1. Landmark Technologies

i. Bio-intensive strategy for the production of MRL compliant grapes

Bio-intensive disease and pest management strategies for safe and sustainable quality grape production resulted in reduction of 26-32% of spray applications. Liquid formulation of *Trichoderma asperelloides* strain 5R containing 5×10^6 spores/ml and wet powder formulation of *B. subtilis* DR-39 at a dose of 2.5 g/l were applied at regular intervals before and after pruning. For the control of insect pests, bioagents Metarhizium and Beauveria were applied as preventive and insecticide applications were need based. At all the locations, the number of detections and pesticide residue concentration were reduced by the application of bio-agents. The products are under process of registration under CIB&RC, GoI.

ii. Integrated Decision Support System (DSS) for Grapes

Developed site-specific decision support systems (DSS) for nutrition and water management, disease risk assessment, insect and mite pest risk assessment and advisory. It provides recommendations based on crop data, farm data, and prevailing weather conditions. Application programming interface (API) has been developed which processes inputs given by mobile or web application.

Cost of production reduced to Rs 1.75 - 2.0 lakh/acre as compared to earlier practice Rs. 2 - 2.5 lakh/acre.

iii. Improving water use efficiency in vineyards

Standardised irrigation schedule based upon pan evaporation and crop growth stage that resulted in an average 52% savings in irrigation water over farmer's practice. Application of drip water below soil surface in black cotton soil (sub surface irrigation) resulted in 25% savings in irrigation water compared to recommended irrigation schedule of sub-surface drip. Demonstrated subsurface technology in farmers' fields in prime grape growing areas like Sangli, Nasik and Pune. In Jath and Chinchani (Sangli Dist.), Manjari (Dist. Pune) and Sawargaon (Dist. Nasik), a saving of 46.8, 44, 25 and 20.3% irrigation water was recorded, respectively under subsurface irrigation technique over farmer's practice. Use of recommended irrigation schedule through surface drip led to 29, 25.8 and 31.6 % irrigation water saving at Walwa, Jath and Palsi in Sangli Dist. respectively.

iv. Implemented good agricultural practices and stringent residue monitoring plan in grapes.

In 2003-04, in collaboration with APEDA, Ministry of Commerce, GoI National Referral Laboratory (NRL) was setup. The package of practice related to the list of recommended pesticides as per their label claims and the list of chemicals for monitoring pesticides for EU, Indonesia, China, Russia and GCC are updated. In 2025, out of the total 12657 samples analysed only 0.74% samples failed for EU-MRL compliance. The grape sample failures in export due to MRL non-compliance reduced to <1% in 2024-25 from 8-10% in 2010-11. The grape export increased from 94 thousand MT (in 2014-15, value: Rs. 973 crores) to 271 thousand MT (in 2024-25, value: 3050 crores).

v. Protocol for production of *in vitro* virus free plant through meristem culture in Dogridge

Grapevines are often infected by more than 80 types viruses which hinders the growth and production of grapes throughout the country. Multiplication and supply of true-to-type

grapevine varieties and rootstocks are generally done through conventional methods due to which chances of spread of virus increases. Several studies conducted in the last few decades has shown the successful utilization of in vitro techniques such as meristem culture, heat therapy, cryotherapy and use of anti-viral chemicals in obtaining virus free plantlets. Initiation in this aspect to produce in vitro virus free plants through meristem and other in vitro techniques such as heat therapy has been started at ICAR NRCG. Protocol for development of in vitro virus free plants of Dogridge has been standardized

vi. Bio-intensive management of powdery mildew of grapes by chitosan @ 2 ml/ha in combination with *Ampelomyces quisqualis* (5 g/L) to produce residue compliant quality grapes.

