# Vision 2030

National Research Centre on Pomegranate
Solapur

www.nrcpomegranate.org

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**National Research Centre on Pomegranate**
Solapur-413 006, Maharashtra, India

www.nrcpomegranate.org

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सत्यमेव जयते

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सचिव एवं महानिदेशक
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SECRETARY & DIRECTOR GENERAL

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कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
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# FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

India has emerged as a leading producer of pomegranate and accounts for almost 50% of the total world produce but it's productivity is far below than other countries. Over the past one decade, country's pomegranate acreage, production and export have increased. National Research Centre on Pomegranate (NRCP), Solapur established in 2005 by the ICAR, has been able to achieve appreciable progress in the areas of germplasm enhancement and identification and management of important biotic and abiotic stresses. We need to diversify its usage and focus our research efforts towards development of post harvest technologies to enhance its utilization through processing and value addition. Application of biotechnology to ensure production of elite planting material and development of varieties possessing resistance and processing traits would be an important intervention to meet the challenges of the pomegranate industry.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

**( S. Ayyappan )**

**Dated the 29th June, 2011**
**New Delhi**

# Preface

The Horticulture sector has made significant development in the past two decades and has emerged as a major source of crop diversification due to country's varied climatic conditions and topographic landscapes. Pomegranate which was being cultivated in restricted areas of the country till last two decades has now emerged as a major crop in some of the states having arid and semi- arid climates with India becoming one of the largest producers of pomegranate in the world. There has been an increase of about 13.41 % and 25.53 % in pomegranate area and production, respectively, in the country during the previous 7 years from 2003-04 to 2010-11. The export has also shown 7 fold increased growth in previous 8 years from 4.7 thousand tonnes in 2001-02 to to 33.4 tonnes in 2009-10.

Pomegranate, though grows under all the climatic conditions of the country, its commercial cultivation takes place in Maharashtra, Karnataka, Andhra Pradesh and Gujarat with Maharashtra occupying approximately 74 % of the area under the crop. National Research Centre on Pomegranate was established in 2005 to enhance quality production and utilization of pomegranate through systematic research. Since its inception, NRCP has made significant achievements in genetic resource enhancement by collecting about 345 germplasm both indigenous and exotic, ascertaining the cause of devastating bacterial blight and managing the disease effectively through development and adoption of orchard health management schedule under the Network project in states of Maharashtra, Karnataka and Andhra Pradesh. Preliminary observations on exploitation of bioagents and integrated management of nutrients and water resources for improved productivity are encouraging.

The centre is committed to tackle some of the core challenges like inadequate availability of healthy and disease free planting material, lack of varieties resistant to biotic and abiotic stresses, and little attention to processing and value addition for which activities involving establishment of tissue culture laboratory, research on hybridization and post harvest technology have already been initiated.
The Vision 2030 document embodies achievements made in respect of various ongoing research and developmental programmes, challenges and opportunities of the pomegranate industry and future strategy of the Centre by involving various stakeholders of food supply chain to provide food and nutritional security for the country.

I express my feelings of profound gratitude to Dr S. Ayyappan, Secretary DARE & Director General, ICAR and Dr H. P. Singh Deputy Director General (Hort.), ICAR for their valuable guidance and co-operation in the development of the research centre. I also take this opportunity to thank Dr S. Rajan ADG (Hort.) and Dr T.P. Rajendran , ADG (Plant Protection ) for their valuable suggestions. The efforts of the staff of NRCP in various research and developmental programmes are thankfully acknowledged.

**(V.T. Jadhav)**
**Director**

NRCP, Solapur
June, 2011

# Preamble

The Pomegranate (*Punica granatum* L.) is native of regions from Iran to northern India and has been known to be cultivated since ancient times (4000BC). At present, it is mainly grown in India, Iran, Afghanistan, Israel, Tunisia, Spain, Turkey and USA, besides, other countries of Asia, Europe and Africa. The fruit tree because of its nutritional, pharmacological, medicinal and industrial uses has become consumer's preferred choice in India and other countries. Pomegranate belongs to the family Punicaceae and is the only genus with two species *P. granatum* L. and *P. protopunica* Balf. under the family. *P. granatum* is the main cultivated species world across while *P. protopunica* occurs in wild form in Socotra islands.

The global pomegranate production is around 15000 thousand tonnes and India alone accounts for about 50% of total world production followed by Iran and USA. In India, about 74 % pomegranate area is in the State of Maharashtra followed by Karnataka, Andhra Pradesh, Gujarat, Rajasthan, Tamil Nadu and others. Though, approximately 66 % of the production comes from Maharashtra, productivity wise Tamil Nadu leads the states ( 47.25 tonnes/ha in 2010-11) against the county's average productivity of 7.59 tonnes/ha. In general, pomegranate over the last one decade has shown rising trend in area expansion, production and export. India's export potential at present is only about 4.0% of its total production, which is very low as compared to other countries like Spain and Israel which export about 37.8% and 23.5% of their produce, respectively.

Pomegranate grows well in arid and semi-arid conditions of the country due to its wide adaptability to varied climatic conditions, drought hardiness, tolerance to salinity and as such marginal landscapes can be brought under pomegranate cultivation to meet ever increasing demand of the growing population of the country.
Indian Council of Agricultural Research, in view of the vast potential of the country for pomegranate production for food and nutritional security established the National Research Centre on Pomegranate at Solapur, Maharashtra in June 2005 with objectives to increase its production, productivity and utilization through basic, strategic and applied research programmes.

NRCP since its inception, has made significant strides by formulating need based research programmes and accomplished significant achievements in horizons of plant genetic resource enhancement and identification of important diseases and insect-pests and their integrated management. The work on nutrient and water use efficiency, exploitations of bio-inoculants in pomegranate production, application of tissue culture in production of disease free planting material and post harvest management of pomegranate is underway. On development side, the entire forest and undulating land has been converted into research farm where experiments are in progress and construction work of Office-cum-Laboratory building is almost complete.

The purpose of the present 'Vision 2030' document is to highlight the major activities and accomplishments of the Centre and envision the various challenges impeding the pomegranate industry and measures to be taken to overcome these obstacles to meet the food and nutritional security of the country.

# Pomegranate Scenario

## National Scenario

### Pomegranate Area, Production and Productivity in India

**Area:**

India is one of the leading countries of the world in pomegranate acreage and production. Pomegranate area in India has shown a growth rate of 13.41% during the previous 7 years as crop area has increased from 96.9 thousand ha in 2003-04 to 109.9 thousand ha in 2010-11 (Fig.1). At present, Maharashtra with an area of 80.9 thousand ha occupies the first position amongst various states of India and accounts for about 74.0% of the total area of the country under pomegranate. The other pomegranate growing states are Karnataka (15.9 thousand ha), Andhra Pradesh (5.6 thousand ha), Gujarat (4.6 thousand ha), Himachal Pradesh (1.3 thousand ha), Rajasthan (0.8 thousand ha), Tamil Nadu (0.4 thousand ha), Orissa (0.2 thousand ha) and Chhatisgarh and Nagaland with 0.1 thousand ha area each . Orissa has taken up pomegranate cultivation recently as until 2007, this crop was not in cultivation in the state. Besides, there are reports of pomegranate cultivation from states of Uttarakhand and Madhya Pradesh also.

Important crop growing districts in different states are as follows.

