

VISION 2047



Indian Council of Agricultural Research
National Research Centre on Pomegranate

Solapur - 413 255, Maharashtra (INDIA)





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Shaping the Future, Honouring the Legacy

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PREFACE

Pomegranate is an important fruit crop of arid and semiarid regions of India. In Ayurveda, this ancient fruit has been considered as “*Paripurna Aushadhalay*” due to its immense medicinal properties. Of late, its importance has increased manifold due to its immense nutritional and medicinal values. By virtue of its potential, today, pomegranate is cultivated globally over 5.83 million ha with a production of 7.01 million tonnes. India is leading producer of pomegranate in the world. In India it is cultivated over 2.23 lakh ha with an annual production of 28.42 lakh tonnes and productivity of about 12.72 MT ha⁻¹. Cultivation of pomegranate has added new dimension in raising the income of farmers. With rapid increase in pomegranate cultivation in India in both traditional and non-traditional areas more and more challenges are being faced by the growers with respect to disease, pests, flower regulation, nutritional imbalances and overall management. Realizing the importance of this crop in sustainable livelihood and immense export potential, Indian Council of Agricultural Research, New Delhi established National Research Centre on Pomegranate on September 25, 2005 at Solapur, Maharashtra.

The centre, since its inception in 2005 has made noteworthy research to develop farmers' friendly techniques *viz.*, production of quality planting material, development of new varieties, plantation techniques in marginal lands, canopy management; soil, irrigation & nutrition management, integrated disease and pest management schedules, maturity indices, developed adhoc list of chemicals for the export by defining the PHI and MRL etc., which enlightened the way for sustainable and quality production. The centre also developed new varieties and focused on different post-harvest technologies and developed many value added products which help in entrepreneurship developments.

Reviewing the research achievements and work done till date and chalked out the plan considering future challenges and strategies need to be adopted in line of SDGs, Govt. programs and initiatives – climate change.

I, solemnly acknowledge all our scientists for their contribution in developing this vision document and expecting their efforts to achieve the targets and goals, so that institute will reach to global stature.

A handwritten signature in blue ink, appearing to read 'R. A. Marathe'.

R. A. Marathe
Director
ICAR-NRCP, Solapur



ICAR – NRC on Pomegranate, Solapur



Vision 2047

Shaping the Future, Honoring the Legacy

1. Introduction of Institute, its role since establishment and present scenario

About

In order to tap the vast potential of quality pomegranate production in the country, the Indian Council of Agricultural Research (ICAR), New Delhi established National Research Centre on Pomegranate (NRCP) during the Xth Five Year Plan on June 16, 2005 at Kegaon, Solapur, Maharashtra. The foundation stone of the Centre was laid on September 25, 2005 while the office cum laboratory building of the centre was inaugurated on July 7, 2013. The centre is placed in an area 45.42 ha at two locations *viz.*, Kegaon (13.83 ha) and Hiraj (29.59 ha) with a distance of 1.3 km.

Role

The Centre has played important role in improving pomegranate scenario in India by developing package of practices and combating important insect-pests and diseases. The centre has germplasm repository of 356 germplasm lines, which are serving as a source for improving fruit yield and quality. The centre is providing quality planting material through PPP mode, identifying suitable soils, developing sound package of practices thereby improving fruit yields and quality. Different value addition technologies, and value added products like Juice, RTS, Anardana, Peel powder, Mouth freshner and muffins has been developed by the centre.

The technologies developed by NRCP has disseminated through transfer of technologies, imparting on-site and in-house trainings to stakeholders and centre has also commercialized various technologies with many nurseries & entrepreneurs. The Centre is also reaching across the India through Tribal Sub Plan, (TSP), Mera Gaon Mera Gaurav (MGMG) and Scheduled Cast Sub Plan (SCSP) by providing technical inputs of pomegranate cultivation in different states. Because of NRCP's interventions, the area, production and export has been increased by 100.0, 268.1 and 138.8 percent respectively (from 2005 to 2024). Increase in productivity by 83.2 percent reflects the effective dissemination of NRCP technologies to the pomegranate stakeholders.

Mandate:

- Basic, strategic and applied research on genetic resource management, crop improvement, production and protection technology for enhanced and sustained productivity of pomegranate.
- Transfer of technology and capacity building of stakeholders for enhancing and sustaining productivity of pomegranate.

Mission:

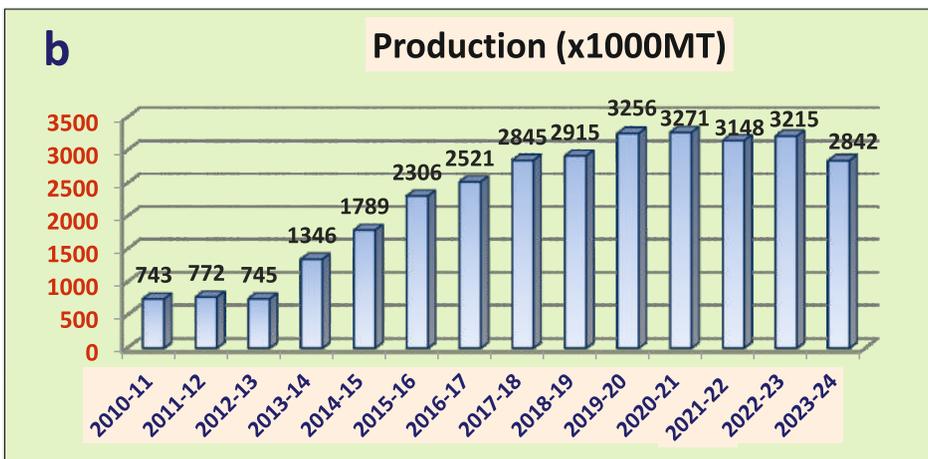
- To establish an international repository of genetic resources, develop suitable technologies for pomegranate production and to improve economic status of farmers in different regions.

