GRAPE PROFILE

भाकृअनुप
ICAR

NATIONAL RESEARCH CENTRE FOR GRAPES
(Indian Council of Agricultural Research)
P.B. No. 3, Manjri Farm P.O., Solapur Road
PUNE - 412 307, India
Tel.: 020-2691-4245 / 5573 / 5574 Fax: 020-26914246
e-mail : nrcgrape.mah@nic.in, nrcgrapes@gmail.com, nrcgrapes@hotmail.com
website : http://nrcgrapes.mah.nic.in

CONTENTS

A. GENERAL ASPECTS

1. Basic information about crop

a. Name

Grape

b. Botanical name, evolution, geographical distribution, wild species, cytogenetical studies, reproduction, pollination control mechanism/fertilization, natural cross-pollination (in 1-2 pages)

Botanical name

Vitis vinifera L.

The Origin : Grape is believed to have originated in Armenia near the Black and Caspian seas in Russia. An independent and recent origin of grapes is also traced to North America. Its leaves and seeds were discovered in north America and Europe in fossil deposits of the Tertiary period of geological time. Seeds were also found in the refuse mounds of the pile dwellers of lakes in south central Europe belonging to the bronze age. From Armenia grapes spread westwards to Europe and Eastwards to Iran and Afghanistan. Grape was introduced into India in 1300 AD by the Moghul invaders. Grape cultivation flourished in Baluchistan and north-west frontier province during the 16th century. In India, grape cultivation declined after the fall of Moghul rulers but was reintroduced in south India (Aurangabad district of Maharashtra) by Mohammed-Bin-Tughlak and since last 50 years grape is commercially cultivated in India.

Evolution

The old *Vitis vinifera* grapes, originating in Armenia, have perfect flowers while the grapes of America, which are of recent origin, usually have imperfect flowers. It is believed that originally varieties with pure male / female flowers to varieties with various degrees of maleness / femaleness to those with perfect flowers existed and during the course of evolution only the varieties with perfect flowers have been selected.

Geographical distribution

In India, grape is grown under two distinct climatic conditions: (i) the sub-tropical climatic conditions of north where the winter temperatures rarely reach the freezing point but vines undergo dormancy in winter, and (ii) the tropical climatic conditions of the peninsular India where the winter are mild and the vines do not undergo dormancy and remain evergreen throughout. Based on the viticultural practices and the incidence of rainfall, the grape-growing regions are classified into three.

Region - I	The mid temperate to subtropical region comprising Punjab, Haryana, Uttar Pradesh, Rajasthan and Delhi
Region - II	Entire Telangana and Rayalseema areas of Andhra Pradesh, excepting the districts of Chttoor and Prakasam, north interior Karnataka and the rain shadow area of the Western Ghats in Maharashtra.
Region - III	All grape growing areas of Tamil Nadu, and the districts of Bangalore, Kolar and Mysore of Karnataka.

Reproductive Biology

The flowers of cultivated grapes are usually hermaphrodite (perfect), while wild grapes are often dioecious. Flower buds just before bloom (anthesis) are covered by the interlocking petals (cap or calyptra). At anthesis the cap separates from the base of the ovary and falls off. The stamens spread out and pollen is shed and falls on to the stigma of the pistil. This is bloom and it lasts from 2 - 7 days depending on temperature. In grapes, not all ovules are capable of fertilization and the unfertilized ovules drop off. This is known as shatter.

Wild species

The *Vitis* genes has approximately 60 inter fertile species. North-western Himalya is also inhabitited with two edible wild species viz. *V. parviflora* and *V. lanata* and numerous natural hybrids of the two species which are locally grown.

Cytogenetic and genomic resources

Chromosomal Status: Commercial grapes mostly belong to Euvitis section comprising of *V. vinifera, V. labrusca, V. riparia* and *V. rupestris* with the haploid chromosome number 19. In the other section, Muscadinia, the haploid chromosome number is 20. The cultivated grapevine (*V. vinifera*) is diploid and has small genome size of 475-500 Mb relative to other plants.

Reproduction

The true to type plants are reproduced by hardwood stem cuttings. Often the plants are propagated through grafts on standard rootstocks. Tissue culture / *in vitro* techniques through shoot tip culture, nodal segments are also standardized for certain varieties / rootstocks for speedy multiplication.

Pollination control mechanism/fertilization

Nearly all cultivated varieties are hermaphroditic and self fertile. Pollination occurs mostly through wind, hence, close planting is useful for effective pollination. Pollination is essential for seeded varieties for fruit set, while in seedless cultivars pollination is also required but embryo aborts after post fertilization leading to seedlessness, this is known as ‘sternospermocarpy’.

Natural cross-pollination

Generally 80% pollination is through self fertilization in grapes, the rest may attribute to cross pollination. Thrips and other minor insects do help in pollination / fertilization but there is not much role for honeybees.

Heterozygosity Status

The species of grapes are quite heterozygous and seedling offsprings show wide genetic variability. Seedlings vary not only in the qualities of their fruit but in vegetative vigour also. Because of these variations, seeds are not used for propagation of vines for commercial purpose.

Breeding Habit

The flowers of *Vitis vinifera* are usually perfect. The calyx consists of five green sepals which stop growth and dry up soon after the bunches appear. The corolla is made up of five greenish petals formally united at the tip. The five stamens are present opposite the petals. Each anther consists of two lobes running length-wise. Each lobe is divided two pollen sacks. The ovary consists of two halves each with two

ovules. Each ovule has one embryo sack containing the egg. Immediately after a flower opens (cap fall) the stigma is coated with a sweet and sticky solution secreted from within to hold the pollen grains. These grapes are self pollinated.

Grapes of American origin have various stages of imperfect flowers ranging from purely female to purely male. These grapes are cross-pollinated.

2. International status
(area, production, productivity)

The total area under grape cultivation in the world is 7,399,546 hectares with the production of 68,952,793 tonnes resulting in a yield of 9.32 (tonnes/ha).

	World (2006)	India (2006)	Per cent share of India	India's rank in the world	Leading countries in the world		
					Name	Qty	Per cent share of world
Grape Area of Harvest (Ha)	7,399,546	60,200	0.81	24	Spain France Italy	1,200,000 842,026 754,987	16.22 11.38 10.20
Grape Production (tonnes)	68,952,793	1,546,300	2.24	13	Italy France Spain	8,325,888 6,692,550 6,401,500	12.07 9.71 9.28
Grape Yield (tonnes/ha)	9.32	25.69		1	India Israel Egypt	25.69 22.67 21.67	
Raisins Production (tonnes)	1,189,483	---	---	---	Turkey USA Iran	376,000 320,000 145,500	31.61 26.90 12.23
Wine Production (tonnes)	27,772,141.8	---	---	---	France Italy Spain	5,349,333 4,711,665 3,643,666	19.26 16.97 13.12

Spain covers the largest area of harvest of 1,200,000 hectares for grapes in the world, which makes a share of 16.22 percent of total area of harvest for grapes in the world. After Spain, France (842,026), Italy (754,987), Turkey (550,000), China (483,200), USA (320,000), Iran (314,547), Portugal (222,528), Argentina (218,991), Romania (187,094), Chile (178,000), Australia (158,167) are the other important grape producing countries.

The largest producer of grapes in the world is Italy 8,325,888 tonnes that make a share of 12.07 per cent of total production of grapes in the world. After Italy, France (6,692,550), Spain (6,401,500), China (6,375,000) USA (6,093,560), and Turkey (4,000,063) are major grape producing countries.

3. National status
(area, production, productivity - growth pattern)

In India, grape is presently cultivated over an area of 60,200 ha which makes 0.81 per cent to total area of harvest in the world. India stands at 24th position in the world for the area of harvest for grapes. As shown in the fig-1 area of harvest in India has increased 50% during last 10 years. The area under grape cultivation has increased considerably by 14,892 ha over the years 1990 to 1994 and then the area of harvest has reached a stable figure of 40,000 ha during 1994 to 2000. After that the growth is very less. The area under grape cultivation is not expanding fast now.

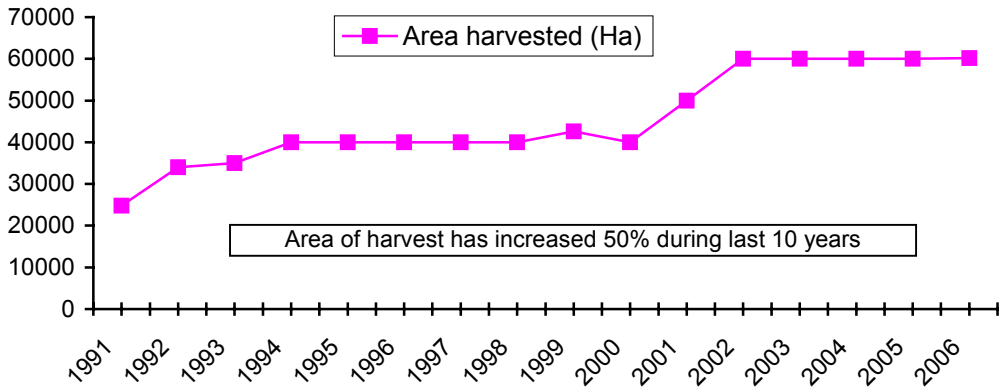

Fig. 1 Grape Area of Harvest (Ha) : India

India is the 13th largest grape producing country in the world with the production of 1,546,300 (tonnes), which makes a share of 2.24 per cent of total production of grapes in the world. Grape production in India is continuously increasing (Fig.2). India has the second highest yield of 25.69 tonnes/Ha in the world.

