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Viticulture for better prospects

Grape, a temperate crop, has been adopted to tropical conditions in India, and most of the area under grape cultivation is in peninsular Indian states, viz. Maharashtra, Karnataka, and Tamil Nadu. The viticultural practices involve double pruning (foundation and fruit pruning) and single cropping to make the grapevines yield under tropical conditions. The area under grapes in India has increased from 52.1 thousand ha (2002-03) to 139 thousand ha (2018-19) (NHB Database), a 2.6 folds increase in 15 years. The production during the corresponding period has increased by 2.38 times. The grape is highly skilled, heavy investment prone and high-value crop. However, in recent years, extreme weather events like hail, unseasonal rainfall, frost, delayed rainfall and temperature stress during the productive period are playing havoc with the grapevine production in India. These factors pose challenges to researchers to develop technologies and/or strategies for sustainable grape cultivation.

Protected cultivation for better yield

Plastic cover is used to grow table grapes in many parts of the world. Spain, where table grape is extensively grown under plastic cover, supplies table grapes to European Union for at least 4-5 months in a year. The intent is to grow crop in otherwise unfavourable conditions by modifying the natural environment to increase yield, improve quality, enhance the stability of production, extend harvesting period and expand the area for production. In grape, like other horticultural crops, climate is the most determinant factor. Though plastic cover helps circumvent the negative effects like rain and diseases during grapevine growing season but it also results in early ripening or delay harvest.

Studies at ICAR-National Research Centre for Grapes for three years conclusively demonstrated the favourable impact of plastic cover on vine growth and productivity. Analysis of three years pooled data showed significant increase in yield from 8.34 MT/ha under open conditions to 18.59 MT/ha under plastic cover. The use of plastic cover was validated in 2017, when rainfall occurred during early growth stage after fruit pruning. The vines in the open and under hailnet experienced severe downy mildew infestation leading to very low productivity whereas, the vines under plastic cover were not affected. The vines under plastic cover recorded significantly higher yield of 18 MT/ha as compared to 7.1 MT/ha, and 3.6 MT/ha in vines under hailnet and open conditions respectively. Considering ₹ 40/kg as farm gate price, the price realization was ₹ 6 lakh/ha more than the income earned from vines raised in the open. Further, another ₹ 69,100 was saved on account of reduction in six sprays for downy mildew disease.

Plastic cover also protects against the damage to vine parts and bunches from hails, reduces berry cracking due to unseasonal rains, reduces impact of temperature on vine growth and productivity besides reducing irrigation water requirement by 20% and provides opportunity for risk free early pruning to avoid glut in the market and improves profitability.

The plastic cover should be woven laminated film, UV stabilised to 580 kLy (Indian conditions) with anti-thermic properties (25% thermicity). It should have 85 to 90% light transmission with 65±5% light diffusion with cloth weight of 140±5% gsm/sqm. It should also have anti-sulphur, anti-drip and anti-dust properties. The life of the plastic cover could range from 3 to 5 years depending upon quality of plastic. The cost of plastic cover ranges between ₹ 2.75 – 4.5 lakh/acre depending upon the source and the cost of structure ranges from ₹ 2.5 – 3.5 lakh/acre for erecting on existing training system. However, considering the price realisation and input saving, this cost can be recovered within 1-2 years.

Decision support system for improved input use efficiency

Grape is high-skilled crop and expert advice is required on day-to-day basis. Most of the viticultural operations are dependent on phenology, weather and soil factors. These factors are site-specific and vary from farm-to-farm. Therefore, the problems are site-specific and the expert advice also varies from farm-to-farm. To provide farm-specific advisory to the farmers, decision support systems (DSS) were developed for irrigation and nutrition management, pest and disease risk assessment, and advisory for their management.

The research on the use of weather forecasting and crop stage based advisory for management of diseases

Effect of rainfall during early growth stages on grapevine yield. (A) Newly emerged panicles affected by downy mildew under open conditions, (B) Healthy panicles under plastic cover, (C) Less bunches under open conditions, (D) More bunches under plastic cover.

and insect pests on grapes have been carried out at ICAR-National Research Centre for Grapes, Pune. During 2009-13, plant protection practices using location-specific weather-forecasting based online advisory for disease and pest management in grapes in growers' vineyards was demonstrated at 49 locations in four districts of Maharashtra. It was observed that in demonstration plots, an average of 9.03 pesticide sprays per plot were saved in comparison with farmer practice plots. Fifteen demonstration plots whose yield data were analyzed, recorded average yield of 13.68 MT/acre as compared to 9.59 MT/acre in the growers' practice plots. In all demonstration plots, residues of recommended pesticides were lower than maximum residue limit (MRL) prescribed in Annexure 5 of Residue Monitoring Plan.