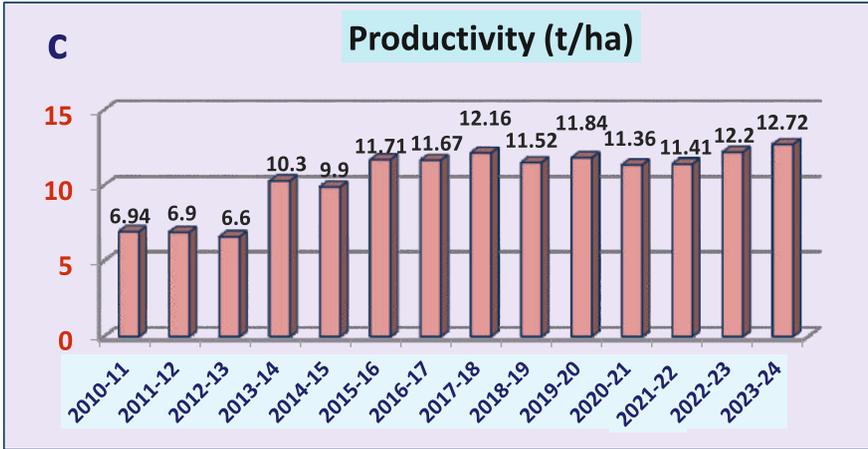
Vision:

- To transform the ICAR-National Research Centre on Pomegranate to an International Centre for Pomegranate Research.

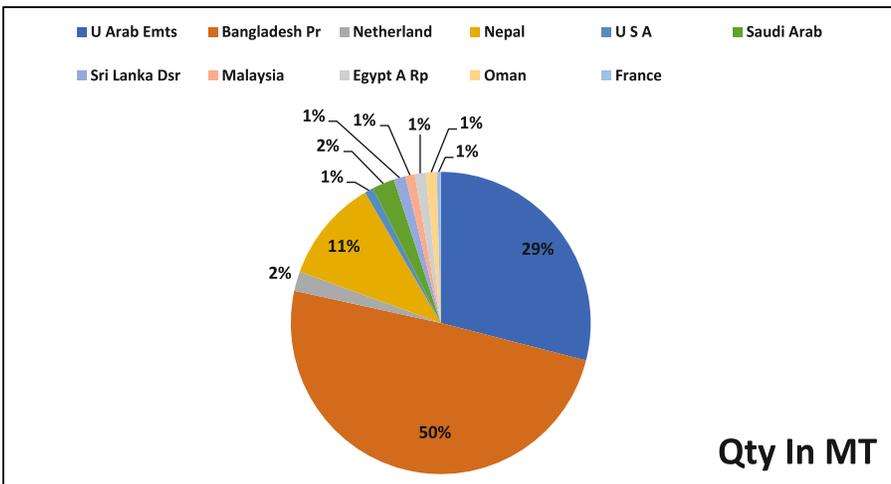
Present Scenario

India is world leader in production and productivity of the pomegranate. In India, pomegranate is being grown in an area of 2.23 lakh ha with the production of 28.42 lakh tonnes with an average productivity of 12.72 tonnes per hectare. Maharashtra is leading state with an area of 1.08 lakh ha followed by Gujarat (0.44), Karnataka (0.23), Rajasthan (0.22) and Andhra Pradesh (0.12). The country has also emerged as a key exporter of fresh pomegranates and arils, with major markets including the Middle East, Europe, South Asia, South East Asia & recently, the United States.





Present India's Pomegranate a) Area b) Production c) Productivity d) Export



Export Destination of Indian Pomegranate

2. Major achievements

Research

The centre has developed following technologies in 19 years journeys which are listed below :

Crop Improvement

- The centre has developed and registered four Pomegranate hybrids viz., Pomegranate var. Solapur Lal, Solapur Anardana, NRCP H- 4 & NRCP H -14. The DUS centre of NRCP also assisted to register farmer variety 'Sharad King' under PPV & FRA and also released an ornamental dwarf pomegranate variety 'Yellow Nana' through centre.
- NRCP has India's largest genetic repository of 356 germplasm collections out of which 194 are indigenous and 162 exotic collections.
- Whole genome sequencing of cultivar Bhagawa has been completed – first time in India. Assembled 346.08Mb (98.17%) of estimated genome size of 352.54Mb (k=31).

Crop Production

- The centre has developed soil suitability criteria, delineated potential areas for pomegranate production, carried out root distribution studies in different soil types and developed unique bedding system of plantation.
- *In-vitro* propagation of pomegranate cv. 'Bhagwa' including bio-hardening to produce quality & disease free planting material to farmers
- Two step Hardwood cutting protocol of pomegranate including bio-hardening.
- Standardised water management schedules on different soil types including quantity, frequency, drip geometry and developed new 'Ring method' and Double lateral system' of irrigation.
- Nutrient management aspects include identification of nutrient deficiency symptoms, soil and leaf sampling technique, nutrient antagonism and nutrient recommendations. Developed organic production protocol with new method of manure application in slurry form.
- A novel bio-formulation for potassium and phosphorous supplementation and the process of preparation has been developed and commercialized with many firms.

