. Use of winery wastes such as pomace, wine lees, can be used to prepare functional foods and neutraceuticals. Production of black seeded raisins will also serve as functional food and can be popularized.

Attention is needed to reduce postharvest losses in table grapes in Indian markets. Technology of packing, cold storage and cold chain transport is very well established in India for export of grapes to Europe. The same is also used for storage of grapes for local markets too, on a limited scale. Use of refrigerated containers for long distance market within country will reduce post harvest losses considerably. To meet the projected requirement it is essential to save every berry produced.

With average 4% growth the annual production of grapes should increase up to 9.75 million MT and it will result in per capita availability of 5.13 kg grapes per year. It is a ambitious target but achievable through appropriate research outputs from research programs suggested

in Annexure 1. More emphasis should be on multifold increase in area under cultivation than on increase in productivity. Scientifically, increase in productivity to limited extent is possible through development of varieties and effective abiotic and biotic stress management, but beyond 30 MT per ha. it will be compromise on quality. To increase in area we should concentrate on none traditional areas in subtropical climate and uncultivated soils in arid and semi-arid zones. At present about 60 per cent of total area under grapes is in Nasik district of Maharashtra State, hence increase in area under cultivation will be very much possible. Low cost, but cost effective technology on protected cultivation will be the key tool to increase area under cultivation.

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Contents

Context

In India most of the grapes are produced in tropical conditions. It is typically tropical viticulture, grown in either "two pruning and single cropping" system in Maharashtra, Karnataka and Andhra Pradesh or in "five pruning and five crops in two years cycle" system in Tamil Nadu. "Single pruning and Single cropping" system is possible in only subtropical conditions of north India in Punjab, Utter Pradesh, Himachal Pradesh, Jammu and Kashmir, West Bengal and NEH region. Presently, the area under viticulture is more than one lakh ha, more than 90 per cent of which is in Maharashtra and Karnataka states, which follow two pruning system; first a foundation in April and then forward pruning in October. The foundation pruning is to remove all canes from arms after harvest to initiate development of new canes. These canes are developed to make it fruitful within about 160 days and then forward pruning is taken to allow emergence of a bunch. Forward pruning is also called fruit pruning. Depending upon severity of winter in the area, it takes about 120 to 160 days after fruit pruning to harvest the crop. In entire viticulture area wherein two pruning and single cropping system is followed, winter is not severe enough for vines to go in dormancy. Hence, depending upon the rain pattern and total rains, growers have opportunity to change the standard time of foundation and fruit pruning. About 5 to 10 per cent vineyards in these areas often take foundation pruning as early as in February and fruit pruning from July onwards. This is done to bring crop in market in November to get higher value. Early pruned vineyards normally face higher risks of rains at early growth or at harvesting stages and thus have high cost of production due to higher expenditure on plant protection. Growers earn higher returns if weather is appropriate, but can lose heavily if it rains after veraison. In the process of staggering prunings for better labour management in case of large holdings, about 5 to 10 per cent vineyards are pruned late. In this case foundation pruning could be in May, while fruit pruning is in November. In these vineyards, young growth after foundation pruning faces hot summer and monsoon rains, while mature bunches have risk of thunder showers or hailstorms in March – April. Most of the technologies developed and standardized are primarily for standard recommended time of prunings. While in early and late pruned vineyards, growers take chances to find their own ways to success.

In Tamil Nadu since 5 crops are taken within two years cycle, with staggering of pruning grapes are available almost throughout the year, except in November, a period when harvesting is avoided due to rains.

Unlike other grape growing countries in the world, India is primarily a table grape growing country. During last 2 decades wine industry is being developed, but has achieved limited success. In most traditional wine grape growing countries, cool winter follows the harvesting season. Hence, the process of fermentation of grapes for wine and its further storage is relatively easy. While in India, harvesting starts with beginning of hot summer and hence wine industry needs to spend on cooling systems to make fermentation process and further storage of wine more comfortable. Quality of wine depends on sugar-acid ratio in grapes. To achieve desired phenolic maturity and sugar–acid ratio in grapes, vineyards have to be ready for harvest before temperatures rise February onwards. Thus, in most wine grape vineyards in tropical climate in Maharashtra and Karnataka, growers need to take risk of pruning early in September, with high cost of protection. Vineyards in tropical conditions in India do not go in dormancy, and thus cost of maintenance of vineyard during vegetative phase is an additional cost. Thus, cost of production of tropical wine in India will be always high as compared to temperate countries. However, state governments are making favorable policies to support wine industry and facilities such as wine parks have been developed. Many universities have started teaching courses on winemaking to develop skilled manpower.

Making raisin or dry grape is in fact a complementary activity to table grape industry in India. As grapes are perishable fruits, cost will always depend on demand and supply. Varieties such as Thompson Seedless and its clones are suitable for both table grapes as well as raisins. The same vineyard can be maintained for table grapes or for raisins during any year based on forecasted demand. Even though technology of cold storage of table grapes is available, it is not very economical for grapes marketed within country. The problem of perishability of table grapes is greatly solved due to development of dry grape industry. Dry grapes are stored in cold storage at 5°C till better rates are recieved. Storage of dry grapes is relatively easy and economical. In recent past raisin industry has emerged as profitable industry in dry and hot belts of Maharashtra and Karnataka states in Sangli, Solapur, Bijapur and Bagalkot districts. Advantage of prevalence of hot and dry weather in these districts at harvesting season is taken and grapes are dried in shades. Even though huge infrastructure has been developed in the form of drying sheds, washing, size and colour grading machines, cold

storages etc. research institutes have made limited interventions to ensure quality improvement. More than 25% of Indian grape production is at present converted in to dry grapes. Even though recently dry grapes have shown good potential for exports, major part is sold within the country.