Subsequently, to provide farm-specific advisory to the farmers, decision support systems (DSS) were developed for pest and disease management as well as for nutrient and water management based on weather forecast and crop phenology. The models for pests, diseases, nutrient and water were integrated into integrated system. The integrated decision support system helps to improve the grape grower's ability to take crucial management decisions on time. It provides recommendations to the grower based on his/her crop data, farm data, and prevailing weather conditions that will support or assist growers' decision making capacity in terms of water, irrigation, pest and disease management. It also helps in guiding growers on pest and disease risks, and nutrient use based upon soil and petiole test. On an average, there is 15% saving of input use namely pesticides, water and nutrients. Considering the saving of labour cost due to reduced number of applications of pesticides and fertilizers, the total cost of production has reduced by 14-17%.

Application programming interface (API) has been developed which processes inputs given by mobile or web application and gives outputs for use in the application. The access to this API is provided to licensed mobile or web application service providers who give access of DSS to farmers via his web/mobile application. The service provider is given license for API access for fixed duration.

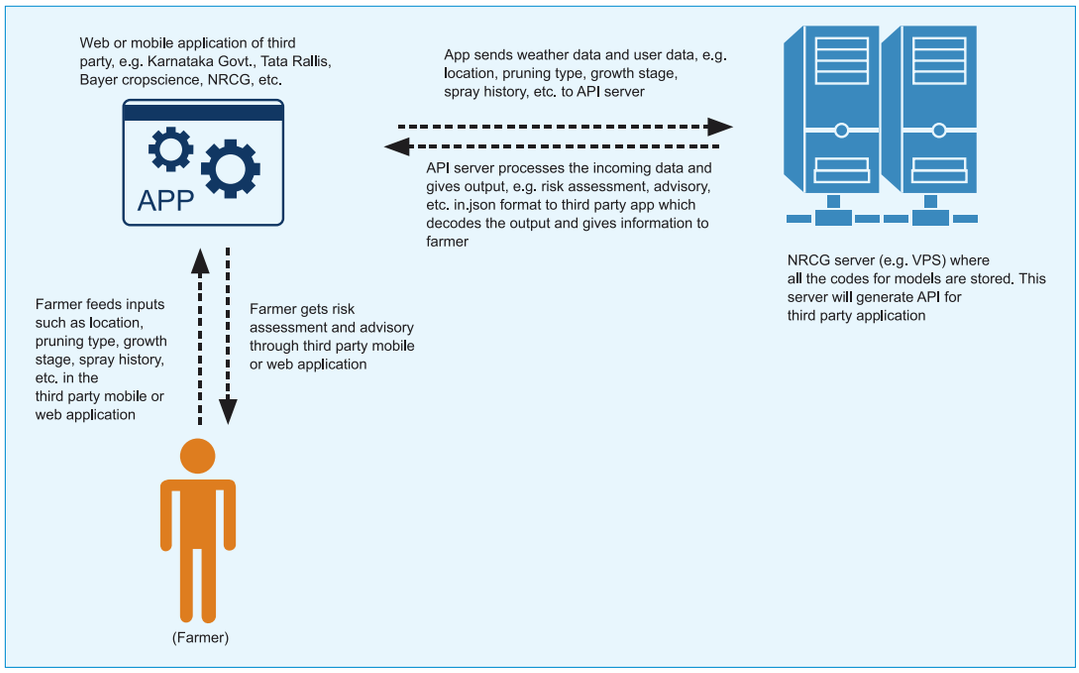
Grape for nutritional security

The grape berries are known for their high nutritive value. Sugars are major content in berries and these have up to 30% of easily digestible sugars viz. glucose and fructose, viz. The berries also contain a large range of organic acids namely malic, tartaric, citric, succinic, gallic, formic, oxalic, salicylic, and others. Grapes are rich source of mineral salts also. Among them, potassium (235 mg), calcium (45 mg), sodium (26 mg), phosphorus (22 mg), manganese, cobalt and iron are available in berries. Fresh grapes (100g) provides 4% of daily intake of calcium, 1.6% of magnesium, 0.12% of phosphorus, 16.4% of iron, 2.7% of copper, and 16.6% of manganese. Same time grapes are rich source of vitamins such as A, B (B_1, B_2, B_3, B_6, B_{12}, etc.), C, E and K. Vitamin E is found specifically in grape seeds.