Crop Protection

- Finished whole Genome sequencing of BBD causing pathogen *Xanthomonas citri* pv. *punicae*.
- A biological formulation with novel strain of *Bacillus comsortium* (Endovita) and *Trichoderma consortium* (Rhizoshield) has been developed for fungal and bacterial disease management.
- Developed IDIPM schedules for the management of various pest and diseases.
- Stem solarization technology to manage bacterial blight disease which is economical, ecofriendly and most effective method.
- Standardized mass production protocol for Fruit-Piercing Moth (*E. materna*).

Post-Harvest Technology

- A wide array of products has been developed, including pomegranate juice, ready-to-serve (RTS) beverages, probiotic drinks, wine, blended drinks, squash, carbonated beverages, anardana, osmo-assisted dried arils, low-calorie fruit drinks, foam-mat and spray-dried pomegranate juice powder, and instant pomegranate fruit drink powder.
- Technologies for effective utilization of pomegranate by-products such as peel and seeds were developed. These include the extraction and microencapsulation of seed oil, development of de-oiled seed cake cookies, peel extract; fiber-rich muffins fortified with pomegranate peel, and peel extract-fortified soy yoghurt designed for lactose-intolerant individuals.

Patents

1. Gaikwad Nilesh N. and Pal Ram Krishna (2022). A Process of Extraction of Virgin Pomegranate Seed Oil with retention of bioactive compounds”. Application No.201611011366 E-2/528/2017/DEL granted during the year 2022.
2. Ashis Maity, R.K.Pal, J.Sharma (2022) Novel bio-formulation for potassium fertilizer supplement in pomegranate and process of preparation thereof. Application No. TEMP/E-1/7237/2018-DEL granted during the year 2022.
3. Trademark for ICAR-NRCP logo has been registered under Class 42 & Class 29
4. SS Dhumal, SS Pokhare, Manjunatha, N and RA Marathe. Filed **4 designs** (Ref. No. 470727-001, 470728-001, 470729-001, and 470730-001) of **Planter Box** for growing pomegranate plants, with ‘Controller General of Patents, Designs & Trade Marks’ Kolkata

Plant Varieties registered

1. **Solapur Lal (NRCP H-6)**: Protected under PPV&FRA, New Delhi with the registration number of REG/2016/1747
2. **Solapur Anardana (NRCP H-12)**: Protected under PPV&FRA, New Delhi with the registration number of REG/2016/1750
3. **NRCP H - 4** protected under PPV&FRA, New Delhi with the registration number of REG/2016/1749
4. **NRCP H-14** protected under PPV&FRA, New Delhi with the registration number of REG/2016/1748
5. ‘**Yellow Nana**’ an ornamental pomegranate variety has been released at institute level by Varsity and Technology Identification and Release Committee.
6. **NRCP (DUS centre) assisted to register farmer’s variety ‘Sharad King’** protected under PPV&FRA, New Delhi with the registration number of REG/2014/1283

Registration of novel beneficial microbes at NAIMCC, ICAR-NBIAM, Mau & NCBI, database

1. *Trichoderma* sp. (4 No) having potential biocontrol ability against pomegranate pathogens (NAIMCC-F-04295, NAIMCC-F-04296, NAIMCC-F-04297, & NAIMCC-F-04297).
2. Endophytic *Bacillus* sp. (3 No) having growth promotion and potential biocontrol ability against pomegranate pathogens (NAIMCC-B-03178, NAIMCC-B-03179 & NAIMCC-B-03180)
3. *Aspergillus* sp. (3 No) having potential biocontrol ability against pomegranate pathogens (NAIMCC-F-04292, NAIMCC-F-04293 & NAIMCC-F-04294)
4. Sequenced *Euwallacea fornicatus* isolate MH-SPR-001 cytochrome c oxidase subunit causing pomegranate wilting submitted to NCBI database on 24.06.2022 with accession numbers (ON063908- ON063909).
5. Sequenced Uncultured *Fusarium* isolate E-8 2B-1 ITS Sequence subunit symbiotic fungi associated pomegranate shot hole borer submitted to NCBI database on 24.06.2022 with accession numbers (MG462858.1).
6. Sequenced *Colletotrichum Gloeosporioides* isolate E-9 1D ITS Sequence of symbiotic fungi associated pomegranate shot hole borer submitted to NCBI database on 24.06.2022 with accession numbers (OM913143.1).

Education & HRD

The institute undergone many MoUs with the academic institutes to benefit the students for the research, NRCP has provided hands on training for under graduates and guided post graduate and doctoral students for their research projects. The NRCP is also part of IARI- Baramati Hub. The different activities conducted by NRCP are detailed below:

- NRCP has got sanction for 'Biotechnology Career Advancement and Re orientation (BioCARE) Programme', a special scheme of the Department of Biotechnology (DBT), Government of India and one student is undergoing PDF programme under the mentorship of NRCP scientist.
- Recognised and affiliated with ICAR – IARI – Baramati Hub: NRCP staff is recognized as Faculty Member –for UG, PG and Ph.D. for teaching and research.
- Till date 1 Post Doc, 10 Ph.D. Scholars, 10 MSc Student and 48 B.Sc. students were enrolled and conducted the research work under the guidance of scientists in executing the research activities
- The ICAR-NRCP has signed MoU with the Universities/ Colleges /Institutes for students' research programme. **MOU with Academic institutions** viz. Punyashlok Ahilyadevi Hekar Solapur University (PAHSU); NAARM@idea, School of Biotechnology & Bioinformatics, D Y Patil (DU), Navi Mumbai; Progressive Education Society's Modern College of Pharmacy, Pune, Maharashtra; Lovely Professional University, Punjab; VNMKV, Parbhani; MPKV, Rahuri; Lokmangal College of Agril. Biotechnology, Solapur, IARI, UAS, Bagalkot, MPKV, Rahuri; VNMKV, Parbhani; Dr. YSR Hort. Uni. West Godavari, AP & Dr. YSP UHF, Nauni, Solan HP.