Europe consumes table grapes throughout the year and thus import it from different part of the world. Until early ninetees table grapes were not available in Europe during April-May. Only in India grapes were available during this period and to exploit this exclusive window India started exporting grapes to Europe in 1990. It was a modest beginning, with total export worth less than Rs. 500 million. Today the exports have grown up to Rs. 16000 million. About 8% of total grape production was exported during 2013-14. Initially, the export was based on the exclusive window, but now Indian growers have adopted the best of the technology to comply with strict quality requirements of EU countries. One of the major fruit importing company in Europe, based on their systematic observations over last 5 years has rated Indian grapes as one the best among about 23 countries exporting grapes to Europe. Interestingly, grapes from traditional grapes exporting countries such as South Africa, Australia, Chile, and Brazil have been rated below Indian grapes. Vineyards producing exportable grapes follow special package of practices, including use of growth regulators to make the bunches loose and the berries bold (>16 mm dia. etc.), manual operations such as thinning and dipping of individual bunches, judicious spraying of agrochemicals for control of diseases and insect pests, covering every bunch with paper to avoid pink berries and to achieve uniform white appearance. More than 90 per cent of India's exportable grapes are produced in Nasik district of Maharashtra state. Therefore excellent infrastructure has been developed to support grape exports. This include state of art pack-houses, pre-cooling chambers and cold storages etc. In export business all the grower exporters, the growers co-operatives, private companies and corporate sectors are involved.

In India, thus, grape sector includes grape growers, wineries, and supporting industries like cold storages, cool chain transport systems, packaging industry, various input manufacturers and suppliers of agrochemicals, irrigation and trellises systems, local marketiers and exporters, and hospitability industry in case of wines.

The complete package of practices including selection of variety and compatible rootstock, vineyard establishment including training systems, variety specific canopy architecture for different end uses such as table grapes, raisin making, or for wine making, use of growth regulators, irrigation and nutrient management, diseases and insect and

mite pests management through use of environment friendly chemicals, bio-pesticides, botanicals has been developed and regularly fine tuned to comply with domestic and international standards. Production of quality grapes with sustainable yields are major objectives. Growers often have tendency to harvest higher yields, and to use inputs inappropriately or in excess resulting in low quality and low input use efficiency. Abiotic and biotic stresses such as drought, soil and water salinity, high incidences of diseases, insects and mite pests are major problems of the industry. High incidence of diseases and pests, especially in case of off-season crops, or under favourable weather conditions for pests, leads to more use of pesticides and have chances of pesticide residues at harvest. However, Residue Monitoring Plan in exportable grapes have brought in extraordinary awareness among grape growers about safe use of pesticides to produce grapes without objectionable residues.

The industry needs constant research support for new improved varieties for table grapes, raisin and wine making with better quality and stress tolerances, to develop technologies for sustainable quality production, especially with less or no use of pesticides and post harvest technologies for value addition. Untimely rains and extreme events such as hailstorms have resulted in huge losses in many vineyards during recent past. There is a fear of regular occurrence of such events due to change in weather. And need for development of economical technologies for protected cultivation is being emphasized. The collaborations with various institutes under ICAR, CSIR and ICMR may be needed to meet the research needs of the industry.

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Challenges

Grape is traditionally, a temperate region crop and in India it is grown in tropical belts for fresh consumption and processed products and thus faces many challenges on different fronts. In coming years, challenges may become tougher due to shift in climate, changing global scenario and associated factors.

Uncertain Weather

Standard pruning times in most areas were decided based on rain pattern of the area, and annual crop cycle was designed such that rain sensitive growth stages such as early shoot growth and harvesting period were avoided during the period of rains. During recent years untimely rains have become more common in grape growing areas resulting in loss in quality and increase in expenditure on plant protection. Extreme events such as thunder storms and hail storms during harvesting periods in many areas have caused total destruction of crop. However, even light rains during harvesting period can induce cracking in berries and/or reduce post harvest shelf-life considerably and reduce profits. Grape crop which requires very high investment, both for establishment of vineyard and then to maintain it, cannot sustain such losses. Unless there is certainty about production the crop cannot be grown economically. The elevated CO_2 as a result of climate change may increase productivity in arid and semiarid conditions in grape growing areas, but it should be supported by availability of irrigation water at critical stages. Delay in monsoon, in situation of less irrigation water, will reduce fruitfulness, while early monsoon, in late pruned vineyards will also reduce fruitfulness due to uncontrolled shoot growth. Grapes are successfully grown in area where average rainfall is around 500 mm, hence in most such areas limited irrigation water is available. Uncertainty of weather thus drastically affects the productivity in grapes.

Climate change will also help some pathogens to become more virulent and/or the plants may become more susceptible, thus increasing disease severity. Recent studies at ICAR-NRCG, have indicated that *Colletotrichum*, which require higher temperature has become dominant pathogen of anthracnose in tropical conditions in place of *Elsinoe* sp. which thrives well in low temperatures. Unseasonal rains may lead to serious downy mildew. The industry has experienced decrease in

productivity during the recent years from more than 25 tons per hectare to 9.2 tons per hectare which was mainly due to infection of downy mildew. There is also likelihood of change in the incidence and pattern of insect pests like mealy bug, thrips and mites. Similarly the other disease incidence pattern is also likely to be affected with the change in climate as has been observed in case of downy mildew.

Availability of Skilled Labour

Unavailability of labours has become major constrain in expanding area under grapes even in traditional grape growing area. Unlike other horticultural crops, requirement of labour in grapes is high. But viticulture is highly technical. Operations such as pruning, shoot thinning, subcane development, bunch thinning, berry thinning, girdling etc. need to be done at right stage and required skilled workers for successful execution. Unavailability of skilled labours whenever required makes the problem more serious. Most of the vineyards are in close vicinity of developing urban areas where skilled labours get higher wages for construction work and hence cost of labour for viticulture is invariably high and increasing day by day. Grape industry has a credit to have generated work for many, but in future without mechanisation, it will not be sustainable.

