भाकृ अनुप
ICAR

वार्षिक प्रतिवेदन
Annual Report
2014-15

(ISO - 9001:2008 Certified Institute)

भा.कृ.अनु.प.– राष्ट्रीय अनार अनुसंधान केन्द्र
ICAR - National Research Centre on Pomegranate

(भारतीय कृषि अनुसंधान परिषद)
(Indian Council of Agricultural Research)

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Solapur - 413 255

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PREFACE

With the establishment of ICAR-National Research Centre on Pomegranate at Solapur, Maharashtra in 2005, India experienced a quantum jump in production and export and became the world leader in area and production of pomegranate. It has come to the rescue on sustainable livelihood security to many farmers in the dry land regions of India particularly in Maharashtra, Karnataka, Gujarat, Telengana, Rajasthan and Madhya Pradesh due to its highest return on investment from a small piece of land. During the past one year pomegranate faced an exponential growth in the expansion of cultivated area by approximately 1000 ha so as the productivity from the national average of 6.9 t/ha to 10.27 t/ha due to awareness on various horticultural technologies supported by organized marketing.

During the past one year several new initiatives and development took place at the ICAR-NRCP Solapur. Apart from reorganization of research projects, the team NRCP attracted 6 externally funded projects. Similarly, 4 ICAR plan projects viz. Flagship project on eradication of bacterial blight in pomegranate, ORP on sucking pests, CRP on borer pests and water management of pomegranate have started functioning with multi-institutional collaboration. Research on processing and value addition of pomegranate got a new focus on the concept of total utilization of pomegranate, e.g. utilization of pruned wood from healthy orchards for planting material, arils for minimal processing or juice extraction or wine production, seed for virgin oil extraction and dried peel for extraction of bio-colour / organic mouth wash etc. Research on mitigation of climate change through protected cultivation of pomegranate under insect proof net house has been initiated. Experiments on sub-surface in-line drip system in pomegranate has been showing great potentiality of water saving (to the tune of 70% as compared to normal on-line surface drip irrigation) in order to achieve **"more crop per drop"** concept. Supplied disease free elite planting materials of pomegranate and technology package for establishment of demonstration orchards at KVK Barkachha, Mirzapur (U.P.), SVPAT, Meerut (U.P.), KVK-Korea (Chattisgarh), CIH-Dimapur (Nagaland), ICAR-CAZRI, Jodhpur (Rajasthan), ICAR-IISWC-Dehradun (Uttarakhand) and to many progressive growers. The research team identified potential endophytes and SSR markers linked with tolerance to bacterial blight. Developed the soil health card of Kegaon research farm of ICAR-NRCP Solapur.

Android based mobile application developed ICAR-NRCP containing the basic information on pomegranate in three languages i.e. Hindi, Marathi and English that was launched by Hon'ble DDG (HS) on 7th Dec, 2015. This application has become very popular among various stakeholders of pomegranate as evident from the feedback and huge downloads (>5000) within a very short time not only from India but also from all over the world. This was the first initiative of **Minimum Government Maximum Governance** principle followed by ICAR-NRCP, Solapur. A meeting with pomegranate exporters, APEDA, progressive growers and MSAMB was held to identify the gaps for boosting export of pomegranate in Europe and USA. ICAR-NRCP Solapur was granted ISO 9001-2008 Certification. Works on construction of 43 bed trainees' hostel and lift irrigation have been initiated. Crop insurance triggers of pomegranate have been prepared. The MIS and FMS system and Rashtriya Swachata Mission were implemented. Finally a Society for Advancement of Research on Pomegranate (SARP) was registered as its founder President with its HQ at ICAR-NRCP Solapur and organized a mega-event of National Seminar-cum-Exhibition on Pomegranate.

I place on record my sincere gratitude to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for providing the opportunity to render my best service. I express my heartfelt thanks to Dr. N.K. Krishna Kumar, DDG (Horticultural Science) for the unwavering support and constant guidance. Thanks are also due to Dr. C.D. Mayee, former Chairman, ASRB and Chairman, RAC of NRCP and members of IMC and RAC for taking keen interest in the overall development of the institute. Last but not least, I'm thankful to all the scientific, technical, administrative and supporting staff of the institute for their wholehearted support and cooperation.

June 15, 2015
Solapur

(R.K. Pal)
Director

ICAR - NRCP : AN INTRODUCTION

Pomegranate (*Punica granatum* L.) is an important fruit crop of arid and semiarid regions of the world. India is one of the leading producers of pomegranate in the world. In 2013-14, the annual increment in area under cultivation of pomegranate has strikingly gone up by 15.92 per cent. In India, it is cultivated over 1.31 lakh ha with an annual production of 13.46 lakh tonnes and average productivity of 10.27 tonnes/ha. Maharashtra state experienced a very rapid growth in pomegranate area during the last 2 decades from 4.6 thousand ha to 90.0 thousand ha and accounts for 68.70 per cent of the total cultivated area under pomegranate in the country. Maharashtra is the leading producer of pomegranate in India followed by Karnataka, Gujarat and Andhra Pradesh. During this year, Gujarat has taken over Andhra Pradesh with respect to area under cultivation. In recent past, pomegranate cultivation has been gaining momentum in Rajasthan, Orissa, Chhattisgarh, Uttarakhand, Madhya Pradesh, Himachal Pradesh and Tamil Nadu.

With the focus of augmenting the production, productivity and utilization of pomegranate through basic, strategic and applied research, ICAR-National Research Centre on Pomegranate was established at Solapur, Maharashtra during 2005 by the Indian Council of Agricultural Research (ICAR). The centre has been functioning at Kegaon, Solapur in its newly built office- cum-laboratory building since 7 July 2013.

The experimental farms sprawl over 46.26 ha area at Kegaon and Hiraj villages with a pomegranate plantation area of 12 ha. Hi-tech polyhouses erected in the farm facilitate the R&D work on mass multiplication of elite, disease free planting material produced through tissue culture and screening of germplasm for bacterial blight tolerance. The experimental farms encompass the state-of-the-art automatic fertigation facilities and water harvesting structures. The national repository of pomegranate at ICAR-NRCP has 304 germplasm collection including the wild accessions, indigenous collections from North Eastern states and western Himalayas including 92 exotic collections from California, Afghanistan and Iran.

Crop improvement, crop production, crop protection and post harvest technology cover the major thrust areas of pomegranate research at ICAR-NRCP, Solapur. The mandates of the centre as per the approved QRT recommendations are :

- To undertake basic, strategic and applied research for crop improvement, productivity, protection, fruit quality, post harvest technology and value addition.
- To act as national repository of pomegranate germplasm and its exchange within and outside the country.
- Technology transfer, training, consultancy and human resource development in the areas of pomegranate research and provide relevant information in public domain.

ICAR-NRC on Pomegranate has made remarkable achievements in identification of causal organism for bacterial blight and developed an Integrated Disease and Insect Pest Management (IDIPM) schedule for management of insect pests and diseases affecting pomegranate. Bacterial blight in pomegranate is the major impediment in pomegranate production in India. In view of non availability of resistant sources for this dreaded disease, scientifically sound management system and community approach are the important steps for mitigation of this challenge.

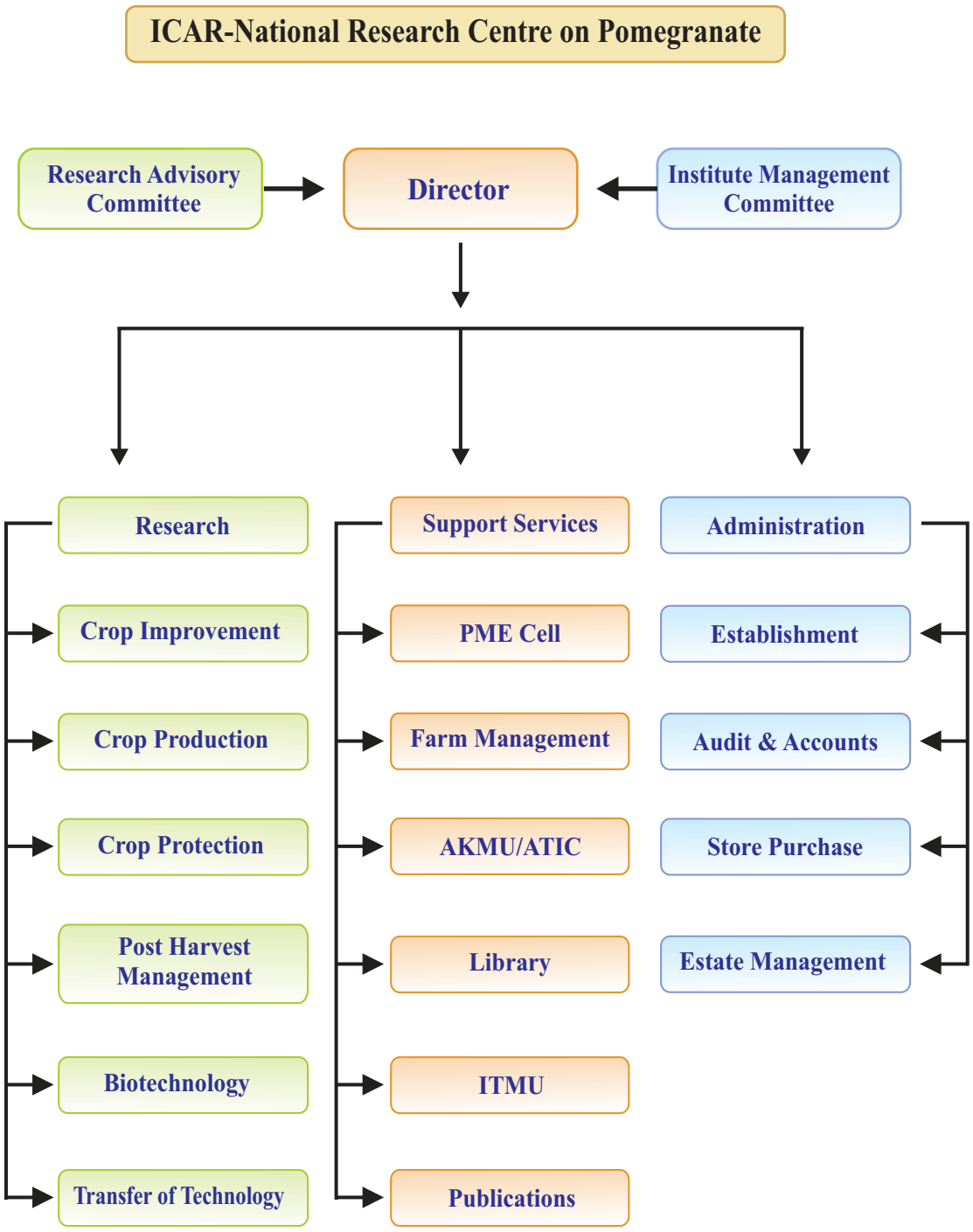
In this context, a video film was developed by ICAR-NRCP in three languages (English, Hindi, Marathi) for creating awareness on management of bacterial blight. An Android based mobile application, developed by ICAR-NRCP contains the basic information on pomegranate in three languages i.e. Hindi, Marathi and English for the benefit of pomegranate growers. Of late, ICAR-NRCP Solapur was granted ISO 9001-2008 Certification.

The low cost technology for production of disease free planting material through hardwood cuttings with 75-80% success has been standardized and commercialized. Protocol has been standardized and commercialized for *in-vitro* propagation of pomegranate cv. Bhagawa with bio-hardening. The technology for preparation of RTS beverage from pomegranate juice has also been commercialized. The protocol for extraction of seed oil from pomegranate seeds has been standardized. The technology for production of sparkling pomegranate wine from pomegranate cvs. Ganesh and Bhagawa was developed. The research team has identified potential endophytes and SSR markers linked with tolerance to bacterial blight. Crop insurance triggers of pomegranate have been prepared. Technical bulletin on 'Pomegranate cultivation, marketing and utilization', NRCP at a glance, Souvenir of the National Seminar-cum-Exhibition on Pomegranate were published by ICAR-NRCP during this year for the benefit of pomegranate growers.

The centre has been equipped with the state of the art facilities, laboratories and farms to carry out research on production, plant protection, crop improvement, and post harvest technologies on pomegranate. Many sophisticated equipment viz. PCR, dry ashing system, walk-in cold rooms, cabinet driers, grinding mill, color difference meter, cold press for seed oil extraction, food texture analyzer, high resolution microscopes, AAS, Photosynthetic apparatus etc. have been procured for various research activities. The ICAR-NRCP is regularly imparting both onsite and off-site trainings on various aspects of pomegranate cultivation. Apart from in-house research activities, the ICAR-NRCP also has various outreach programmes.

ICAR-NRCP is closely associated with All India Pomegranate Growers' and Research Association besides Maharashtra Pomegranate Growers' and Research Association, State Department of Horticulture, State Agricultural Universities, KVKs and other stakeholders of pomegranate cultivation. To cater the needs of a large number of farmers visiting the centre, a touch screen kiosk has been procured for demonstration of scientific management practices. The website of ICAR-NRCP designed as per the uniformity guidelines of ICAR offers the regular update on weather, farmers' alert and important events etc besides freely downloadable publications for farmers and researchers.

A Society for Advancement of Research on Pomegranate (SARP) was registered at ICAR-NRCP, Solapur with Dr. R.K. Pal as its founder President and organized within 6 months of its establishment a mega-event of National Seminar-cum-Exhibition on Pomegranate. During 2014, ICAR-NRCP Solapur was granted ISO 9001-2008 Certification for its high standard research and management activities.