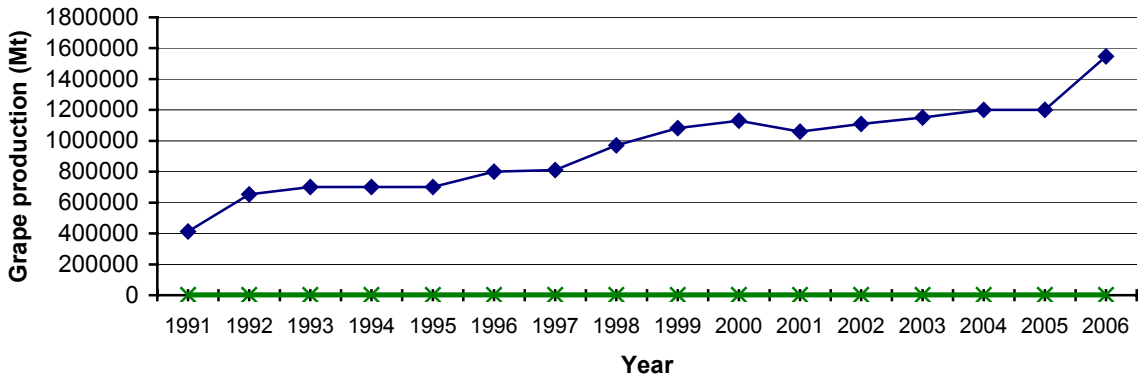

Fig. 2 Pattern of grape production in India

4. Expected output and outcome in time-frame

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
1. Conserving Plant Genetic Resources	i. Augmentation, maintenance, evaluation, characterization, documentation, utilization and conservation of genetic resources of horticultural crops.	i. To augment indigenously available grape Germplasm and introducing exotic Germplasm	i. Ten indigenous accessions and 2 *Vitis* species collected from Kinnaur. 315 accessions have been studied for Ampelographic characters, fruit yield and quality attributes. National active Germplasm site is being established with a cumulative number of 412 accessions.	Up to 2006
		ii. Developing information system of grape Germplasm	i. An electronic database on morphological and evaluation characters of grape Germplasm has been developed. Presently the data is available for 138 accessions on 42 characters. Similarly to develop database on molecular characterization, the system was analyzed and user requirements were identified. The Database has been designed in MS ACCESS. Table structures for band, variety, primer and test data etc. were created.	- do -
		iii. Molecular characterization of grape Germplasm	i. 24 rootstocks and 44 other accessions were characterized with micro satellite and AFLP markers	- do -
2. Variety Improvement in yield in view of biotic & abiotic stresses	i. To undertake basic, strategic, applied and anticipatory multi-disciplinary and multilocation research to develop location specific technologies for improving the productivity and quality of horticultural crops	i. To develop high efficient cross breeding technique involving seedless female parents	i. Achieved higher percentage of embryo recovery (upto 30% as against 5% in conventional) and plantlet establishment through prebloom application of cytokinins.	- do -
	ii. To develop high yielding varieties of horticultural crops with good quality and resistance to biotic and abiotic stresses to cater the needs of domestic and export markets.	i. Introgression of downy mildew tolerance in commercial cultivars of grapes through cross breeding and *in vitro* embryo rescue techniques.	i. 643 hybrid plantlets obtained as a result of ER technique and are being maintained in polyhouse conditions with 62% success. 150 hybrid plants were field grafted out of which 82% survived. The efforts to transfer to field conditions are continued.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
		ii. Identification of molecular markers closely linked to downy mildew resistance in grape.	i. Two very promising SSR markers showing association with downy mildew resistance/ susceptibility were identified.	- do -
		iii. Breeding of grape varieties through Clonal Selection	i. A 17-3 is a self-thinning and extremely sensitive to hormones is being accepted for export table purposes with low cost of production.	- do -
		iv. Evaluation of rootstocks for promising table grape varieties	i. Thompson Seedless and Tas-A-Ganesh grafted on Dog ridge performed better in yield and quality parameters followed by those on 110 R rootstocks. Lowest yield was recorded on own rooted varieties. In Flame Seedless, vegetative growth was more on Dog ridge rootstocks and yield and quality parameters were more on St. George.	- do -
		v. Evaluation of rootstocks for salinity tolerance.	i. Dog ridge and 110 R rootstocks were known to restrict uptake of Na^+ from soil solution while, 110 R could restrict uptake of Cl^- to a greater extent followed by Dog ridge.	- do -
		vi. Screening of rootstocks for drought tolerance	i. Rootstocks Dog ridge and 110 R recorded higher WUE and root to shoot length ratio at 50 % moisture stress followed by 1103P, 99 R and St. George	- do -
3. Production Technology and Protection technology for crops	i. To standardize technologies for crop protection through integrated pest management and biological control using bioagents, predators, antagonists and botanicals.	i. Integrated Management of Insect pests of Grape.	i. Schedule of Integrated management of grape mealy bug was standardized which involves removal of barks and swabbing with dichlorvos 2 ml + Name oil 5 ml + Fish oil 2 ml in a lit of water, use of sticky bands, removal of alternate hosts, release of lady bird beetle, use of various botanicals and chemicals.	- do -
		ii. Use of potassium bicarbonate to control powdery mildew in grapes.	i. Spray of potassium bi-carbonate, 5g/l could control of powdery mildew on par with that achieved by sprays of sulfur 2.0 g/l. ii. Potassium bi-carbonate 5 g/l + hexaconazol 0.5 ml/l also showed excellent control of the powdery mildew. Addition of non-ionic surfactant (1 ml/3 l) further increased the efficacy of the spray.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
	ii. To standardize organic production technologies using suitable biofertilizers, biopesticides substrates, biodynamics, etc to do away with the ill effects of residues of pesticides and harmful chemicals.	i. Use of botanicals and biocontrol agents to control insect pests in grapes.	i. Release of lady bird beetles *Cryptolaemus montrouzieri* @ 1000/ during August and December for the management of mealybugs. Use of *Verticillium lecanii* and *Beauveria bassiana* @ 5 ml or g/ lit for the management of mealybugs and thrips. Use of neem formulations Azadirachtin 1% @ 2 ml or 5% @ 1 ml/l or NSKE 5% for the management of thrips, mealybugs and mites.	- do -
		ii. Minimizing pesticide residues in grapes.	i. PHI of the 14 agrochemicals used in grapes was established using GC / HPLC / GC-MS / LC-MS/MS as applicable.	- do -
		iii. Studies on Persistence and sorption of Thiamethoxam Residues in soil.	i. The extent of adsorption was more in clay soil than in the red-sandy soil. The linear adsorption coefficient K_D was higher in clay soil indicating greater adsorption than in red-sandy soil.	- do -
		iv. Bioremediation of Methomyl and Lambda-cyhalothrin Residues in Grape Berries	i. Significant biodegradation was observed with *Trichoderma harzianum* 5R. in the presence of sucrose in the medium.	- do -
	iii. To develop/evolve cost effective production technologies in horticultural crops to make horticulture as remunerative venture.	i. Developing petiole nutrient standards for Thompson seedless vines on Dog ridge.	i. Diagnosis of nutrient imbalance by DRIS low yielding vineyards revealed that ratios of N/P and N/K were found to be more critical during bud differentiation stage and P/N had greater physiological rationale during flowering stage. The nutrient concentration in petioles of the low yielding population differed significantly and Mg alone accounted for nearly 60.97 % variation.	- do -
		ii. To develop the schedule of nutrient application through fertigation in Thompson seedless vines raised on Dog ridge rootstock.	i. Application of 40% NPK dose through drip produced the yield equivalent or better than direct soil application of 100% NPK (recommended dose). The fertigation reduced the NPK dose by 60%.	- do -
		iii. To develop irrigation schedule for Thompson seedless vines raised on Dog Ridge rootstock	i. The new irrigation schedule based on growth stage and pan evaporation resulted in an average 52% savings in irrigation water.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
		iv. To study the effect of mulch and anti-stress for improving WUE in grapes	i. Treatments with mulch + antistress combination at 75 % irrigation level of the recommended irrigation produced yield and brix yield equivalent to 100% irrigation level.	- do -
		v. To standardize concentrations of bioregulators in grape varieties.	i. Concentration of Growth regulators like GA_3, Cytokinins (CPPU, Combine etc) along with time and stage of application were standardized for producing exportable quality Thompson Seedless, Tas-A-Ganesh and Sharad Seedless grapes.	- do -
			ii. Concentration of hydrogen cyanamide was standardized for uniform and quick sprouting after October pruning. Various growth inhibitors were tested for controlling excess vigor and increasing fruitfulness in T. Seedless grapes.	- do -
		vi. To develop disease management system based on weather forecasting.	i. Disease forecasting system including "u Metos" automatic weather data recorder, disease forecasting software "Metwin 2" was tested and demonstrated to growers. During the demonstrations 4 to 11 sprays of the fungicides could be saved as compared to farmers practice of spray schedule based disease management.	- do -
			ii. Model estimating day-to-day risk of powdery mildew in vineyard using daily observations on RH, Temperature and rainfall was developed and tested. The model was incorporated in "Expert system" and the CD of the software named SKAI-PMEXPERT was released for the use of the growers.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
		vii. Standardization of Canopy Architecture to Maximize the Production of Quality Grapes	i. In Thompson Seedless and Tas- A-Ganesh grapes, the growth parameters (shoot length, shoot diameter and biomass) and yield was more in double stem compared to the single stem. The shoot length was higher in upward positioned shoots followed by horizontal and downward positioned shoots. Maximum bud fruitfulness was recorded in the shoots positioned at upward position. Yield and quality was higher in straight cane compared to sub canes. Significantly higher yield was recorded in sub cane at 6^{th} bud followed by 7^{th} node. The yield level decreased with increasing the number of buds for pinching.	- do -
			ii. Maximum yield was recorded with retention of 40 bunches per vine in Sharad Seedless grapes. Fore pruning on 14^{th} September resulted in increased yield and quality parameters.	- do -
		viii. Studies on improving the fungicide use efficiency in grapes.	i. Spray of antistress an acrylic polymer at 4 ml / liter after fruit set was known to control powdery mildew disease.	- do -
			ii. Addition of 25-30 g of citric acid per 100 liter of spray solution was effective in enhancing the efficacy of benzimidazole group of fungicides.	- do -
			iii. Use of a surfactant containing polyether polymethylsiloxane copolymer 100% (Break-thru), at the rate of 0.5 ml/l or 0.3 ml/l along-with spray mix of hexaconazole 5 EC 1ml/l, carbendazim 50WP 1g/l, and metalaxyl+mancozeb (1:8) 72WP 2.5 g/l, for spraying, during this period, significantly increased the efficacy of the fungicides in control of powdery mildew, anthracnose and downy mildew, respectively.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
	iv. To standardize post-harvest management technologies, processing and value addition to minimize the post harvest losses for making the price remunerative and enhancing the profitability of horticulture through products diversification for export and domestic markets.	i. To study effect of pre-harvest sprays on post-harvest decay of grapes.	i. Spraying bunches with *Trichoderma harzianum* isolate 5R, at 20 and 5-3 days before harvest and packing grapes with 2.3g $Na_2S_2O_5$ has been very effective in controlling post harvest decay, in grapes harvested after rains. Similarly, some petroleum oils, botanicals, and micro-organisms show promise for reducing post harvest decay and desiccation.	- do -
		i. Identification of practices, which causes post harvest decay and evolving control measures.	i. *Alternaria* infection mainly occurs at the pedicle end, and practices like rough handling or vertical shaking of packed boxes, leading to mechanical detachment of the skin from the pedicle enhance infection. Delayed harvest leading to over maturity of the berries, or bruising injury also increased infection. Bruising injuries during harvesting, handling or transport, increased *Cladosporium* infection of berries. *Aspergillus* damage was observed in berries, which split or cracked due to injuries. Increased rotting due to *Rhizopus stolonifer* was observed in grapes which got wet due to preharvest rains, or water from dew, spray etc. *Botryodiplodia* infection was recorded more from dry areas.	- do -
		ii. To identify microorganisms which causes post harvest decay in exportable grapes.	i. During storage at $0 \pm 0.5\ ^0C$, post harvest decay was minimal and caused due to *Alternaria alternata* and *Cladosporium sphaerospermum.* Infection of both these fungi was restricted to individual berries. On shelf, *Aspergillus* spp. mainly *A. niger, Botryodiplodia theobromae,* and *Penicillium* spp. were found associated with individual berries, while *Rhizopus stolonifer* was associated with bunch rot.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
4. Production of quality breeder seeds/planting material	i. To strengthen the production of breeders seeds, parental lines and nucleus planting material of horticultural crops.	i. Standardization of propagation techniques for grape rootstocks	i. IBA concentration was standardized for different rootstocks for propagation through hardwood cuttings. June to August was found best time getting maximum rooting percentage in rootstocks. September is the ideal time for *in situ* grafting in raising rootstock vineyards. Potting mixture of soil, sand and cocopeat in equal proportion was found to be best for multiplication of Dog ridge rootstock.	- do -
		ii. To introduce and distribute elite plant material	i. Red Globe, Italia and Crimson seedless have put under MLT in TN, Andhra, Karnataka and Maharashtra at 8 locations. The trial is on going.	
		iii. To develop resistance breeding program	i. Six donors of downy mildew and anthracnose resistance were spared to IIHR in their breeding program, which were exclusively collected and maintained by NRCG.	- do -
		iv. Improvement through clonal selections and distribution of planting material.	i. Clonal selections such as A17-3 from Centennial Seedless (Export table grape), Chardonnay (better yielder), KR White (for raisin) and A25-1 (for red table wine) are being to progressive farmers and research centers under AICRP on grapes.	- do -
5. Cropping system research for productivity enhancement	—	—	—	—
6. Diversification	i. To identify suitable crops and standardize technologies for crop diversification.	i. To evolve varieties for raisin and wine varieties	i. Distribution of plant material of certain promising table and wine grape varieties such as Red Globe, 2A clone, A 17-3 (Table purpose) , Merlot, Cabernet Sauvignon, Chenin Blanc, Shiraz, Pusa Navrang, Sauvignon Blanc(for wine) etc. to farmers were given under MTA. 175 farmers have been benefited from this Foundation plant Supply program that includes 8 SAU's and 4 Institutes.	- do -