Production of Grapes as per Consumer Preference

The world outside India prefers bold white berries, but Indians like long berries with golden shade. Crispiness in berries, with long shelflife is one of the universally preferred character. Varieties with such desired characters will attract more consumers.

In tropical climate grapes suffer from economically important diseases like downy mildew and powdery mildew, and insect pests such as thrips, jassids and mealy bugs. In efforts to control them growers need to spray lots of pesticides. The food safety conscious consumers therefore often avoid eating grapes in fear of bad effects of pesticide residues. But in reality, indiscriminate use of pesticide in viticulture has reduced considerably in last 2 decades. Information on MRL (Maximum Residue Limits) and PHI (Pre Harvest Intervals) have rationalised use of new generation safer pesticides and risk of residues have considerably reduced. However, programs to educate more farmers for appropriate use of safer plant protection chemicals, and making consumers aware of these developments are important to increase the consumption of grapes in India. Indian farmers are complying stringent food safety norms of European Union and exporting grapes to Europe with good

acceptability is a testimony of these developments. Even then providing residue free grapes to Indian consumers especially under changing climate will be a challenge.

Even though we are making reasonably good quality raisins in India, in north India consumers prefer raisins imported from temperate countries. The best raisins of India gets only one third of rates that such imported raisins get in Indian market. If the quality of raisins is climate related, it will be great challenge to develop technology to improve quality of Indian raisins.

Grapes are also known for many nutraceutical and pharmaceutical properties. However, very less efforts have been made to exploit these commercially. Development of varieties containing more compounds with nutraceutical/pharmaceutical properties and its use in wine/juice industry will attract more consumers to grapes.

High Cost of Production

Maintenance and harvesting of optimum quality production requires specialized trellis system. The system ensures better spread of canopy, to provide maximum surface area for receiving more sunlight light on leaves, and protect bunches from direct light. Such structures involve use of steel in the form of angle irons and GI wires. With current rates of steel and labours erecting of such a structure costs between 4 to 6 lakhs per hectare depending upon actual amount and quality of material used. Cost of vineyard establishment therefore is higher than any other fruit crop. Further annual production cost for good quality crop is also very high as it require costly inputs like agrochemicals, and manual skilled labours, etc. Development of technologies for precision viticulture to optimise efficient use of all inputs will be only way to reduce cost of production in grapes.

The processing industry like wine is also fully dependent on imported plant materials of wine grape varieties, machinery and equipment of wineries, cultures of microbes/yeast and packaging materials etc. The cost of imported material is high and increases the cost of wine production, thus making it less competitive in global market. Today, in many wineries even the wine maker is invited from outside India. Thus as wine industry develops, all inputs industries also will have to be developed in India to make Indian wines globally competitive.

Promotion of Viticulture in New Areas

Presently most of the commercial viticulture in India is present in tropical region, however, there is a scope to develop it in areas with

subtropical climate in northern part. Cultivation of grapes in subtropical climate in India is expected to be more economical, as dormancy period during winter will reduce cost of maintenance of vineyards, and as the fruit development period will be during summer, it will attract less diseases. Currently the problem is due to possibility of rains during harvesting and can be solved by more research. Protected cultivation to increase canopy temperatures during February to achieve early sprouting, and to protect mature bunches from rain during pre-harvest period may provide economical solution. Early maturing and rain tolerant varieties are also expected to be effective. Rains are problem to mainly table grapes, but growing grapes for wine or juice is possible and less risky.

Climate change, such as increase in temperatures in cooler areas may open a possibility of growing grapes in new area.

Competition in Markets

India can produce table grapes during April-May, when no other country in the world has grapes. Thus, India will have advantage of exclusive market window in international trade. However, India can have table grapes almost throughout the year and if good quality grapes are produced considering consumer preference exports can be extended in many more countries and beyond period of exclusive window. In Europe, there is a demand of coloured table grapes during June-July and no country is able to supply it as on date. Grape growing area in Cumbum in Tamil Nadu has potential to produce quality coloured grapes during this period. If such potential is exploited India can extend their exclusive window. Supply, demand, trade policies, and consumers are the drivers of market competitiveness. Fruit type i.e. seeded or seedless, berry colour, taste, other fruit quality parameters, diversification and availability of processed and value added products are main factors for creating new markets and making them more competitive in the years to come. The supply and availability of other fruits in the season also have influence on competition. Availability of new fruits or processed products may affect consumer demand and create competitiveness in markets during coming decades.

Resource Availability

Major grape growing areas are around big cities and urbanization in these area will reduce area under viticulture and availability of cultivable land. The effect of climate change may open up other sites for grape growing than the existing ones. The grape cultivation may have to be extended to unconventional and marginal land areas. If irrigation

water is available, grapes can be successfully and economically grown in light marginal lands in low rainfall areas. Developing varieties and production technologies for such regions will be research challenge in coming decades.

Quarantine Issues

Transportation of fruits and plant material from one place to other always provide chance of introduction of new insect-pests, diseases, weeds etc. which were not available in particular region. Due to change in trade policies and open market, entry of new insect-pests, diseases, weeds etc. with fresh grape may become frequent, which will pose threat to grape cultivation in the country and also divert research focus to management/control of new pests and diseases. The quarantine laws are not complied in full spirit and therefore there is a need to enforce laws in full measure to restrict the entry of new diseases, insect pests and host pests.

Presence of disease or insect pest which is not present in importing country can pose a serious non-tariff barrier for exports and also will add to cost of export to comply with quarantine needs of importing countries.

Soil Health Management

The deterioration of soil health is also becoming serious issue. Indiscriminate application of fertilizers, soil drenching of pesticides for controlling various pests, change of irrigation methods and water quality are major factors responsible for soil health degradation. Deteriorated soil health will affect the vine health and its longevity leading to poor crop and berry quality. Consideration of soil health will become prime issue for replanting the grape in same field. New arable land may be required for planting of new vineyards.