**Maharashtra:** Solapur, Nashik, Sangli, Satara, Ahmednagar and Pune. Besides, pomegranate cultivation is also observed to some extent in Osmanabad, Jalna, Beed, Aurangabad, Jalgaon and Dhule districts of the state. **Karnataka**: Bijapur, Bagalkot, Koppal, Belgaun, Gadag, Bellary, Raichur, Tumkur, Chitradurg and Davanagere.**Andhra Pradesh**: Anantpur and Mahaboob nagar.**Gujarat**: Bhavnagar and Ahmedabad.

**Production:**

India produced 834.7 thousand tonnes of pomegranate in 2010-11 and at present is the largest producer of pomegranate globally ( Fig.1). Country's production has increased by 25.53% in the last 7 years. Production wise Maharashtra ranks first (554.7 thousand t) and is responsible for 66.45% of the total country's production, followed by Karnataka (149.2 thousand t), Andhra Pradesh (56.4 thousand t) Gujarat. (479 thousand t) and

Tamil Nadu (18.9 thousand t). Rest of the country's pomegranate production is contributed by other states.

**Productivity:**

Although India is leading country in pomegranate area and production, its av. productivity is only 7.59 t/ha which is quite low. Surprisingly, the productivity varies greatly amongst different states ( 0.38  47.25 t/ha) with Tamil Nadu revealing the maximum productivity of 47.25 t/ha ( 2010-11). The productivity of major pomegranate growing states of Maharashtra, Karnataka, Andhra Pradesh and Gujarat is 6.85, 9.38, 10.07 and 10.41 t/ha, respectively.

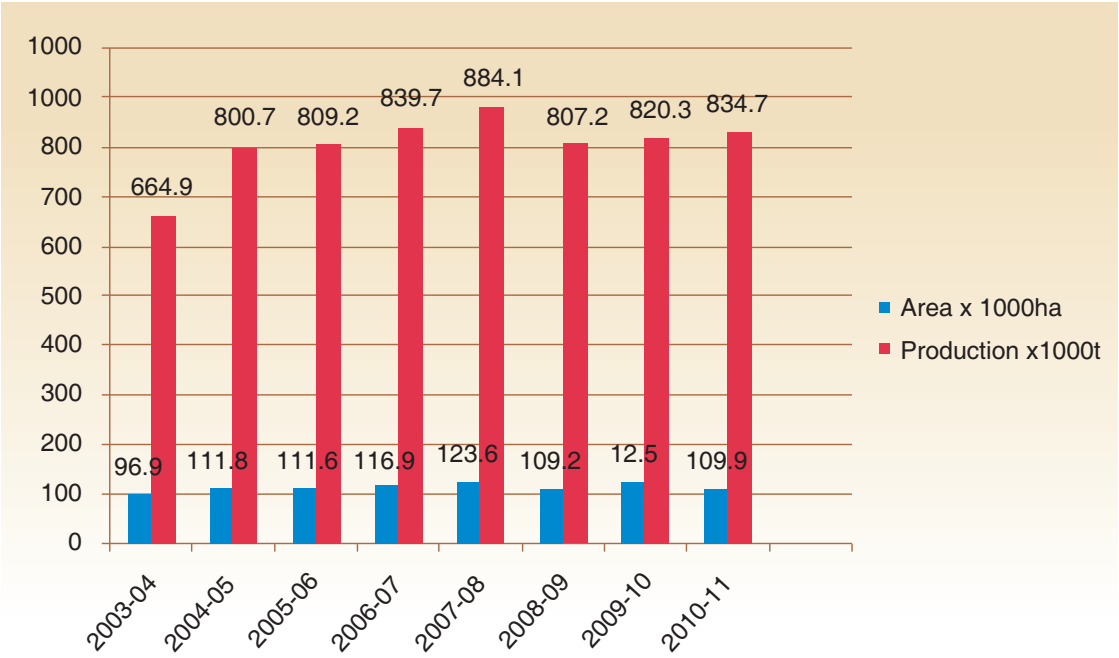


Fig.1: Pomegranate Area and production in India from 2003-04 to 2010-11
(Source: Indian Horticultural data base)

**International Scenario**

Globally, India ranks first in pomegranate area (109.9 thousand ha) followed by Iran (65 thousand ha), Turkey ( 7.6 thousand ha), USA (6.07 thousand ha), Tunisia (2.6 thousand ha), Afghanistan ( 2.5 thousand ha), Spain ( 2.4 thousand ha) and Israel (1.5 thousand ha) (Fig. 2). Current estimates of USA's (California) area under pomegranate are 10.0 thousand ha. Other pomegranate producing countries are China (statistics of area not known), Pakistan, Egypt, Morocco and Italy. India also leads in production worldwide with total production of 834.7 thousand t followed by Iran ( 600 thousand t),

USA (110 thousand t), Turkey (56 thousand t), Spain (37 thousand t), Tunisia (25 thousand t), Afghanistan (24 thousand t) and Israel ( 17 thousand t) (Fig. 3).

Productivity of India, which is about 6.5 t/ha, however, is far below than other countries like USA (18.1 t/ha), Spain ( 15.4 t/ha), Israel (11.3 t/ha), Afghanistan and Tunisia (9.6 t/ha each) and Iran (9.2 t/ha).

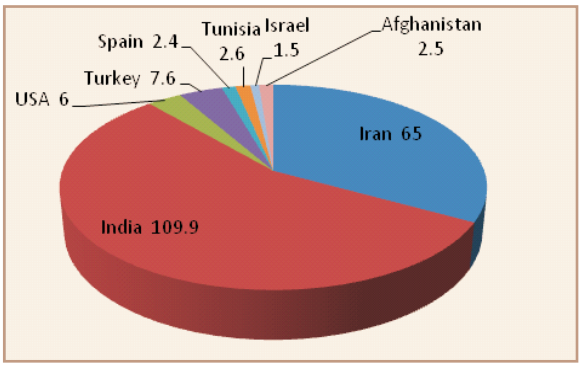


Fig. 2: Pomegranate area (x1000ha) in different countries

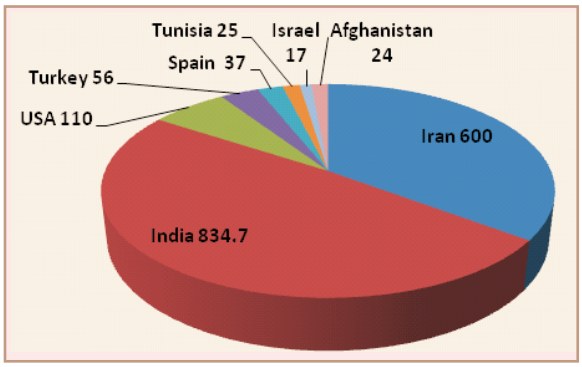


Fig. 3: Pomegranate production (x1000 t) of different countries

## Export

India exports superior quality pomegranate to ASEAN, Gulf and European Union countries and USA. During the year 2009-10 India exported about 33.4 thousand tonnes of pomegranate valued at Rs 1194 million. The country witnessed growth of 600.4 % in its export market over the past 8 years when it exported only 4.7 thousand tonnes valued at Rs 104.1 million in 2001-02. However, India exports only 4.07% of its total production which is quite below the export figures of other countries like Spain (37.8%), Israel (23.5%), USA (15.4%), Afghanistan (12.5%) and Iran (10.0%). Nevertheless, in terms of global export share, India occupies second position having 24.6% export share with Iran leading the list having export share of 48.0% followed by USA's (13.6%) and Spain (11.2%) (Fig. 4).