Organizational Structure

कार्यकारी सारांश

भा.कृ.अनु.प.-राष्ट्रीय अनार अनुसंधान केन्द्र के दस वैज्ञानिक,पाँच तकनिकी, एवं दो सहायक कर्मचारीयों द्वारा 2014-15 में विभिन्न शोध, प्रशिक्षण, विस्तार, तकनिकी हस्तांतरण तथा अन्य पहलों का विवरण निम्नलिखित है ।

तीस नए जननद्रव्यों के प्रक्षेत्र जीन कोष नें रखरखाव के अलावा 15 जननद्रव्यों के लिए आई.सी.संख्या प्राप्त की गई । क्रार्योपरिरक्षण अध्ययन के दौरान 'भगवा' तथा 'जोधपुर रेड' किस्मों के नर पुष्पों के परागकण की अंकुरण क्षमता अच्छी पायी गई । बारह किस्मों तथा 32 जंगली जननद्रव्यों के सीक्वेंस रीलेटेड ऑम्लीफाइड पालीमार्फिज़्म द्वारा आनुवंशिक भिन्नता अध्ययन से दानों समूहों में सार्थक भिन्नता पायी गई । चव्वालीस बहुरूपी एस एस आर चिन्हकों के माध्ययम से 88 जंगली तथा खेती योग्य अनार के जननद्रव्यों का आनुवंशिक भिन्नता तथा पापुलेशन स्ट्रक्चर अध्ययन किया गया। नेबर ज्वाइनिंग ट्री में चार में से तीन समूहों को जंगली जननद्रव्यों के झुंड में रखा तथा एक समूह को खेती योग्य झुंड में रखा गया। आणविक भिन्नता विश्लेषण ने उत्तराखंण्ड एवं हिमाचल प्रदेश (समूह 1 एवं 2) तथा मध्यम एवं कम ऊँचाई वाले जम्मू एवं कश्मीर (समूह 3) से संग्रहीत जननद्रव्यों तथा खेती वाली किस्मों (समूह 4) के बीच क्रमश: 0.23, 0.20 एवं 0.19 की आनुवंशिक दूरी दर्शायी गई । माध्य आनुवंशिक दूरी समूह 1 एवं 2 के बीच 0.07 पायी गई तथा यह दूरी समूह 1 और 3 के बीच 0.17 तथा समूह 2 और 3 के बीच 0.15 पायी गई । समूहों के बीच का वेरियस समूह के अंदर के वेरीयस कम पाया गया, इससे यह प्रतीत हुआ की जीन्स का बिना अवरोध एक समूह से दूसरे समूह के बीच संचार रहा था ।

एक सशक्त बहुरूपी 44 एस एस आर चिन्हकों के समूह के इस्तेमाल से 88 जंगली तथा खेती योग्य जननद्रव्यों की जीनो टाइपिंग की गई, जिनकी फिनोटाइपिंग पहले से ही की गई थी । जनरल लीनीयर माडल के माध्यम से चार चिन्हकों को फल अम्लता, फ्ल भार तथा बैक्टेरियल ब्लाईट सहष्णुता से जुडा हुआ पाया गया । पी जी सी टी 001 बानीफिरानी करेक्शन के उपरान्त दोनों वर्षो के लिए फल भार से जुडा हुआ पाया गया । पी जी सी टी 001 फल भार एवं बैक्टेरीयल ब्लाईट सहष्णुता से भी जुडा हुआ पाया गया । तीन पद्धितियों क्रमश: सीटेब-एल आई सी एल, डायरेक्ट जोल आर एन ए मिनी प्रेप तथा ट्रायजोल का अधिक फिनाल वाली अनार की कोशिकाओं से उच्च दर्जेके आर.एन.ए. निष्कर्षण पर सापेक्षिक प्रभाव का अध्ययन किया गया । सीटेब-एल आई सी एल पद्धति द्वारा आर एन ए की मात्रा 603-636 माइक्रो ग्रा प्रति ताजा ग्राम भार/ड्यूल कल्चर तकनीक द्वारा 17 जीवाणु तथा 3 फफूंद इडोफाइट्स की स्क्रीनींग इन विट्रो में की गई । जीवाणु आइसोलेट्स ने एक्स ए पी की वृद्धि को 17.95 - 34.04 प्रतिशत तक रोकी तथा फफूँद के लिए यह संख्या 43.88% इएफ 2 के लिए एवं 50.08% इएफ 3 के लिए पायी गई । पाँच जीवाणु तथा तीन फफूँद इडोफाइट्स के उपयोग से फस्कन उत्पादन में घटाव अथवा सम्पूर्ण अवरोधन हो गया, फस्कन जो कि बीमारी का कारक हो ता है, इससे यह निष्कर्ष निकाला की ये इडोफाइट्स एक्स ए पी की बीमारी क्षमता का सम्पूर्ण नाश करते है।

सात व्यवसायिक किस्मों के मूल्यांकन ('गणेश', 'भगवा', 'रुबी' 'जालोर सीडलेस', 'जी-137', 'अरक्ता', मुदुला') में सर्वाधिक उपज 'जी -137' (25.65 कि. ग्रा प्रति पेड) जिसके उपरान्त 'गणेश' (23.52 कि. ग्रा प्रति पेड) में पाया गया जबकि पौधे 4.5 x 3.5 मी. की दूरी पर थे तथा 6 वर्ष की आयु के थे। बैक्टीरियल ब्लाईट सहिष्णु संकर के विकास के लिए उपयोग में लाये गए 6: क्रासेस में से सबसे ज्यादा फलस्थापना गणेश x एवं भगवा x एक्सेशन 5 में पाया गया (40.0%) ।

माडिफाइड एम एस मिडियम में मिश्रित बी.ए पी., एन ए ए तथा एडनीन सल्फेट पर कल्चर स्थापन 'सुपर भगवा' तथा 'वडर फुल' में क्रमश: 83 एवं 82.50 प्रतिशत पाया गया । माइक्रो शूटिंग के प्रति पक्ष शाखों की औसत संख्या 'वंडरफुल' (3.90) की तुलना में सुपर भगवा (4.1) में अधिक थी। जडा सफलता भी 'सुपर

भगवा' (72%) में वंडरफुल (66%) की तुला में अधिक पाया गया ।

चार व्यवसायिक किस्मों में बायोमास विभाजन विश्लेषण में मुदुला' में सर्वाधिक नत्रजन (56.82 ग्रा/पौधा) फास्फेट (4.45 ग्रा/पौध) कैल्शियम (16.48 ग्रा/पौध) मैग्निशियम (13.39 ग्रा/पौध) तथा गंधक (16.48 ग्रा/पौध) पाया गया तथा गणेश में पोटाश (30.01 ग्रा/पौध) सबसे अधिक पाया गया । विभिन्न किस्मों द्वारा गुरु पोषक तत्वों के उद्ग्रहण का क्रम इस प्रकार पाया गया, कैल्शिय त्रजा पोटाश गंधक फास्फेट । जबकि पोशक तत्वों के उपयोग में 'भगवा' सबसे प्रभावशाली पाया गया तथा इसके बाद 'गणेश', मृदुला', और 'अरक्ता' का स्थान था ।

फल भार एवं उपज ने फास्फेट एवं मैग्नीज एकत्रण के साथ सकारात्मक सहसम्बधन दर्शाया । कुल फिनाल ने कैल्शियम तथा पोटाश के साथ, एंथोसायनीन कैल्शियम के साथ तथा रस में सम्मलित एस्कार्बिक एसिड ने फास्फेट एकत्रण के साथ सकारात्मक सहसंबंधा दर्शाया, रस में सम्मलित कुल घुलाशील ठोस ने फास्फेट तथा मैग्नीज के साथ और रस अम्लता ने फ्ल में जस्ता एकत्रण के साथ सकारात्मक सहसम्बंधन दर्शाया ।

वानस्पतिक वृद्धि प्राचलों की दृष्टी से ऊपसतहीय ठिंबक सिंचन दो लेटरल (30 x 30 सें मी) तथा के साथ चार ठिंबकों एवं 0.2 ई टी आर वाष्पोत्सर्जन के साथ अय संप्रयोगों की तुलना में बेहतर था । दो लेटरलों के साथ उपसतहीय ठिंबक सिंचन मृदा नमी को बरकरार रखो में उत्तम था । गने के बगास या काली प्रवेशक पालीथीन द्वारा पलवारान, उपज तथा जल संरक्षण की दृष्टी से दूसरे जैविक तथा अजैविक पलवारों की तुलना में बेहतर पाया गया है।

कुल मिलाकर 204 ट्रायकोंडर्मा स्पीसीज, 177 स्युडोमोनास स्पीसीज एवं 118 बॅसिलस स्पीसीज. का उत्प्रेषण तथा इन विट्रो प्रभावशीलता अध्ययन एक्स ए पी के खिलाफ किया गया था । ब्लाईट नियंत्रण के लिए दो नई प्रभावशाली स्पीसीज स्युडोमोनास जेलीकुलाटा और स्यूडोमोनास प्लीकोग्लोसिडिया पायी गई। स्युडोमोनास फ्लोरसेन्स के तीन सशक्त वियोजनों का जैथोमोनास एग्झोीपोडिस पी.वी. प्युनिकी के खिलाफ परीक्षण किया गया । बैक्टीरियल ब्लाइट जीवाणु के निवेषन के 7-15 दिन पुर्व छिड़काव की स्थिति में सभी तीन वियोजन ब्लाइट के विरुध्द प्रभावशाली पाये गए। कंट्रोल की तुलना में (68.33% आपतन एवं ग्रेड 3 तीव्रता) ब्लाइट आपतन 58.54-66.83% तथा तीव्रता 22.23-33.33% इन वियोजनों के प्रभाव से कम पायी गई । स्युडोमोनास के निवेश्य के लिए नीम तेल, करंज तेल अनुकुल पाये गए जबकि लौंग तथा लौंग कली तेल एक्स एग्झोीपोडिस की वृध्दि को एन विट्रो स्थिति में रोकता पाया गया। सिलिकना, सेलिसिलिक एसिड तथा चिटोसन आधारित फार्मुलेशन ब्लाइट को क्रमश: 75.5, 74.5 तथा 71.5% कंट्रोल की तुलना में (34.0) घटाते पाए गए । ब्लाइट न्युनन, फल फ टाव रोकने एवं फल संख्या/ऊपज बढ़ाने में सल्फेट आफ पोटाश की सार्थक भूमिका पायी गई है।

'भगवा', 'नाना', 'दारु', 'गणेश' के इन सिलाको पीसीआर एम्पलिफिकेशन के बाद जैन्थोमोनास इटरेक्टींग जीन होमोलागस सीक्वेंस 8 में से 6 प्राइमर्स में पाया गया । ये जींस जैथोमोनास आक्रमण के प्रभावशाली नियंत्रण के लिए महत्वपूर्ण हैं।

दृढ़ काष्ठकर्तन द्वारा स्वस्थ पौध सामग्री के लिए स्वच्छता नवाचार का विकास किया गया । -80^0 से पर 20% ग्लीसराल, जैथोमोनास के दीर्घ कालीक भंडारण के लिए प्रभावशाली तरीका पाया गया । 101 सप्ताह के भण्डारण के बाद भी वियोजा पैथोजनिक थे । मल्टीलोकस सीक्वेंस टायपिंग पर आधारित जीनोटायपिंग, अनार में संकीर्ण आनुवंशिक बेस अथवा कम आनुवंशिक भिन्नता, आयडेंटिकल एलील प्रोफाइल के जरिए दर्शाती पायी गई ।

एक हजार से अधिक दारू के संततियों को ब्लाईट के खिलाफ स्क्रीन किया गया, दो पौधों के छोड़कर सभी संवेदनशील पाये गए । 66 संग्रहण ब्लाइट विमुक्त तथा 14 कम संवेदनशील/सहिष्णु पाये गए जिनमें 5% से कम अथवा बराबर ब्लाइट था। इसमें से चार संग्रहक आई सी 318793, 318743, 318716 तथा 1181, 2010 की स्क्रनिंग में भी कम संवेदनशील पाये गए थे।

विभिन्न मौसमी घटकों में से तापमान 25-30^0 से. तथा सापेक्षिक आद्रता 50% से अधिक, ब्लाइट के प्रसार में सबसे महत्वपूर्ण घटक थे । वायु वेग, वर्षा एवं

वर्षावाले दिन, वो अन्य घटक थे जो सार्थक तथा सकारात्मक रुप से ब्लाईट को प्रभावित करते हुए पाये गए। 30% से कम सापेक्षिक आद्रता सार्थक परन्तु नकारात्मक रूप से ब्लाइट को प्रभावित करती पायी गई ।

मर रोग के लिए सीरेटोसीस्टीस फिम्ब्रीयाटा 80.46 नमुनों में अकेले या किसी अन्य जीव के साथ पाया गया जबकि 46.13% नमूनों में अकेले पाया गया । सूत्रकृमि ने 9.2 नमूनों में अकेले तथा 20.69 % नमूनों में सीरेटोसीस्टीस फिम्ब्रीयाटा के साथ संक्रमण किया। ग्रसित मृदा में सीरेटोसीस्टीस फिम्ब्रायाटा 19 महीनों तक जीवित पाया गया । चार जैव एजेट्स में से बी ए 6 (1) मर रोग की शुरूआत को 8 हफ्ते तक पीछे करो में प्रभावशाली रहा था । 50% मर रोग आने में 24 हफ्ते लग गए । आई सी 1272, 1289, 1256 एवं 1253 जननद्रव्य विभिन्न फफूँद एवं सडऩ किटाणुओं से युक्त पाये गए ।

पाली प्रोपयलीन नान वोवन बैग्स ने फल चूषीशलभ के खिलाफ 100 प्रतिशत सुरक्षा दि परन्तु इन बैग्स ने ब्लाईट आपतन, तीव्रता एवं फ ल सडऩ को बढा दिया । इन बैग्स के प्रयोग से फल का रंग तथा विटामिन सी फल रस में बढा हुआ पाया गया ।

उष्म परिरक्षण ने दर्शाया की वह 80^0 से. पर 2 मिनट के लिए रस प्रसंस्करण में प्रभावशाली हैं । आधे कटे फल से निकाले गए रस में अस्कार्बिक एसिड, एंथोसायनिन, कुल फिनाल मात्रा एवं रंग, दानों से निकाले गए रस की तुलना में अधिक पाया गया । न्यूनतम प्रसंस्करण एवं संवेष्टा अध्ययन से यह ज्ञात हुआ की सेलिसलिक एसिड, घृतकुमारी लेप एवं अस्कार्बिक एसिड : सायट्रिक एसिड के उपचार से और (5^0 से. पर भण्डारण से) फल की निधानी आयु 19 दिनों तक बढाई जा सकती है और जीवाणु संख्या भी स्वीकार्य सीमा के अंदर रहती है । बीज तेल प्राप्ति के लिए 11 जननद्रव्यों का विश्लेषण तथा टेक्सचर एनलाइजर द्वारा बीज संण्यूति टेक्शुअर के लिए 27 जननद्रव्यों का विश्लेषण किया गया ।

अनार के बीज से तेल निष्कर्षण के लिए कोल्ड प्रेस तथा केबीनेट ड्रायर एवं ग्राइडर, मूल्यवर्धक कोंजूगेटेड लिनोलिक एसिड युक्त बीज तेल के व्यवसायिक निष्कर्षण के लिए स्थापित किये गए । 'गणेश' तथा 'भगवा' किस्म से अनार की पारदर्शी मदिरा बनाने के नवाचार को मानकीकृत किया गया । गणेश तथा भगवा किस्म के पारदर्शी मदिरा के इद्रिग्राही गुणांका में ये मदिरा उत्कृष्ट पायी गई तथा इनका गुणांक क्रमश: 8.04 और 8.00 पाया गया ।

केद्र की अनुसंधान गतिविधियों के अलावा भा.कृ.अनु.प. - रा.अ.अनु.के. ने अय भा.कृ.अनु.प. के संस्थानों जैसे रा.बा.अनु.सं, बंगलुरू, राष्ट्रीय अंगूर अनुसंधान केद्र, पुणे तथा भा.कृ.अनु.सं. के साथ सहयोगात्मक अनुंसंधान शुरू किया है। इसी प्रकार भा.कृ.अनु.प.-रा.अ.अनु.के. ने बाह्य पोषित परियोजनाओंको राष्ट्रीय बागवानी बोर्ड,रिलायस इडस्ट्रीज लि., इंडोफि ल केमिकल्स लि. के माध्यम से विभिन्न अनुबंध परिक्षण एवं विस्तार विषयों पर अकर्षित किया है। वर्ष 2014-2015 के दौरान 1 हेक्टेयर क्षेत्र में नई विकसित संकरों, आशाजनक सलेक्शस एवं उन्नत लाइस का रोपण किया गया है ।