Genetically Modified Grapes

Genetic modification is a necessary evil in crops like grape. With conventional breeding it is difficult to develop varieties with characters needed by the growers, traders, and consumers. Naturally loose bunches, bold and crisp berries, are characters needed by growers and consumers, while long shelf-life is the requirement of traders to transport long distance. To grow grapes under adverse conditions of soil health and favourable climate for diseases, varieties with biotic and abiotic resistance will have advantage. Most of such traits are not present in popular varieties and improvement of popular varieties by

incorporating such traits is possible with bio-technological methods for genetic modification. Research focus on this promising technology and the trade of fresh grapes and processed products will be affected by policies of Indian Government and importing countries with respect to genetic modification.

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Operating Environment

Research on viticulture was on limited scale in State Agriculture Universities. Focused research was carried out in ICAR-Indian Institute of Horticulture Research, Bangalore and ICAR-Indian Agriculture Research Institute New Delhi. Innovative farmers in Maharashtra in close contact with scientists in these research institutes developed commercial viticulture in Maharashtra and India started exporting grapes to Europe in 1990 and got a place in viticulture map of the world. Need for advance research in tropical viticulture to guide growers increased with time and ICAR-National Research Centre for Grapes was established in 1998 with the mandate "To undertake mission oriented programme involving basic and strategic research for resolving the major biotic and abiotic constraints affecting the production, productivity and utilization of grapes". To fulfil this mandate a number of focused research programs were formulated and significant achievements have been made during last 18 years.

- A large grape germplasm is collected and characterized by morphological and molecular methods. Based on molecular analysis, a set of core collection representing entire genetic diversity, were identified.
- Germplasm sources with multiple disease resistance have been identified through extensive field screening.
- Two databases one each on germplasm and molecular data were created to manage all this information.
- 'Manjri Naveen' an early ripening clonal selection from the Centennial Seedless having self-thinning bunches, uniform, naturally bold, white, seedless berries with firm pulp and mild flavor was released.
- Kishmish Rozavis White, a white mutant selection from Kishmish Rozavis suitable for raisins and table purpose and A18-3, a black seedless variety with rudimentary seeds, regular yielder and suited for table purpose and raisins were identified.
- Country Bangalore, E-12/2, Pusa Navrang and Medika (Pusa Navrang x Flame Seedless hybrid developed at the Institute) have been identified as suitable for juice production.
- Clone 2A of Thompson Seedless, Red Globe, Crimson Seedless, Flame Seedless and Italia were introduced.

- Red Globe a naturally bold (size > 22mm), seeded table grape variety is now recommended for both domestic and international markets.
- Flame Seedless, a short duration variety (90-110 days) is recommended for north India based on its performance in AICRP trials.
- Fantasy Seedless is identified for export for its good fruit traits and better shelf life.
- Cabernet Sauvignon, Shiraz and Merlot have been found suitable for red wine production, while Chenin Blanc and Sauvignon Blanc for white wine under Indian conditions. Indian wineries are using only these varieties for the production of red and white wines.
- Dogridge rootstock was found suitable for growing Thompson Seedless and its clone Tas-A-Ganesh.
- 110R was found suitable for saline soils due to its sodium exclusion property.
- Techniques for improving water use efficiency through irrigation scheduling based on pan evaporation and vine growth stage, subsurface irrigation, use of mulch and antistress were developed to economize and optimize the water use.
- Technique for improving the fertilizer use efficiency through growth stage wise fertigation scheduling was developed to economize the use of fertilizer.
- Petiole nutrient guide for Thompson Seedless grown on Dogridge rootstock was developed.
- The causes of several disorders like bunch stem necrosis, leaf reddening were identified as nutrient imbalances, which could be corrected by proper nutrient application for optimum production with quality.
- The schedule for economic use of bio-regulators in enhancing bud-break and for improving quality was standardized for several commercial varieties.
- The canopy architecture and other agrotechniques were standardized for optimizing fruit quality in Tas-A-Ganesh variety grafted on Dogridge rootstock.
- Nursery techniques for increasing rooting and further establishment of different grape rootstocks were also standardized.
- Weather forecast based disease management resulted in considerable saving of number of sprays during one year of production cycle as compared to conventional pre-determined schedule based management. Prototype disease forecasting software for powdery

mildew management was also developed and made available to the growers. A web based system for location specific weather information based disease management advisory has also been developed, and popularised.

- Risk of major diseases and pests and risk based advice on disease and insect pest management is also updated every week on Institute's website (http://nrcgrapes.nic.in).
- Diagnosis of atypical downy mildew infection on pre-bloom bunch was done using conventional and molecular studies and pre-disposing factors were identified, which helped growers in saving their crops.
- The implication of climate change on shift on anthracnose pathogen was elucidated.
- Grapevine leaf roll virus-3 was shown to be present in some grape cultivars India.
- Seasonal incidence of major insect pests viz. mealy bugs, flea beetle, thrips and jassids was observed in vineyards of Maharashtra and Andhra Pradesh. Insect incidence showed correlation with weather parameters.
- A survey on fruit fly infestation revealed that the Indian vineyards are free from the incidence of fruit fly infestation. This has opened up China market for the export of grape.
- New generation pesticides, environmentally friendly chemicals, botanicals were tested for their bio-efficacy and residue data in controlling diseases and insect pests and effective molecules were included in the recommended schedule for their management.
- To address food safety issues, the safe use of fungicides, based on the chance of development of resistance in the pathogen and the pre-harvest interval, is being taught to growers.
- Dissipation rate kinetics for many chemicals was also studied and their pre harvest interval (PHI) was calculated to recommend their safe use.
- The postharvest pathogens in Indian grapes were studied and, the worldwide major postharvest pathogen, i.e. *Botrytis cinerea*, was not found in Indian grapes.
- Several pre and postharvest technologies were developed for improving shelf life which included pre-harvest applications of bio control fungus *Trichoderma harzianum*. This technology not only helped in improving shelf life but also minimized sulfur di-oxide injury during storage.
- Quality of Indian raisins was harmonized with the Codex standards.
- Several techniques like dose of ethyl oleate and dipping time were

developed to minimize browning during raisin making.