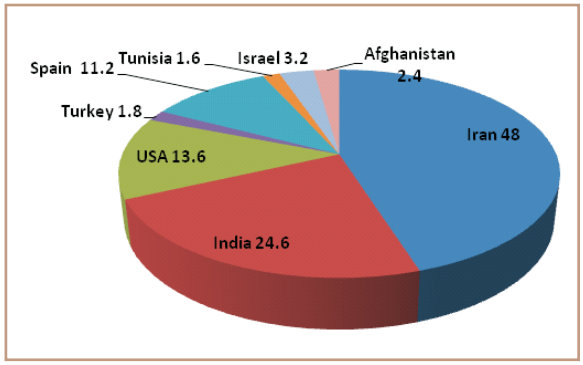


Fig. 4: Per cent export share of different countries in global market

## SWOT Analysis

**Strengths:** The country has vast area under arid and semi-arid regions which is most suitable for pomegranate cultivation due to plant's hardy and drought tolerant features and also its ability to thrive on soils of varied physico-chemical features viz. calcareous, alkaline soil, deep, acidic loam and a wide range of soils in between these. Marginal and degraded lands, which otherwise are unsuitable for major agricultural crops, are suitable for pomegranate cultivation. Pomegranate under tropical and subtropical conditions of the country flowers and produces fruits throughout the year as such the potential of the crop can be utilized for export as unlike India the supply from other pomegranate countries is only for a specific period of the year. Availability of vast biodiversity in the country particularly in north-western Himalayan regions provides good opportunity to use wild pomegranate accessions for identifying resistant genes against various biotic and abiotic stresses. Pomegranate is both self and cross - pollinated crop which reduces the risk of fruit setting. Pomegranate has comparatibly better shelf-life than other perishable fruits like grapes, sapota, mangoes etc. which may help in its long transportation and increased storage. Pomegranate because of its high nutritional and medicinal properties, finds place in health care and pharmaceutical industry. The fruit possesses health - giving properties that qualifies it as super- food. Research results reveal that pomegranate polyphenols reduce heart attack risk, pomegranate juice inhibits the growth of prostrate cancer, is anti-inflammatory, antiseptic and improves digestion.

**Weaknesses:** Non-availability of varieties resistant to diseases and insect-pests and lack of early maturing varieties makes adoption of orchard health management practices less effective and less economical. Scarcity of adequate disease free planting material due to limited facilities and research on frontier areas like molecular biotechnology increases the risk of disease and insect- pest outbreak. Inadequate focus on Post harvest technology resulting in in-efficient utilization of pomegranate. Pomegranate being non-climacteric fruit has to be harvested at right maturity time as fruit can not be ripened off the tree even with chemical treatment, while delayed harvesting may result in disorders like fruit splitting and aril browning. Plant is highly vulnerable to wind, hence wind breaks are required to be planted around the orchard for protecting the pomegranate plantation from wind.

**Opportunities:** Pomegranate cultivation can be extended to potential non-traditional areas for food and nutritional security for growing population of the country and also for raising mother nurseries for producing disease free planting material. Pomegranate is a

high value crop and has resulted in high economic returns than other fruit both in domestic and international market. Development of pomegranate industry through advanced technological approach would provide opportunities for economic development in the rural areas, alleviate unemployment and provide skill for entrepreneurship. As pomegranate flowers throughout the year under tropical and sub-tropical conditions, exploiting flower regulation and fruit harvest throughout the year as per the demand of the national and international market. Enhancement of Pomegranate utilization through product diversification, value addition and processing as fruit can be processed into snack ready aril packs, juice, jelly, and wine. Besides, it would benefit the several stakeholders in the supply demand food chain. With the involvement of the corporate sector in the supply chain even the cracked or slightly damaged fruits are being utilized for processing purpose thereby benefiting the growers in the process. In view of the vast potential of pomegranate in processing industry and involvement of corporate sector in the food chain, plenty of opportunities may be created for strong public-private partnership in agricultural research and development.

**Threats:** Prevalence of various biotic and abiotic stresses have threatened the crop cultivation resulting in enormous losses. Bacterial blight and wilt are dreadful diseases which have ruined crop cultivation during past one decade. Adoption of orchard health management schedule in affected orchards has proved effective in mitigating these diseases. Erosion of pomegranate diversity due to deforestation and area expansion for other arable crops is a cause of concern and measures are required to preserve the wild germplasm for improvement of pomegranate. Growers usually get uneconomical returns for the crop whose harvest coincides with other fruits in the market. Market surveys and post harvest management of pomegranate need special attention to overcome this threat. Indiscriminate use of pesticides, often resulting in residues exceeding the prescribed tolerable limits, is another threat to health and export. Growers need to be educated about pre- harvest interval of sprays, permissible maximum residue levels and judicious use of pesticides. The impact of climate change in coming years may adversely affect the pomegranate cultivation and measures are needed to mitigate the ramifications of climate change by developing adaptation technologies. The following measures may be required to counter the challenges of climate change. i) Developing region based weather forecasting models for growers to schedule their management practices in advance ii) Developing new varieties resistant to heat and water stress iii) Breeding short duration varieties to avoid adverse weather conditions iv) Application of biotechnology for developing climate change resilient varieties by conserving, characterizing and utilizing germplasm for production

enhancement v) Adjustment in cultural practices by shifting the crop season from spring (January-February flowering) to Autumn (September October flowering) may result in mitigating losses due to important diseases like bacterial blight and other insect-pests which otherwise are prevalent in severe proportion in summer rainy season vi) Application of drip and sprinkler irrigation systems to improve water and nutrient use efficiency for enhancing pomegranate productivity vi) Soil moisture conservation through use of mulching is an important measure, besides it also raises organic content of the soil.

# National Research Centre on Pomegranate

In order to exploit the vast potential in the country for the production of quality pomegranate, National Research Centre on Pomegranate, Solapur (Maharashtra) was established by the Indian Council for Agricultural Research on June 16, 2005. However, Center's foundation stone was laid by the Union Agriculture Minister on September 25, 2005. The centre was set up with a view to give fillip to the production of pomegranate, both for domestic consumption and export through basic and strategic research.

## Mandate

- To develop suitable varieties with high yield potential and quality fruits having resistance to biotic and abiotic stresses.
- To undertake basic, strategic and applied research for developing production and post harvest technologies.
- To act as national repository of pomegranate.
- To provide consultancy on pomegranate.
- To transfer technology to pomegranate growers.

## Infrastructure

National Research Centre on Pomegranate has been provided 59.31 ha land at Kegaon (20.83 ha) and Hiraj (37.64 ha) villages in Solapur for its research and developmental activities. The entire area which was forest and undulating at the time of NRCP's establishment in 2005, has been developed into a research farm. Experimental plots have been developed at Kegaon farm with drip irrigation facilities where experiments under different disciplines are in progress. At present, development of research plots at Hiraj block is in progress and some experimental plots have already been prepared and trials are in progress. Pomegranate plantation has been done in 8 ha area in Kegaon and 3 ha in Hiraj research blocks. Office-cum- Laboratory building of the centre is nearing its completion and the centre would be soon shifting from its present location ( Centre of Rabi Sorghum, Shelgi) to its new building at Kegaon (Fig. 5).The centre has established laboratories of Horticulture, Plant pathology and Soil science where as laboratories of Entomology, Tissue culture, Post harvest technology and Soil and Water Conservation and Engineering are being established. Hi-tech polyhouse (Fig. 6) and shade nethouse have been constructed for tissue culture work.