Based on the state of art facilities infrastructure, multi-disciplinary expertise and experience, NRCP offers the following services:

- Human resource development through conducting trainings, seminars, symposium to the different stakeholders at regular intervals.
- Need based trainings to the farmers on the pomegranate production and management strategies for doubling the income.
- NRCP also provides services like soil analysis, disease diagnosis and technical guidance to the farmers and other stake-holders.
- Bi-monthly advisory to the farmers on crop regulation, disease and pest managements practices of pomegranate during crop period.

Out reach

1. Institute has developed a multilingual mobile application- ‘Solapur Anar’ – It is available in six languages viz., English, Hindi, Marathi, Telugu, Kannada and Gujrati.
2. **Dalimb Mitra:** A social media digital platform started in 2021 in 4 languages reaching all over India for pomegranate production advisories.
3. User friendly ICAR –NRCP Website has been developed.
4. Linkages have also been developed with extension and development agencies like APEDA, NHB, Department of Agriculture, Government of Telangana; Department of Agriculture, Government of Karnataka and Department of Agriculture, Government of Maharashtra, Rashtriya Krishi Vikas Yojana (RKVY) Projects, Govt of Maharashtra; Agribusiness Network Project (MAGNET), Pune, Govt of MS; Scientific and Engineering Research Board, (DST - SERB), New Delhi; Bhabha Atomic Research Centre, DAE, Trombay, Mumbai. Commissionerate of Agriculture, Pune; APEDA, NHB, PPV&FRA, NMPB, MIDH, MoA&FW, New Delhi; KVK, Solapur; KVK, Mohol; KVK, Baramati and ATARI, Pune, KVK Gudamalani, KVK Baramati, KVK Narayangaon and ATMA Solapur.

Commercialization

The technologies developed by NRCP have been commercialized with 46 leading firms across the India are listed below:

1. *In vitro* propagation of pomegranate cultivar Bhagawa including biohardening
2. Development of pomegranate juice & RTS beverage.
3. Two step Hardwood cutting protocol of pomegranate including biohardening.
4. Process of minimal processing and shelf -life extension of minimally processed arils.
5. A novel bio-formulation for potassium fertilizer supplement and process of preparation thereof.
6. Propagation of planting material of pomegranate var. Solapur Lal.
7. Propagation of planting material through air layers/hard wood cutting of pomegranate var. Solapur Lal.
8. Extraction of virgin pomegranate seed oil.
9. Standardization of mass production protocol for pomegranate fruit piercing moth (*Eudocima maternal*).
10. *Trichoderma consortium* technology for growth promotion and root protection against soil borne pathogens of pomegranate (Rhizoshield).
11. *Bacillus consortium* strains for bacterial blight management in Pomegranate (Endovita).
12. Propagation of planting material of pomegranate var. Solapur Anardana.

Special achievements

- A Special Postal Cover on ICAR –NRCP, Solapur has been released by Department of Posts, India in recognition of services rendered to the pomegranate stakeholders on 25th September 2021, 17th Foundation day of NRCP, Solapur.
- ICAR –NRC on Pomegranate Solapur has been recognized as one of the centre under this Clean plant Centre on Pomegranate under Clean Plant Programme - Asian Development Bank funded project exclusively launched by Govt. of India under National Horticulture Board (NHB), MoA & FW. The centre will act as nodal centre for conservation of Foundation G1 material which is true to type pomegranate genotypes / genotypes under protected / disease free environment and will supplied to nursery-mens for further multiplication following particular protocol

- Centre has two projects under Rashtriya Krishi Vikas Yojana (RKVY) Projects, Govt of Maharashtra)
 1. Setting up of Biocontrol production 'Laboratory to demonstrate and popularize the use of Biocontrol agents for Sustainable Pest Management in Pomegranate of Rs. 34 6.80 Lakhs
 2. Establishment of Plant Health Clinic for Pomegranate growing regions of Maharashtra Rs. 311.00

3. Targets

- The target is to increase area under pomegranate to 6.0 lakh ha by 2047.
- Production is targeted to 18 million tonnes with an average productivity of 30.0t/ha.
- Export will be raised to tune of 5 million tonnes to capture market of European Union, America and especially unexplored African market.
- In India 52.9 million ha are marginal lands and are considered as non -cultivable areas. These lands can be used for pomegranate cultivation, creating protected cultivation facilities and other infrastructure for pomegranate industry.
- Standardization of package of practices for protected cultivation and targeted to bringing 5 % area of total area under cultivation.
- Increasing organic pomegranate production area from < 1.0 % to 10.0 % for sustainability.
- Development of diagnosis kit for detection of important disease like BBD at nursery stage.
- The cultivation of pomegranate will be promoted to NEH regions with new variety and SOPs for humid, sub humid and temperate regions.
- Varieties will be developed for resistance/tolerance against biotic & abiotic stresses and ornamental purpose.
- Varieties for processing purpose and longer shelf-life.
- Utilization of pomegranate through value addition for functional food, cosmetics and pharmaceutical products.
- Research projects and programmes will be chalked out on the basis of stakeholders demand, prioritized to address the problems of stakeholders (farmers, NGOs, state agencies) under changing climate & global competition.