मानव संसाधन गतिविधियों एवं क्षमता निर्माण को सुदृढ.करने के उद्देश्य से केन्द्र के वैज्ञानिकों ने देश भर के विभिन्न शोध संस्थानों में प्रशिक्षण प्राप्त किया है। इसी प्रकार कर्मचारीयों को विशेषज्ञ द्वारा एफ.एम. एस. - एम. आय. एस विषय पर प्रशिक्षण दिया गया । प्रशासनिक कर्मचारीयों को सचिवालय प्रशिक्षण एवं प्रबंधन संस्थान, नई दिल्ली में प्रशिक्षण हेतु भेजा गया था । वर्ष 2014-15 के दौरान भा.कृ.अनु.प.-रा.अ.अनु.के. द्वारा विभिन्न प्रशिक्षण कार्यक्रम एवं कार्यशालाऐं आयोजित कि गई । एक हजार से ज्यादा अनार उत्पादकों को केन्द्र पर अथवा गुजरात तथा महाराष्ट्र में विभिन्न जगहों पर अनार के आदर्श उत्पादन तकनीक के बारे में प्रशिक्षित किया गया ।

25 सितम्बर 2014 को भा.कृ.अनु.प. - रा.अ.अनु.के. ने अपने स्थापना दिवस समारोह के अवसर पर प्रगतिशील किसानों के एक छोटे समूह को उद्यमिता विकास के विभिन पहलुओं जैसे अनार में पौध सामग्री उत्पादन, मूल्यसम्वर्धन (रस, आरटी एस, मदिरा उत्पादन), इत्यादी विषयों पर प्रशिक्षण दिया है। भविष्य के बदलावों को ध्यान में रखतें हुए विजन 2050 में महत्वपूर्ण

संशोधन किये गए है। विभिन्न बहारों में अनार की फसल (अम्बे, मृग एवं हस्थ बहार) लेने हेतु पालन की जानेवाली सूची तथा बेमौसम बरसात एवं ओलावृष्टि के नुकसान से निपटने के तरीकों के बारे अत्याधुनिक एवं नवीन जानकारीयाँ भा.कृ.अनु.प.-रा.अ.अनु. के. की वेबसाईट पर नियमित रूप से अपलोड की जाती थी ।

जिन तीन तकनीकों का व्यवसायिकरण वर्ष 2014-15 में रा.अ.अनु. के. द्वारा किया गया वे थे अनार किस्म भगवा का इ विट्रो प्रवर्धन एवं जैवदृढीकरण (एम/एस हार्टी फ्लोरल बायोटेक, सोलापुर एवं के.एफ. बायोप्लांट्स प्रा. लि. पुणे) अनार से पेय पदार्थ का विकास (एम/एस जी के 1 फॉर्म फ्रेश चेरापल्ली, तेलंगाना) और अनार में दो चरणीय दृढक़ाष्ट कर्तन नवाचार एवं जैवदृढीकरण (एम/एस भोसले नर्सरी, जलगॉव, महाराष्ट्र तथा एम/एस हरीयाली हाईटेक, अहमदागर, महाराष्ट्र)

अनार में पोषण, आजीविका सुरक्षा एवं उद्यमिता विकास पर एक राष्ट्रीय संगोष्ठी एवं प्रदर्शनी का आयोजन संयुक्त रूप से भा.कृ. अनु. प.-रा. अ. अनु. के. एवं सोसायटी फॉर अडव्हासमट ऑफ रिसर्च ऑन पोमग्रनेट (सार्प) द्वारा दिसम्बर 5-7, 2014 के दौरान किया गया । इस वर्ष लिफ्ट सिंचाई सुविधा एवं प्रशिक्षण छात्रवास का कार्य भा.कृ. अनु.प. के अनुमोदन उपरान्त शुरू किया गया।

EXECUTIVE SUMMARY

Brief summary of achievements on various research, training, extension, technology transfer and other new initiatives taken by ICAR-National Research Centre on Pomegranate with 10 scientific, 5 technical and two supporting staff during the year 2014-15 are mentioned below.

Apart from maintenance of 304 pomegranate collection in the field gene bank, this year IC number for 15 germplasm was obtained. Feasibility of pollen cryopreservation in pomegranate revealed good pollen viability for male flowers of cv.Bhagawa and cv. Jodhpur Red. Elucidation of genetic diversity of 12 pomegranate (*Punica granatum* L.) cultivars and 32 wild Accessions by using Sequence Related Amplified Polymorphism (SRAP) revealed a significant variability between the cultivated and wild germplasm of pomegranate. Genetic diversity and population structure of 88 wild and cultivated types was studied using 44 polymorphic SSRs. The NJ tree resolved 4 clusters, with 3 clusters of wild types and 1 cluster containing all cultivated pomegranates. Molecular diversity analysis showed mean genetic distances of 0.23, 0.20, and 0.19 for the accessions from Uttarakhand and Himachal Pradesh (clusters I and II) and collections from the mid- to low-altitude Jammu and Kashmir (cluster III) with cultivated pomegranate (cluster IV), respectively. The mean genetic distance between the wildtype-1 (cluster I) and wildtype-2 (cluster II) was 0.07, whereas that between wild-type 1 and 3 was 0.17. The distance between wild-type 2 and 3 type was 0.15. The variance was lower between clusters than within the clusters which indicated unrestricted gene flow among all clusters.

A robust set of 44 polymorphic SSRs with eighty-eight cultivated and wild genotypes of pomegranate were used to generate molecular data for which phenotyping was done earlier. The GLM approach identified 3 markers linked with acidity, fruit weight, and bacterial blight across the seasons. The PGCT001 association with fruit weight was significant after Boniferroni correction during both seasons and was also significant by the MLM approach. PGCT001 was associated with both fruit weight and bacterial blight. Three methods namely, CTAB-LiCl method, Direct-zol™ RNA MiniPrep (ZymoResearch), and TRIzol® reagent (Life technologies) were compared for isolation of good quality RNAs from high ploy phenol containing tissues of pomegranate. The total RNAs yield ranged from 603-636 µg/g fresh weight for young leaves, seedling and flower buds, the ratio of 260/280 was in the range of 1.85-2.02 with RIN values of 8.5 each suggesting good quality of RNA extracted using CTAB-LiCl method.

In vitro screening of 17 bacterial and 3 fungal endophytes was done using dual culture technique. The bacterial isolates inhibited growth of Xap from 17.95 to 54.04%. The inhibition of *X. axonopodis* pv. *punicae* with fungal endophytes ranged between 43.88% in EF2 to 54.08% in EF3. Five bacterial and 3 fungal isolates also resulted in reduction or complete inhibition of fuscan production- a character of virulence, thus indicating reduction of or complete loss in virulence of Xap by these isolates.

Evaluation of seven commercial cultivars (Ganesh, Bhagawa, Ruby, Jalore Seedless, G-137, Arakta, Mridula) revealed highest yield by G-137 (25.68kg/plant) which was followed by Ganesh (23.52kg/plant) at a spacing of 4.5 x 3.0 m during the sixth year of planting. Among six crosses undertaken for development of bacterial blight tolerant hybrids the fruit set was found to be the highest (40.0%) in crosses between 'Bhagawa x Nana' and Bhagawa x Acc-5.

The culture establishment for the cultivars 'Super Bhagawa' and 'Wonderful' were 83.00 and 82.50 %, respectively on modified MS medium supplemented with BAP, NAA, and adenine sulphate. Average number of side shoots per micro shoot was higher in Super Bhagawa (4.10) compared to Wonderful (3.90). The rooting success was found to

be better in Super Bhagawa (72.0%) compared to Wonderful (66.0%).

Biomass partitioning analysis of four commercial varieties revealed the highest uptake of N (56.82g/plant), P (4.45g/plant), Ca (111.03g/plant), Mg (13.39g/plant) & S (16.48g/plant) by Mridula while Ganesh recorded the highest uptake of K (30.01g/plant). The variety 'Arakta' registered the lowest uptake of all the macro-elements. The uptake pattern of different varieties of pomegranate before flower bud initiation followed the order of Ca>N>K>S>Mg>P while uptake pattern of micro-nutrients followed the order of Fe>Cu>Mn>Zn. Among the four varieties, Bhagawa was found to be the most efficient utilizer of nutrients followed by Ganesh, Mridula and Arakta.

Fruit weight and yield showed positive correlation with accumulation of P and Mn in fruits. Total phenol content showed positive significant correlation with Ca and K, anthocyanin content had positive correlation with Ca and ascorbic acid content of juice had strong positive correlation with P content of fruit. TSS of fruit juice was positively correlated with P and Mn and acidity of juice was positively correlated with Zn content of fruit.

Subsurface drip irrigation with double laterals (30*30 cm) with 4 drippers having low evapotranspiration at 0.2*ETr was found better with respect to vegetative growth parameters as compared to other methods. Soil moisture retention was also higher in the SDI with double laterals (30*30 cm). Mulching with wither sugarcane bagasse or using black pervious PE film recorded better yield performance and water conservation in pomegranate with irrigation at 0.4*ETr capmared to other organic and inorganic mulches.

A total of 204 *Trichoderma sp.,* 177 *Pseudonomas sp.* and 158 *Bacillus sp* were isolated and *in vitro* efficacy studies against bacterial blight pathogen Xap were conducted. Two effective new species for controlling blight were identified as *Pseudomonas geniculata* and *Pseudomonas plecoglossicidia* Three potential isolates of *Pseudomonas fluorescens* were tested against *Xanthomonas axonopodis* pv. *punicae* (Xap). All three isolates effectively checked BB when sprayed twice 15 and 7 days before XAP inoculation. The isolates reduced BB incidence by 58.54-66.83% and severity by 22.23-33.33 per cent over control with BB incidence of 68.33% and severity grade 3. Among delivery systems for *P. fluorescens* neem oil, pongamia oil and fatty acids were compatible with *P. fluorescens* . Clove oil and clove bud oil could inhibit *X. axonopodis* pv *punicae* under *in vitro* condition.

Silicon, salicylic acid and chitosan based formulations reduced bacterial blight (BB) incidence by 75.5%, 74.5% and 71.5%, respectively, over control (34.0%). Application of potash as SOP played highly significant role in reducing bacterial blight, fruit cracking and increasing number of fruits/plant. The PCR amplification of Bhagawa, Nana, Daru and Ganesh using the *in silico* revealed the presence of the *Xanthomonas* interacting gene homologous sequence in six out of eight genic primers. These genes would be very useful for effective control of *Xanthomonas* invasion.

Sanitization protocol for hardwood cutting planting material of pomegranate was developed. Long term storage of Xap in 20% Glycerol at -80°C was effective storage method . Isolates proved pathogenic even after 101 weeks of storage. Genotyping based on Multilocus Sequence Typing revealed narrow genetic base or low genetic diversity of pomegranate through identical allele profile.

Over 1000 pomegranate (Daru) progeny plants were subjected to screening against bacterial blight (BB) in which only 2 plants showed tolerant reaction to BB. The 6 collections were found free from blight and 14 showed slight susceptibility/tolerance with ≤5% blight. Among these, 4 accessions - IC-318793, IC-318743, IC-318716 and 1181 were also found slightly susceptible in 2010 screening.

Among various weather parameters influencing bacterial blight in field, temperature from 25-35°C accompanied with humidity above 50%, was the most important parameter significantly

influencing bacterial blight incidence. Among the other factors significantly and positively influencing bacterial blight were wind speed, rainfall and rainy days. RH below 30% significantly but negatively influenced bacterial blight.

Ceratocystis fimbriata was found associated with 80.46% sample as either alone or in association with other organisms. *C. fimbriata* alone was present in 47.13% samples and nematode *Meloidogyne incognita* in 9.2% *samples,* whereas in 20.69%, nematode was found associated with *C. fimbriata*. Survivability of *C. fimbriata* in infested soil was recorded up to 19 months. Among 4 bioagents tested BA6 (1) was most promising with delay of wilt initiation by 8weeks and maximum wilt reaching to 50% in 24 weeks. Germplasm accessions, IC-1272, IC-1289, IC-1256 and IC-1253 were found free from various fungal spot and rot pathogens.

Polypropylene nonwoven bags gave 100 per cent protection against Fruit sucking moth, but increased incidence and severity of bacterial blight and fruit rots. The PPNW bags also improved red colour of arils and VitaminC content in juice.

Thermal processing at 80°C and 2 minutes was found highly effective. The juice extracted from halved fruits had higher ascorbic acid, anthocyanin, total phenol content and better colour as compared to juice extracted from arils. Studies on minimal processing and packaging for standardization revealed that treatment of salicylic acid, Aloe Vera Gel and Ascorbic acid : Citric acid were found to be suitable for extension of shelflife of arils up to 19 days with total microbial count below acceptable limits when stored at 5°C. Eleven pomegranate germplasm were analysed for recovery of seed oil content and twenty seven germplasm were evaluated for seed texture using fiid texture analyzer.

Pomegranate seed oil extraction unit based on cold press technology was established along with cabinet dryer, grinder for extraction of high value conjugated linolinic acid rich pomegranate seed oil on commercial scale. Protocol was standardized for preparation of sparkling wine from Ganesh and Bhagawa varieties of pomegranate. Organoleptic scoring of sparkling wine from Ganesh and Bhagawa were highly acceptable with an overall acceptability of 8.04 and 8.00 respectively.

Apart from in-house research activities, ICAR-NRCP has initiated collaborative research with other ICAR institutes namely IIHR, Bengaluru; NRC Grapes, Pune and IARI, New Delhi. Similarly, NRCP also attracted external funding from National Horticulture Board, Gurgaon; M/s. Reliance Industries Ltd and M/s. Indofil Chemicals Limited for various contract research trial and extension related projects. During the year 2014-15, 1ha area was planted with newly developed hybrids, promising selections and improved lines.

The scientists from the institute have undergone training in various research institutes of India to strengthen the human resource development activities and capacity building. Similarly, all the staff were also trained by expert on FMS-MIS aspects. Administrative staff were also sent for undergoing training organized by ISTM, New Delhi. During the period 2014-15, several training programmes and workshop have been organized by ICAR-NRCP. More than 1000 pomegranate growers were trained both at ICAR-NRCP, Solapur and at various places of Gujarat and Maharashtra state on Model Production Technologies on pomegranate.

ICAR-NRCP also celebrated its foundation day on 25.09.2014 in which a small group of progressive farmers were trained on various aspects of entrepreneurship development viz., planting material production and value addition (Juice RTS, Wine making) of pomegranate. The vision 2050 document for ICAR-NRCP was revised taking into consideration the probable changes likely to happen in future. The website of ICAR-NRCP was also regularly updated with latest information on several mitigation strategies for unseasonal rain, hailstorm damage and regular schedules to be followed for taking pomegranate crop in different seasons *(Ambe bahar, Mrig bahar, Hasth Bahar).*

The following three technologies, "*In vitro* propagation of pomegranate cultivar Bhagawa including biohardening" (M/s. HortiFloral Biotech, Solapur and M/s. KF Bioplants Pvt. Ltd., Pune), "Development of RTS beverage from pomegranate" (M/s. GK1Farm Fresh, Cherlapally, Telangana) and "Two step Hardwood cutting protocol of pomegranate including biohardening" (M/s. Bhosale Nursery, at Jadgaon, Maharashtra and M/s. Hariyali Hitech, Ahmednagar, Maharashtra) were commercialized during 2014-15.

A National Seminar-cum-Exhibition on 'Pomegranate for Nutrition, livelihood Security and Entrepreneurship Development' was jointly organized by ICAR-National Research Centre on Pomegranate, Solapur & Society for Advancement of Research on Pomegranate, Solapur during 5th to 7th December, 2014. During this year two major items of works i.e. lift irrigation facility and construction of 43 bed trainees hostel have been initiated with the approval of ICAR.