Fig.5: Newly constructed office-cum-laboratory building of NRCP at Kegaon

Fig.6: A high tech polyhouse for Tissue culture work

Advanced equipments have been purchased to carryout work in different disciplines and some of these include, Portable Photosynthesis system, UV and Atomic Absorption spectrophotometer, Refrigerated Ultra centrifuge. Automatic plate pourer stacker, Colony counter and Compound microscope with phase contrast, fluorescent, CCD camera and image analyzing facility.

The centre has established its own **Library** which has 1075 books and subscribes to 16 scientific journals and **ARIS Cell.**

Farm operations: High hp and Mini Tractors, Implements for farm operations, Vermicompost unit, Micro irrigation system, two dug wells, two bore-wells, two water harvesting structures (135 and 48 lakh litre capacity) and a water sump of 1.25 lakh litre capacity have been developed. **Meteorological observatory:** Both, Manual Meteorological observatory and Automatic weather station have been installed and are functioning.

**Manpower:** Manpower position during XIth plan and proposed during XIIth plan is depicted in Table 1.

Table 1: Human Resources at present and proposed during XII Plan

| Sl.No | Category | Staff in position during XI Plan (till June 2011) | Sanctioned staff in XI Plan | Staff proposed during XII Plan |
|---|---|---|---|---|
| 1 | RMP | 1 | 1 | 1 |
| 1 | Scientists | 9 | 9 | 17 |
| 2 | Technical | 5 | 6 | 27* |
| 3 | Administrative | 4 | 10 | 14* |
| 4 | Supporting | 2 | 2 | 36* |
| | **Total** | **21** | **28** | **95** |

* : Administrative, Technical and Supporting staff positions proposed during XII Plan are as per the staff ratio suggested by the council depending on scientists position.

**Budget:** The expenditure incurred during X, XI plans and proposed for XII plan is mentioned in Tables 2, 3 and 4, respectively.

Table 2: Budget and Expenditure during Xth Plan (2002-2007) (Rs in lakhs).

| Sl.No | Head | Revised Xth Plan outlay | RE 2004-05 | RE 2005-06 | RE 2006-07 | Expenditure | Refunded |
|---|---|---|---|---|---|---|---|
| A | Recurring contingencies | 100.00 | 0.31 | 19.37 | 80.32 | 95.77 | 4.22 |
| B | Non Recurring contingencies | 592.5 | - | 80.62 | 511.18 | 585.5 | 7.00 |
| | Grand Total (A+B) | 692.50 | 0.31 | 99.99 | 592.50 | 681.27 | 11.22 |

Table 3: Budget Outlay and Expenditure during XI th Plan (Rs in Lakhs)

| Sl.No. | Head | Outlay XI Plan | Expenditure | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 |
| A | Recurring contingencies | 535.00 | 57.80 | 71.00 | 93.55 | 109.00 | - |
| B | Non-Recurring Contingencies | 1405.00 | 5.00 | 179.00 | 106.45 | 216.00 | - |
| | Grand Total (A+B) | 1940.00 | 62.80 | 250.00 | 200.00 | 325.00 | 400.00 |

Table 4: Proposed outlay for the XII th Plan

| Sl.No | Head | Proposed outlay for XII Plan (Rs in Lakhs) |
|---|---|---|
| A | Recurring contingencies | 685.00 |
| B | Non-Recurring contingencies | 1865.00 |
| | Total (A+B) | 2550.00 |

## Project Review, Reporting and Evaluation Arrangements

**N**RCP has following committees for monitoring and reviewing different R&D programmes. 1.Institute Management Committee (IMC). 2. Research Advisory Committee (RAC). 3. Institute Research Council (IRC). 4. Quinquennial Review Team (QRT). QRT recently reviewed the R& D activities in September 2010 of previous 5 years from June 2005 to June 2010.

## RESEARCH ACHIEVEMENTS (2005-2011)

### Crop Improvement

**Germplasm Collection**: The Centre has collected and maintained 345 germplasm from India (177 accessions) and abroad (168 accessions). **DNA fingerprinting of germplasm:** DNA fingerprinting of 64 germplasm was done in collaboration with NBPGR. IISR method produced more polymorphic profiles in comparison to SSR and RAPD. The overall interaspecific polymorphism was very significant and suggested that germplasm were significantly diverse. **Evaluation of gamma irradiated population:** Gamma irradiated population revealed more than 30 mutants with distinct characters having desirable semi dwarf growth habit, high bearing, pink, red and creamy arils, red and yellow skin, bold arils (>40g/100arils), high TSS (15-16°brix) and large fruits (>400g each).**Establishment of hybridization block**: Four commercial cultivars (Ganesh, Bhagawa, Ruby, Jalore seedless) crossed with three bacterial blight resistant/tolerant varieties (Nana, Kalpitya, Nayana ) and good fruit set obtained in all the crosses. These are being evaluated for bacterial blight resistance.

### Crop Production

**Evaluation of rootstock**: **Graft success** of 84% after 30 days of grafting was recorded in cvs. Mridula (rootstock) and Ganesh (scion) graft combination. **Evaluation of training system**: Evaluation of growth performance of single, double and triple stem training systems revealed significantly superior growth of double and triple stem training systems in terms of plant height and spread as comparison to single stem.

**Status of pomegranate orchards' soil**: Soil physico-chemical properties revealed that the surveyed orchards (Maharashtra) were suitable for pomegranate cultivation as their pH ranged between 7.4-8.8, EC 0.1-1.7 dS/m, organic carbon varied between 0.15 1.53%, $CaCo_3$ ranged between 5.0-23%, N (169-482kg/ha), and K (134-1052kg/ha) and was in permissible range. Micronutrient deficiency of iron and Zinc noticed in some orchards.

Survey of Karnataka orchards (Bagalkot, Koppal, Bijapur districts) revealed soil pH (6.8-8.9), EC ( 0.13-1.41 dS/m), OC (0.37-1.93%), $CaCo_3$ (0.13-10.24%) and available N (83-335kg/ha) and K (95.2-1741.6kg/ha). The micronutrient status varied in different orchards. Majority of the soils were low in DTPA extractable Fe and sufficient in Mn and Cu contents.

**Nutrient deficiency symptoms:** Studies have been conducted for identification of nutrient deficiency symptoms with respect to Nitrogen, phosphorus, potassium, calcium, magnesium and Sulphur.

**Influence of bioagents on growth and physiological parameters of pomegranate**: Application of bioagents like *Pseudomonas fluorescens, Azospirillum* and PPFM (pink pigmented facultative methylotrophs) was beneficial for the growth and biomass production (Figs.7, 8).

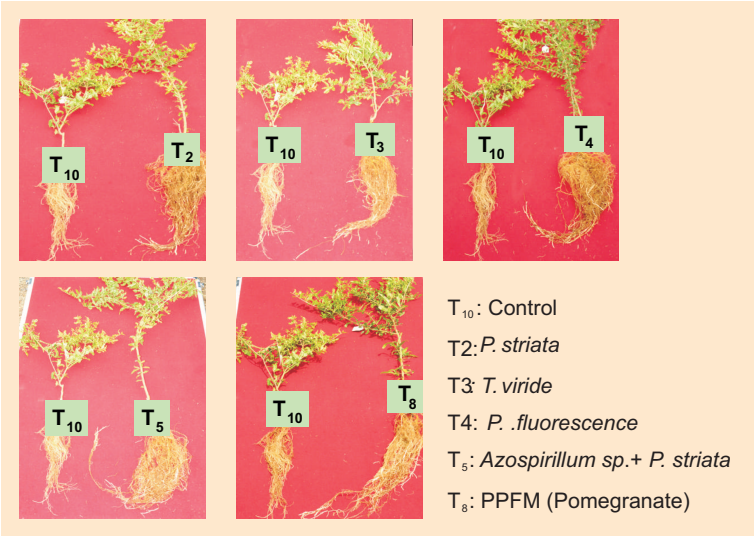


Fig.7:Effect of bioagents on root and shoot growth of poamegranate

Fig.8: Effect of PPFM on growth of pomegranate

**Potassium solubilizing fungi:** Inoculations of potassium solubilization fungi (KSF) namely *Penicillium spp. isolated* at the centre, resulted in higher plant biomass of pomegranate under pot culture study.