Programme Area/Head	Objectives/Targets	Output	Outcome	Time frame
7. Training and retraining	i. To upscale the knowledge and skill of scientific and technical staff.	i. To train scientific and technical staff of the institute to upscale knowledge and skill	i. Most of the scientists have participated in seminars, symposia, training programme in their respective discipline both at national and international levels. Similarly technical and administrative staff have been sent to training in the filed of financial and administrative matters.	- do -
8. Demonstration for technology update	i. To disseminate technologies developed at the Centre	i. To participate in the growers' seminar, conduct field visits etc.	i. Participated in regional seminars organized by Maharashtra State Grape Growers' Association, Pune and its regional units at Sangli, Solapur and Nasik.	- do -
			ii. Participated in exhibitions organized by various agencies.	- do -
			iii. Also participated in growers' seminars organized by State Department of Horticulture of Karnataka, Andhra Pradesh etc.	- do -
9. Training of farmers, farm women, trainers etc,	i To conduct training for farmers, trainers etc. on grape cultivation and management practices	i. Conducted training programmes establishment of new vineyard, judicious use of plant growth regulators in grapes, development of integrated disease and insect pest management in grapes, recent advances in viticulture, management of bud for appropriate production and quality, nutrient management in grapes, advances in tropical viticulture, ensuring fruitfulness in grapes, etc.	i. Trained farmers and trainers on technologies for grape cultivation and management.	- do -

5. Constraint analysis

Narrow varietal base is the most salient weakness hampering the exports of grapes from India. Among the green seedless grape varieties grown in India only Thompson Seedless and its clone Tas-A-Ganesh have demand in European markets. The variety Thompson Seedless also seems to have degenerated its original attributes due to continuous perpetuation. The commercial cultivars are susceptible to mildew and other diseases warranting high inputs on their management. Although some wild cultivars hold promise for use as donor parents in resistance breeding programmes, they can not be grown out of their native habitat, hence, warrant *in situ* conservation. Specificity of most popular variety, Thompson Seedless in its climatic requirements has problem of cracking and rotting in the event of rains during ripening and short period is available for ripening in the sub-tropical plains of north India. The increasing soil salinity and water shortage adversely affect the shoot vigour and vine canopy thereby are a threat to the production of quality grapes. India has the distintion of having highest productivity however; heavy yield results in poor quality of grapes and short life of the vines. The proportion of export quality grape reduces drastically with increase in yield over 20 t/ha. Under the tropical climate of peninsular India, incidence of diseases like downy mildew, powdery mildew and anthracnose is severe, especially under wet and cloudy conditions, which affect the yield and quality of the fruits. Sole dependence on fungicides for disease management and the heavy spray schedule has increased the pesticide residues levels to the extent of jeopardizing the exports and creating an aversion to grapes in the minds of the elite, health conscious Indian consumer. More use of systemic fungicides with single point mode of action has increased the chances of development of resistance in the pathogens. Use of pathogen specific fungicides has led to the resurgence of weak pathogens and development of new disease complexes in the field as well as storage. Lack of proper training on harvesting and handling practices in workers employed at the 'on farm packing houses' of small growers / exporters has adversely affected the post storage shelf life. The distance of India from the potential markets in the European continent and other countries require long duration refrigerated storage during transport by sea, which is the only economical means of transport of grapes. Lack of adequate cold chain infrastructure at production sites to maintain the cold chain from harvest to cold storage is also an impediment besides the bad roads and inadequate and inconsistent power supply. Although the Indian raisins comply with most of the quality parameters specified by Codex, yet some important physical and organoleptic parameters need to be improved to make the Indian raisins internationally acceptable.

6. Projection of increase in productivity

Grape productivity in India is highest in the world and there is little scope to increase it further. However, much is still desired as far as the quality is concerned, therefore, emphasis is on improving quality while sustaining the present high productivity.

7. Research thrust areas

i. Solving the marketing problems by improving the quality of grapes to international standards thus increasing the export of fresh grapes as well as developing technology for expanding the period of harvest, identify new areas for

off-season cropping, standardize techniques for protected cultivation of grapes preventing post harvest losses; introducing / identifying varieties and developing indigenous technology for processing of grapes, raisins, wine and juice etc.

ii. Reducing the cost of cultivation including the initial cost of establishing a vineyard and the annual recurring costs through economic and efficient use of inputs and disease resistant varieties.

iii. Minimize yield losses due to diseases and pests by effective prevention by developing disease-forecasting models and evolve effective prophylactic control measures.

iv. Increase in production through expansion of the area under grapes by developing suitable technology for saline soils and drought prone areas by evolving / introduce salt and drought tolerant rootstocks and water management practices.

v. Monitoring pesticide residue in fresh grapes and reviewing their levels below the MRL fixed by the importing countries

8. Export / Import – during last three years

Grape

Grape export from India is 53,910 tonnes valued at 48,505 (1000US$) that makes a share of 1.54% of total export of grapes in world. India's grape import is very less. It is about 1500 tonnes valued at 1761 (1000US$) that make 0.05% of total quantity of grapes imported in the world. In the world India ranks 74th in import of grapes.

Raisin

Export of raisins from India is 140 tonnes valued at 178.27 (1000 $) that make a share of 0.02% of total volume of export of raisins in world. In world India ranks 39th in export of raisins. Import of raisins in India is 7770 tonnes valued at 11732 (000 $) that make a share of 1.04% of total import of raisins in the world.

Wine

Export of wine from India is 480 tonnes valued at 1204.54 (1000 $). India exports 0.01 % of total quantity of wine exported in the world. Import of wine in India is 1690 tonnes valued at 9424 (1000$) that make a share of 0.02% of total volume of wine imported in the world.

Grape juice

Export of grape juice from India is 10 tonnes valued at 3,000 $. India exports 0.001% of total world export of grape juice. Import of Grape juice in India is 190 tonnes valued at 259 (1000$) that make 0.024% of total quantity of grape juice imported in the world.