RESEARCH ACHIEVEMENTS

1. GENETIC RESOURCES

1.1. Genetic diversity and population structure

An investigation was undertaken to study the genetic diversity and population structure of 88 wild and cultivated pomegranate genotypes using 44 polymorphic SSR markers. The neighbor joining (NJ) tree resolved 4 clusters, with 3 clusters of wild types and 1 cluster containing all cultivated pomegranates. Clusters I and II were wild types from high-altitude areas (600-2200 m above mean sea level) in the Himalayas (states of Uttarakhand and Himachal Pradesh of India) and were adapted to temperate conditions. The wild types of cluster III belonged to the low to mid hill regions (600-1600 msl) of the Himalayas (state of Jammu and Kashmir of India). Cluster IV, the cultivated types, included commercial varieties, local types and introduced varieties. Cluster IV was further divided into 4 sub-clusters.

Population structure analysis based on model-based assumptions was used to estimate K- 2 to K-10 clusters each with 3 iterations. The results were analyzed for mean $\pm$ SD LnP(K) and ΔK values as estimated by Structure Harvester. K-4 was the most appropriate cluster size for this population, with ΔK = 214. Population structure analysis revealed information pertaining to the ancestry of cultivated pomegranates in addition to corroborating the results of NJ analysis. Similar to NJ analysis, population structure analysis resolved 4 different clusters, with I and II the wild collections from the mid and high altitudes of the Himalayas and III, being wild collections from the low and mid altitudes of the Himalayas (Jammu and Kashmir). Cluster IV contained accessions belonging to all cultivated types, which were spread into 4 subclusters across the cluster. Lineages of cultivated pomegranates could be tracked to an admixture of genomes from high-, mid- and low-altitude wild types collected from Uttarakhand, Himachal Pradesh and Jammu and Kashmir in various proportions, thus contributing to the diversity of cultivars.

The results obtained by NJ tree analysis and population structure completely agreed with the PCA analysis. PCA explained 60% of the total variation, which indicates the robustness of the analysis. PCA revealed the closeness of cluster III (Daru types of Jammu and Kashmir) with the cultivated types, which indicates that these accessions are progenitors of cultivated pomegranates.

Molecular diversity analysis showed mean genetic distances of 0.23, 0.20, and 0.19 for the accessions from Uttarakhand and Himachal Pradesh (clusters I and II) and collections from the mid to low altitude Jammu and Kashmir (cluster III) with cultivated pomegranate (cluster IV). The mean genetic distance between the wild-type 1 (cluster I) and wild-type 2 (cluster II) was 0.07, whereas that between wild-type 1 and 3 was 0.17. The distance between wild-type 2 and 3 type was 0.15. Variance was lower between clusters than within clusters, which indicates unrestricted gene flow among all groups. The overall *FST* (index of population differentiation) was 0.18 among the collection studied.

Genetic diversity analysis of 88 pomegranate genotypes through Neighbour Joining tree categorized the population into 4 clusters out of which 3 comprised of wild types (Cluster I & II – wild type from high altitude area of 600-2200m above msl; Cluster III – wild types of low- mid hill regions of 600-1600 m above msl) and 1 cultivated type (Cluster IV).

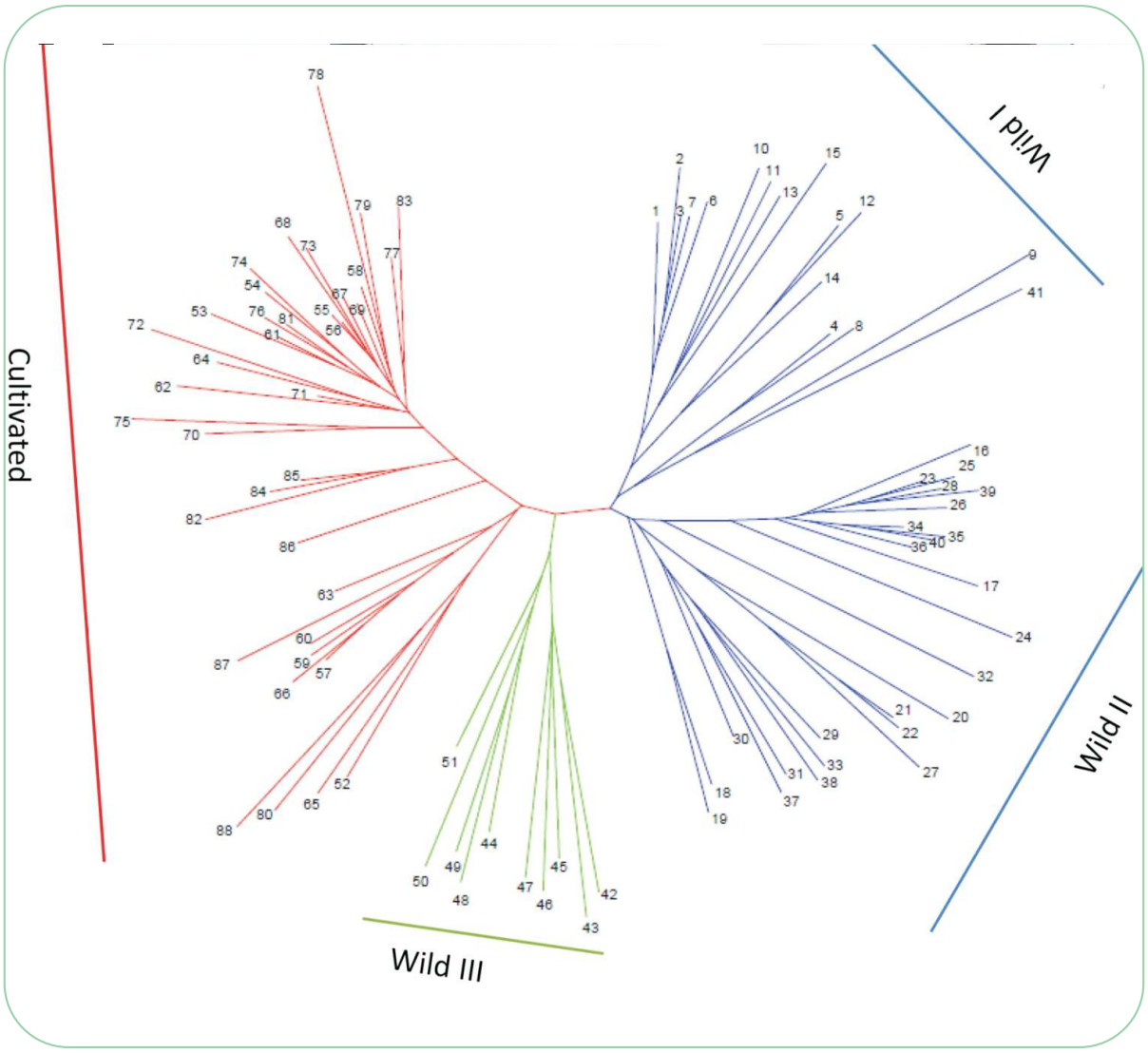
List of pomegranate varieties/genotypes used for genetic diversity analysis

S.No	Pomegranate genotypes	S. No	Pomegranate genotypes	S. No.	Pomegranate genotypes
1.	IC-524027	31.	IC-318743	61.	Poona Collection
2.	IC-524028	32.	IC-318744	62.	Double Flower
3.	IC-524030	33.	IC-318749	63.	Shaili Shirin
4.	IC-524031	34.	IC-318753	64.	Amlidana
5.	IC-444199	35.	IC-318754	65.	Buldhana Local
6.	IC-444200	36.	IC-318762	66.	GKVK - 1
7.	IC-444201	37.	IC-318764	67.	Chaupani Seedless
8.	IC-444202	38.	IC-318766	68.	Orange China
9.	IC-444204	39.	IC-318779	69.	Jodhpur Local
10.	IC-444206	40.	IC-318790	70.	KA-2
11.	IC-444207	41.	IC-318793	71.	Bassein Seedless
12.	IC-444208	42.	Acc. 1	72.	Yercaud
13.	IC-540195	43.	Acc. 2	73.	Dholka
14.	IC-540202	44.	Acc. 3	74.	Kalpitiya
15.	IC-318702	45.	Acc. 4	75.	Jodhpur red
16.	IC-318703	46.	Acc. 6	76.	Muscat
17.	IC-318705	47.	Acc. 8	77.	KRS-32
18.	IC-318706	48.	Acc. 9	78.	Alandi
19.	IC-318707	49.	Acc. 10	79.	JS X Ganesh
20.	IC-318712	50.	Acc. 11	80.	Gul-e- Shah Red
21.	IC-318716	51.	Acc. 12	81.	Ganesh
22.	IC-318718	52.	Allah	82.	Bhagawa
23.	IC-318720	53.	Kandhari	83.	G-137
24.	IC-318723	54.	Bedana Thinskin	84.	Arakta
25.	IC-318724	55.	Jalore Seedless	85.	Mridula
26.	IC-318728	56.	J. Seedless	86.	EC-24686
27.	IC-318733	57.	Surkh-Anar	87.	EC-62812
28.	IC-318734	58.	Kerala Local	88.	EC-81839
29.	IC-318735	59.	Surat-Anar		
30.	IC-318740	60.	AHPGC		

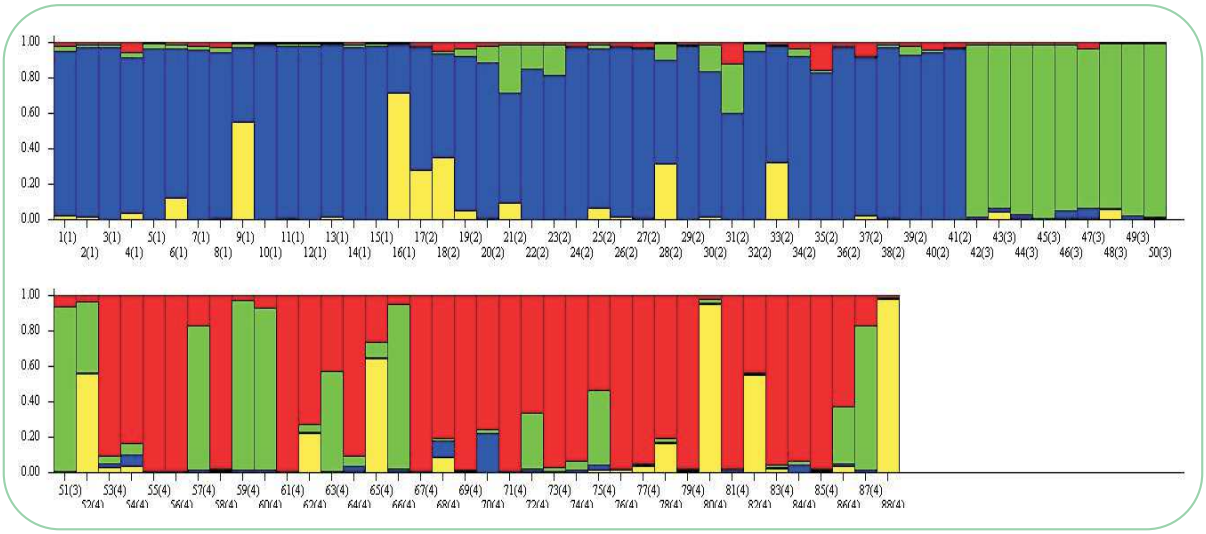
Analysis of molecular variance (AMOVA)

Source of variation	Df	Sum of squares	Variance components	Percentage of variation
Among population	3	149.331	1.138	18.42
Within population	88	602.00	6.841	81.58
Total	91	751.331	7.979	

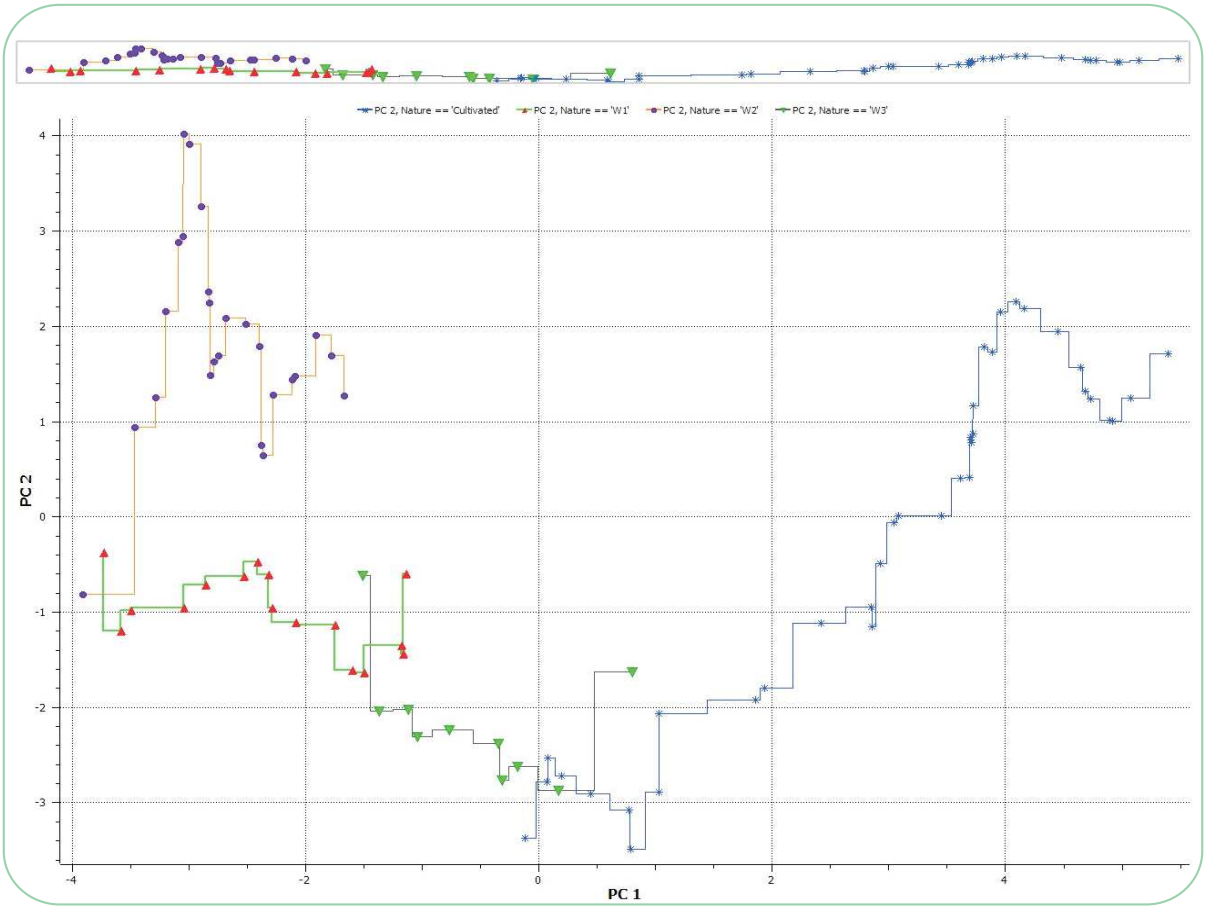
Overall Fixation Index F_{ST} : 0.18421



Neighbor-joining tree depicting estimated relationships across 88 diverse pomegranate collections (blue: cluster I and II; green: cluster III; red: cultivated type/cluster IV)



Shared ancestry as revealed by population structure analysis across 88 diverse pomegranate collection (number in parenthesis refers to cluster)



Principal component analysis of wild-type and cultivar collections of pomegranate (W1, 2 and 3 refers to clusters I, II and III, respectively)

1.2. Germplasm screening against diseases and insect pests

Diseases

In all, 155 germplasm was screened for economically important diseases and insect pests. Out of 155 germplasm / accessions, 19 were free from bacterial blight (0 severity), 27 partially susceptible (≤5.5% severity), 36 moderately susceptible (>5.5-18.05 severity) and 73 highly susceptible (>18.0% disease severity). For fungal spot/rots, out of 31 germplasm screened, 4 were found free, 6 partially susceptible and rest were moderately susceptible.