**Effect of solarization on nutrient availability, enzyme activity and growth of pomegranate (*Punica granatum*) air layers on various potting mixtures.** Mixing of farm yard manure to solarized soil sand media significantly increased available nutrient status (particularly K&P) alkaline and acid phosphatase activity and plant growth and vigor.

**Stool layering**: Out of six spacing geometry tested for stool layering technique in cv. Bhagawa, a spacing of 1 x 0.5m was found suitable for the stool layering.(Fig.9).

Fig.9: Stool layering in pomegranate

**Response of various organic sources of nutrients on growth, yield and quality of pomegranate**: Amongst the organic manure treatments, plant height and plant spread was highest in green manuring with *Crotalaria juncea* treatment (Figs.10,11) However, application of inorganic fertilizers produced highest plant growth.

Fig.10:*In situ* green manuring with *Crotalaria juncea*

Fig.11: *Ex situ* green manuring with *Pongamia glabra*

Studies on performance of pomegranate orchards on different soil mixtures used for pit filling, performance of pomegranate under different planting systems, frequency of irrigation are in progress.

## Plant Protection

**Surveys for diseases and insect-pests:** Exhaustive surveys of Maharashtra, Karnataka and Andhra Pradesh during 2005-2010 for diseases and insect-pests revealed bacterial blight and wilt followed by fruit spot and rots due to different pathogens to be the major diseases affecting the pomegranate orchards. Amongst

insect-pests , fruit borer (*Deudorix isocrates*), fruit sucking moth (*Othreis* spp.) and various other sucking insects like aphids, thrips, white flies, scale insects and mealy bugs were found prevalent in varying proportions .

**Bacterial blight**: Blight was found prevalent in all the major pomegranate growing states of Maharashtra (52.2%), Karnataka (58.3%) and Andhra Pradesh (43.7%). In Maharashtra blight severity was quite high in districts of Solapur, Sangli, Nashik, Osmanabad, Jalna and Pune. Blight resulted in 60-80 % losses under epidemic conditions. **Causal organism**: On the basis of disease symptoms, cultural studies, pathogenicity tests and molecular markers (PCR based technology), the causal organism was identified as *Xanthomonas axonopodis* pv. *punicae.* **Epidemiology:** Blight was more severe during the rainy season (July-September) as compared to other months of the year. Relative humidity and rainfall were significantly and positively correlated with the disease, where as temperatures had non-significant correlation. However, hourly temperatures between 25.0-35.0°C & RH > 30.0% were found positively correlated with the disease. The disease remained prevalent through out the year at a temperature range of 9.0-43.0°C .**Management**: Spray schedules comprising of streptocycline (500ppm) + carbendazim (0.2%) and streptocycline (500ppm) alone were quite effective and significantly superior over control. **OHM schedule**: The adoption of OHM schedule in orchards under the 'Network Project' resulted in effective control of bacterial blight. The average blight control ranged between 67.4% - 73.97% with an average productivity of 7.94 t/ha to 9.28 t/ha.. The av. benefit on the basis of cost-benefit ratio was 1:2.3  1: 4.3. The adoption of same package at Hiraj orchard during 2007-08 had resulted in 82.2% blight control with increased production of 16 t/ha (Figs 12, 13).

Fig.12; Bacterial blight affected orchard before adoption

Fig.13: Healthy and blight free fruit in OHM package adopted orchard

**New bactericides:** Three new antibiotics (Piperaciline @500ppm), dichloropene @500ppm & Triclosan (0.5%), which were found effective *in vitro* against *Xanthomonas axonopo*ds pv. *punicae* were found more effective than streptocycline under field conditions.

**Screening of germplasm for blight resistance:** Screening of germplasm under field conditions revealed that out of 63 accessions, 5 were partially resistant (Nana, IC-1182, IC-1197, IC-1198, and IC-1205) .**Screening under net house conditions:** Out of 240 germplasm screened under net house conditions, only four plants were found free from bacterial blight (one each of Nana, Nana x Ruby and 2 of Nana x Kalpitya).

**Leaf and fruit Spots:** Different fruit spots and rots prevalent in the orchards were due to *Cercospora punicae*, *Colletotrichum gloeosporioides*, *Alternaria alternate, Sphaceloma punicae, Drecslera rostrata, Phytophthora nicotianae* All these were managed with sprays of carbendazim (0.15%)/ thiophanate methyl (0.1%)/copper oxychloride (0.2%)/ mancozeb (0.2%) at regular intervals. The spots were more severe during the rainy season.

**Wilt:** Wilt, another major disease, was prevalent in mild to severe form in all the three states of Maharashtra(49.2%) , Karnataka (61.1%) and Andhra Pradesh (8.6%). Disease was severe in Solapur, Nashik, Ahmed Nagar, Pune and Satara districts of the State. *Ceratocystis fimbriata*, was observed to be the major causal organism of wilt. Besides, other pathogens found associated with wilt infections included *Fusarium* spp., *Macrophomina phaseolina,* root-knot nematode (*Meloidogyne incognita*), shot hole borer, (*Xyleborus fornicatus*) , and stem borer ( *Celosterna spinator*). **Screening of germplasm for wilt resistance**: All the germplasm accessions screened against wilt in a *C. fimbriata* infested sick plot, were found susceptible to wilt. Besides, *C.fimbriata* was also able to infect other genus *Lawsonia inermis.*. **Management:**. Under field conditions wilt was managed effectively by drenching the soil around plants with carbendazim (0.2%)/propiconazole (0.15%)/mancozeb (0.2%) + chlorpyriphos (0.2%) at monthly intervals. Application of phorate (20g/plant) reduced nematode infestation, thereby, managing wilt infections. Bioagents like *Trichoderma viride* and Kalisena (*Aspergillus niger*) were also found effective against *C. fimbriata* under *in vitro* and pot culture studies.

**Insect-pests:** Surveys revealed prevalence of various insect-pests of pomegranate in Maharashtra, Karnataka and Andhra Pradesh. The major insect-pests included fruit

borer, fruit sucking moth, shot hole borer, stem borer, several sucking pests such as aphids, thrips, white flies, mealy bugs, scale insects and mites. Three species of fruit sucking moth *Othreis maternal*, O. *fullonia*, *O. homoena* and one unknown secondary fruit sucking moth were found associated with pomegranate.

**Production of disease free plants through Tissue culture**: Tissue culture laboratory is being established for production of disease free planting material.

## Post Harvest Technology

**Effect pre-harvest sprays of lac formulations on post harvest quality of pomegranate**: Pre-harvest sprays of lac formulations during fruit development stage improved shelf life of pomegranate fruits.

## HRD / Transfer of Technology

The Centre demonstrated OHM schedule successfully at growers' orchards at Solapur, Pune and Osmanabad districts for mitigating bacterial blight disease at 9 locations during 2007-2010.