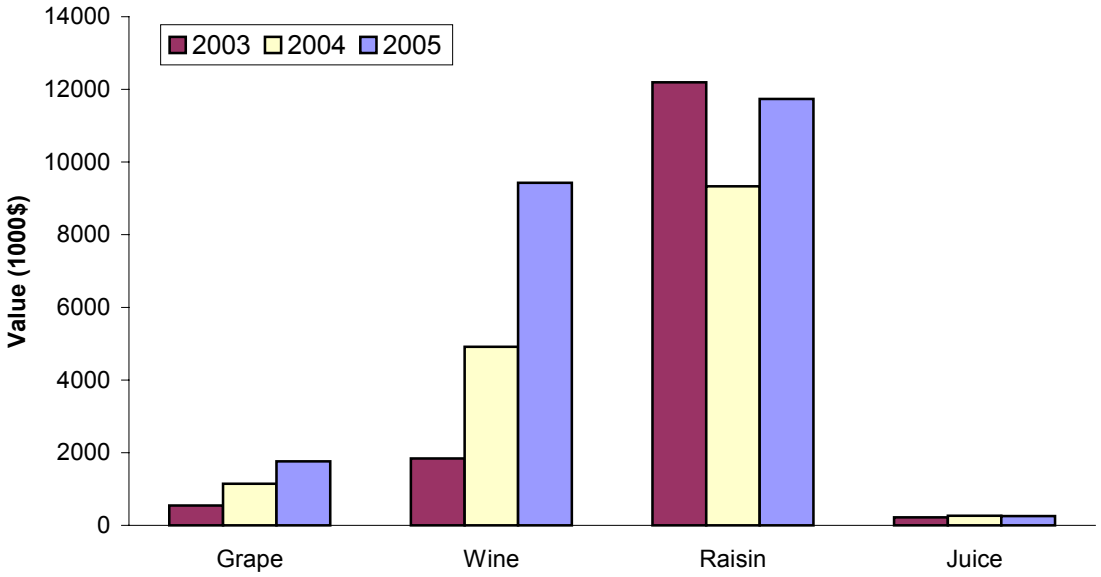

Fig. 3. Import in India: Grapes, wine, raisins and juice

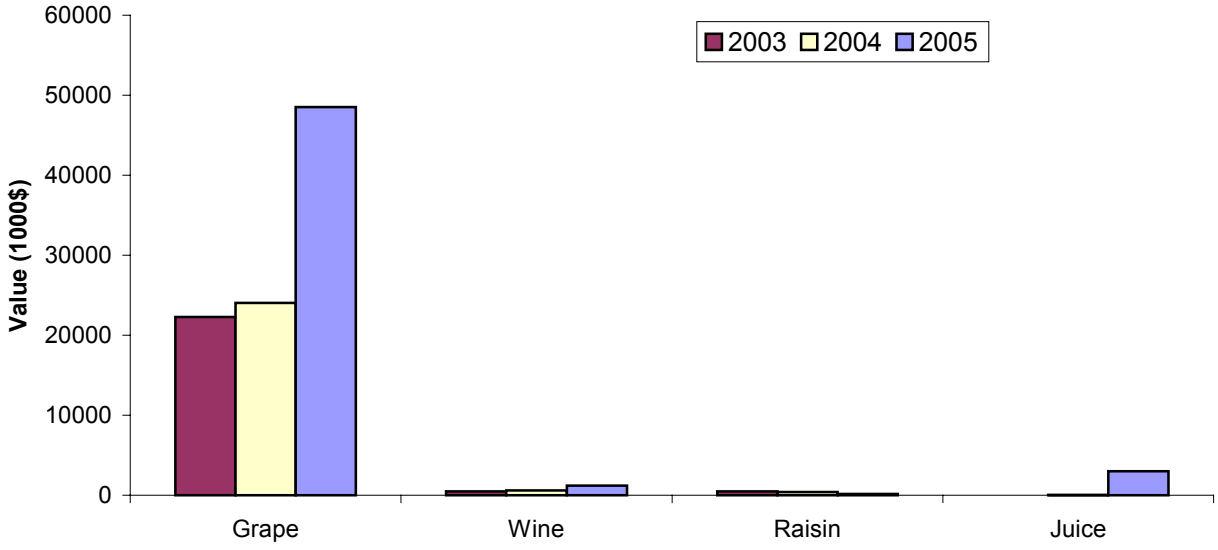

Fig. 4. Export from India: Grapes, wine, raisins and juice

B. TECHNOLOGICAL ASPECTS

9. Plant Genetic Resources

a. Utilization

(Number in MTS, Number utilized, Remarks)

Analysis of accessions used

Planned hybridization has been initiated utilizing the available genotypes for incorporation of downy mildew tolerance in commercial grapes. Under a NATP sponsored project interspecific hybridization is carried out along with embryo rescue techniques in collaboration with NCL, Pune. The hybridization involved Thompson Seedless and Flame Seedless as female parents each crossed with St.George *(V. rupestris)*, *V.candicans*, Fruhroter Veltliner (*V. vinifera*) *Seyve-Villard* hybrid (SV-18402, a poly *vitis* species), Lake Emerald, Concord, Catawba (all of *V. labrusca*), and *V .tiliefolia*. All the male parents are known to be highly tolerant to downy mildew disease. Nearly 400 F_1 hybrid plants have been obtained and are awaiting field evaluation at the Centre.

Attempts are being made to utilize male sterile lines for mass hybridization programmes. Out of 6 male sterile lines (Katta Kurgan, Spin Sahebi, Madelien Angivine, *Vitis parviflora*, Neagra Vertis and Arka Trishna) available in the germplasm 3 male sterile seeded genotypes such as Katta Kurgan, Spin Sahebi and *Vitis parviflora* have been crossed with seedless genotypes such as Thompson Seedless, Flame seedless, Crimson Seedless, Centennial seedless, Kishmish Chernyi and seeded; Red Globe and Christmas Rose. *Vitis parviflora* being resistant to downy mildew, powdery mildew and anthracnose is most useful among the indigenous species.

Rootstock accessions such as Teleki 5A *(V.berlandieri x V.riparia*) is crossed with 110 R(*V.berlandieri x V. rupestris*), SO4 (*V.berlandieri x V.riparia*), 1103 P (*V.berlandieri x V. rupestris and St.George (V. rupestris*). The F1 progeny is under further studies.

b. Evaluation

(Number of active collections, No. evaluated, Remarks)

Evaluation of table varieties

The fruit yield in kg per vine among 25 seeded table grape varieties evaluated, Arka Majestic (36.3), Red Globe (36.2), Arka Chitra (25.5), Cheema Sahebi(24.05), Christmas Rose(20.8), E8/24(20.0), Spin Sahebi(18.6), Madhu Angoor (17.4) and Hussain Kadu(17.1) were high yielders. However based on brix yield (kg/vine) obtained in Red Globe (7.36), Arka Majestic (6.63), Spin Sahebi95.8), Christmas Rose(4.2), Madhu Angoor(3.7) and Hussain Kadu (3.4) were promising, except Arka Majestic due to its uneven ripening.

Among twenty white seedless varieties A 17-3 (22.4 kg/vine), Arka Shweta (17.7 kg/vine) and Arkavati (16.8 kg/vine) were high yielders. Perlette ans New Perlette were the earliest followed by A 17-3. A 17-3 had uniform, oval shaped bold berries suitable for export purposes. Marroo seedless (18.34), Flame seedless (15.4 kg/vine), A 18-3 (12.2

kg/vine) and Sharad seedless (11.6 kg/vine) were good yielders among coloured seedless varieties.

Evaluation for juice quality

Hussain Black Kabuli (16.9 kg/vine), Athens (13.7 kg/vine) and Country Bangalore (11.8 kg/vine) were high yielders. Country Banglore, Gulabi x Bangalore Purple, and Hybrid 23-14 were suited for membrane extraction of the juice, where in the first two varieties had lower PPO activity which is a necessity for long storage life of juice. While Concord and Arka Shyam were not suited for membrane extraction due to high pectin content. The Organoleptic score also indicated that Country Bangalore, Gulabi x Bangalore Purple, Concord, Arka Shyam and Pusa Navrang were acceptable.

Performance of wine varieties

In wine varieties, based on brix yield(kg/vine), Ugni Blanc (4.6), Chenin Blanc (4.2) Shiraz (4.2), Grenache (3.2), Convent Large Black (2.6), Cabernet Sauvignon (2.4) and Carignane(2.5) were promising. High TSS was recorded in Black Prince (26.3), Pinot Noir (24.9). Chardonnay (23.7) Convent Large Black (24.8), Merlot (22.7), cabernet Sauvignon (22.0), Grenache (20.7) and Saperavi (19.3).

Evaluation for earliness in Table grapes

Evaluation for maturity period in 256 accessions indicated that Early Perlette, Venus(*V.labrusca*), Superior Seedless (Brazil), A 18-3, A 17-3, Cardinal, Beauty Seedless, Charas, E 29/4, Arka Krishna, Pearl of Csaba, Delight, Fateasca Alba, Pusa Urvashi, Seibel 9309, Centennial Seedless etc were the early ripeners, where as Doradillo was the most late ripener.

Evaluation of grape accessions for maturity period

Sl. No.	Maturity	Maturity Period (days after pruning)	Number of accessions
1	Very early maturity	< 105	95
2	Early maturity	106 to 115	120
3.	Medium maturity	116 to 125	40
4.	Late maturity	> 126	1

Evaluation for raisin quality

Thirty one seedless (white and coloured) varieties were evaluated for their raisin quality using Austrlian dip emulsion and shade drying method. Bold sized raisins were obtained in Superior seedless, A17-3, A39-2, Centennial seedless among white raisins and Crimson seedless and A18-3 among red varieties.

Screening for disease resistance

All the accessions were screened for downy mildew resistance *in vivo* conditions and those exhibiting resistance *in vivo* were screened under *in vitro*. Among these

varieties Carolina Black Rose, SV-23501, SV-12309, SV-12375, Seibel 9308 and St. George were found to be immune.

All the 10 indigenous accessions collected from Kinnaur (Himachal Pradesh), such as Choultu Black, Choultu White, Rangspey Black, Rangspey White, Choultu Red, Kinnauri-1, *V.parviflora, V.lanata*, Kanai local and Ribba black have been found immune to powdery mildew under field conditions at Pune.

c. Collection and Conservation
[Only LTS] (Number collected, Remarks) (Number conserved, Remarks)

NRCG has developed an active field gene bank which also serves as National active germplasm site for grapes in the country. As on 31st March 2006 the Centre has a cumulative collection of 415 accessions.