Screening of germplasm against wilt

All the plants of 5 germplasm (IC-318705, IC-318779, IC-1204, IC-1182 and Sirin Anar) screened for wilt resistance through artificial inoculation with *Ceratocystis fimbriata* were found susceptible to wilt pathogen in September 2014.

Insect pests

Thirty one germplasm available at Hiraj were screened for insect-pests infestation in 2014. The major damage was observed to be caused by thrips (*Scrirtothrips dorsalis*) and fruit borer (*Deudorix isocrates*) whereas mites (*Tenuipalpus punicae*) and fruit moth (*Othreis* spp) infestation was observed in traces (<5.0%). Thrips infestation varied between 1.83- 12.0%. Out of 31 germplasm, 16 were found free from thrips attack. Fruit borer infestation ranged from 1.6 – 20.0%. Out of 31 germplasm, 10 were found free from fruit borer infestation.

The germplasm /accessions found free or slightly susceptible/tolerant to diseases and insect pests in 2014 were recorded.

Pomegranate germplasm free or slightly susceptible to diseases and insect pests (2014)

Reaction of germplasm	Germplasm	Total no. of germplasm
Bacterial Blight		
R	Mukteswar, IC-1277, IC-1278, IC-1280, IC-1276, IC-1272, IC-1259, IC-1256, IC-1253, IC-318716, IC-318973, IC-318712,IC-318702, IC-318706,IC-318743,IC-318764, IC-318734,IC-318705, IC-318762	19
SS/T	IC-1279, IC-1281, IC-1274, IC-1258, IC-1254, 1197, 1184, 1181, 1262,Almoda , IC-31879, IC-31873, IC-318776, IC-318740, IC-318735, IC-31872 , IC-318707, EC-676964, AccNo.13, AccNO.1, AccNO.6, AccNO.5, AccNo.4, AccNo.2, AccNo.1, EC -676951, AccNo.1 2	27
Fungal fruit spots and rots		
R	IC-1272, IC-1259, IC-1256, IC-1253	4
SS/T	IC-1257, IC-1258, IC-1266, IC-1271, IC-1273, IC-1276	6
Thrips		
R	IC-1187, IC-1253, IC-1254, IC-1256, IC-1257, IC-1258, IC-1259, IC-1263, IC-1270, IC-1272, IC-1275, IC-1276, IC-1278, IC-1279, IC-1285, IC-1286	16
SS/T	IC-1260, IC-1261, IC1265, IC-1266, IC-1267, IC-1271, IC-1274, IC-1280, IC-1284	9
Fruit Borer		
R	IC-1187, IC-1253, IC-1259, IC-1266, IC-1270, IC-1272, IC-1279, IC-1280, IC-1283, IC-1285	10
SS/T	IC-1254, IC-1256, IC-1261, IC-1267, IC-1269, IC-1271, IC-1274, IC-1276, IC-1278, IC-1281, IC-1282, IC-1286	12

Note: R: Disease free- 0 Severity/infestation; SS/T: Slightly susceptible/Tolerant- >0-5.5% severity/infestation

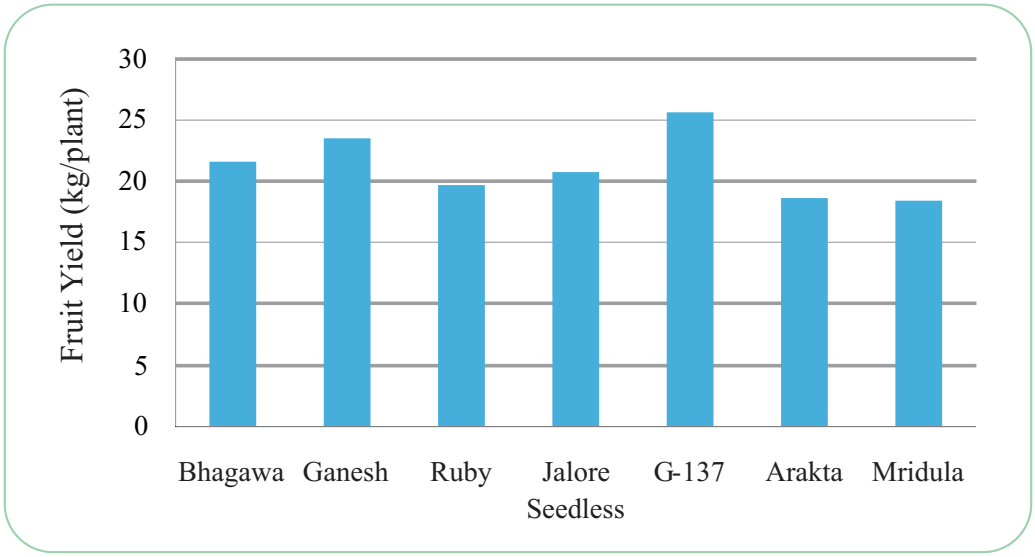
2. CROP IMPROVEMENT

2.1. Identification of desirable traits

2.1.1. Identification of desirable traits in commercial cultivars

Seven commercial varieties of pomegranate viz., Ganesh, Bhagwa, Ruby, Jalore Seedless, G-137, Arakta and Mridula, planted at 4.5x3.0 m spacing were evaluated for quantitative and qualitative traits under field condition during the sixth year of planting. The cultivars differed significantly for yield and related traits. The yield/plant in cv. G-137 was 25.68kg followed by Ganesh (23.52kg). The TSS/acid ratio in Jalore Seedless was 37.67 which was followed by 36.82 in G-137 and 35.78 in Ganesh. The cv. Bhagawa had maximum bold arils having 35.2g/100 arils as compared to other cultivars.

Four varieties (Bhagwa, Ganesh, Arakta and Mridula) were analyzed for fruit quality parameters. Total phenol content of juice ranged from 1060.00 to 1770.00 mg l^{-1}GAE. The variety Arakta registered the highest phenol content (1770 mgl^{-1} GAE) followed by Mridula (1616.67 mg l^{-1} GAE) and Bhagawa (1503.33 mg l^{-1}GAE) that were at par with each other. Least phenol content in juice was recorded in Ganesh (1060.00 mg l^{-1}GAE). The anthocyanin content of arils was similar in Bhagawa (78.15 mg /100 g arils), Arakta (79.18 mg/100 g arils) and Mridula (78.47 mg/100 g arils), while Ganesh recorded the least anthocyanin content (26.32 mg/100 g arils). Ascorbic acid in juice varied from 17.50 to 20.41 mg/100 ml juice. Maximum ascorbic acid was found in the juice of Ganesh (20.41 mg/100 ml juice), followed by Bhagawa (18.75 mg/100 ml juice) and Arakta (18.75 mg/100 ml juice) that were at par with each other. Fruit juice of Mridula registered the lowest ascorbic acid content. Reducing sugar varied from 12.93 to 14.44% while non-reducing sugar ranged from 0.10 to 0.21%. Reducing sugar and total sugar were significantly higher in Mridula and Arakta than Bhagawa and Ganesh. The least sugar content was noted in Ganesh. Mridula was recorded for the highest non-reducing sugar content. Hence, from the point of view of nutritional attributes cvs. Bhagawa, Arakta and Mridula were found better than cv. Ganesh.



Comparative field performance of commercial pomegranate cultivars

2.1.2. Identification of desirable traits in bacterial blight tolerant genotypes/ varieties

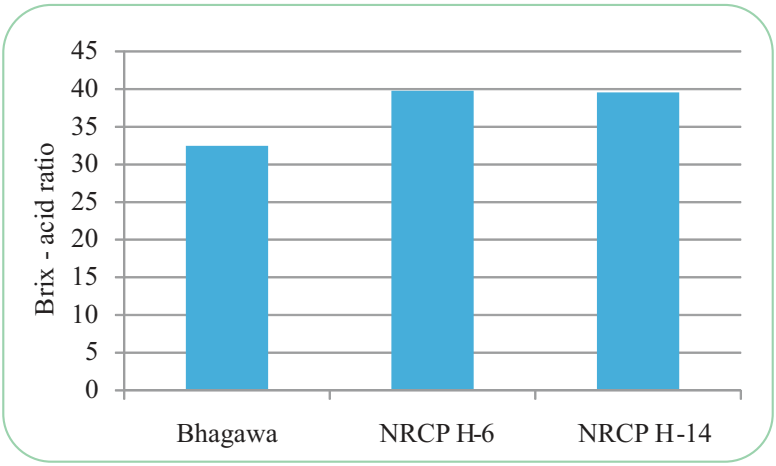
Four bacterial blight tolerant varieties of pomegranate viz., Nana, Daru, Kalpitiya and Nayana were evaluated for quantitative and qualitative traits in comparison with Bhagawa during the sixth year of planting. The varieties differed significantly for various traits. Out of four bacterial blight tolerant genotypes, Daru was found to be better for rind thickness of 3.56mm than the existing leading susceptible cv. Bhagawa (3.28mm). The rind thickness of Kalpitiya (3.24mm) was found on par with Bhagwa (3.28mm). The titrable acidity was highest in Nana (4.80%) which was significantly higher compared to Daru (2.24%). The Brix/acid ratio in Nayana (36.22) was more than Bhagawa (32.45) whereas it was least in Nana (2.60%).

Evaluation of bacterial blight tolerant genotypes

Genotype	Rind thickness (mm)	Acidity (%)	BBD score (% severity)
Nana	1.14	4.80	Tolerant (<10%)
Daru	3.56	2.24	Tolerant (<10%)
Kalpitiya	3.24	0.58	Tolerant (<10%)
Nayana	3.04	0.45	Tolerant (<10%)
Bhagawa	3.28	0.49	Susceptible (>50%)

2.1.3. Identification of desirable traits in pomegranate varieties

Eleven varieties of pomegranate were evaluated for physico-chemical parameters in comparison with Bhagawa during the sixth year of planting. The varieties differed significantly for physico-chemical parameters. The yield/plant was highest (24.04 kg) in Muskat whereas it was 22.74 kg in KRS. Kerala Local recorded the Brix-acid ratio of 32.76 which was at par with Bhagawa (32.45), Muskat (31.88), Kasuri (31.88) and Jyoti (31.67).



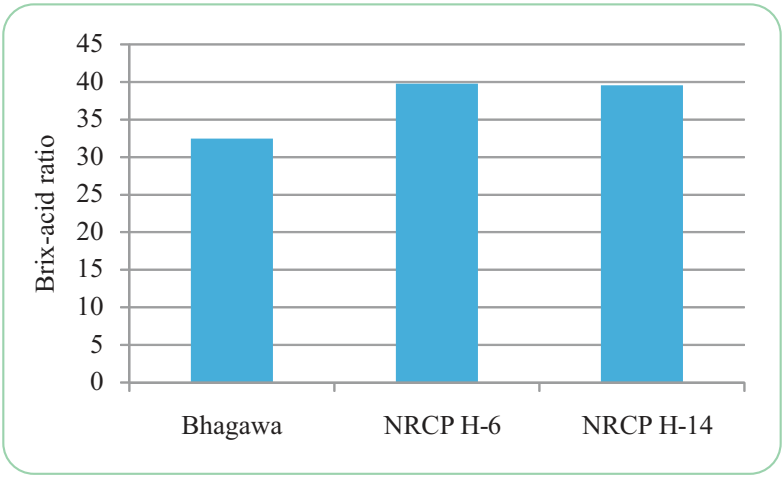
Comparison of pomegranate varieties for fruit Brix-acid ratio

2.1.4. Evaluation of pomegranate hybrids

In comparison to Bhagawa, twenty NRCP hybrids developed at ICAR-NRCP, Solapur [Bx3/3{(Gxn) xD}] were assessed during the sixth year of planting. Out of these hybrids, NRCP H-6 and NRCP H-14 were found better than existing cv. Bhagawa with respect to brix-acid ratio. However, the average fruit size was low in these hybrids.

Identification of desirable traits in NRCP hybrids for table purpose

NRCP hybrid	No. fruits/ plant	Fruit weight (g)	Fruit yield (kg/ plant)	Rind thickness (mm)	100 Aril weight (g)	TSS (ºB)	Acidity (%)	Brix-acid ratio
Bhagawa	75.20	288.10	21.67	3.20	35.20	15.90	0.49	32.45
NRCP H-6	105.00	236.20	24.80	3.21	38.50	17.50	0.44	39.77
NRCP H-14	98.00	263.50	25.82	2.36	44.50	17.80	0.45	39.56



Comparison of NRCP hybrids for brix-acid ratio

Similarly, the titrable acidity was found very high in NRCP H-4 (5.76%). This was followed by NRCP H-12 (4.80%). Pomegranate hybrids, NRCP H-1 (3.58%), NRCP H-15 (3.58%) and NRCP H-3 (3.04%) were sour in taste with medium titrable acidity. The hybrids with high titrable acidity are suitable for processing (*anardana*) purpose.

Among eight hybrids developed by ICAR-IIHR, Bengaluru using cv. Ruby as pollen donor, hybrid Sweet 6/7 and Sweet 7/10 were found suitable for table purpose due to high brix- acid ratio (>36) compared to Bhagawa (32.45). However, average fruit size and yield per plant were much lower in these hybrids as compared to cv. Bhagawa.

Sweet 6/7

Sweet 7/10

2.2. Improvement through hybridization

2.2.1. Hybridization for bacterial blight tolerance

Among six crosses undertaken for development of bacterial blight tolerant hybrids, the fruitset (%) ranged from 30.0 to 40.0% and was highest in 'Bhagawa x Nana' and 'Bhagawa x Acc. 5' (40%).