- A local yeast strain was identified for making quality wine from Cabernet Sauvignon.
- Safe use of chemicals and their monitoring from farm to plate has been standardized in association with APEDA and other stakeholders for domestic and export market.
- National Referral laboratory of this institute has set an example to other research institutes in food safety. Presently, Food Safety and Standards Authority of India (FSAAI), Ministry of food processing industries (MoFPI) and Agricultural and Processed Food Products Export Development Authority (APEDA) are working hand in hand with this institute to take food safety issue to other food commodity in the country

In coming forty years, globalization, trade liberalization, changes in consumer preference, public concern about food safety and the environment, may alter the context in which grape research is to be conducted. Emerging approaches in biotechnology and genomics, ecosystem science and social science may also transform the practices and products of viticulture and therefore we have to think and follow new approaches and strategies for research.

Some of the important components of operational environment are

Administrative and Legal Systems

ICAR-National Research Centre for Grapes with its mandate of research, education and extension, while formulation of guidelines, laws, rules and regulations to promote grape and wine industry particularly with respect to trade related issues taken up by, other organizations such as Indian Grape Processing Board (IGPB), APEDA, Central Insecticide Board (CIB), FSSAI, phyto-sanitary departments etc. Needed technical information is generated by ICAR-NRC for Grapes. While above organizations help to promote and develop markets of Indian wine, raisins, juice and fresh grapes in domestic and export markets. They should also assist in negotiations pertaining to national and international wine laws; should define the consignment which ensures labelling of export products as per their vintage, variety, and region for better traceability.

Government Policies

Genuine planting material in terms of its genetic purity, free of pests and diseases etc. is the key input in successful grape production. Nursery certification programs and their policies in perennial fruit

crops like grape are not so well established as in annual crops (cereals, pulses and oil seeds etc.). NHB has introduced nursery gradings in horticulture crops. A strong certification program with guidelines should be formulated at government level to ensure quality planting material available to growers. Help of government in importing advanced tools, equipments and machines for grape cultivation and processing through appropriate import policies will boost the research since mechanisation of farm operations will be a major research focus in the years to come.

Manpower and Capacity Building

With increase in demand for better quality grapes and processed products, the existing infrastructure and manpower may not be sufficient to conduct more intensive and advanced research. Well-developed experimental vineyards, training of scientists and technical personnel in specific fields of their specialization, installation of advanced equipment in both laboratory and vineyards and imparting skill to operate advanced equipment are some of the technological options to meet the goals set in this document.

Socio-economic and Cultural Environment

In search of assured income and better life, agriculture labourers are migrating to cosmopolitan cities. As majority of the cultural operations in vineyards are labour oriented there will be acute shortage of skilled manpower in years to come and thus a major threat to grape industry. Mechanization of the cultural operations at all levels such as vineyard establishment and management-digging, planting, training and pruning, canopy management practices, harvesting has to be developed to sustain grape production in rural areas.

With the growing awareness about health benefits of grape consumption, there may be quality consciousness in consumers to demand better quality grapes for fresh consumption and also the processed products such as raisins, wine, juice and other functional foods derived from grapes. In years to come, grape production and processing should therefore, be taken up in more scientific way with aim to maintain quality in terms of nutrition, shelf life, appearance, packaging, labelling with declaration of information as required by food laws..

Environmental considerations are increasingly important with respect to use of agrochemicals. Grape cultivation is one of the largest users of pesticides than other food crops. Environmental concerns should therefore, pave way for both public and private initiatives to adopt more

friendly cultural, production and distribution practices.

Economic Trends

Lowering of tariffs and reduction of quotas under the World Trade Organization has now shifted trade barriers more in the direction of sanitary and phyto-sanitary regulations. As the flow of trade increases, the regulatory agencies demand more of qualitative components of wine and other products for marketing. The expansion of trade in grape and grape products and the development of new products make monitoring activities more difficult for public organizations. Hence, new monitoring techniques need to be developed to ameliorate such problems. Some of the example may be identification of variety by biochemical and molecular methods, and identification of source variety of wine by fingerprinting using highly sophisticated method to know its purity etc. should be established. This can be carried out in public private partnership mode.

Increase in purchase power of common people may result in more demand for new processed products such as grape candies, grape jam, grape concentrate etc. Hence, development of cost effective technologies for such products is required. Establishment of small scale industries for such products in rural areas will help in providing employment to rural youths and thereby increase their economic status.

Interaction with Stakeholders

Constant interaction among stakeholders of grape industry would have positive impact on the research focus of the institute. Constant feedback from grape growers about the pros and cons of technologies adopted and problems encountered in grape cultivation would allow researchers to reorient their research for their betterment.

Most of the wineries in India hire wine makers from other countries during crushing season to monitor the quality of grapes and final product. The wine prepared in those wineries suits to consumers in importing countries. However, there is a strong need to prepare wine as per the taste of Indian consumers. Hence, there should be constant interaction between winery persons, wine makers and researches to develop technologies for preparing wine for Indian consumers.

Public private partnership should be strengthened with respect to manufacturers of agrochemicals (fungicides, pesticides, growth regulators etc.), manufacturers of packing materials (cartons, bottles, punnets, etc.) to have mutual benefits. Technologies developed at the institute should reach to grape growers for their benefits. Hence, developmental

departments and agricultural universities in States should train their extension personnel at research institute to disseminate new technologies to grape growers.

Research Programs

With the changes in climatic conditions, it is essential to undertake simulation studies to known the influence of extreme climatic conditions on growth and productivity of grapes. Based on these studies, models and decision support systems should be designed and developed.