Challenges and Growth Vision

- Climate change, vagaries of weather fluctuations, unseasonal and uneven distribution of rains, leads to many production problems.
- Enhancement of national germplasm repository to international stature.
- Breaking of mono-culturing in pomegranate by bringing new varieties under cultivation.
- Lack of dedicated breeding programs for development of abiotic stresses-tolerant varieties.
- Lack of validated biochemical, molecular, and genetic markers for key physiological disorders.
- Presently, the farmers have limited access to good quality certified disease & pest free planting material of true to type varieties.
- In view of antioxidant, medicinal and nutraceutical properties of pomegranate, there is great demand for organically produced pomegranate fruits.
- At present only <1% of pomegranate area is under natural/organic practices.
- Degradation of soil health; physical, chemical and biological degradation including loss of soil microbial diversity.

- Reduced water availability, quality and ground water levels and water use efficiency during crop critical growth stages of pomegranate.
- Lack of bio-formulations and bio-agents for management of insect-pest and diseases
- Little work has been done on AI based diagnosis of diseases and pest, soil health, fertilizer recommendation, non-destructive fruit quality evaluation and plant health.
- Insufficient work on farm mechanisation, harvesting and processing tools.
- Lack of information on carbon sequestration and carbon credits in case of pomegranate orchards.
- Lack of globally compliant phytosanitary protocols for boosting exports / import.
- The pomegranate industry also witnessed nuisance of uneducated consultants.
- The lack of deployment of AI and IoT models in pomegranate orchards is due to a shortage of large, high-quality annotated datasets that capture the variability of pomegranate orchards across different agro-climatic zones, canopy architectures, disease incidence patterns, and management practices.
- Lack of digital traceability or block chain-based systems.
- Need to encourage cross-functional collaboration to broaden knowledge horizons and facilitate industry-driven projects.
- Need for processing and value addition infrastructure in pomegranate production catchment.
- Protocol requirement for Export of fresh pomegranate to long distant premium markets through sea shipment.
- Demand for plant based nutraceuticals/ natural preservatives and colorants over synthetic/chemicals for combating diseases and life style disorders.
- Lack of skill development programs:- National and International exposure visits are needed.
- Need to strengthen the extension of established and cutting-edge technologies to farmers.

4. Road Map and Action plan

On going

- Collection, characterization, and conservation of at least 30 germplasm lines with the identification of 5 elite lines and their utilization for trait-specific crop improvement. It is also expected to release one climate-resilient variety.
- Capacity building by conducting farmer training programs on organic farming practices and soil health management, establishment of Agri-Horti Export Hub integrating infrastructure for processing, packaging, and logistics for export-oriented produce. This also required policy support from the Government and funding through public-private partnerships and international collaborations. Target is to bring 25% pomegranate area under natural /organic farming.
- To strengthen the extension of established and cutting-edge pomegranate production technologies to farmers, plan will be chalked out by forming effective linkages between research institutes, Krishi Vigyan Kendras (KVKs), and private partnerships. Collaborative frameworks will be established for regular interaction and feedback.
- Capacity Building Programs includes trainings, regional workshops and farmer field schools for KVK staff and extension workers. Efforts will be made to develop easy mass access to technology-related information utilizing digital platforms, user-friendly modules, mobile apps and mobile advisory services for technology updates.

A. Short term

- Standardisation of crop regulation and canopy architecture, with one standard canopy management protocol demonstration, along with practical POPs for induction of off-season bahars.
- On station research trial on nature friendly sustainable production systems reducing GHG emission, improving soil microbial and nutrient dynamics and overall soil health.
- Development of POP for climate smart, input efficient protected cultivation technology for different varieties and bahars (seasons) of pomegranate.
- Establishment state-of-the-art Biocontrol Production Units for biocontrol agents production and Mobile Plant Health Clinic.
- Water availability and irrigation use efficiency will be addressed using insitu rainwater harvesting models, low water demanding cultivars and adoption of precision irrigation systems (micro-irrigation and fertigation) incorporating sensors, AI-driven water use efficiency and weather modelling.
- Development of export destination specific sea protocols for export of fresh fruits in collaboration with APEDA, state marketing boards, NPPO and exporters.
- Development of green technologies (solar greenhouse drying, green extraction techniques, non- thermal processing etc.) for sustainable pomegranate processing.
- Promotion and demonstration of renewable energy (solar dryers, solar-assisted processing, solar PV for on-farm energy needs, and solar-powered cold chain) techniques in processing and protected cultivation.
- Utilization of bioactive rich extract from peel, flower, seeds etc. in functional foods, pharmaceuticals and cosmetics.
- Application of advanced pomegranate juice and arils processing technologies like MAP, Non-thermal technologies etc., and its dissemination to entrepreneurs.
- Establishment of Museum, Technology park and auditorium with advanced smart extension education unit.
- Farmer awareness programs and demonstration campaigns, aggressive campaigns for technology dissemination in different states, in-house and on-farm training programs, exhibitions and extensive use of social media platform.
- The pathogen free mother plants with good horticultural traits will be registered with a unique identification number.
- The state of art facilities like pathogen testing laboratories will be established and accredited.
- Developing and promoting eco-friendly and IDIPM practices for insect- pests and diseases of pomegranate. Development and validation of efficient field deployable biocontrol agents and eco-friendly formulations at multi-location especially at all the agriculture universities.
- Pilot scale deployment of AI-based solutions for pest and disease diagnosis, a multi-lingual mobile app, UAV spray characteristics and development of SOPs for precision spraying.

B. Mid Term

- Biomarker based screening of germplasm and advanced breeding lines for physiological disorders.
- Large-scale genotyping and barcoding, including 10 varietal barcodes, 2 SNP-based marker assay platforms, and 5 morphological markers for varietal identity and clonal fidelity.
- Enhancement of genetic resource and their characterization for utilization in breeding program.