Because the vines have been properly trained on trellis system and most of them grafted on a salt tolerant rootstock 'DogRidge', the collection is also meant as MTS (medium term storage) form of conservation.

The following is the categorization of NRCG, Pune germplasm

i. White seeded : 85 accessions in the field

ii. Coloured seeded : 160 accessions in the field

iii. White seedless : 44 accessions in the field

iv. Coloured seedless : 22 accessions in the field

v. Rootstock accessions : 24 accessions in the field

vi. Accessions maintained in polyhouse : 65 Accessions

The main sources of collection have been ;

i. AICRP centers working on grapes such as ;
   a. ANGRAU, Hyderabad
   b. Agharkar Res.Institute, Pune
   c. Regional Fruit Research Station, PAU,Abohar, Punjab
   d. Division of Fruits & Hortic.Tech. IARI, New Delhi
   e. IIHR, Bangalore
   f. MPKV, Rahuri,

ii. Other Research Stations :
   g. RFRS, YSPUHF,Sharbo, Kinnaur, Himachal Pradesh
   h. NBPGR Regional Station, Hyderabad

iii. Through Explorations:
   i. Kinnaur Region, Himachal Pradesh
   j. Konkan Region, Maharashtra

iv. From Growers' fields & Wineries in the country (As direct introductions in collaborations with France, Italy, Australia, USA and South Africa)

v. Introduction from :

k. Russia, Brazil, Nigeria, Ukrain, Japan, Uzbekistan, USA, Canada, Korea, Morocco, etc.,

d. Molecular characterization
(Number, Remarks)

This work is carried out in collaboration with Agharkar Research Institute, Pune as only recently the concerned expertise and facilities are being established at our centre. The salient features of these studies in collaboration with ARI, Pune is detailed below.

Fifteen rootstock accessions were analysed using RAPD and ISSR primers and genetic diversity within rootstock was studied. Few genotypic specific bands were also observed which would help in identifying particular rootstock. Similarly 31 grape varieties (23 seedless and 8 seeded) were analysed for their genetic relationships using both RAPD and ISSR markers. A few genotypic specific bands were observed which could be used in cultivar identifications.

Molecular characterization of grape accessions is initiated recently at this Centre after facility to do so was established. Twenty two rootstocks and 24 other accessions are already characterized with several SSR and AFLP primers. Data is analysed to establish their genetic relationship.

10. Registration of germplasm
(Number, Remarks, Specific traits)

In this context the work on establishment of core germplasm is being followed up intensively at this centre, with a priority to identify duplicate accessions present in the germplasm.

Both ampelometric characterization and molecular characterizations are being carried out to identify duplicates. The information has been submitted in format for obtaining the registration of grape germplasm at NBPGR, New Delhi.

11. Genetic studies

Evaluation for self male sterility in grape varieties

Sr. No.	Variety	Bunches set (%)	No. of berries	No. of seed set/bunch	Weight of seed(g)/ bunch	Seed germination (%)
1	Arka Trishna	40.0	7.8±12.1	6.4±11.7	0.04±0.08	0.0
2	Madelein Angevine	0.0	0.0	0.0	0.0	0.0
3.	Spin Sahebi	30.0	5.0 ±9.48	18.4±44.4	0.493±1.22	0.0
4.	Katta Kurgan	50.0	1.4±1.55	0.0	0.0	0.0
5.	*Vitis parviflora*	0.0	0.0	0.0	0.0	0.0

The male sterility in 5 genotypes viz. Arka Trishna, Madelein Angevine, Spin Sahebi, Katta Kurgan and *Vitis parviflora* was noticed initially by the presence of reflex stamens. However to further establish this character, 20 bunches were selected at pre-flowering stage in each genotype and bagged for selfing for about 10 days. Observations recorded between fruit set and veraison indicate bunch set in Arka Trishna (40%), Spin Sahebi (30%) and Katta Kurgan (50%) with few berries (Table 4). Berries developed parthenocarpic or with undersized/ shrivelled seeds in Arka Trishna, Katta Kurgan and Spin Sahebi and none of the seeds germinated. There was no berry set in selfed Madelien Angevine and *Vitis parviflora*. Studies on inheritance of male sterility in grapes are being pursued.

Genetic variability, heritability among quantitative characters and scope for selection/improvement

Based on the observations recorded for two consecutive years representing 138 accessions with nine parameters genetic variability, heritability and expected genetic gain were studied. High phenotypic coefficient of variation was observed for fruit yield, bunch weight, number of bunches per vine and berry diameter (which are also the yield determinants). Scope for genetic advancement through selection exists only for fruit yield through bunch number and mean bunch weight. Further improvement in fruit quality parameters like TSS, juice content, and berry diameter is limited through direct selections, hence may be resorted to hybridization for improvement in these characters.

Genetic Variability among 138 grape accessions during 3rd harvest season at NRCG, Pune

Variable	Mean ±SEM	Range	PCV	GCV	Heritability	Expected genetic gain
Pruning wt.(kg)	0.946±.0.03	0.09 - 4.78	70.12	61.36	0.7659	94.51
Bunches/vine	45.13 ±1.34	1.33 - 157.00	70.62	64.87	0.8438	104.85
Bunch wt(g)	194.0±5.1	24 - 826	69.15	65.20	0.8888	108.10
Yield/vine (kg)/5.41^2 m	8.59±0.37	0.20 - 48.00	103.94	99.08	0.9086	166.10
Berry diameter (mm)	14.00±0.13	9.00 - 20.50	13.00	10.53	0.8100	18.52
Juice%	66.28± 0.71	30.0 - 90.0	95.26	57.12	0.5996	15.53
TSS (^{o} Brix)	20.95±0.24	12.1 - 32.0	15.52	12.37	0.6361	17.36
Acidity %	0.49±0.01	0.15 - 1.09	30.80	26.37	0.7333	39.73
TSS: Acid Ratio	48.29±1.29	14.0 - 113.0	36.37	29.27	0.6479	41.45

The correlation coefficients among these characters indicated that very high positive significant coorelations existed between yield per vine and bunch number

(0.699), yield and mean bunch weight (0.624), TSS and TSS:Acid ratio (0.488), juice percentage and berry diameter (0.307 each), mean bunch weight and biomass (0.213). Whereas high negative correlations existed between acidity and TSS:Acid ratio (-0.820), berry diameter and TSS (-0.364), juice percentage and TSS (-0.311).

Correlation Coefficients among quantitative characters in 138 grape accessions

Character	Bunch number	Bunch weight	Pruning weight	Yield/ vine	Berry diameter	Juice (%)	TSS (°B)	Acidity (%)	TSS: Acid ratio
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2	-0.089	1.000							
3	-0.115	0.213**	1.000						
4	0.699**	0.624**	0.022	1.000					
5	0.128	0.137*	0.059	0.195**	1.000				
6	0.029	0.135*	-0.025	0.163*	0.307**	1.000			
7	-0.128	-0.032	0.124	-0.087	-0.364**	-0.311**	1.000		
8	-0.112	0.093	0.058	-0.040	-0.024	0.035	-0.114	1.000	
9	0.037	-0.093	-0.035	-0.029	-0.127	-0.184**	0.488**	-0.820**	1.000

12. Biotechnology

Forty-four downy mildew resistant and susceptible grape accessions are analysed with several SSR and AFLP markers in an attempt to identify marker closely linked to the disease resistance. Several promising AFLP and SSR bands are identified. These bands were extracted and purified. Cloning of these fragment is under progress.

An inter- institutional collaborative study was undertaken with NCL, Pune to introgress downy mildew resistance in commercial seedless cultivars. Thompson seedless and Flame seedless as female parents (stenospermocarpic varieties) were crossed with 8 donors for the disease resistance. Crossed berries were harvested immature at about 30 days after pollination and were processed for ovule/embryo culture. Also in a study the prebloom application of benzyl adenine at 30 ppm had positive influence on the percentage embryo recovery, germination and development of hybrid plants in majority of crosses. As a result of *in vitro* embryo rescue work about 643 hybrid plants belonging to different cross combinations could be produced.

In another study in collaboration with NCL, Pune micropropagation protocols were standardized in selected grape varieties (Red Globe, 2A clone, Crimson seedless and Italia) and rootstocks (110R and 1103 P). These micropropagated plants are under field evaluations in 3 locations.

The following is the brief description of protocols;

2A clone and Italia: Auxillary buds cultured on Murashige and Skoog medium supplemented with BAP (0.5 to 2.5 mg/l) sprouted and induced multiple shoots. These

shoots were elongated on MS basal medium with reduced BAP concentration. Rooting in shoots could be obtained on either half or full strength salts of MS basal medium supplemented with IBA, IAA,IPA or NAA (0.1 and 0.2 mg/l) both in solid and liquid media. Rooted shoots were hardened in plastic cups containing different substrate mixtures like soil, sand, coco-peat, Irish peat moss, saw dust, rice husk, cow dung, compost, vermi-compost, soilrite, perlite, vermiculite in various combinations. Hardened plants were transferred to green house for further establishment.

Crimson seedless, Red Globe, 110R and 1103 P : Single noded stem cuttings from field grown vines were cultured on MS basal medium supplemented with various concentrations of BAP and Auxins to induce multiple shoots. Bud break was observed after 15-20 days of inoculation. Induction of multiple shoots could be obtained on MS basal medium supplemented with BAP (2 mg/l) + IBA (0.2 mg/l) or BAP (2.0 mg/l) + IAA (0.1 mg/l). Elongation of shoots was better on lower concentrations of above hormones. Elongated shoots were rooted *in vitro* on half strength MS basal medium supplemented with auxins like IAA, IBA and NAA (0.1 – 0.3 mg/l). Rooted shoots were transferred to plastic cups containing a mixture of sand + soil (1:1) and kept under high humidity and high light intensity conditions for hardening.