Hybridization between commercial cultivar and bacterial blight tolerant lines

S. No	Cross	No of flowers crossed	No. of crossed fruits	Fruitset (%)
1	Bhagawa x Nana	20	8	40.0
2	Bhagawa x (Bhagawa x Nayana)	10	3	30.0
3	Bhagawa x Daru	40	12	30.0
4	Bhagawa x Acc. 5	15	6	40.0
5	Bhagawa x Patna-5	30	10	33.3
6	Bhagawa x 1128	25	8	32.0

Bhagawa x Nana

Bhagawa x (Bhagawa x Nayana)

Bhagawa x Daru

Bhagawa x Acc. 5

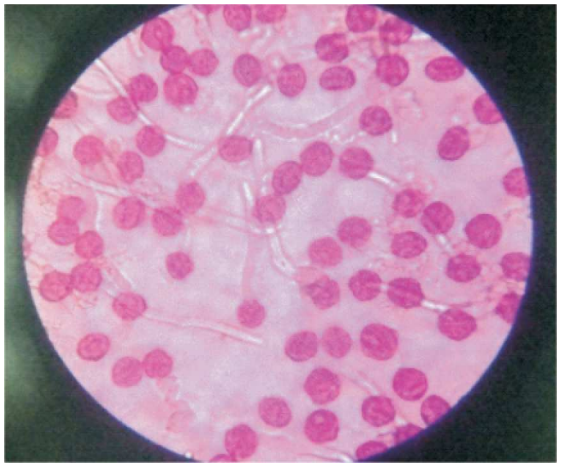
Bhagawa x Patna-5

Bhagawa x 1128

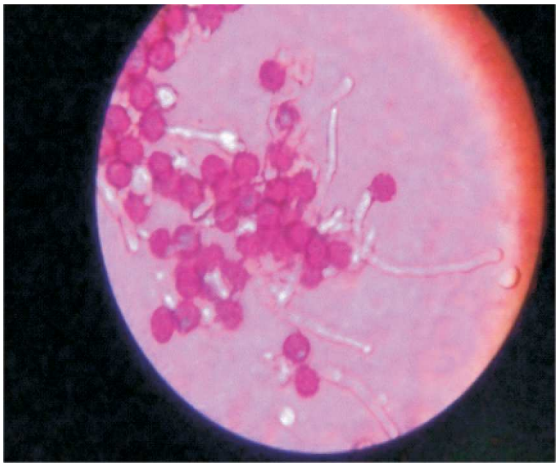
Hybridization for bacterial blight tolerance

2.3. Pollen cryopreservation

An investigation was carried out on feasibility of pollen cryopreservation of pomegranate cvs. Bhagawa, Jodhpur Red, P-23, Yercaud, Jodhpur Collection and five wild accessions viz., 318736, 318752, IIHR-SH 21/6, IIHR-SH 21/13, Bhagawa OP 20/6 collected from Western Himalayan region were selected from the Experimental orchard of Division of Fruit Crops, IIHR, Bangalore. Preliminary results revealed that male flowers from cv. Jodhpur Red and wild collection 318752 showed higher pollen germination compared to others.



Pollen germination in pomegranate cv. Bhagawa



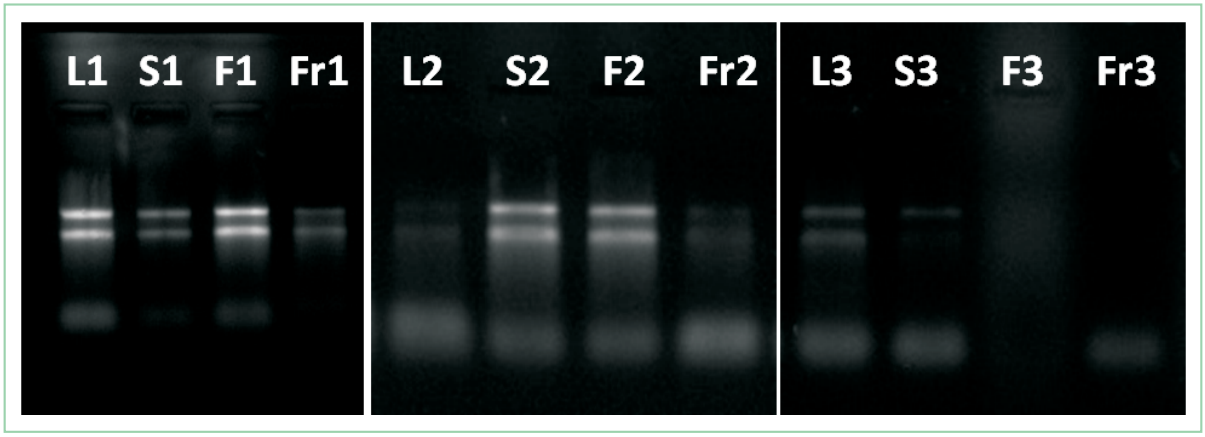
Pollen germination in wild accession 318752

2.4. RNA isolation

2.4.1. RNA isolation form high polyphenol containing tissues

The research was carried out partly at National Research Centre on Pomegranate, Solapur, Maharashtra, India and partly at West Virgina State University, WV, USA. Four types of plant tissues were utilized in this work namely, young leaves (L); all parts of 15-20 days old seedlings, mixed together (S); 7-10 days old flower buds (F) and mature fruit peel of pomegranate (Fr). The material was collected from greenhouse grown plants and flash-freezed in liquid nitrogen, and stored at -80°C until extraction. The methods used for RNA isolation were CTAB-LiCl method, Direct-zol™ RNA MiniPrep (ZymoResearch), and TRIzol® reagent (Life technologies). The plasticware used for RNA extractions were treated with 0.5% diethylpyrocarbonate (DEPC) solution to inactivate RNases, and the solutions used were prepared with RNase free water.

CTAB-LiCl and Direct-zol™ RNA MiniPrep (Zymo Research) RNA extraction methods yielded good results, with CTAB-LiCl method RNAs from young leaves, seedlings and flower buds had RIN value of 8.5 each whereas yield ranged from 603-636 µg/g FW. Similarly, in Direct-zol method, both quality and quantity of RNA extracted from young seedlings and flower buds were good with RIN value of 8.6 and 8.7 and yield of 292 and 252µg/g FW, respectively (Table 1). The ratio of 260/280 was in the range of 1.85-2.02 for young leaves, seedlings and flower buds, suggesting good quality of RNA extracted using CTAB-LiCl. Similarly, the ratio was found to be 2.02 for seedlings and 1.92 for flower buds with Direct-zol™ RNA MiniPrep (Zymo Research) RNA extraction method. However, both the methods failed to yield good quality RNA from mature fruit peel. TRIzol® reagent based method failed to yield good quality RNA from high phenol containing flower and fruit tissues.



Agarose gel electrophoresis of RNA extracted through different methods (L1- Fr1: RNA extracted using CTAB-LiCl method, L2-Fr2: Direct-zol™ RNA MiniPrep, L3-Fr3: TRIzol®)

3. CROP PRODUCTION

3.1. Plant propagation

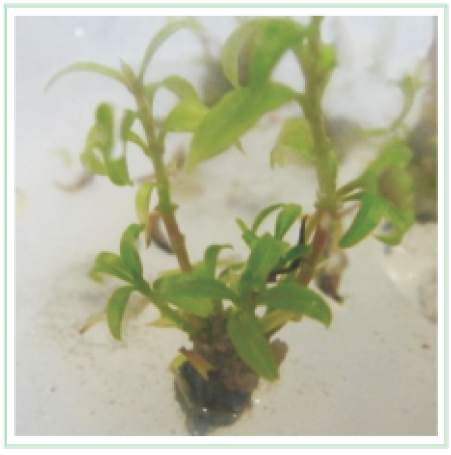
3.1.1. *In vitro* propagation of cv. Super Bhagawa and Wonderful

The *in vitro* culture establishment, multiplication and *in vitro* rooting stages of pomegranate cultivars Super Bhagawa and Wonderful have been standardized using shoot tips from the field grown plants. The culture establishment for the cultivars Super Bhagawa and Wonderful were 83.00 and 82.50 %, respectively on modified MS medium supplemented with BAP, NAA, and adenine sulpahte. Average number of side shoots per micro shoot for Super Bhagawa was 4.10 on modified MS medium supplemented with BAP, Kinetin and NAA, on the same media and growth regulator combinations, it was 3.90 in case of Wonderful. As high as 72.00 % rooting of microshoots was obtained in Super Bhagawa with WPM medium supplemented with IBA and with the same combination rooting in Wonderful was 66.00 %.

Established cultures of 'Super Bhagawa'

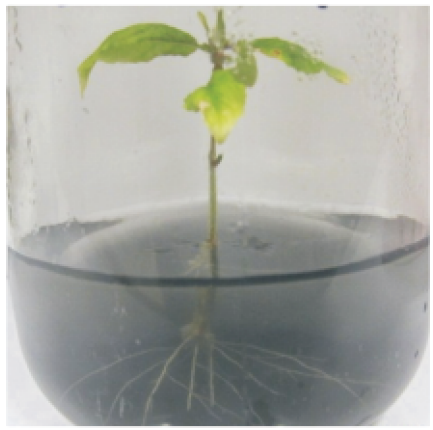
Established cultures of 'Wonderful'

***In vitro* multiplication of 'Super Bhagawa'**



***In vitro* multiplication of 'Wonderful'**

In vitro rooting in 'Super Bhagawa'



In vitro rooting in 'Wonderful'

3.1.2. Isolation of endophytes from pomegranate plant parts

The endophytes were isolated from four different genotypes (Bhagawa, Ganesh, Nana and Daru) and *in vitro* propagated plant cultures of pomegranate cultivar Bhagawa. Leaves, stems and roots were used for isolation of endophytes and in case of *in vitro* plant cultures the microbial population seemed to be oozing out from explants were taken. Selective media for bacterial and fungal endophytes were used for isolation using standard techniques. In all, 14 bacterial and 3 fungal isolates were obtained from different genotypes and plant parts and 3 bacteria were obtained from *in vitro* plant cultures and maintained as pure culture.

Population of bacterial endophyte (EB) and fungal endophytes (EF) in field plants of pomegranate

Variety	Endophyte population x10^5 (isolate number/s)			Number of isolates
	Stem	Leaves	Roots	
Ganesh	80.00 (EB1)	26.67 (EB2)	73.33 (EB3)	3 bacterial
Bhagawa	21.67 (EB9, EB11) 3.00 (EF2)	25.67 (EB4, EB5, EB10)	36.00 (EB6,EB7 EB8) 12.00 (EF1, EF3)	8 bacterial + 3 fungal
Nana	7.00 (EB12)	-	-	1 bacterial
Daru	5.0 (EB14)	-	3.33 (EB13)	2 bacterial

3.1.3. *In vitro* screening of endophytes against bacterial blight pathogen

In-vitro screening of 17 bacterial endophytes including 3 tissue culture isolates and 3 fungal isolates was done using dual culture technique. Bacterial endophytes were screened on NGA medium whereas the fungal endophytes on PDA medium. Inhibition percentage was recorded after 8 days of inoculation. The isolates inhibited growth of Xap from 17.95 to 54.04%. EB3, EF3 and TC9 had bactericidal effect as restreaking of *Xap* colony from dual culture on fresh media did not result in any *Xap* growth.

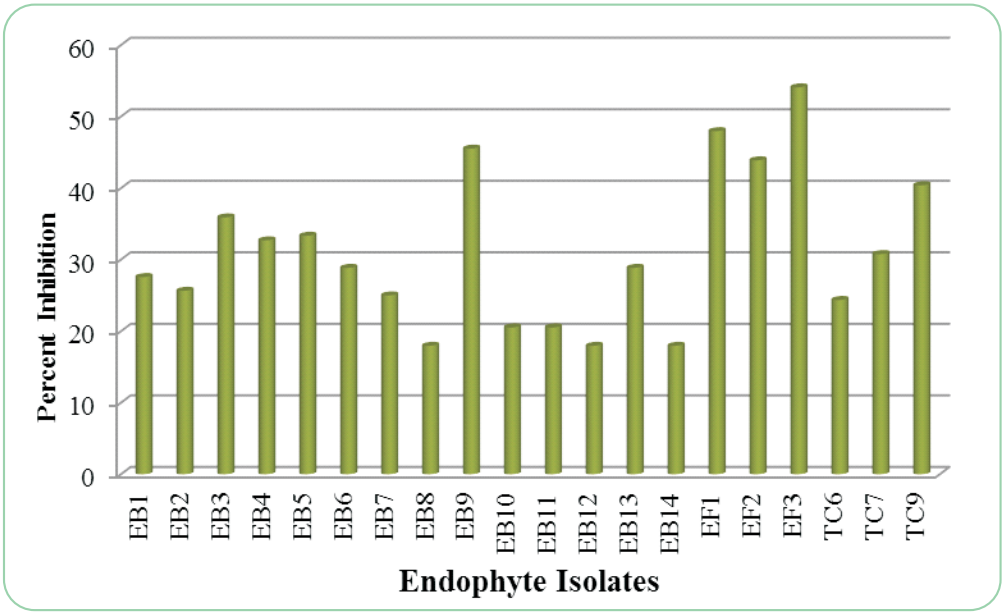
All fungal endophytes proved significantly effective against *X. axonopodis* pv. *punicae* when compared to control, but all 3 endophytes were at par

among themselves. The inhibition with fungal endophytes ranged between 43.88% (EF2) to 54.08% (EF3).

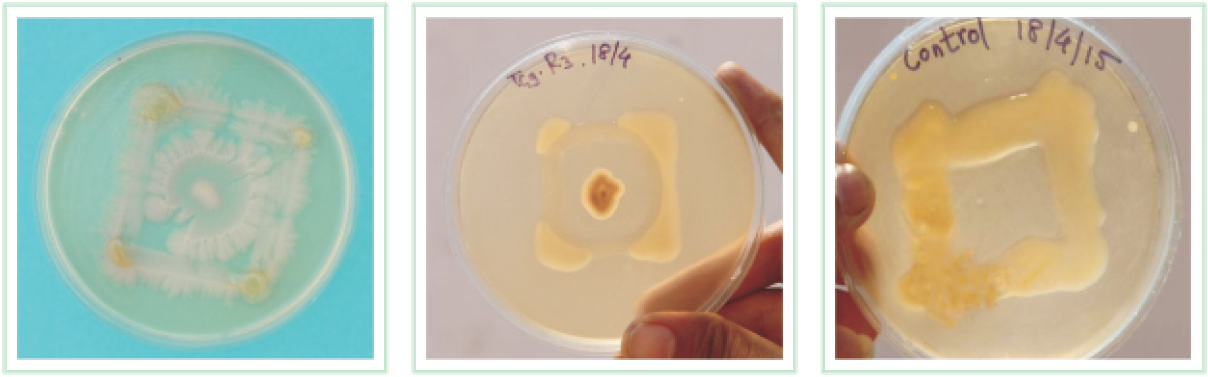
Five bacterial and 3 fungal isolates also resulted in reduction or complete inhibition of fuscan production- a character of virulence, thus indicating reduction of or complete loss in virulence of *Xap* by these isolates.

When bacterial endophytes screened *in vitro*, all bacterial endophytes proved significantly effective against *X. axonopodis* pv. *punicae* when compared to control. But amongst all the endophytes, EB9 showed minimum growth of *Xap* and per cent inhibition followed by TC9. EB8 and EB14 showed minimum inhibition percentage. When the metabolites of promising endophytes were screened against *Xap* to determine the antibacterial activity, EB3 proved significantly effective followed by EB5 and TC9. Metabolites from EB4 were found to be ineffective against *Xap*.

In all, five bacterial isolates (EB3, EB4, EB5, EB9, TC9) and three fungal endophytes (EF1, EF2 and EF3) were selected as potential endophytes for further screening in pot culture trials.



Inhibition of *X. axonopodis* pv. *punicae* growth with endophytes in dual culture



EB9 TC9 Control

EF1 EF3 Control

Inhibition of *Xap* growth with endophytes in dual culture

3.2. Nutrient management

Four varieties namely, Bhagawa, Ganesh, Arakta and Mridula are popularly grown at commercial scale in India particularly in the Deccan Plateau region. India has emerged as the largest producer of pomegranate in the world. However, there is ample scope to increase productivity by employing sound nutrient management practices for different commercially grown genotypes of pomegranate. For developing sound nutrient management practices, it is very much essential to understand the behavior of nutrients within the plant, nutrient uptake and their requirement pattern by different commercially grown genotypes. This research aims to analyze partitioning of biomass and nutrient in different plant parts, nutrient uptake by different commercially grown genotypes and relation of nutrients in fruit with fruit yield and quality attributes.