- Varietal diversification, focused breeding program to develop and promote processable and bio-fortified varieties with branding and promotional activities
- Under Clean Plant Programme (CPP) scheme, all promising varieties will be collected, maintained under protected environment for supplying true to type and disease free plants to nursery growers for the development of 'Mother block' for the production of certified disease & pest free planting material.
- Development of hi-tech systems for expediting production and supply of pomegranate saplings with traceability.
- Standardisation of one POP for hast bahar flower induction and establishment of a mother block with SOP for quality planting material production.
- Clean Plant Programme (CPP) will link with revolving scheme for the establishment of tissue culture laboratory and production of healthy, true to type and disease free planting materials on large scale.
- Development and validation of a standardised and documented protocol for the protected cultivation, to be adopted across different zones.
- For sustenance of organic farming, work will be done to create awareness through rigorous awareness programs.
- Enhance input use efficiency using AI based nutrient deficiency diagnostics tools, soil and leaf analysis based nutrient advisory and sensor-based nutrient supply systems. It also includes use of nano fertilizers; crop and zone specific customised nutrient formulations, secondary and multi-micronutrients nutrient mixtures.
- The strategic approach for implementing natural or organic farming system in pomegranate includes comprehensive surveys to identify high organic carbon soils clusters based natural farming zones in collaborate with state governments and local stakeholders, identification of region-specific varieties with export potential.
- Developmental studies of different tools like hydraulic pruners, soil moisture meters, and mini tillers for small farmers and train users through workshops and development of basic digital monitoring systems at orchard level.
- Evaluation of pest and disease control through natural component based bio-formulations.
- Development of diagnosis kit for important diseases and pests at nursery level.
- Application of robotics arms, E-nose, & machine learning for automation of pomegranate processing and non-destructive quality evaluation.
- Pilot scale production of functional food pharma, and cosmetic products for commercial utilization of pomegranate processing byproducts.
- Partner with tech companies, global institutions for knowledge exchange and resource sharing. Encourage cross-functional collaboration to broaden knowledge horizons and facilitate industry-driven projects.
- Standardization and validation of extraction methods for punicalagin and natural colour from pomegranate peel and flower delivering purified industrial inputs.

C. Long term

- To cope up climate change scenario, we have to foster multidisciplinary approaches combining soil, water, crop, and ecosystem management. Adoption of climate smart agriculture models using remote sensing, weather forecasting tools, AI, IoT, robotics, drones, sensors, GIS, 5G enabled practices etc.
- Climate-resilient breeding programs includes genetic enhancement, stress tolerance cultivars by screening large germplasm of pomegranate and also through conventional and molecular approaches using modern biotech & genomic tools including gene editing.
- Development of four resistant lines for biotic and abiotic stresses and one processable variety through conventional and molecular breeding approaches.

- Import and evaluation of commercial leading pomegranate varieties from different countries. Establishment of aseptic tissue culture protocols using axenic media for elite genotypes and rootstocks.
- Model certification system for tissue-culture plants with traceability needs to be developed to promote the growth of the tissue culture (TC) industry in India.
- Establishing certified pest-free production clusters with traceable, export-compliant phytosanitary frameworks.
- Development and validation of a standardised and documented protocol for the protected cultivation, to be adopted across different zones.
- Protected and vertical farming and soil less agriculture with PoP will be promoted.
- Pomegranate based Integrated Farming Modules for different pomegranate growing regions.
- Soil degradation issues will be addressed using different approaches like adoption of carbon farming to reduce, reuse and recycle of carbon into carbon credits, zero tillage and IFS practices and use of nature friendly microbial consortia to enhance soil fertility and biodiversity.
- For sustaining soil health, use of indigenous mineral resources, novel fertilizers, sensor-based nutrient supply systems, crop planning considering carbon footprint, revision of fertilizer recommendations will be implemented.
- Use of Artificial Intelligence-based disease prediction in NF systems - Microbiome and soil biology research in NF orchards - Block chain for traceability and certification- Biodiversity impact of long-term NF-Integration of drones and precision tech in NF input application.
- Insect-pest and disease dynamics during production period of different flowering seasons will be studied.
- Resistance management through rotational use of biological cum new pesticides with novel mode of action will be developed for insect- pests and diseases.
- Exploring the possibilities of omics (genomics, proteomics, and metabolomics) studies for insect-pest and diseases.
- Innovative marketing strategy need to be developed emphasizing fresh fruits, processed organic products through complete value chain.
- High tech orchard mechanisation - robotic and autonomous mechanization tools, robotic & hydraulic pruners, weeders, and planters, canopy shapers, mini tillers, sprayers and surveillance equipment.
- Integration of block-chain or digital ledger technology to track farm inputs, crop history, and harvests for export quality and transparency.
- R&D for LiDAR/drone-assisted pruning suggestion tools or semi-automated saws to support structural pruning.
- Utilization of high value compounds or industrial use (food, pharmaceutical, cosmetics, and textile).
- New regional centres will be established to address region specific problems and maintaining native diversity of pomegranate.