13. Varieties
(production, quality, resistance)

Sl. No.	Name of the variety	Year of release	Production (Q/ha)	Maturity	Specific traits (quality resistance)	Area of adaptation
1.	Red Globe	2002	10 t/ha	Late	Table purpose, excellent keeping quality, bold berries	Maharashtra, Karnataka, Andhra Pradesh
2.	Shiraz	2005	8 t/ha	Late	Table wine	Maharashtra, Karnataka
3.	Cabernet Sauvignon	2002	5 t/ha	Late	Table wine	Maharashtra, Karnataka
4.	Merlot	2002	4 t/ha	Mid	Sweet table wine	Maharashtra, Karnataka
5.	Sultanine-II	2004	10 t/ha	Mid	Table grape export quality	Maharashtra, Karnataka

14. Hybrids
(production, quality, resistance)

Sl. No.	Name of the variety	Year of release	Production (Q/ha)	Maturity	Specific traits (quality resistance)	Area of adaptation
1.	A 17-3	2002	10 t/ha	Early	Self sizing export quality	Maharashtra, Karnataka and Andhra Pradesh
2.	Kishmish Rozavis white	2003	2 t/raisins / ha	Late	Flavoured raisin	Maharashtra, Karnataka and Andhra Pradesh
3.	Chardonnay (NRC for Grapes clone)	2005	5 t/ha	Late	Better yielder	Maharashtra (Nasik and Pune)

Hybridization work has been started only recently at NRCG. Some of the F1 progenies are raised and field evaluation studies are on going.

15. Production Technology

a. Integrated Nutrient Management

Depending on variety and region, the recommended nutrient doses range from 435-1100 kg N, 240-1332 kg P_2O_5 and 120-1337 kg K_2O. To avoid over-fertilization of vineyards, the annual dose of nutrients is fixed based on the petiole nutrient contents determined at the initiation of bud differentiation (45 days after spur pruning) in the tropical regions, but at full bloom in the subtropical region. Petiole of the fifth leaf from base is to be sampled on the 45^{th} day after April pruning, while that of the leaf opposite to the cluster if at full bloom. The proportion of N, P_2O_5 and K_2O are different at different stages of vine growth. Low levels of N, more of P_2O_5, medium of K_2O are applied during the growth cycle while; high N, medium P_2O_5 and high K_2O levels are applied during the fruiting season.

Indiscriminate use of chemical fertilizers has aggravated the problem of soil salinity, particularly in saline-alkali soils and heavy clayey soils irrigated with water containing more salts. In such situations, the best results are obtained by supplying the nutrients through organic sources and soluble fertilizers that have low salt-index. Approximately 40-60 per cent of the nutrients can be supplied through organic manures (cattle manure, bone meal and green manure).

Magnesium deficiency is common in vineyards and magnesium is given through soil. Iron and Zinc are the micronutrients mainly given through foliage.

Similarly as much quantity of soluble fertilizer as possible should be used. It is recommended to use 40 per cent of the annual dose in organic forms, 30 per cent as inorganic fertilizers and the rest 30 per cent (equivalent to 20 per cent of the absolute

dose on account of 33.3 per cent increased efficiency) in the form of soluble fertilizers through fertigation.

Fertigation schedule for a vineyard requiring 500 kg N, 500 kg P_2O_5 and 100 kg K_2O/ha/year is given below, as a case.

Required doses through fertigation:

		N	**P_2O_5**	**K_2O**
1.	Required nutrients (kg/ha)	500	500	1000
2.	Through organics (40%)	200	200	400
3.	Through inorganic nutrients in soil (30%)	150	150	300
4.	Through fertigation (20% equivalent to 30%)	100	100	200

b. Integrated Water management

Irrigation should be given to plants before the plant shows symptoms of moisture stress. Since the feeder roots concentrate only on the top layer of soil, give light and frequent irrigation than heavy and less frequent irrigation. Operating the drip @ one hour per day once in two days is better in heavy clay soils but it is advisable every day in light sandy soils. The entire trench should be wetted by placing the drippers at 60 cm intervals.

c. Integrated Weed Management

Weeds are controlled manually, mechanically or by use of chemical weedicides like the pre-emergent Atrazine (2-3 kg a.i. / ha), Simazine (2.0 - 6.0 kg a.i. / ha), Diuron (2-4 kg a.i. / ha), and the post-emergent Paraquat (7.5 kg / ha), Glyphosate (2.0 kg a.i. / ha), Dalapon (8.75 kg / ha).

d. Resource Conservation Technology

- Use of rootstocks, subsurface irrigation, mulching, drip irrigation has been recommended to conserve water resources
- Nutrient application through fertigation instead of soil application is recommended to prevent overuse of fertilizer and sustain soil health.
- Technologies to decompose farm waste like pruned material is being developed. The decomposed material is used to improve soil texture and health.

e. Cropping system

Not practiced in grape cultivation.

f. Farming system

Not practiced in grape cultivation.

g. Crop Diversification

In India, grape is cultivated predominantly for table purpose and Thompson Seedless a colourless seedless variety is the most preferred variety by the consumers. However, recent changes in global scenario has shifted emphasis to wine grape. The

Centre has initiated the research to develop the technology for wine grape production. Also processing of grape into raisin and juice is gaining importance to avoid glut in the market. In table grape also instead of colourless varieties, several coloured varieties like Sharad Seedless. Red Globe, Flame Seedless is gaining consumer acceptance and technologies for these varieties is being developed.

h. Organic farming

Research on different components of organic farming in grape is initiated, e.g. biological control, botanicals and environmentally safe chemicals are under evaluation for pest management and quality improvement.

i. Other components of Production Technology (in Annexure)

Given in Annexure 2A

16. Protection technology

a. Key pests, diseases – geographic distribution and their economic importance, epidemiological/epizootic studies etc.

i. Downy mildew

Downy mildew of grapes is caused by the obligate parasitic fungus, *Plasmopara viticola.* All varieties of grapes in the species *Vitis vinifera* are highly susceptible, *V. aestivalis* and *V. labrusca* are less susceptible, while *V. cordifolia*, *V rupestris* and *V. rotundifolia* are relatively resistant. Downy mildew is a highly destructive disease of grapevines in all grape-growing areas causing up to 100% losses if the disease is not controlled during favourable weather.

P. viticola survives in the soil as oospores on fallen leaves or resting sporangia or on buds / leaves as dormant mycelium. Temperature in the range of 17 – 32.5^{o}C and afternoon RH more than 48 % favour primary infection. The sporangia are dispersed due to wind, rain splashes etc. At least 4 hours of darkness, more than 98 % RH and 13^{0}C or more temperature are required for production of sporangia. For infection the foliage must remain wet for at least 2-3 hours. After infection the visual symptoms may appear anywhere after 5 or more days, depending upon the weather conditions. Sporangia are produced on the lower surface of the leaves and are dispersed by rain or wind.

ii. Powdery Mildew

Powdery mildew is a second most important disease of grapes. It is caused by the obligate parasitic fungus *Uncinula necator* (Schw.) Burr. is a serious problem in most of the grape growing areas of India. In Maharashtra, Andhra Pradesh, and Karnataka powdery mildew becomes a serious problem after November i.e about six weeks after bud break, and the risk of the disease continues till 12th or 13th week after bud break till the berry softening stage (veraison) sets in. In Punjab and UP the early fruit growth stage i.e. March – April is the high-risk period for powdery mildew. In Kinnaur, a mountainous district of HP (up to 9000 ft MSL) cloudy weather during early summer leads to high incidence of disease on new vigorous growth.

Under favourable weather conditions any green succulent tissue can be infected by powdery mildew, but berries after veraison are resistant. However, green pedicel of berries even at harvest is susceptible and if infected, can reduce the shelf life of the berries. In peninsular India, the fungus is believed to survive as active inoculum in the canopy or as dormant mycelium in the buds.

Optimum temperature for growth is 25°C, the range being 21-27°C. The fungus does not grow below 6-10°C or above 33-36°C. At optimum temperature and RH, the time from germination of spores to sporulation from the newly developed colonies is approx. 5 days. Free water does not favour disease development.

iii. Anthracnose

Anthracnose is present in almost all the grape growing regions of the country except high mountain zones of Kinnaur district and Kashmir valley. Anthracnose reduces the quality of the vine. Almost all the commercial grape varieties are susceptible.

Anthracnose is caused by the fungus *Elsinoe ampilina* (de Bary) Shear (syn. *E. viticola* Raciborski, anamorph *Sohaceloma ampelinum* de Bary. On leaves Anthracnose produces small, circular lesions which later result in 'Shot Hole' symptoms. The bark of the stem may get completely killed and the infection may go down deep till the pith of the shoot. If the infection is at the base of the stem, it may crack and break. Bunches can be infected at any stage from before flowering till veraison. Young affected inflorescence appears charred.

The fungus survives in the form of mycelium on the cankerous lesions on the canes or the stem. Rain or dew is required for the sporulation of the pathogen. 2 mm or more of rain favours is required for conidial dissemination. For infection at least 12 hrs free moisture is required. Optimum temperatures for disease development are 24-26^{o}C. Symptoms appear in 13 days at 2^{o}C and 4 days at 32^{o}C.

iv. Bacterial canker

Grapevine bacterial canker disease has become a serious disease in the entire grape growing regions of peninsular India. *V. vinifera* is highly susceptible while other Vitaceae genera and some *Vitis* species were highly resistant. Seedless *V. vinif*era cultivars are more susceptible than seeded cultivars. Among the seedless cultivars, coloured are more susceptible than white cultivars.

Bacterial canker is caused by the bacterium, *Xanthomonas campestris* pv. *viticola*. It is a gram-negative rod with round ends, motile by single polar flagellum. The bacterium infects all the aerial parts of the vine. Even after severe infection when the leaves are almost burnt out, they remain firmly attached to the shoot. Irregular growth, stunting and splitting of the shoot were observed in the advanced stages of infection. Severe infection leads to the death of leaves and affected the growth of canes.