The grapes are packed with polyphenols which have well established antioxidant activities. Polyphenols are mainly found in grape skin and seeds, and coloured grapes have higher polyphenols. Antioxidants are molecules that safely interact with free radicals to stop the condition of oxidative stress. Resveratrol, a polyphenol found in high quantity in grapes, has ability to reduce the risk of heart disease through antioxidant and anti-inflammatory activities. Flavonoids can help protect the heart against blood clots and may reduce the damage of high cholesterol. Grapes and grape-based products are excellent sources of various anticancer agents also. The grapes have possible ability to help prevent breast, colon and prostate cancers. Anthocyanins are another class of polyphenolic antioxidants, which are widely present in coloured grapes. These phytochemicals have an anti-allergic, anti-inflammatory, anti-microbial, as well as anti-cancer activity.

Wealth from Waste: A grape perspective

Industrial processing of grapes generates large quantities of solid residues that consist of a mixture of grape skins, pulp, stalks and seed together named as grape pomace. These by-products are an important source of dietary fibre and phenolic compounds, with antimicrobial



Decision Support System workflow

and antioxidant properties. The grape pomace contains lots of bioactive phytochemicals such as phenols, flavonoids, anthocyanins, stilbenes etc. having various health benefits. Considering the immense nutritional and nutraceutical values, utilization of these wastes in food products, and development of new high value products not only saves soil and water from pollution, but sustains this industry by earning additional income.

The juice of Manjari Medika, a grape variety developed by ICAR-National Research Centre for Grapes, is attractive red colour and contains high anthocyanin content. One kg grapes contains 4-6 mg anthocyanins. The Centre has developed Zero Waste concept of grape processing for this variety. Zero waste concept is the conservation of all resources by means of responsible production, consumption, reuse, and recovery of all products, packaging, and materials, without burning them, and without discharges to land, water, or air that threaten the environment or human health. In case of Manjari Medika, Zero Waste concept based technologies have been developed for juicing, anthocyanin extraction, utilization of pomace in making high quality bakery products (cookies and breads) and remaining seeds for extraction of high quality grape seed oil and organic manure. Schematic diagram shows the utilization of all bi-products from Manjari Medika grapes.

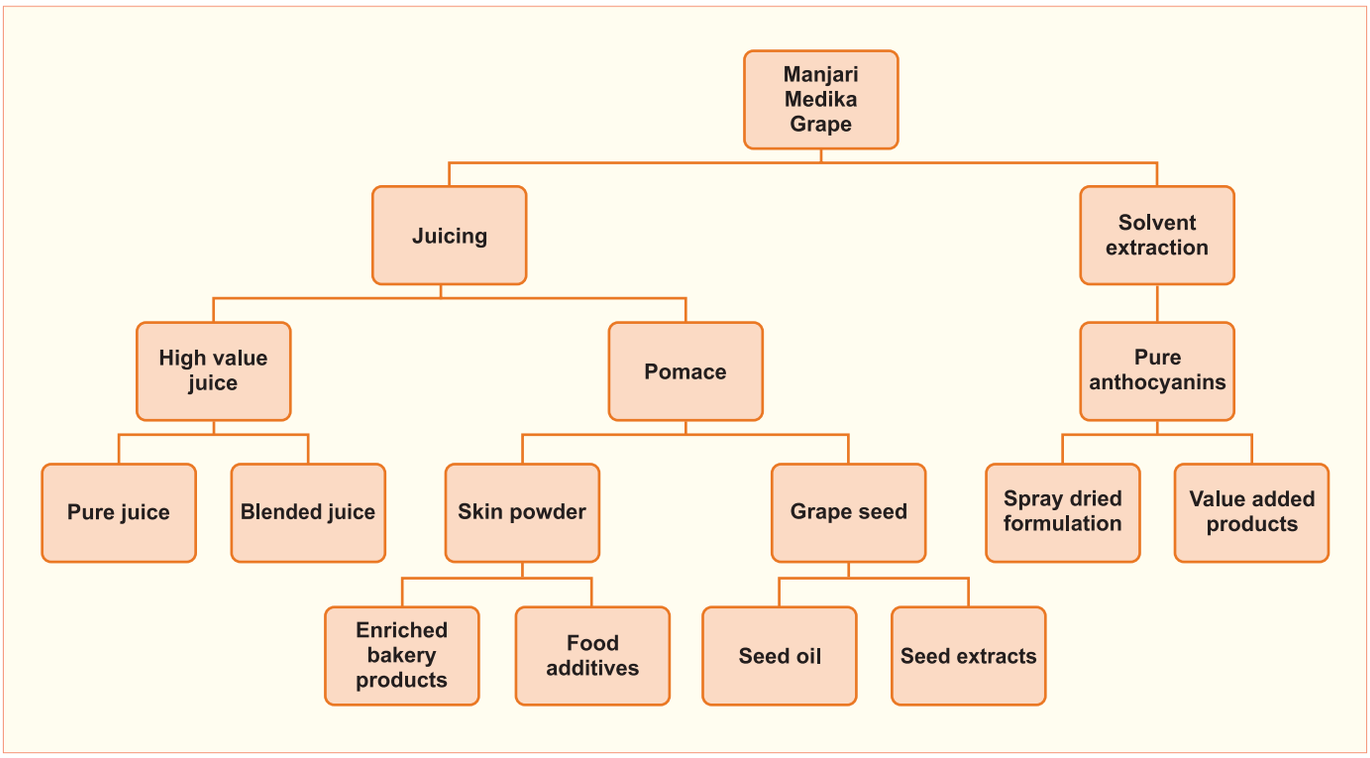
A juice recovery of more than 70% is recorded in this variety. TSS content in the juice is achieved more than 20°B easily. The juice is very dark in colour and found with higher anthocyanins and polyphenolic content. Due to higher anthocyanins and phenolic content, higher antioxidant activities were recorded in the juice of Manjari Medika. Besides the nutritional and functional properties, the juice has higher level of acceptance based on sensory properties.