Current studies in plant genomics science promises to provide additional breakthroughs that will influence how future crop varieties are developed. Genetic mapping techniques that use DNA markers are increasing the rate of breeding new grape varieties. Modern techniques for isolating and characterizing new genes and for determining the functions of genes resulted in a wealth of knowledge. Genes involved in cold, drought and saline tolerance, flower development and vegetative growth, reproductive functions and embryo development, resistance to fungi, bacteria and nematodes have been identified. This information will certainly revolutionize the pace at which the new varieties are developed.

Advances in nutritional science research have greatly expanded our understanding of the essential nutrients and their role in the etiology of major diseases in human. This could be used to develop functional foods with specific nutritional attributes and development of nutritionally fortified foods.

A number of diseases seriously affect grape production by reducing vine productivity, reduced quality and thus increase costs leading to severe losses to growers. The control of these diseases is necessary to maintain the required quality of grapes and grape products, for the economic health of the affected producers and to limit the opportunity for the diseases to spread to other areas.

Establishing strong collaboration with national and international institutes in multidisciplinary approach or network or consortia mode would help in developing technologies and resolve the issues in a holistic manner. Imparting education on all the aspects of Viticulture and Enology through full time graduate degree, PG Diploma, Certificate courses may help in developing specialists at all the levels so that grape cultivation and processing will be done in systematic manner with trained man power.

Opportunities & Strengths

The Grape is one of the first commercially cultivated fruit crop and its cultivation has developed into science by itself. While most of the grape production in the world is for wine making, India has emerged as primarily table grapes producing country. Production of dry grapes in India is progressing gradually as profitable and less risky industry. India is making quality tropical wines, but faces competition from very well developed wine industry in the rest of the world. In view of this scenario several opportunities are in sight to develop grape industry successfully during future years

Genetic-resource Enhancement

The genetic resource is the wealth for successful future. The ICAR-NRC Grapes is the National active repository for grapes and has about 524grape accessions. Grape germplasm with desired traits is important hence focus of the research should be on characterization of available germplasm keeping in view the desired characters.

Loose bunch, bold and crispy berries with long shelf-life are the desired characters of the table grapes. At present, in Thompson Seedless, or in Sharad Seedless to achieve these characters growers make lot of efforts such as application of growth regulators, manual thinning of bunches in a vine or thinning of berries in a bunch etc. In the recent past breeders have found that such desired traits are naturally present in few germplasm and developed hybrids which do not require application of growth regulators or manual thinning of berries. Most of such varieties are patented and thus not available to in India for commercial cultivation. Many of such varieties have shelf-life up to 6 to 9 months in cold storage, thus any grape growing country can easily compete with Indian grapes in Europe market during exclusive market window. India should therefore have such varieties and also should collect gerplasm with such traits for future breeding program.

In case of most of the cultivated clones of Thompson Seedless and Sharad Seedless rains during flowering leads to flower drop or bunch rots resulting in heavy yield losses. 2A clone of Thompsom Seedless do not suffer losses under such situations. Such traits could be identified in other germplasm also for future breeding programs.

Black seeded raisins are in good demand as they are known to have

medicinal properties due to presence of anti-cancer chemicals in seeds or antioxidants in skin. Varieties suitable for such raisin production can be collected and characterised.

Traits suitable for mechanisation could be identified to use or even to develop new machine for mechanisation.

New Technologies

Protected cultivation of grapes using plastic cover has changed the scenario of table grape cultivation in Spain and Itali. Until last 20-25 years there were no large scale cultivation of grapes in southern part of Spain and Itali as area use to suffer from frost, rains and hailstorms during grape season. Today these areas produce more table grapes than India. All vineyards in these areas are covered with plastic. Technology is in method of erecting of plastic cover and properties of plastic used. It is a low cost technology where there is a minimum use of steel and both vine canopy and plastic cover rests on GI wire, and no supporting pipes in vineyard are erected with cement concret.Properties of plastic are such that it protects from frost, rains and hailstorms. When outside day temperatures are very high under the plastic it is low and when night temperatures are very low under the plastic it is warmer. Development of such a technology may also change the table grape scenario in India. In tropical belt it can make early pruning in August-September safe by protecting vines from rain during early growth and at harvest. In late pruned vineyards it can protect vines from low temperatures during fruit growth, and from rain and hails during harvesting. It can also make possible to grow grapes in central and North India where frost and rains at harvest are problems.

Biotechnology has a considerable potential to address many of the challenges in the grape. Biotechnology tools like MAS will be developed to speed up the grape breeding for important traits. Biotechnological techniques such as somatic embryogenesis, multiple shoot development in tissue culture etc. can be exploited rapid multiplication of planting material. Genome analysis will allow allele mining for different traits and global expression analysis by RNA sequencing will allow elucidation of gene function and study of effect of different conditions at cellular level itself. Such analysis will be utilized for developing grape varieties with desirable traits like disease resistance, self-thinning, tolerant to abiotic stress and good quality. Global protein analysis through different proteomics approaches will allow understanding of host – pathogen interaction for major diseases like downy mildew and powdery mildew and help in developing breeding as well as management strategies.

High through put analysis for metabolites could be useful for identification of nutraceutical and development of functional food.

Nanotechnology is expected to play important role in processing of grape juice to wine as well as in pest control. Pesticide formulation based on nanotechnology will be used for effective pest control and ensure food safety.

Availability of machinery for different farm operations will improve input use efficiency and circumvent the difficulties associated with shortage of skilled field manpower.

Bio-control methods for disease and insect pest control would provide opportunities to grow grapes with minimal pesticide use.