Organized Model Training Course on Production, Protection and Post harvest management of pomegranate sponsored by Department of Agriculture and Cooperation Ministry of Agriculture, for State Department officers from different states during December 6-13, 2010.

Scientists, Technical and Administrative staff members are being deputed for various short and long training courses related to their fields for capacity building.

**Publications:** The centre has brought out 61 publications as research articles in peer reviewed journals, Book chapters, Review articles, Training manuals, Technical and Extension bulletins, Pamphlets and Popular articles.

## Impact

Pomegranate is a high value crop, mostly used as fresh fruit and to some extent for processing. Having long shelf-life, it is an ideal fruit crop for long distance transport and prolonged storage. It is an ideal crop for the sustainability of small holdings, as pomegranate is well suited to the topography and agro-climate of arid and semi-arid regions. In addition, it provides nutritional security, has high potential to develop wastelands widely available in the region and an ideal crop for diversification. Horticulture research has led to innovations in pomegranate production, thereby, transforming livelihood of people in these semi - arid regions. Since 2000, many

pomegranate growers have been distressed and had started uprooting their orchards due to the enormous losses caused by bacterial blight in particular and other diseases and insect-pests in general. However, Orchard Health Management (OHM) schedule developed in 2007 by the NRCP in collaboration with SAUs, ICAR Institutes and State department of Agriculture restored the confidence in growers to continue pomegranate cultivation profitably. Adoption of OHM schedule in 72 growers' orchards resulted in effective management of bacterial blight and higher quality fruit yields in 57 orchards during 2008-09 and 2009-10 in three major pomegranate growing States of the country. The average cost-benefit ratio ( inputs applied to output) of the management practices and produce obtained was 1:4. Fruit cracking, a major problem in pomegranate in some areas has been managed with proper and regular irrigation and sprays of boron (0.2%) resulting in better gains. Drip irrigation is a remarkable innovation by which pomegranate growers have been greatly benefited as the system saves 50% water requirement as compared to flood surface irrigation and application of nutrients through fertigation results in about 30% increased yields.

# Vision 2030

National Research Centre on Pomegranate envisages various research programmes to face the complex challenges impeding the quality pomegranate production by adopting novel technologies available in the country and abroad for enhancing pomegranate productivity and utilization for the benefit of the various stakeholders involved in the food supply chain. The centre would also strive to become one of the leading organizations with pomegranate germplasm repository.

Vision, Mission, objectives and functions of the NRCP are mentioned hereunder.

## Vision

Promotion of pomegranate industry for enhancing production, utilization and export.

## Mission

To establish repository of pomegranate genetic resources and develop suitable technologies for sustainable production and utilization to meet domestic and export demand.

National Research Centre on Pomegranate would formulate its programmes keeping in view the following objectives to accomplish its Vision and Mission.

## Objectives

- Develop suitable varieties with high yield potential and quality fruits having resistance to biotic and abiotic stresses.
- Undertake basic, strategic and applied research for developing production, protection and post harvest technology for quality production, increasing shelf life and value addition for profitability.
- Act as national repository of pomegranate for further breeding programmes to evolve varieties with high yield and quality fruit traits for health benefits, besides, having resistance against diseases, insect-pests and abiotic stresses.
- Utilization of technologies like molecular biotechnology, genetic engineering, bioinformatics and nanotechnology for pomegranate improvement, production of disease free elite planting material, development of diagnostics for pathogen detection, characterization of germplasm, development of transgenics and packaging.

- Developing technologies for efficient use of nutrients and water for sustainable pomegranate production.
- Exploitation of bio-inoculants for pomegranate productivity and protection.
- Human resource development and capacity building for efficient use and further transfer of technology.
- Pesticide residue analysis of fruits for health and export purpose.

## FUNCTIONS

- To serve as knowledge repository of pomegranate and establish national and international linkages and envisage changing research needs.
- To plan, formulate and conduct research for sustainable pomegranate production and coordinating with other national and international organizations for further development of pomegranate.
- To provide consultancy on pomegranate.
- To disseminate pomegranate technology to growers through different media.
- To involve various stakeholders in food supply chain for developing programmes for production enhancement and utilization besides benefiting growers and generating employment through the involvement of agri-business sector.

## Perspective

During the last one decade although there has been marked increase in the area of pomegranate in the country, production has not been convincing. Several factors could be attributed to the low productivity of the crop, some of which are outbreak of dreadful disease like bacterial blight in epidemic proportion, non-availability of disease resistant cultivars, little awareness of technical know-how about production and protection technologies such as nutrient and water management, flower regulation, cropping season and integrated disease and insect-pest management schedules among the growers. However, effective dissemination of mentioned technologies evolved by ICAR institutes and SAUs have shown positive impact on increased production of crop. In view of the increasing population of the country, expanding pomegranate cultivation may contribute towards providing effective source of food and nutritional security. Although we are leading country of the world in area and production, still far behind in productivity levels as compared to other pomegranate producing countries like Spain, USA and Iran and under such conditions it becomes imperative to adopt innovative technologies for sustained production of the crop. Also, at present country exports only about 4.0% of its total production which is again very low when compared to countries like Spain (37.8%), Israel (23.52%) and USA (15.42%). In order to achieve higher production, productivity and utilization of pomegranate, following key challenges need to be stressed.

In view of the versatile adaptability of the pomegranate, human health benefits, and product diversification through production of processed products like juice, jelly and wine the demand of pomegranate by industries may upsurge further and we may need to produce more.

Keeping in view the growth in area, production and export of pomegranate over the past one decade, it is expected that the pomegranate growth would increase further in years to come. As per the projections, pomegranate area in the country would increase from present 109.9 thousand ha (2010-11) to 332.35 thousand ha and production would increase from present figures of 834.7 thousand tonnes to 2525.31 thousand tonnes in coming 20 years period by 2030.Export which has increased almost 7 fold during the past one decade is further likely to increase from present 33.4 thousand tonnes in 2009-10 to 107.10 thousand tonnes by 2030 (Fig. 14).

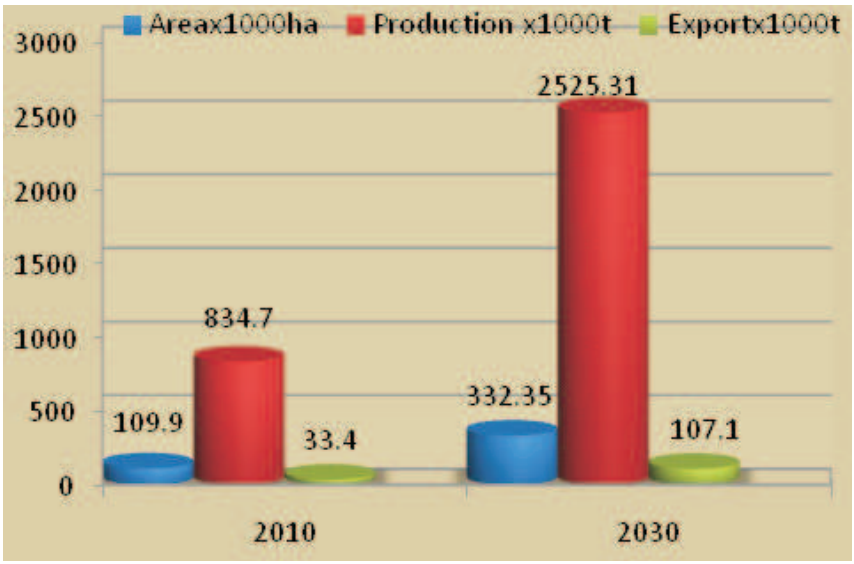


Fig. 14: Pomegranate projected area, production and export by 2030

**Critical inputs: Manpower** : The proposed scientific, technical and administrative staff required is mentioned in Table 1. **Fund requirement:** The expected fund requirement to carry out the programmes is mentioned in Table 5.