Three applications of chitosan @ 4 mL/L alternated with two applications of *Ampelomyces quisqualis* @ 5mL/L from flowering to veraison stage were effective in controlling the powdery mildew disease.

vii. Bacillus *subtilis* bio formulation

Application of *Bacillus subtilis* to grapevine enhanced degradation of 10 pesticides that are commonly used in grape vineyards by 12.73-65.55%. This technology helps in degrading the pesticide residue which is a major constraint in grape export.

viii. Monitoring based simple and effective manual removal strategy for grapevine stem borer, *Celosterna scabrator*

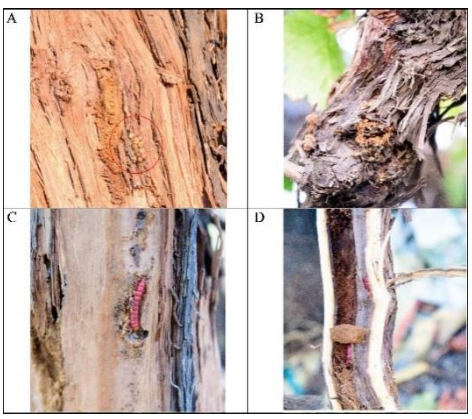
C. scabrator causes 30.10-56.26% yield loss and no other effective management

Monitoring during November-April months at 10 days interval for two initial infestation symptoms and manual removal of the grubs.

Validated in seven *C. scabrator* infested vineyards in Nashik resulting in 100% pest control and 96.84 per cent reduction in the infestation in subsequent year. 100% pest control and 96.84 per cent reduction in the infestation in subsequent year.

ix. Loose bark removal: A simple yet effective method for managing wood borer, *Dervishiya cadambae* (Lepidoptera: Cossidae) infestation in grapevines

Dervishiya cadambae, a wood borer, poses a serious threat to Indian grapevines, causing significant damage and yield loss. Currently, no other established management method exists.



Regular monitoring and, bark removal during the initial infestation stage when larvae feed beneath it during July to September months. Minimum cost and management without use of pesticides. 15.79% yield gain on first year and 100% yield gain subsequent years as continued infestation renders vineyards unproductive.

x. **Development and validation of a residue analysis method for ethylene oxide and 2 chloroethanol in foods by Gas Chromatography Tandem Mass Spectrometry**

A novel method is reported for the residue analysis of ethylene oxide (EO) in diverse food matrices, namely oil seeds, cereals, fresh/processed fruits and vegetables, herbs and spices, etc. The method has a global appeal considering the importance of selective and sensitive detection of EO for facilitation of international trade.

xi. Method for extraction of grape seed oil comprising bioactive compounds from a Manjari Medika variety of grape

It provided 10-12% oil recovery. The oil comprised rich contents of bioactive fatty acids, vitamin E (1200 to 1500 mg/kg) especially γ-tocotrienol (890 - 1070 mg/kg), which is well-known for its protective properties for tissue from exposure to atmospheric radiation (Patent No.: 202011014416, Dated of Grant: 29/09/2023).

xii. Simple one pot route for the synthesis of activated carbon nanoparticles from grape pomace and its application as d-SPE clean-up agent in multi-residue analysis of pesticides

A one pot route for preparation of activated nano carbon from grape poamce was optimized through an acid surface activation. The activated carbon is used as a cheaper and efficient replacement of GCB in d-SPE clean-up in multi-residue analysis of pesticides. (Patent No.: 202221023880, Date of Grant: 30/01/2024)

xiii. Enriched cookies & breads with pomace

The Cookies and breads were enriched through replacing fine wheat flour by adding grape pomace powder. The addition of grape pomace powder increased antioxidant properties comprising ferric reducing antioxidant power, total phenol content, flavonoid and anthocyanins in bakery products.

xiv. Yoghurt with antioxidants

Yoghurt with antioxidants: Addition of processed fine wine lees (FWL) significantly improved physico-chemical, functional and rheological properties of yoghurt. Due to attractive colour and aroma imparted by FWL increased sensory acceptance was noted. Intake of this specific product will certainly be health beneficial as well as the technology will encourage proper disposal of winery wastes which will reduce impact on environment. (Patent No. 368911, Date of grant: 09/06/2021).

xv. A package of technology with chemical free process has been developed to produce raisins in collaboration with ICAR-CIAE, Bhopal.

It includes a grape de-bunching machine (capacity: 150 kg/h) to separate intact grape berries, abrasive pre-treatment equipment (capacity: 135-150 kg/h) to remove waxy layer from the grape surface, drying protocol for grapes, packaging and storage of raisins. This package of technology is suitable to produce good quality raisins without use of any chemicals in the entire process with reduced drying time (by 30-40 %). It also reduced input costs in terms of labour, chemicals (ethyl oleate and potassium carbonate), water and sulfur.