Management of Natural Resources to Improve Production Efficiency

More than 80% of the grape cultivation is confined to the hot semi-arid agro climatic region. Moisture stress and salinity are the key problems faced by the farming community for sustaining grape productivity. Ground water is the major contributing factor to salinity. The nutrient and water use efficiency is very poor because of poor physicochemical properties of the soil, uncertainty in water availability and poor quality irrigation water. The Soil organic pool is crucial to improve the fertility status of soil. Thus integrated nutrient management incorporating the judicious combination of organics, biofertilizers and inorganics and nutrient use based on stock-scion variety combination to mitigate different abiotic stresses is needed. Phenomenal success due to introduction of Dogridge rootstock has been experienced by growers in Maharashtra and Karnataka States. Refinement of this technology by introducing most suitable rootstock to available soil conditions may lead to more sustainable productivity.

Seasonal changes in climatic conditions have an impact on grape productivity through observable changes in terms of phenological events, such as bud burst, flowering, veraison, harvest and finally yield. Nutrient and Irrigation schedule, therefore, needs to be standardised under such situations. Phenomics and Precision viticulture practices using the advances in remote sensing has to be implemented to meet these targets. Remote sensing technology can also be used for estimation of area under cultivation, forewarning of outbreak of downy mildew and powdery mildew or insect pests, forecasting market arrivals of different varieties etc.

Bio-risk Management

Some of the major pests and diseases, threatening the grape industry

in other countries (e.g. Botrytisetc.) are not reported form our country. Bio-risk is increasing with climate change and owing to trans-boundary insect-pests and diseases. It is adding cost, reducing food production and is adversely affecting farm income. Even though few viruses in grapes have been reported in literature none posed danger to table grapes yet. With encouragement to wine industry wine grape cultivation increased and symptoms of Grapvine Leaf Roll Virus was found to be present in most vineyards of coloured varieties possibly affecting productivity and wine quality.To overcome problem of bio-risk, besides emphasis on classical bio control strategies, efforts would be made to develop effective and integrated risk-and-disaster management systems. Bio-risk intelligent system e. g. early warning systems, drought indicators, migratory movement of bio-risk agents would be developed with the help of different information and communication technologies (ICT), for taking informed decision at the local, regional and national level. DNA barcoding and sequencing techniques will be used for monitoring and minimizing biosecurity elements.

Diversification and Value Addition

Diversification for value addition and to prevent market glut has great potential. Open global market, expanding hospitality sector, increasing international travel and exposure is likely to increase demand and market for wine, juice and other processed products. Therefore, research focus would be to develop technologies for improved and cost competitive wine. Native microbial diversity will be explored to obtain quality wine. Research will also be intensified on raisin and juice, enhancing shelf life for table grape and improving commercial traits like size and colour through pre and post-harvest approaches to meet the demand of domestic and international market. Geographical indicators will be developed to provide specificity to the grapes and its processed products e.g. wine, raisins and juice produced in different regions of the country. Growing upper middle class with more expenditure power, increased health consciousness and expanding retail market open up opportunity to explore and promote alternate uses of grape like medicinal/antioxidants, distillery, pigment, grape seed oil etc.

Technology Transfer Systems

Although, it is important to continuously strive to develop new and better technologies. Their effective delivery mechanism would greatly help in bridging wide gap between the potential and the realized productivity. More far-reaching, participatory information and

communication technology would be evolved by optimizing print and delivery systems and by showcasing research products for effectively linking research accomplishments with the stakeholders. Public private partnership will also be explored both for technology development and their transfer. ICAR hub meeting inviting state extension department and SAU would also be organized regularly to transfer the technology to beneficiaries. New ICT tools will be utilized for effective technology dissemination.

Human Resource Development

Enhancing quality of human resource is a pre-requisite for implementing and upgrading research programmes, developing technologies, evolving institutional arrangements to face challenges and harness opportunities. Maintaining global standards and enhancing competitiveness are equally important in agri-business and in technology development. Efforts will be therefore, made to enhance competence and develop state-of-the art infrastructure.

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Goals and Targets

Increasing the production and productivity of grape to meet the demand of growing population is the prime goal for next four decades. Diversifications for value addition and consumer preference are other important goals.

The grape is high value and high investment crop. One who decides to grow grapes decides it after studying technical information needed and ensuring the assured profits. Hence, increase in area under grape production is very gradual. Secure quality production and consistent profits are two major considerations for grape grower. Innovative and adventurous grape growers were equipped to face miner adversities like rains during early growth. But adverse weather during maturity of the crop and extrem events like hailstorms are difficult to manage and lead to huge losses. Off late such events are becoming more frequent and wide spread in major grape growing areas. If the situation continues for long, the profitability of crop will become questionable. Before it actually happens so, development of technologies such as protected cultivation has to be developed and standardised to sustain the productivity under adverse conditions

The viticulture is likely to be developed in low rainfall area, where availability and quality of irrigation water will be major issue. Thus our major goal will be to improve water use efficiency (WUE). It can be through

- Development of varieties and/or rootstocks requiring less water and tolerance to drought and salinity
- Development of soil based irrigation schedule
- Use of irrigation systems with low evaporation losses
- Innovative irrigation systems based on knowledge on stress physiology eg. Partial Root Drying (PRD)
- Targeted irrigation based on need at specific growth stage

Introduction of new varieties for higher yield, desired quality alongwith compatible rootstock and other packages on Canopy management, INM, IPM will also help in achieving higher production and productivity. An IT based decision support system based on weather information, for forewarning of the risks related to diseases and pests will help in contingency planning for sustained productivity. In efforts to produce loose bunches and bold berries with more than 16 mm

diameter in tables use of growth regulators have increased. Such grapes have good appearance, but have thick skin, and palatability has adversely effected. Defining optimum use of growth regulators in table grapes to improve palatability is essential.

Continued efforts to give attention to food safety (residue management, mycotoxins) of table grapes and processed products, are needed to ensure growing demands for grapes. Development of technologies for management of diseases and insect pastes with the help of safer pesticides, bio-control agents, botanicals etc. needs to be developed to produce residue free grapes. Reducing agrochemical pollution in vineyard ecosystem should be given importance. Development of improved pesticide delivery systems which reduce drift and dripping hazard will help in abetting environmental pollution in the vineyard ecosystem. New pest control devices involving use of attractants based on semiochemicals, light and colour should be developed as alternate to pesticides thereby reducing environmental pollution.