3.2.1 Partitioning of biomass before flower bud initiation

The dry matter accumulation of 3-years old pomegranate plant before flower bud initiation differed significantly among the varieties. Multiple mean comparison of the four varieties indicated that all varieties allocated more dry matter to shoots than roots. The highest dry matter of above ground shoot (3359.70 g plant^{-1}) was produced in variety Ganesh which was followed by Mridula (2878.34 g plant^{-1}) whereas Bhagawa and Arakta had the lowest (2067.70 and 2089.42 g plant^{-1} respectively) above ground shoot biomass. However, Mridula had the highest root dry matter (2399.96 g plant^{-1}) followed

by Ganesh (1900.02 g plant^{-1}) while Bhagawa had the lowest root dry matter (1519.56 g plant^{-1}). The leaf dry matter content also differed considerably among the four varieties. The cv. Ganesh had the highest leaf dry matter (617.46 g plant^{-1}) and cv. Arakta had the lowest (335.16 g plant^{-1}). In totality, Ganesh produced maximum dry matter (5259.72 g plant^{-1}) which was at par with that of Mridula (5278.30 g plant^{-1}). This has led to low root-shoot ratio in cv. Ganesh while it was high in Arakta.

3.2.2. Distribution of nutrients before flower bud initiation

Plant nutrients are mainly derived from soil solution through absorption by roots. After absorption, the nutrients get distributed in different plant components based on their behavior within the plant. The distribution pattern of macro and micronutrients followed similar trend in all the varieties studied but, only differed in magnitude. The highest concentration of N, P, K and S was found in leaves while lowest concentration was noted in stem. On the contrary, highest concentration of Ca was traced in stem and the lowest concentration was found in roots. Magnesium (Mg) was most concentrated in leaves and least concentrated in current shoots.

Among the micronutrient cations, manganese (Mn) and zinc (Zn) concentration showed little variation within the plant. Unlike, Mn and Zn, iron was most concentrated in roots and least in current shoot while copper (Cu) was highly concentrated in stem and least concentrated in roots.

Cultivar Mridula is more N & P loving whereas Ganesh is more K loving cultivar. Uptake of nutrients by cv. Bhagawa was least.

3.2.3. Uptake of nutrients before flower bud initiation

The varieties of pomegranate differed in their uptake of macro and micro-nutrients. Nitrogen uptake prior to flower bud initiation ranged from 33.67 to 56.82 g plant^{-1}. The variety Mridula recorded the highest uptake of N while lowest uptake was noted with Bhagawa. Phosphorus uptake ranged from 2.31 to 4.45 g plant^{-1} with maximum uptake noted in Mridula. Potassium uptake varied from 16.35 to 30.01 g plant^{-1}. The highest uptake of K was recorded in Ganesh, while the lowest uptake was noted in Bhagawa. Calcium was taken up in larger quantity than other macro-nutrients. Calcium uptake ranged from 70.08 to 111.03 g plant^{-1}. Maximun uptake of Ca was observed in Mridula (111.03 g plant^{-1}) followed by Ganesh (98.52 g plant^{-1}). The variety Bhagawa registered the lowest uptake of Ca. Magnesium uptake ranged from 6.93 to 13.39 g plant^{-1} with highest uptake noted in Mridula followed by Ganesh. Similarly, sulphur uptake varied from 7.17 to 16.48 g plant^{-1}. It also followed the similar trend as that of Mg. Overall, the variety Mridula recorded the highest uptake of N, P, Ca, Mg & S while Ganesh recorded the highest uptake of K. The variety Bhagawa registered the lowest uptake of all the macro-elements. The uptake pattern of different varieties of pomegranate before flower bud initiation followed the order of Ca>N>K>S>Mg>P.

Iron uptake varied from 2824.12 to 4684.72 mg plant^{-1} with maximum uptake noted in Ganesh followed by Mridula. The uptake of Mn ranged from 116.25 to 198.58 mg plant^{-1}. Like Fe, the highest uptake of Mn was noted in Ganesh (198.58 mg plant^{-1}) followed by Mridula (174.63 mg plant^{-1}). Zinc uptake in different varieties varied from 77.64 to 136.64 mg plant^{-1}, while Cu uptake ranged from 1419.22 to 3289.57 mg plant^{-1}. The variety Mridula recorded the highest uptake of Zn and Cu followed by Ganesh. Here also, Bhagawa recorded the lowest uptake of cationic micronutrients (Fe, Mn, Zn &Cu). The uptake pattern of micro-nutrients before flower bud initiation followed the order of Fe>Cu>Mn>Zn.

The highest concentration of N, P, K and S was found in leaves while lowest concentration was noted in stem. On the contrary, highest concentration of Ca was traced in stem and the lowest concentration was found in roots. Magnesium (Mg) was most concentrated in leaves and least concentrated in current shoots. Iron was most concentrated in roots and least in current shoot while copper (Cu) was highly concentrated in stem and least concentrated in roots.

3.2.4 Fruit yield attributes

Different varieties of pomegranate produced varied number of fruits per plant. The highest number of fruits was recorded in Ganesh (75 nos. plant^{-1}) which was at par with that of Bhagawa (71 fruits plant^{-1}) followed by Mridula (68 fruits plant^{-1}), while it was lowest in Arakta (63 fruits plant^{-1}). Fruit weight ranged from 265.50 to 295.00 g fruit^{-1}. Fruit weight of Bhagawa and Ganesh was significantly higher than that of Mridula and Arakta. Maximum fruit yield was recorded with Ganesh (22.17 kg plant^{-1}) which was closely followed by Bhagawa (19.81 kg plant^{-1}) and Mridula (18.26 kg plant^{-1}). While the lowest fruit yield was noted with the variety Arakta.

3.2.5. Nutritional quality of fruit

Nitrogen (N) concentration in arils was higher compared to rind and it ranged from 9.77 to 15.12 g kg^{-1}. All the four varieties except Mridula had N content in fruit at par with each other. Mridula had significantly low N content in fruit. Phosphorus concentration in arils ranged from 0.85 to 4.21 g kg^{-1} while in rind it varied from 1.29 to 1.77 g kg^{-1}. Phosphorus (P) content in fruit ranged from 85.03 to 191.17 mg fruit^{-1}. The highest P content was recorded in Ganesh (191.17 mg fruit^{-1}) followed by Bhagawa (131.29 mg fruit^{-1}) and the variety Arakta registered the lowest content of P (85.03 mg fruit^{-1}). Potassium (K) concentration in rind was higher than in arils. Potassium concentration in arils varied from 8.80 to 17.73 g kg^{-1}, while in rind it ranged from 14.97 to 19.53 g kg^{-1}. The highest K content was recorded in Arakta (1259.24 mg fruit^{-1}) followed by other three varieties which were at par with each other. Calcium (Ca) concentration in arils was found to vary from 2.35 to 7.11 g kg^{-1}, while in rind, it varied from 4.18 to 5.28 g kg^{-1}. Except Arakta, Ca concentration was higher in rind than in arils. Calcium content in fruit varied from 203.38 to 407.41 mg fruit^{-1}. The highest Ca content was found in Arakta (407.41 mg fruit^{-1}) followed by Bhagawa (265.37 mg fruit^{-1}), while the lowest Ca content was detected in Ganesh (203.38 mg fruit^{-1}). Magnesium concentration in arils ranged from 1.40 to 2.16 g kg^{-1} and its content in fruit varied from 95.13 to 137.73 mg fruit^{-1}. Maximum Mg content was noticed in Arakta (137.73 mg fruit^{-1}) which was at par with Ganesh (133.94 mg fruit^{-1}). Mridula and Bhagawa recorded the least content of Mg. Sulphur concentration in arils varied from 0.50 to 0.98 g kg^{-1}, while in rind it ranged from 0.33 to 1.03 g kg^{-1}. The highest concentration of S in arils was found in Bhagawa (0.98 g kg^{-1}) followed by Mridula (0.65 g kg^{-1}) and Ganesh (0.58 g kg^{-1}), while the least concentration was traced in Arakta (0.50 g kg^{-1}).

Iron concentration in arils varied from 63.80 to 668.57 g kg^{-1}. Bhagawa and Mridula had the highest concentration of Fe, while the least concentration was noticed in Arakta (63.80 g kg^{-1}). Iron content in fruit varied from 4.08 to 27.68 mg fruit^{-1}. Mridula had the highest content of Fe followed by Bhagawa (23.05 mg fruit^{-1}) and Ganesh (20.49 mg fruit^{-1}), while Arakta registered the lowest content of Fe. Manganese concentration in arils ranged from 7.10 to 26.23 g kg^{-1} with maximum concentration detected in Bhagawa (26.23 g kg^{-1}) which was at par with Ganesh (25.08 g kg^{-1}). The least concentration of Mn was detected in Arakta (7.10 g kg^{-1}). In rind Mn concentration varied from 16.80 to 19.73 g kg^{-1}. The variety Ganesh and Bhagawa had the highest content of Mn in fruit, while the least content was recorded in Arakta. Zinc concentration in arils ranged from 21.40 to 41.87 g kg^{-1} with maximum concentration noted in Bhagawa

(41.87 g kg^{-1}) followed by Ganesh (31.24 g kg^{-1}) and Mridula (29.33 g kg^{-1}), while Arakta recorded the least concentration of Zn. In rind Zn concentration ranged from 8.13 to 22.40 g kg^{-1}. Bhagawa registered the highest content of Zn and it was significantly different from other varieties which were at par with each other. Copper concentration in arils was found to vary from 12.07 to 64.70 g kg^{-1}, while in rind it ranged from 8.17 to 11.88 g kg^{-1}. Mridula recorded the highest aril concentration of Cu followed by Ganesh (47.53 g kg^{-1}) and Bhagawa (20.12 g kg^{-1}). The least Cu concentration was noted in the arils of Arakta (12.07 g kg^{-1}). Fruit Cu content ranged from 0.82 to 2.79 mg $fruit^{-1}$. The variety Mridula was noted for the highest content of Cu while Arakta registered the lowest Cu content.

The variety Mridula recorded the highest uptake of N, P, Ca, Mg & S while Ganesh recorded the highest uptake of K. Fruits of cv. Arakta registered the lowest uptake of all the macro-elements. The uptake pattern of nutrients in different varieties of pomegranate before flower bud initiation followed the order of Ca>N>K>S>Mg>P while uptake pattern of micro-nutrients followed the order of Fe>Cu>Mn>Zn. Among the four varieties, Bhagawa was found to be the most efficient utilize of nutrients followed by Ganesh, Mridula and Arakta

3.2.6. Nutrient removal with the harvest

The varieties also differed in their nutrient removal pattern with the harvest. Bhagawa, Ganesh and Arakta removed similar quantity of N with the harvest, while Mridula removed significantly lesser quantity of N. Phosphorus removal with the harvest ranged from 5.36 to 14.40 g $plant^{-1}$. Ganesh removed the highest quantity of P (14.40 g $plant^{-1}$) followed by Bhagawa (9.34 g $plant^{-1}$) while Mridula and Arakta recorded the least removal of P from the soil with harvest. Arakta removed significantly higher amount of K (79.58 g $plant^{-1}$) than other three varieties which were at par with each other. Calcium removal with the harvest ranged from 15.31 to 25.74 g $plant^{-1}$. As like K, Arakta also removed maximum quantity of Ca followed Bhagawa (18.87 g $plant^{-1}$) and Mridula (16.14 g $plant^{-1}$). Ganesh registered the least Ca removal with the harvest. Magnesium removal ranged from 6.77 to 10.03 g $plant^{-1}$ with maximum removal recorded in Ganesh (10.03 g $plant^{-1}$) followed by Arakta (8.76 g $plant^{-1}$) and Mridula (7.25 g $plant^{-1}$). Removal of Fe varied from 258.23 to 1867.99 mg $plant^{-1}$. Mridula and Bhagawa removed significantly higher amount of Fe than Ganesh (1536.48 mg $plant^{-1}$) and Arakta (258.23 mg $plant^{-1}$). Manganese removal ranged from 52.41 to 110.26 mg $plant^{-1}$ with maximum removal recorded in Ganesh (110.26 mg $plant^{-1}$) and Bhagawa (99.30 mg $plant^{-1}$) which were at par with each other followed by Mridula (84.91 mg $plant^{-1}$). The least removal of Mn was noted in Arakta (52.41 mg $plant^{-1}$). Bhagawa removed significantly higher amount of Zn (135.87 mg $plant^{-1}$) than other three varieties which were at par with each other. Copper removal with the harvest varied from 51.46 to 188.08 mg $plant^{-1}$. Mridula removed maximum quantity of Cu followed by Ganesh (152.40 mg $plant^{-1}$) while Bhagawa and Arakta were the least remover of Cu.

Among the four varieties, Bhagawa was found to be the most efficient utilizer of nutrients (NER=69.03) followed by Ganesh (NER= 59.75), Mridula (NER= 50.28) and Arakta (NER= 49.70).

3.2.7. Relation between nutrient accumulated in fruit and fruit yield attributes

Pearson correlation was used to investigate the interrelationship among fruit nutrient accumulation and fruit yield attributes. Significant ($p<0.05$) strong relationships were revealed among the investigated parameters. Number of fruits per plant showed significantly good correlation with fruit accumulation of P (r= 0.747**), Mn (r= 0.745**), Zn

(r= 0.612*), N (r= 0.565*) and Fe (r= 0.516*) in a plant. Fruit weight was positively correlated with fruit accumulation of Mn (r= 0.744**), P (r= 0.699*) and Zn (r= 0.527). Interestingly, fruit yield showed positive correlation with fruit accumulation of P (r= 0.782**) and Mn (r= 0.594*) in each plant.

3.2.8. Relation between fruit nutrient content and fruit quality attributes

Pearson correlation was also used to find out the interrelationship among fruit nutrient content and fruit quality attributes viz. total soluble solid (TSS), acidity, total phenol, anthocyanin, ascorbic acid, reducing and non-reducing sugar and total sugar. It was found that TSS of fruit juice was positively correlated with P (r= 0.574*) and Mn (r= 0.509*) however it had negative correlation with Ca (r= -0.438*) content of fruit. Acidity of juice was positively correlated with Zn (r= 0.665) while it was negatively correlated with Mg (r= -0.514*) content of fruit. Total phenol content showed positive significant relation with Ca (r= 0.709*) and K (r= 0.503*) and it had strong negative correlation with P (r= -0.890**) and Mn (r= -0.675*) content of fruit. Similarly, anthocyanin content had positive correlation with Ca (r= 0.557*) while it showed significant strong negative correlation with P (r= -0.892**) and negative correlation with Mn (r= -0.501*) content of fruit. Ascorbic acid content of juice had strong positive correlation with P (r= 0.771**) content of fruit. Reducing sugar and total sugar of fruit showed strong negative correlation with P (r= -0.824**, r= -0.831** respectively) and significant negative correlation with Mn (r= -0.498*, r= -0.533*), while they had positive correlation with Ca (r^2= 0.477*, r= 0.461*) content of fruit. However, non-reducing sugar showed significant negative correlation with P (r= -0.588*) and positive correlation with Cu (r= 0.566*) content of fruit.