5. Way forward

1. To improve present national average productivity of pomegranate to 30 t/ha
2. Establishment of model nurseries.
3. Hi-tech protected cultivation for enhanced productivity under climate risk situations.
4. Increasing input use efficiency: Soil, water and nutrient management schedules based on soil types and region specific will be developed.
5. Standardization canopy management practices for high density planting in pomegranate.
6. Developing Bio-intensive eco-friendly pest and disease management strategies
7. To increase pomegranate export by (1) developing pomegranate varieties with large fruit size (>300g) and (2) bringing more chemicals under Label claim.
8. To develop more processing varieties with high TSS (18-20%).
9. Varietal Barcoding for identification of varieties at nursery and field stage.
10. Enriching Field Gene Bank with new exotic germplasm of *Punica granatum* and addition of *Punica protopunica*, the only known species, harnessing of natural biodiversity, and identification of resistant / tolerant sources against biotic and abiotic stresses.
11. Nutrient use efficiency will be improved by using advanced micro-irrigation systems, developing AI based nutrient deficiency diagnostics tools, soil and leaf analysis based nutrient advisor
12. Identification of markers associated with traits of economic importance and their utilization with pomegranate improvement.
13. Bringing FPO/ FPCs to facilitate small and remote farming community.
14. Promoting value addition and Horti-Entrepreneurs development creating awareness among farmers and end users throughout India.
15. ICAR-NRCP aims to establish **India's first National Pomegranate AI Data Repository**, integrating images, sensor data, genomic profiles, weather records, and farm management logs from diverse production clusters.

6. SWOT Analysis — ICAR-NRCP, Solapur

Strengths (Internal, positive)

1. **Mandate & Centre of Excellence for Pomegranate:** The NRCP has a clear, focused national mandate on pomegranate research, concentrating institutional expertise, germplasm resources, and credibility to influence policy and industry standards.
2. **Location advantage (Solapur region):** Proximity to major pomegranate growing belts provides easy access to diverse agro-climatic orchards for on-farm trials, participatory research and rapid validation of agronomic practices.
3. **Experienced scientific leadership & multidisciplinary staff:** Skilled scientists in pomology, pathology, entomology, post-harvest, processing and social sciences who can design integrated projects from nursery to market.
4. **Existing germplasm, breeding & infrastructure:** Established germplasm collections, breeding lines, and basic lab/field infrastructure accelerate varietal improvement and seed/material distribution activities.
5. **Extension & stakeholder linkages:** Maintains good rapport with farmer groups, state departments, nurseries, and local industry—facilitating technology demonstration, adoption, and feedback loops.
6. **Track record of variety releases and demonstrated technologies:** Credibility from past varietal releases, demonstrated canopy/processing/PHM interventions that assist in scaling and mobilizing funding.

7. **Potential for public-private partnerships (PPPs):** The strong applied research focus makes NRCP an attractive partner for processors, nursery entrepreneurs, and ag-tech firms, especially in value addition and mechanisation.
8. **Strategic national relevance for export and processing:** Research outputs can directly inform export compliance (residue-free produce, traceability) and meet the processing industry's needs (processing varieties, aril quality).

Weaknesses (Internal, limiting factors)

1. **Limited advanced computational/AI capacity:** Few in-house data scientists or AI engineers; limited experience in large-scale data management, high-throughput phenotyping, and ML pipelines.
2. **Gaps in high-end infrastructure:** A lack or insufficiency of advanced genomics platforms, hyperspectral imaging, robotic automation labs, and pilot-scale processing units are needed for rapid commercialisation.
3. **Scaling nursery and quality planting material systems:** While mother blocks exist, standardised, certified large-scale planting material supply and quality control systems need strengthening to prevent varietal admixture.
4. **Resource constraints & intermittent project funding:** A heavy dependence on time-bound projects and grants can limit long-term program continuity and the retention of specialised staff.
5. **Limited commercialisation & IP pathway experience:** Weaknesses in business incubation, product commercialisation channels, and intellectual property management reduce the pace at which lab innovations become market-ready.
6. **Data fragmentation and poor long-term data curation:** Field and lab data often reside in silos without unified metadata standards or a long-term repository, hampering reproducibility and AI model training.
7. **Extension bandwidth vs demand:** Extension teams may be overstretched; farmer: scientist ratios and geographic spread limit the frequency and intensity of hands-on training and follow-up.

Opportunities (External, positive)