## Critical Inputs

Table 5: Tentative fund requirement for carrying out the programmes (Rs in lakh)

| Programmes | 2011-12 | | 2012-2017 | | 2017-2022 | | 2022-2027 | | 2027-2030 | | Total | | Total (Plan + Non-Plan) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan | |
| Crop Improvement | 100.0 | 156.5 | 637.5 | 204.75 | 835.0 | 268.25 | 1095.0 | 351.5 | 1304.25 | 419.00 | 3971.75 | 1400.0 | 5371.75 |
| Crop Production | 120.0 | 187.8 | 765.0 | 245.70 | 1002.0 | 321.90 | 1314.0 | 421.8 | 1565.10 | 502.80 | 4766.10 | 1680.0 | 6446.10 |
| Crop Protection | 100.0 | 156.5 | 637.5 | 204.75 | 835.0 | 268.25 | 1095.0 | 351.5 | 1304.25 | 419.00 | 3971.75 | 1400.0 | 5371.75 |
| Post Harvest Technology | 60.0 | 93.9 | 382.5 | 122.85 | 501.0 | 160.95 | 657.0 | 210.9 | 782.55 | 251.40 | 2383.05 | 840.0 | 3223.05 |
| Transfer of Technology | 20.0 | 31.3 | 127.5 | 40.95 | 167.0 | 53.65 | 219.0 | 70.3 | 260.85 | 83.80 | 794.35 | 280.0 | 1074.35 |
| Total | 400.0 | 626.0 | 2550.0 | 819.0 | 3340.0 | 1073.00 | 4380.0 | 1406.0 | 5217.0 | 1676.00 | 15887.0 | 5600.00 | 21487.00 |

# Harnessing Science

Although conventional methods are available to achieve most of the goals set by the NRCP, these methods often have not been found very convincing in achieving the desired results in a given period of time. However, advent of innovative technologies and tools like molecular biotechnology, informatics, bioinformatics, nanotechnology and precision farming have contributed significantly in enhancing production through nutrient and water use efficiency, developing varieties resistant to biotic and abiotic stresses, developing transgenics for disease resistance, production and mass multiplication of disease free planting material and detection of pathogens for accurate diagnosis of a diseases. The NRCP, besides working on conventional scientific methods would be harnessing these novel technologies to accomplish the desirable results as mentioned below.

**Germplasm Enhancement**: The centre has already collected about 345 germplasm both indigenous and exotic and these would be used for sustainable pomegranate production through i) Evaluation of germplasm for biotic and abiotic stresses ii) Evaluation of germplasm for any variability, natural or induced through mutagens and iii) characterization of germplasm through molecular biotechnology. DNA finger printing of the germplasm is being performed using ISSR and RAPD methods in collaboration with NBPGR, New Delhi where IISR method produced more polymorphic profiles to SSR and RAPD methods.

**Biotechnology:** Biotechnology is also being used to develop transgenics resistant against bacterial blight at IIHR Bangalore. NRCP has already established linkages with IIHR Bangalore where facilities for biotechnological approach exists. NRCP also got identified bacterial blight cultures as *Xanthomonas axonopodis* v. *punicae* from CICR Nagpur through PCR based technology available at the Institute. Molecular biotechnology is also being utilized for the development of diagnostic kit for detection of bacterial blight pathogen (*Xanthomonas axonopodis* pv. *punicae*) at IARI New Delhi and NRCP would be working in collaboration with IARI on molecular aspects of bacterial blight as the institute has well equipped laboratory facilities to carry out bitechnology work. NRCP has also established linkages with Agharkar Research Institute, Pune for identification of bioagents based on molecular markers. Efforts would also be made to develop transgenics through genetic engineering resistant to abiotic stresses like fruit cracking, sunscald and internal breakdown of arils. Genes expressing

under various stresses would be identified for their probable use in the transgenics. Pyramiding of selected genes in an elite genotype would be attempted for developing abiotic stress resistant transgenic plants. Biotechnology is also being used at the NRCP for production and mass multiplication of elite disease free plants through tissue culture.

**Production enhancement through management of natural resources**: Studies would be conducted to enhance the nutrient and water use efficiency for sustainable production of pomegranate. Integrated plant nutrient system (IPNS) and Integrated disease and pest management (IDPM) systems would be developed and perfected by harnessing science of informatics through ICT ( Information and communication technology) based surveys in collaboration with NCIPM, New Delhi. Geoinformatics in precision farming would be utilized for pomegranate production, protection, weed control and forecasts of diseases and insect-pests and their management which would reduce the input cost, increase the yield and reduce the environmental impacts by suitable inputs applied to crop needs. Development of simulation models based on Geographical information System (GIS) would be helpful in visualizing different climate scenarios and their pomegranate production. Studies would be conducted on plant canopy architectural engineering and suitable rootstocks for enhancing productivity through efficient use of water and nutrients. In order to exploit the potential of bioagents in pomegranate productivity centre will be having linkages with organizations like NBAIM, Mau. Drip irrigation and fertigation systems are being used and would be further improved to enhance pomegranate production through efficient use of water and nutrients.

**Post Harvest Technology**: In view of the known nutritional and medicinal properties of the pomegranate and for enhancing crop utilization, NRCP would be initiating studies on processing by developing value added products like aril packs, juice, jelly and wine. The linkages are being established with CIPHET Ludhiana, IIHR Bangalore, CFTRI Mysore, MPKV Rahuri and MAU Parbhani. For the purpose of processing, the centre has already got analysed fruits for their physico-chemical properties from NIN Hyderabad. Studies on post harvest losses and their management would be carried out by application of chemicals and storing fruits in cold storage at required temperatures and humidity.

**Pesticide Residue Analysis**: Pesticide residue levels in food commodities are becoming a major concern for food regulators all over the world, hence it is essential

that adequate monitoring should be in place to eliminate possibility of presence of the residues in the fruits in excess of prescribed limits. NRCP has already been getting analysed the fruits from NRCG Pune for residual levels. Similarly there are many recognized private laboratories in the state for conducting pesticide residual analysis of fruits particularly for export purpose as these laboratories have advanced pesticide monitoring equipments. NRCP has already submitted a project proposal on 'Establishment of referral laboratory for pesticide residue analysis' to APEDA for approval.

**Transfer of Technology**: Efforts would be made to deliver the developed technology in a more effective mechanism through information and communication technology delivery system for linking research with other stakeholders.

Besides, NRCP has established linkages with International organizations like Agricultural Research Organization ,Israel and USDA, USA( California) for exchange of germplasm.

# Strategies and Framework

Following strategies and related activities will be prioritized and carried out to achieve the vision and objectives of the centre.

1. Germplasm enhancement and developing varieties for quality yield, resistance to biotic and abiotic stresses through conventional and molecular breeding.

- Survey, collection, evaluation, characterization, conservation and propagation of pomegranate.
- Evolving high yielding and disease resistant varieties against bacterial blight and other biotic and abiotic stresses through conventional breeding and transgenics
- Screening of germplasm for bacterial blight and wilt resistance and other biotic and abiotic stresses.