The bacterium spreads from one season to the other through the unpruned diseased canes. Infected dormant buds and arms or trunk with cankerous lesions harbour live inoculum of the bacteria. Bacterial inoculum from infected parts spreads through rain splashes. The disease spreads from one place to the other through infected planting material. The optimum temperature for the bacterium growth was 25-30^{o}C. Free water as a result of rainfall, dew or high RH (>80%), helps in infection and spread of the disease.

Epidemics occur when rain coincides with wind as the wind induced injuries help in infections.

v. Rust

Rust disease occurs mainly in the tropical areas of the country. It is an important disease of Bangalore Blue in south interior Karnataka, but is also reported on Black Prince from Salem, Nilgiri and Coimbatore (TN) and on Beauty Seedless and Cardinal in UP. It does not affect the other *vinifera* varieties. Six vitis species (*V. berlandieri, V. candicans, V. champini, V. palmata, V. parviflora and V. tiliefolia*) and two rootstocks (*berlandieri* X *riparia* and *riparia* X *rupestris*) were highly resistant. It affects the rootstock Dogridge and from infected stocks plants it is transmitted to the scion cultivars Thomson Seedless and Tas-A-Ganesh. The disease can cause severe defoliation during July-August and January-February, which usually coincides with veraison, and thus hampers the berry ripening and development.

Rust is caused by a macrocyclic fungus called as *Phakospora vitis* (syn *Physopella vitis, P. ampelopsidis*) which produces the uredial and telial stages on grape. The orangish-yellow uredospores can be produced on grapes almost throughout the year in the tropical and sub tropical regions while the telial stage is found on grapes in temperate areas as the teliospores develop only at low temperatures. The symptoms occur mainly on the mature leaves. In severe infections the entire leaf area may be covered by these fruiting bodies and the leaves fall off.

The optimum conditions for germination of spores is 24^0 C temperature, 75% or more RH, and low light intensity or darkness. RH less than 45% is not favourable for disease development.

vi. Leaf blight and bunch necrosis

The disease is reported from all the grape growing regions of India. Seedless varieties were more susceptible than the seeded ones. Severe infection results in complete drying and defoliation of the leaf. The fungus also infects inflorescence, berries, rachis and the bunch stalk. It produces dark brown to purplish patches on the affected areas. The young berries may get completely dried up and mummified. *Alternaria* also causes post harvest rotting even in the low temperatures of cold stores. It usually infects at the pedicle attachment site or wherever the berry skin is damaged due to abrasions.

The disease is caused by a fungus known as *Alternaria alternata.* The fungus survives on infected plant parts on the vine or the soil saprophytic. The pathogen penetrates the host tissue through stomata, lenticels and micro-cracks in the epidermis.

vii. Dead arm and wilt

The disease is reported from Andhra Pradesh and Punjab. Anab-e-Shahi is more susceptible than Thompson Seedless in A.P. It does not affect Bangalore Blue. The dead arm reported from India is different than the *Eutypa* dieback reported from the USA.Initially few leaves become yellow and start to dry up followed by rapid drying up of the canes and the arms, ultimately the whole vine may die.

It is believed to be the result of infection by *Phomopsis viticola, Botryodiplodia theobromae, Macrophomina phaseolina, Pestalotiopsis viticola* etc. The fungi survive in dead / partially infected wood on the vines or in the soil.

Insect pests

i. Flea Beetles

The adult beetles (*Scelodonta strigicollis)* scrap the sprouting buds and eat them up completely after each pruning. Damaged buds fail to sprout. The beetles also feed on tender shoots and leaves causing substantial damage to the emerging shoots. The pest also attacks roots, tendrils, mature leaves. It is found in all major grape growing in India. In north India, the beetles start their activity mainly from May onwards, though they are seen scraping the sprouting buds in early March. . In south and west India, the emergence of the beetle synchronises with the pruning season.

ii. Thrips

Thrips (*Rhipiphorothrips cruentatis)* suck sap from lower leaf surface and berries. The affected / injured leaf surface develops a speckled silvery effect, which later turns brown. It is observed in all major grape growing regions in India. It is a severe pest and able to cause 50-100% marketable yield loss. Found throughout the year but in epidemic form during flowering and early berry formation stage.

iii. Mealy bug

The following species of mealy bugs are reported from India. *Maconellicoccus hirsutus, Planococcus citri, Ferrisia virgata, Dysmicoccus brevipes, Nipaecoccus viridis, Planococcoides robustus*. It is found in all major grape growing regions in India. It is a very severe pest and is able to cause 50-100% yield loss. Severe in November to March in peninsular India. Mealy bug infected bunches are covered with sooty mold and are unfit for marketing.

iv. Stem borer

Stem borer (*Celosterna seabrator* Fbr.) makes holes on the main stem and arms. Leaves on affected parts turn yellow and mottled and ultimately dry and drop down. It is the pest found in major grape growing in India. Endemic pest and can cause up to 25% loss. Its occurrence is maximum during November to April.

b. Patho-types, Bio-types of key pests

___

c. Cultural controls

___

d. Chemical controls

I. Diseases

Name of Fungicide	Diseases Controlled
1. Nonsystemic fungicides	
Bordeaux mixture 1 % as Post pruning spray 0.5 % as spray on foliage 10 % as paste on cut ends	Most of the fungal diseases and suppression of bacterial canker. Preferred immediately after pruning or during rainy days. Should be avoided on very young shoots during cold temperatures.
Ferrous Sulphate Spray ($FeSO_4$ 10 % + H_2SO_4 1 %) Or Ferrous Sulphate Paste (1Kg. $FeSO_4$ + 125 ml. $H2SO_4$ + 2 L water)	Anthracnose. It is the only fungicide with the potential to eradicate inoculum from anthracnose spots from the stem.
Sulphur Wettable powder (2 g./ L.water)	Powdery Mildew. Should be avoided during hot climates and on fruits. It also helps to kill the eggs of lepidopterous insect pests of grape laid on leaves and mites.
Copper oxychloride (COC) (3g. / L. water)	Most fungal diseases, and suppression of bacterial canker
Captan (2g./ L.water)	Anthracnose, Downy mildew, Rust, Leaf Spots, *Botryodiplodia*
Dithiocarbamates Ziram (Cuman-L, 4 ml./ L.), Zineb (Dithene-Z-78),and Mancozeb (Dithene-M-45) 2-2.5 g./L.	Same as Captan. Most of these fungicides should not be used during less than 75 days before harvest, due to risk of ETU residue.
Chlorothalonil (Kavach) 2 – 2.5 g./ L.	Same as Captan, but should not be preferred during fruiting season. Control rust after April pruning.
Dinocap (Karathane), 0.25 ml./ L.	Powdery mildew
Ipridion (Rovral), 2 g. / L.	*Botrytis*
2. Systemic fungicides	
Carbendazim (Bavistin, Derasol, Agrozim, etc.) 1 g./ L.	Anthracnose, Powdery mildew, Rust, Leaf spot, *Botryodiplodia,* Post-harvest rots.
Benomyl (Benlate) 0.5 – 1 g. / L.	-do-
Tridemefon (Bayleton), 1 g./ L.	Powdery mildew
Hexaconazole (Anvil, Contaf), 0.5 ml./ L.	-do-

Name of Fungicide	Diseases Controlled
Myclobutanil (Sisthane), 0.5 ml. /L.	-do-
Panconazole (Topas), 0.5 ml. / L.	-do-
Metalaxyl (Available as mixture of Metalaxyl 8 %+ Mancozeb 64% eg. Ridomil Mz., Asolt, Krylaxyl Mz., Dithomil, etc.), 3 – 4 g./ L.	Downy mildew
Fosetyl Al (Aliette) 3 g. / L.or Similar chemicals based on(Potasium) salts of phosphoric acid (Akomin, Phytolexin, Phosjet, etc.), 3 ml./ L.	Control downy mildew through indirect action i.e. by inducing resistance in host against pathogen.
Cymoxanil (Available as mixture of Cymoxanil and Mancozeb), 2.5 – 3 g. / L.	Downy mildew

II. Insect Pests

i. Flea Beetle

Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations *viz.,* 50000 ppm formulation is sprayed at 1ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml per liter dose, respectively. Spraying with Carbaryl 50 WP @ 2 ml/l or Imidacloprid 200 SL @ 0.3 ml/l are recommended to control this pest.

ii. Mealy bug

i. Neem based, emulsifiable water soluble formulations can be sprayed. Doses depend on azadirachtin concentrations in formulations viz., 50000 ppm formulation is sprayed at 1ml / l, while that with 10000 ppm and 3000 ppm can be sprayed at 2.5 ml and 5 ml per liter dose, respectively.

ii. Spray of Chlorpyriphos 20 EC @ 2 ml/l is only permitted before bud break or as stem treatment immediately after April pruning. Foliar spray of Malathion 50 EC @ 2ml/l or Phosalone 35 EC @ 2ml/l or Methomyl 40 SP 1g/l or Dichlorvos 76 WSC @ 2 ml/l helps in reducing mealy bug population. If mealy bug incidence is noticed sporadically, then it is advisable to go for swabbing of stem and arms with 2 ml of Dichlorvos + 2 g of fish oil resin soap + 5 ml neem based insecticide in a liter of water.

iii. Thrips

If thrips incidence is noticed spray with Thiamethaxam 25 WG @ 25 g / 100 litre water or Dimethoate 30 EC @ 1 ml/ litre or Endosulfan 35 EC 2ml/l.

e. Biological control/Bio-control agents

i. Diseases

Studies conducted at NRC for Grapes have shown that the bio control agent *Trichoderma harzianum* can be used in grapes especially for the control of post harvest pathogens. In the grapes meant for export, two sprays of *Trichoderma harzianum* strain

5R given 20 and 3/5 days before harvest can provide very good control of post-harvest diseases at reduced dose of sodium metabisulphite (Grape Guard). *Trichoderma* treated grapes thus had reduced sulphur dioxide injury and also retained their freshness for longer duration. In grapes meant for local markets, even a single spray given 5-1 day before harvest has given good results. In case of enhanced rotting of grapes due to rains occurring few days before harvest, spray of *Trichoderma* has effectively prevented the spoilage of fruits.