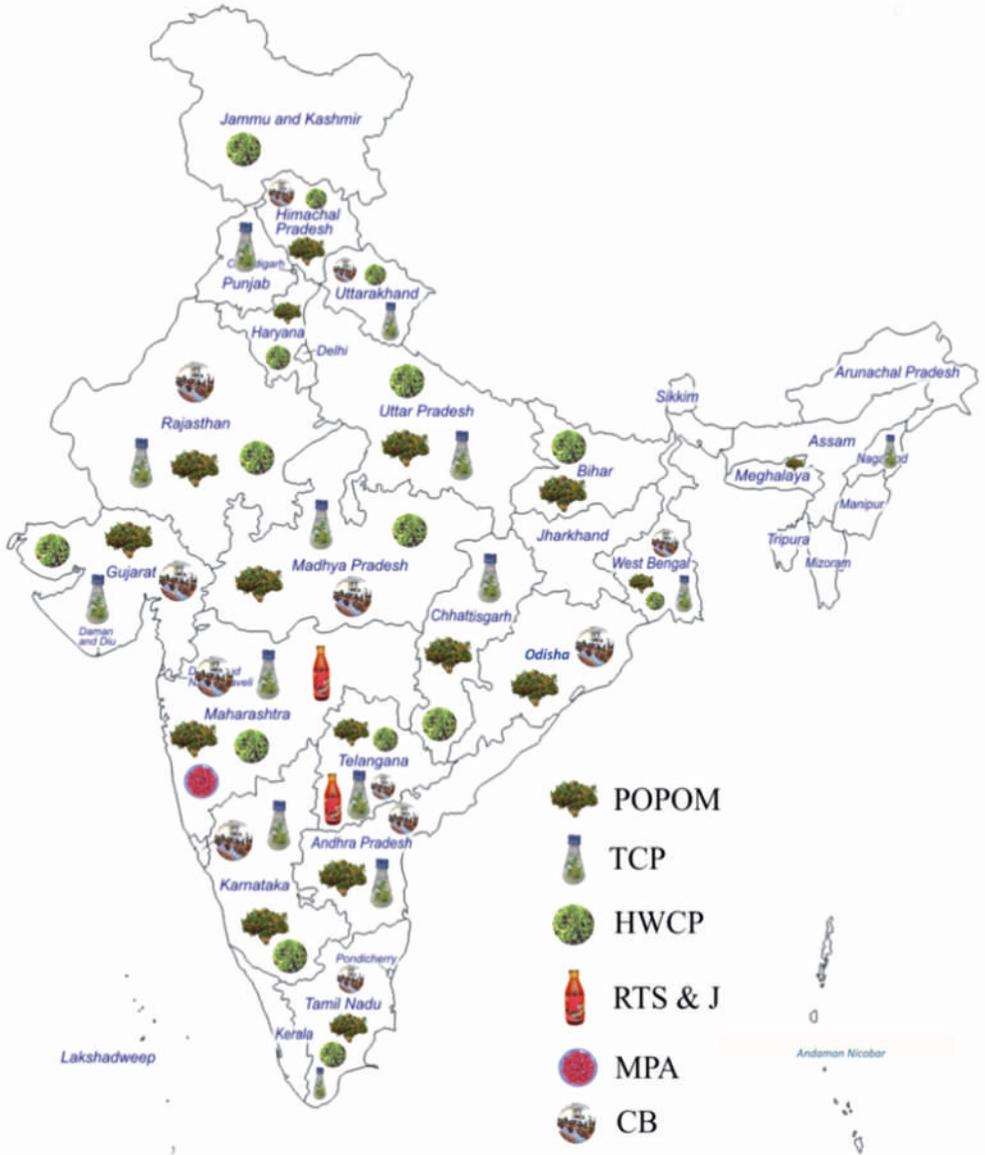
1. **Rising global demand for functional foods & nutraceuticals:** Pomegranate's bioactive components (punicalagin, anthocyanins) create demand for standardised extraction, higher-value processing and exports.
2. **Adoption of AI, IoT and precision ag in horticulture:** Opportunity to lead national efforts in smart-orchard technology (AI diagnostics, precision irrigation, automated sorting) and create export-ready, traceable supply chains.
3. **Public & private funding for climate-resilient agriculture:** Opportunities to access national schemes, international climate funds and CSR/industry R&D for protected cultivation, water-saving tech and resilient varieties.
4. **Value-chain partnerships & startups:** Collaborations with ag-tech startups, processing units, exporters and consumer brands can drive pilot commercialisation and co-investment in pilot plants and digital tools.
5. **Waste valorisation and circular bioeconomy:** By-product utilisation (peel, membrane) for nutraceuticals, natural colours, and bio-inputs aligns with the circular economy and offers additional revenue streams for farmers/processors.
6. **Export market diversification & premiumization:** Demand from premium markets for residue-free, traceable fruits can command price premiums; NRCP can certify and enable market readiness.
7. **Policy support for mechanisation and digitalisation:** National programs encouraging mechanisation (harvesting, sorting) and digital traceability (blockchain) help scale technology adoption.
8. **Training & capacity building leadership:** Opportunity to become the national training hub for pomegranate AI, protected cultivation, quality planting material and post-harvest tech.

Threats (External, risks to address)

1. **Climate variability & extreme events:** Droughts, unseasonal rains, heat waves and new pest/disease dynamics threaten yield stability and can outpace varietal adaptation timelines.
2. **Emergence of new pests/diseases & resistance issues:** Rapidly evolving pathogens/pests or pesticide resistance could undermine existing management strategies and demand agile R&D responses.
3. **Market volatility & trade barriers:** Price volatility, phytosanitary restrictions and changing trade policies can reduce returns for growers and affect export feasibility.
4. **Competition from private breeders & other regions:** Private sector or other countries may develop competing varieties/processing tech faster, eroding market share and influence.
5. **Data privacy, regulatory, and ethical concerns:** The use of AI, farmer data aggregation, and traceability systems raises governance and privacy issues if not properly managed.

Strategic implications & Recommended Actions

1. **Build an AI & Data Hub:** Establish the proposed **AI-Pomegranate Centre** with a core team: data scientists, farm data engineers, agronomists and pathologists; invest in a national data repository and standards for metadata and annotation.
2. **Targeted infrastructure investment:** Prioritise funds for high-throughput phenotyping (imaging), genomics (sequencers or access partnerships) and pilot processing.
3. **Strengthen nursery certification & mother blocks:** Implement robust clonal fidelity testing (barcoding/SNP checks), certified nursery schemes and SOPs to scale quality planting material.
4. **Design sustainable funding models:** Diversify funding via PPPs, consultancy services, fee-based training, and value-added product licensing to reduce overreliance on grants.
5. **Scale extension with digital channels:** Deploy multilingual AI mobile apps, remote advisory, and an expanded mobile plant health clinic fleet to increase reach cost-effectively.
6. **Commercialisation & IP cell:** Create an incubation centre and accelerate pilot products, value-added extracts and licensing deals.
7. **Risk & climate resilience planning:** Fast-track breeding for resilience, promote protected cultivation, and develop contingency plans for supply-chain shocks.





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