2. Development of technology for sustainable pomegranate production.

- Identification of suitable soils for sustainable pomegranate production.
- Development of Integrated plant nutrient system (IPNS).
- Improving water use efficiency of pomegranate during different phenological stages and seasons.
- Screening of rootstocks for resistance to wilt and nematodes and abiotic stresses.
- Exploitation of bio-agents for pomegranate production and protection.
- Standardization of canopy architecture.
- Production of elite, disease and insect-pest free plantlets through tissue culture and their mass multiplication.

3. Identification and management of important diseases and insect-pests of pomegranate.

- Development of effective Integrated disease and insect-pest management (IDPM) schedule for mitigation of important diseases namely bacterial blight, wilt and fruit spots and rots and insect-pests like fruit borer and sucking pests of pomegranate.
- Studies on Fruit borer (*Deudorix Isocrates*) and fruit sucking pests of pomegranate and their management
- Development of new and effective molecules/ bio-formulations for the management of important diseases and insect-pests. Development of weather based forecasting system for major diseases and insect-pests.
- Development of diagnostic kits for detection of important diseases like bacterial blight and wilt.

- Studies on physiological disorders of pomegranate and their management.
- Pesticide residue analysis of fruits for safety standards.

4. Product diversification, value addition and management of post harvest losses of pomegranate.
- Technology for increasing shelf life of fruits.
- Development of Cold stores for long storage of fruits for management of post harvest losses
- Development of technology for processing and value addition.

5. Transfer of Technology /HRD
- Training courses for extension personnel and growers on pomegranate production.
- Organization of farmers' fairs and front line demonstrations based on technology developed Capacity building of personnel.

# Epilogue

National Research Centre on Pomegranate established in 2005 by the Indian Council of Agricultural Research to enhance pomegranate quality production and utilization through basic, strategic and applied research, has been working on research programmes developed by it on the basis of centre's mandate and problems of farming community since then. After about five and a half years of its establishment some of the goals under different projects have been achieved and activities related to remaining are being carried out and some new programmes have just been formulated.

Under the plant improvement programme, the centre has collected about 345 germplasm from different parts of the country and USA which are being maintained at the field gene bank of the centre. Some of the germplasm have been characterized through DNA fingerprinting and found polymorphic, thereby, revealing interaspecific diversity. Efforts to create variability through gamma irradiation have resulted in about 35 mutants in the population of cv Ganesh and are being evaluated for different growth parameters for further use in breeding programmes. Work on hybridization for breeding varieties for blight resistance and also for enhancing quality and yield has been initiated involving commercial and blight tolerant cultivars.

For enhancing pomegranate production different activities have been undertaken and experiments are in progress on identification of suitable soils, integrated nutrient and water management for their efficient use in enhancing production and organic pomegranate production. Some major nutrient deficiency symptoms have been identified. Efficiency of drip irrigation and fertigation systems in improving pomegranate production and quality is being studied. Tissue culture laboratory is being established and work on standardization of protocol for developing healthy and disease free plantlets is underway.. Exploitation of bioagents for pomegranate production and protection, which forms an important part of the ongoing studies, has revealed promising results.

In plant protection, major diseases and insect-pests have been identified on the basis of exhaustive surveys. The causal organism of intractable bacterial blight, the most dreadful disease which ravaged the pomegranate plantation in all major pomegranate growing states during the past one decade, has been identified on the basis of cultural and molecular (PCR based technique) studies as *Xanthomonas axonopodis* pv.

*punicae* . The etiology of another threatening disease, wilt, has also been ascertained and *Ceratocystis fimbriata* has been observed to be the major cause of the disease. Orchard Health Management schedule has been developed for the integrated management of various diseases with main focus on bacterial blight and important insect-pests and found effective in bacterial blight mitigation and increasing yields at many locations. The biology of fruit borer (*Deudorix Isocrates*) and fruit sucking moth (*Othreis* spp.) is being studied.

Post harvest management and processing for enhanced utilization and marketability of pomegranate would be the major thrust area of the NRCP in coming years, for which project has been formulated and some experiments on management of post harvest losses are in progress.

Technologies related to pomegranate production have been effectively delivered to the growers and extension workers and other stakeholders in the food chain through Technical bulletins, Training manuals, Books, and print and air media. Besides, training courses for state department staff and farmers' day are being also organized to disseminate the latest technology to growers for sustainable pomegranate production.

# Annexure

**Strategy Plan Framework**

Table 6: Progremmes, Targets and Actions for achieving goals .

| Programme | Objectives | Actions | Performance measures |
|---|---|---|---|
| 1.Pomegranate Improvement | i) Germplasm enhancement | a. Survey, collection, evaluation, characterization, conservation and propagation of pomegranate. | Germplasm maintained and characterized |
| | ii) Development of varieties resistant against biotic and abiotic stresses with high yields | a. Evolving high yielding and disease resistant varieties against bacterial blight and other biotic and abiotic stresses through conventional breeding and transgenics. | Developed resistant varieties with high quality yields. |
| | | b. Screening of germplasm for bacterial blight and wilt resistance and other biotic and abiotic stresses. | Germplasm found resistant. |
| 2.Pomegranate Production | i) Development of technology for sustainable pomegranate production. | a. Identification of suitable soils for sustainable pomegranate production. | Suitable soils identified for sustainable pomegranate production. |
| | | b. Development of Integrated plant nutrient system (IPNS). | Developed IPNS for quality yields. |
| | | c. Improving water use efficiency of pomegranate during different phenological stages and seasons. | Developed efficient irrigation technology for pomegranate. |
| | | c. Screening of rootstocks for resistance to wilt and nematodes and abiotic stresses. | Identified resistant rootstocks against wilt and abiotic stresses. |
| | | d. Identification of dwarfing rootstocks for high and ultra high density planting. | Technology developed for high density planting. |
| | | e. Exploitation of bio -inoculants for pomegranate production and protection. | Technology involving bio-inoculants developed for quality production. |
| | | f. Standardization of canopy architecture. | Canopy architecture standardized for quality higher yields. |

| Programme | Objectives | Action | Performance measures |
|---|---|---|---|
| | ii) Production of healthy and disease free planting material. | a. Production of elite, disease and insect-pest free plantlets through tissue culture and their mass multiplication. | Produced elite and disease free pomegranate saplings (quantity) . |
| 3. Pomegranate Protection. | i) Identification and management of important diseases and insect-pests of pomegranate. | a. Development of effective Integrated disease and insect-pest management (IDPM) schedule for mitigation of important diseases namely bacterial blight, wilt and fruit spots and rots and insect-pests like fruit borer and sucking pests of pomegranate. | Developed IDPM schedule for the management of important diseases and insect-pests of pomegranate. |
| | | b. Studies on Fruit borer (*Deudorix Isocrates* ) and fruit sucking pets of pomegranate and their management. | Technology developed to manage fruit borer and fruit sucking pests. |
| | | c. Development of weather based forecasting system for major diseases and insect -pests. | Developed forecasting model for predicting important diseases and insect-pests severity. |
| 4. Post Harvest Technology | i) Product diversification, value addition and management of post harvest losses of pomegranate. | a. Technology for management of post harvest losses and increasing shelf life of fruits. | a. Technology developed for increasing shelf life of fruits. |
| | | b. Development of Cold stores for long storage of fruits. | Cold store constructed. |
| | | c. Technology for processing of fruits and development of processed products like aril packs, juice and wine. | Processed products developed. |
| 5. Transfer of Technology | i) Organizing training courses, farmer' fairs and Demonstration trials depicting developed technology. | a. Training courses for extension personnel on pomegranate production and Organization of farmers' fairs and front line demonstrations based on technology developed. | a.Trainings and Demonstrations organized. |

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