Because of its attractive colour, Manjari Medika juice can be used for enriching and giving colour to juices of other grape varieties. The blending with Manjari Medika will not only give attractiveness but also enrich other grape juices with additional functional properties.

Grape pomace is a rich source of bioactive phytochemicals. Technologies have been developed for the production of high value bakery products like cookies, bread etc. Up to 15% of maida can be replaced with grape pomace and such cookies were attractive in colour with higher nutritional, functional and sensory properties. Similarly, breads and muffins prepared after replacing maida by pomace powder of Manjari Medika were highly attractive in colour, had higher nutritional, functional properties and dietary fibre.

Juice from Manjari Medika

Grape cookies



'Zero waste' processing of Manjari Medika

Micro-encapsulated anthocyanin powder

The Manjari Medika grapes are rich in phenolic compounds, especially anthocyanins. ICAR-NRCG developed a technology for the extraction, isolation and purification of anthocyanins from Manjari Medika. The extracted anthocyanin was formulated to microencapsulated capsules (10%) (meet the 50% dietary requirement of anthocyanins) through spray drying technology. Our collaborative study with CSIR-Indian Institute of Chemical Biology, Kolkata established the *in-vitro* and *in vivo* anticancer activities of these anthocyanins against colon cancer. Combination of IC_{30} dosage of IR radiation and anthocyanin treatment resulted in more than 50% cell death in human colorectal carcinoma cell, suggesting radio sensitizing effect of anthocyanin indicating relevance for the treatment of cancer radio therapy.

A technology has been developed for extraction of phenolic compound and vitamin-E enriched grape seed oil from Manjari Medika seeds through super critical fluid extraction. Significantly higher levels of total vitamin E, gamma tocotrienol and phenolic compounds especially resveratrol were found in SFE extracted GSO as compared to cold-pressed oil. The anticipated bioactive potential was estimated through *in vivo* animal studies to evaluate the radioprotective effect of GSO on the modulation of IR-induced intestinal injury.

The cost: benefit (CB) ratio of grape cultivation approximately ranges from 1.03 in table grape to 1.34 and 1.46 in raisin and wine/juice grape cultivation. In all these, no waste/bi-product utilizations were considered in CB ratio calculation. Our internal estimate of CB ratio for the Zero waste processing technology of Manjari Medika suggests a CB ration of 2.3 to 3.5 if we utilize judiciously all the wastes or bi-products generated out of the juice industry. This CB ratio is highly encouraging in our future target of doubling the farmers' income by 2030.

For further interaction, please write to:
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