Development of technologies for processed products from grapes is needed to increase the area under grapes. Such technologies should include varieties for specific purpose, package of practice for its commercial cultivation, methods for processing, packaging of product etc. NRCG has identified new variety named Medika for juice. Variety is rich in some compounds known for its neutraceutical properties. Technology should be developed to produce this variety for juice or other functional foods such as anthocyanin rich powder etc. Small scale industry should develop based on such technology. Many such functional foods can be developed from biproducts of winery. With increase in awareness about health benefits of grapes, the demand of new products such as nutraceutical and functional foods will increase. There is also ample scope for secondary metabolites of grapes such as tannins, antioxidants, pigments, etc. for use in cosmetics and natural aromas. Development of technology for frozen grapes is another area which has not been explored and exploited so far and has potential to widen scope of fruit basket.

Use of non-conventional energy such as wind and solar which have potential of development in grape growing areas can be explored and exploited to meet local needs. If power requirements for irrigation and fertigation, spraying, or even processing of grapes etc. are fulfilled by such energy sources, it will increase profitability of grapes and its processed products.

Grape is a perishable commodity and the losses after harvesting are significant. Therefore, reduction in post-harvest losses by means

of maintaining cold chains and proper handling of the produce will contribute in meeting the targets.

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Way Forward

At present, total grape production in country is approximately 2.58 million MT with per capita availability of 2 kilogram. Considering the growth rate of 4% and to maintain status quo, the projected demand for grape in 2050 will be approximately 9.75 million MT. Thus the grape production needs to be increased 3.78 folds. Such an increase is difficult to be achieved alone through increase in productivity. Increase in productivity beyond 30 MT per ha. in grapes may lead to compromise on quality. Increase in production thus can be achieved through increase in area under grape cultivation. Presently more than 60 per cent area under grapes is in Nasik district in Maharashtra state and there is tremendous scope to increase area under grapes. It can be done by promoting grapes in new areas. Low rainfall areas, with availability of limited irrigation water in tropical climate have shown production of quality table and raisin grapes. Investments on watershade managent, development on open plastic lined water tanks for assured irrigation will help in exploiting marginal lands for viticulture successfully. If cost effective technologies for protected cultivation are developed area under viticulture in tropical condition will substantially increase and in subtropical climate in North India and central India will also start commercial production of grapes. Dry temperate areas in Himalaya such as Leh, Ladak have wild grapevines growing for many years. These areas can produce quality raisins. With climate change large area in this region could become suitable for grape cultivation, especially with increase in summer temperatures in the region.

To achieve the targets and meet the challenges, broad research programs have been formulated for next 40 years (Annexure 1). Climate resilient viticulture will be the prime focus. Development of new varieties, identification of rootstocks suitable for different conditions, canopy architecture, pest risk analysis and decision support systems will be primarily based on climate change. Focus on improving input use efficiency to reduce cost of product emphasises on precision viticulture. To implement precision viticulture use of advance information and communication technology will be needed. For sustained productivity management of vineyard ecosystem through management of soil health, IPM, IDM etc. need focus. To keep the markets stable, technology to prepare processed products will be advantage. Value addition

through geographical indication, and by producing functional foods and nutraceuticals will be need of future. Mechanisation of vineyard operations will be unavoidable in situations of labour shortage and increase in area under cultivation. Developed technologies must be properly disseminated through trainings, on-farm demonstrations to achieve successful effects of the technology. And to do all activities trained manpower and liberal investments from government will be needed. All these aspects have reflected in proposed research programs.

Annexure 1: Strategic Framework/road map to achieve targets in Vision 2050

Research programs	Approach	Performance measure
Climate resilient viticulture	Multidisciplinary research to sustain grape productivity and quality under changing climate conditions	Development, evaluation and identification of varieties and rootstocks resilient to climate change Low cost technologies for protected cultivation Canopy architecture modifications Site specific varieties for new areas Pest risk analysis to assess emergence of new pests and diseases Decision support system/s for sustained grape production under abiotic and biotic stress Functional genomics of biotic and abiotic stress response in grape
Precision Viticulture	Technology development for improved and need based resource utilization	Development of short statured/duration varieties suitable for high density planting and improved input use efficiency Delivery systems (nanotechnology, drippers, sprayers etc.) Disease/pest forecasting based management Sensor based robotics in vineyard operations Use of information and communication technology Development of technologies for improved Input use efficiency (fertilizers, water, bio regulators, pesticides, fungicides etc.)
Plant health and vineyard ecosystem management	Development of technologies, tools and strategies to tackle different aspects of plant and soil health and ensure food and consumer safety	Breeding for disease resistant varieties Identification and management of nutrient disorders Identification and management of physiological disorders Integrated Insect and Mite Pest Management and
Integrated Disease Management		Soil health management (including weed management, biofertilizers, bioremediation, heavy metals, persistence studies)

		Biosecurity and quarantine Monitoring and management of pesticide resistance in pests Monitoring of grape and processed products to ensure compliance with national and global food safety regulations Utilization of vineyard and processing industry waste
Value Addition and new generation products	Product diversification for improved marketability and price realisation	Breeding and evaluation of grape varieties for targeted value added products Improved technologies for the production of processed products like wine, raisin etc. Geographical indicators for table grapes and processed products Technologies for new generation products like nutraceutical/functional foods etc. including metabolomics
Mechanisation for grape production **Technology dissemination**	Public private partnership for increasing mechanisation in viticulture Participatory approach for technology dissemination	Evaluation and adoption of machines and tools for vineyard operations Training programmes for grape growers and extension personnel On-farm demonstration of technologies Grower's seminars, Web/video conferencing and other ICT tools

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Laser typeset at M/s Print-O-World, 2568, Shadipur, New Delhi 110008 and printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.