Soil application / spray of *Trichoderma* during monsoon or rainy periods during September and October can also be given for reducing the inoculum of pathogens like *Alternaria, Cladosporium, Botryodiplodia* etc. These sprays can be given in combination with safe fungicides.

Insect pests

i. Mealy bug

i) Release of Australian lady beetle *Cryptolaemus mountrazeri* @ 1000-1500 per acre in the month of January is recommended. Single grub can feed 900-1500 eggs or 300 nymphs or 30 adults in its lifetime. Sprays of insecticides should be avoided during and after the release of beetles/grubs. Release should be done during evening hours. If grubs are released it needs to be placed on mealy bug colonies with the help of small paintbrush.

ii) Use of formulation of bio-control agent *Beauveria bassiana* or *Verticillium lecanii* @ 5 gm or ml is advised whenever there is a laps of 15 days after fungicides spray and wherever temperatures are between 25 to 30^0C and relative humidity is of above 90 %.

ii. Thrips

Use of formulation of bio-control agent *Beauveria bassiana* or *Metarhizium anisopleae* @ 5 gm or ml is advised whenever there is a lapse of 15 days after fungicides spray and wherever temperatures are between 25 to 30^0C and relative humidity is of above 90 %.

f. Forecasting of diseases and pests

A disease forecasting software, Metwin 2 from Austria is tested for forecasting of diseases under Indian conditions and is found useful in the forecasting of downy mildew and anthracnose disease. Forecasting based disease management resulted in considerable saving of sprays during one year of production cycle as compared to conventional pre-determined schedule based management

Forecasting of insect pests using their seasonal incidence and weather parameters is under progress.

g. Integrated pest management
(disease, insects, weeds, nematodes, others)

Mealy bug

Integrated management consists of manual removal of bark during September, pasting a ring of any sticky substance on the trunk and angle irons, spray of methomyl or

dichlorvos during active growth of bunches, bio-control by *Cryptolaemus* beetles near veraison, and *Verticillium lecanii* after veraison

Flea Beetle:

Removing the loose bark after April pruning and rubbing the stems with jute cloth helps in removing the egg masses. ii) Put bundles of dry shreds of banana on the pruned end of the vines in the evening. Beetles, which take shelter on these at night, can be shaken and collected in the morning and kill them by putting in buckets containing water mixed with kerosene and iii) Spraying with carbaryl @ 0.15% or with soil application of malathion dust or chlorpyriphos dust @ 10 kg / ac.

Thrips

Avoid excess use of Nitrogenous fertilizers as well as over-irrigation. Use of *Beauveria bassiana* @ 5 gm or ml is whenever there is a laps of 5 to 10 days after fungicides spray, and temperatures are of 30 to 35 0c and relative humidity above 80% Thiamethaxam 25 WG @ 25 g / 100 litre water or Dimethoate 30 EC @ 1 ml/ litre or Endosulfan 35 EC 2ml/

Stem borers

Make a hole and remove grub by piercing with barbed wire and kill.. Light trap helps in attracting the beetles so collect and kill. Make a hole and pour dichlorvos 2ml/vine and close or put aluminium phosphide tablet ½ per vine.

17. Breeder Seed production
(as per format of DSR)

Rootstocks / varieties with known characteristics are used as foundation plant material for propagation in the nursery. The propagated material is distributed to the farmers.

18. Mechanization

Several farm operations like spraying, irrigation through drip irrigation and nutrient application through fertigation are mechanized.

19. Value addition/Product Diversification/Byproduct utilization

Grape is used for different purposes like table, wine, juice and raisins. Several varieties for different purposes have been identified. Research is underway to develop improved technologies for processing ‘MARK’ on by product of wine industry is used to extract tannins, polyphenols etc. which are responsible for the medicinal properties of grape.

20. Transfer of technology
(Training, FLD, Field days, Kisan Melas, etc.)

Transfer of technology including field demonstration forms an integral part of the activities of the National Research Centre for Grapes. The Centre enjoys very strong research-extension linkage with the grape growers associations of various states, especially Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu.

The Scientists of the Centre are actively interacting with the grape growers during field visits, participation in extension seminars organized by the State Government and growers' associations, farmers fairs etc. and also during the visit of the growers to the Centre. Scientists participate in about 20-25 such seminars in a year in different grape growing areas. Scientists share the latest technical information on various aspects of grape enterprise and also try to understand new problems faced by this sector and effectively disseminate technologies through various other media also. The Centre also has been conducting various training programmes on different aspects of viticulture. In association with State Bank of India, Pune the Centre has also adopted growers in different grape growing regions of Maharashtra to advice them on means to increase the production of quality grapes.

To educate grape growers on newly emerging technologies / problems the Centre has published popular articles, research articles and technical bulletins and other institute publications. Till now, the Centre has generated 23 research articles, 110 popular articles, 5 technical bulletins, one video CD and 5 other publications on various aspects of grape cultivation.

So far the Centre has transferred the following technologies to the growers, which have been well accepted.

- Irrigating grafted Thompson Seedless vines based on pan evaporation and growth stages.
- Application of nutrients through drip in grafted Thompson Seedless vines.
- Correction of nutritional disorders viz. Inward leaf curl (Potassium deficiency) and Bunch stem necrosis (Calcium and Magnesium deficiency) by appropriate nutrient application.
- Moisture conservation techniques like mulching, subsurface irrigation and use of antitranspirant.
- Use of *Trichoderma* for improving the postharvest shelf life of grapes. The field results especially in preventing decay occurring after pre-harvest rains are very encouraging.
- Disease forecasting technique developed by the Centre is being used by the leading grape growing and processing societies besides the Govt. of Maharashtra in their package of practices for disease management.
- Other areas of management of canopy, diseases, insects, herbs, and quality of fruits have been covered in technology transfer including Integrated Pest Management (IPM), Integrated Nutrient Management (INM) etc.

21. Impact analysis/Socio-Economic studies

a. Production function

b. Employment function

c. Economic Surplus

d. Total factor productivity

In absence of any Economics Scientist structured studies to study impact / socio-economic aspects, have not been taken up so far.

Annexure

i. Other components of Production Technology

I. Training Systems

Bower System:

Owing to the high productive potential, bower was very popular system of training in the past. It is highly suitable for vigorous varieties in which vigour does not hamper the productivity. But in varieties like Thompson Seedless and Tas-A-Ganesh, this system impairs the fruitfulness of buds due to excessive vine vigour and foliage density.

This system of training protects the berries from sunburn but also encourages downy mildew and powdery mildew. It is also not convenient for cultural operations and consumes more labour.

Flat Roof Gable System:

An interconnected Y trellis forming a flat roof gable has been developed, combining the advantages of both bower and the extended Y systems and eliminating their disadvantages. This system is particularly suited for vines grafted on rootstocks for converting their vigour into productivity. In this system, the trellis is fixed in rows at a distance of 25 cm. The length of stem of Y is 1.2 m. There is provision for two rows of cordon wires with a gap of 50 cm. The number of cordons can be one or two as per the choice of the grower and vigour of vines. It is always better to have two rows of cordons in vigorous vines. The length of each arm of Y is 1.2 m. Three foliage wires run across each sloping arm with a gap of 30-35 cm. Rows of sloping arm are interconnected by a thick wire, across which run two more wires to support the foliage. Thus between two rows, a narrow bower forms.

The bunches are protected from direct sunlight and well exposed to sprays of fungicides. The clusters hang within the reach of the worker of an average height. Shoots, as in Y-system are exposed to good sunlight for fruit bud formation. Movement of tractor for farm operations is not hindered. Owing to these advantages, this system is gaining popularity among the growers in Maharashtra, Andhra Pradesh and Karnataka (Photo 1).

II. Pruning

In Peninsular India because of tropical climate and high degree of apical dominance, vine is pruned twice in a year. First pruning in April, called foundation pruning or back pruning is done to build frame work. Second pruning in October called fruit pruning or forward pruning is done to get fruiting canes. Vines flower in November-December and come to harvest in March-April.

In U.P., vines undergo natural dormancy in winter. Hence, only one pruning is done in the month of late January to mid-February, vines flower in March-April and come to harvest in June.

III. Growth Substances

Over production has lead to poor quality in Thompson Seedless in the hot tropical region. Cane being only six months old in this region, it has a limited reserves and can

not support more than a cluster or two depending upon its thickness. Experiments have shown that approximately 2600 cm^2 leaf area is required to support a cluster weighing 500 g with 20°B. The practices followed to improve the quality are dealt below.

Shoot and Cluster Thinning: Only one or two clusters are retained per cane depending upon the thickness of the later. Irrespective of the number of clusters retained, the apical two or three shoots only are retained. In vines trained to flat roof gable, individual shoot length is encouraged, rather than the total shoot length for preventing sunburn to the berries.

Production of Loose Clusters: Prebloom GA sprays of 10 ppm and 15 ppm are given respectively on the 11th and 14th day after budbreak for cluster elongation. Rachides of the clusters are trimmed to retain 8-12, depending on the number of leaves available per cluster. Clusters are dipped in GA solution of 30-40 ppm when 10-20% of the flowers open in each cluster for berry thinning.

Increasing Berry Size: Approximately 90-120 berries are retained per cluster depending upon the number of leaves available to nourish it. Approximately 8-10 berries are retained for every leaf depending on its size. Clusters are dipped in GA solution of 40-50 ppm concentration once at 3-4 mm size of the berries and again at 7-8 mm size. When berry diameter is to be increased to more than 16 mm, clusters are dipped in a mixture of 10 ppm BA + 25 ppm GA or 2 ppm CPPU + 25 ppm GA or 1 ppm brassinosteroid + 25 ppm GA instead of GA alone at these two stages of berry growth.

In addition to the treatment with growth regulators, berry size and crispness are increased by girdling of the stem. The width and depth of girdling are one to one and a half mm. Girdling as done at 4-5 mm diameter of the berries.

Increasing the TSS Content: Berry thinning and cluster thinning to maintain adequate leaf/fruit ratio (5 cm/g), girdling will ensure TSS content of 20°B.