Fruit weight and yield showed positive correlation with fruit accumulation of P and Mn in each plant. Total phenol content showed positive significant relation with Ca and K, anthocyanin content had positive correlation with Ca and ascorbic acid content of juice had strong positive correlation with P content of fruit. TSS of fruit juice was positively correlated with P and Mn and acidity of juice was positively correlated with Zn content of fruit.

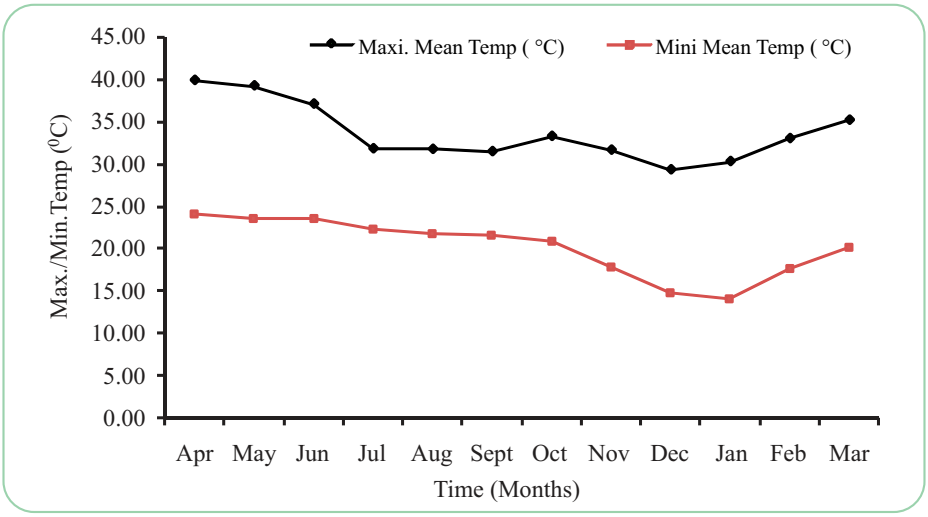
3.3. Water management

3.3.1. Weather Report

Various weather parameters viz., air temperature, soil temperature, relative humidity, wind speed, evaporation, rainfall, bright sunshine hrs. etc. were recorded daily at 7.30 and 14.30 hrs from April-2014 to March-2015 and the details are given below.

Air Temperature

The mean monthly maximum temperature varied from 29.3 to 39.9 ^{0}C. May was the hottest month and was highest (42.4^{0}C) on 25th May 2015 and lowest (9.4^{0}C) on 12th January 2015. The temperature gradually increased from April 2014 to May 2014 and then started declining till January 2015 then again it increased. Mean monthly minimum temperature varied from 9.4 ^{0}C in January 2015 to 28.0 ^{0}C in April.

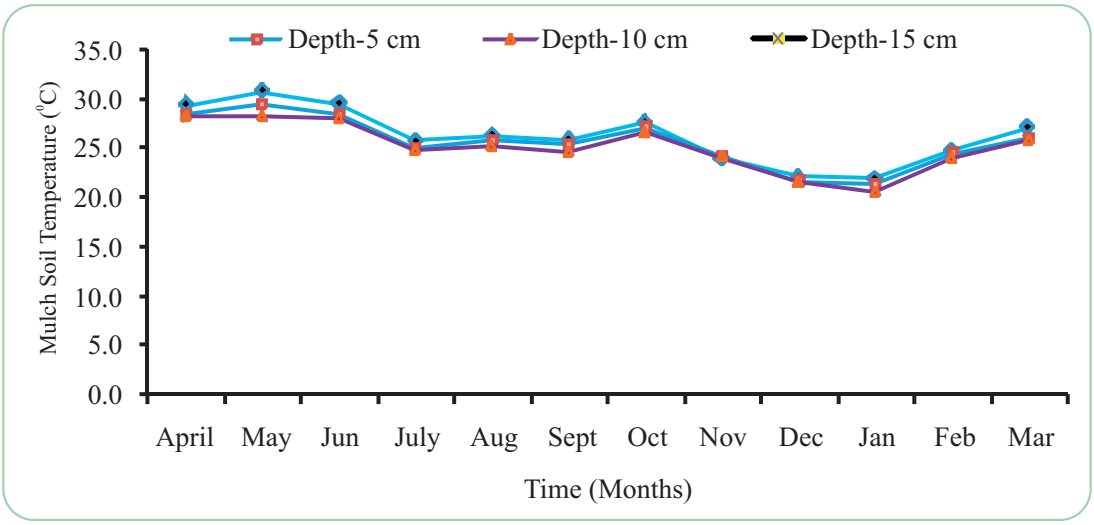


Mean monthly variation of tempearture (^{0}C)

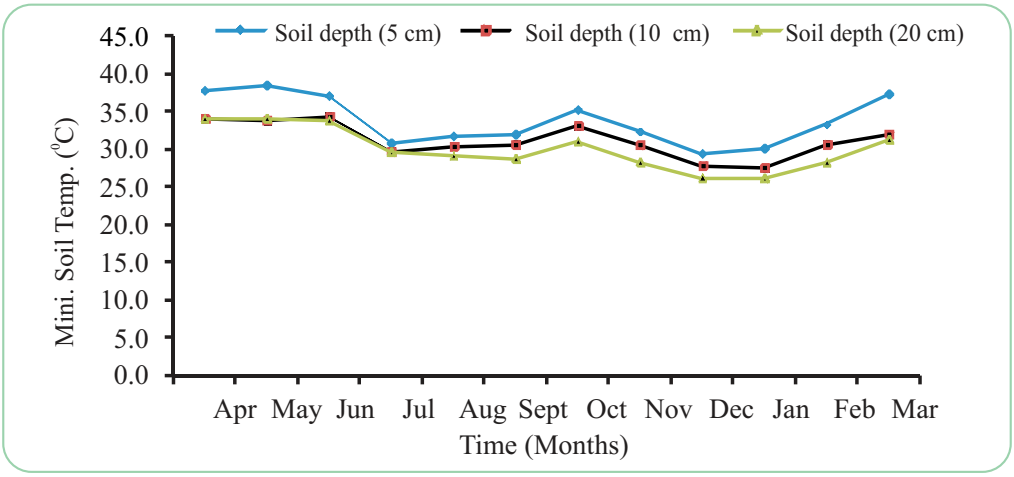
Soil Temperature

Soil temperature in the morning increased with increase in soil depth from 5 to 20 cm whereas, it decreased with increase in soil depth in the evening hrs. During morning hours, mean monthly temperature of surface soil was highest in the month of May 2014 (32.0 ^{0}C) and lowest in December 2014 (23.7 ^{0}C). Soil temperature was always less than the air temperature.

During evening hours, mean monthly temperature of surface soil was highest in May 2014 (35.5 ^{0}C) and lowest in January 2015 (27.8 ^{0}C).



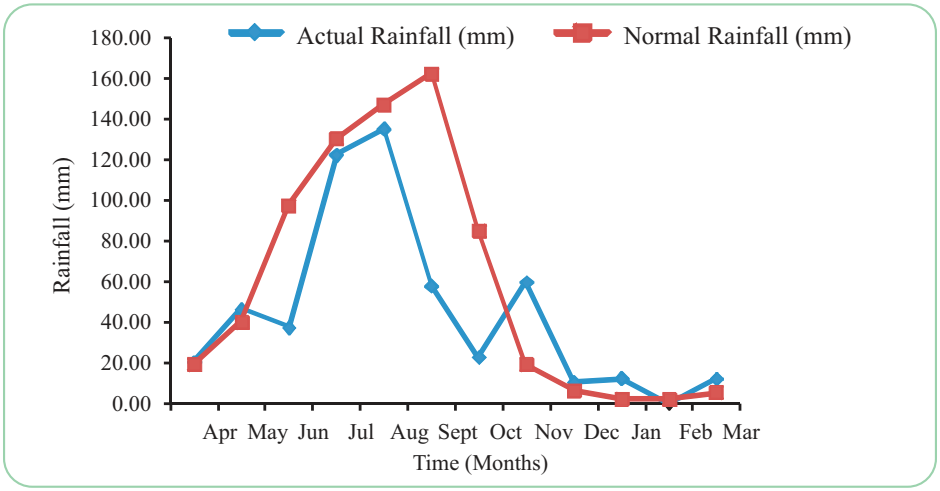
Soil temperature variation in the morning hours



Soil temperature variation in the evening hours

Rainfall and rainy days

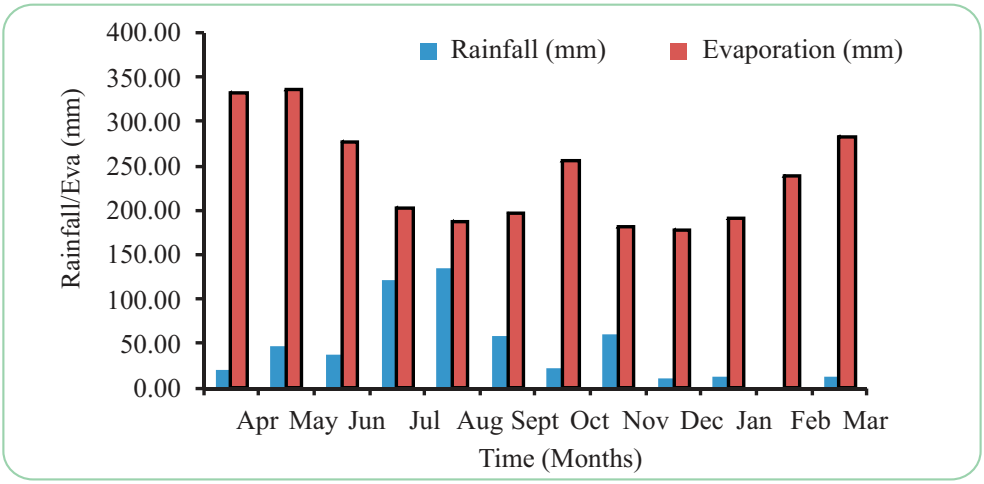
Total rainfall received during April 2014 to March 2015 at ICAR-NRCP, Solapur was 535.70 mm which was distributed over 61 days (rainfall of any amount) and 43 days (rainfall more than 2.5 mm). Annual rainfall was about 230.7 mm less than that of last year (766.4mm). More than 57.00 % of rainfall was received during June to October 2014. There were 304 days without any rain. Highest amount of rainfall for a single day was recorded on 30th August 2014 (53.30 mm). The analysis showed that the monthly rainfall in 2014-15 during December-March had a downward trend compared to normal rainfall.



Deviation of monthly rainfall-2014 from normal rainfall

Evaporation

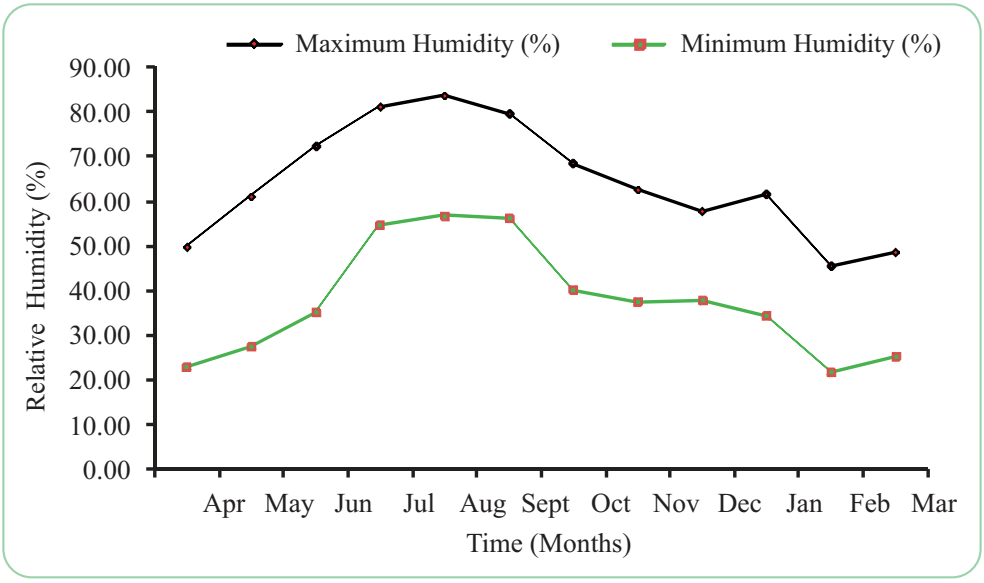
Total monthly evaporation was highest in May (336 mm) and lowest (177.4 mm) in December Evaporation recorded in a single day was highest (16.4 mm) on 26th May and lowest (0.5 mm) on 26th October. From April to March evaporation was higher than the rainfall. This indicates the water stress from April 2014 to March 2015. The total evaporation for this year was 2858.90 mm.



Distribution of total rainfall and evaporation

Relative humidity

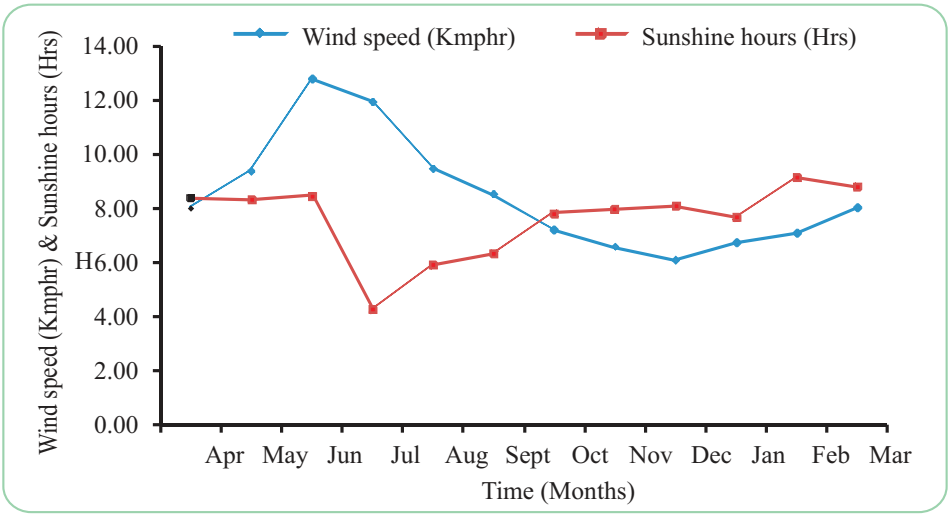
The mean monthly maximum relative humidity at ICAR-NRCP, Solapur was maximum in Aug. (83.65 %) and minimum in Feb (21.61 %). Minimum relative humidity remained low during Dec to Mar. Maximum relative humidity varied from 45.5 % to 83.6 %.



Variation of relative humidity

Sunshine hours and wind speed

The sunshine hour at ICAR-NRCP, Solapur ranged from 4.3 hrs day in July to 9.1 hrs/day in February. From June to October, sunshine hours ranged from 4.25 to 8.47 hrs/day. However, Nov. onwards, sunshine was available for more than 7.8 hrs /day. Mean monthly wind speed ranged from 6.1 km/hr in December to 12.8 km/hr in June. During the rainy season, wind was blowing at 7.2 to 12.8 km/hr. Wind speed was highest (16.08 km/hr) on 18th Jul. and lowest (4.1 km/hr) on 10th January, 2015.



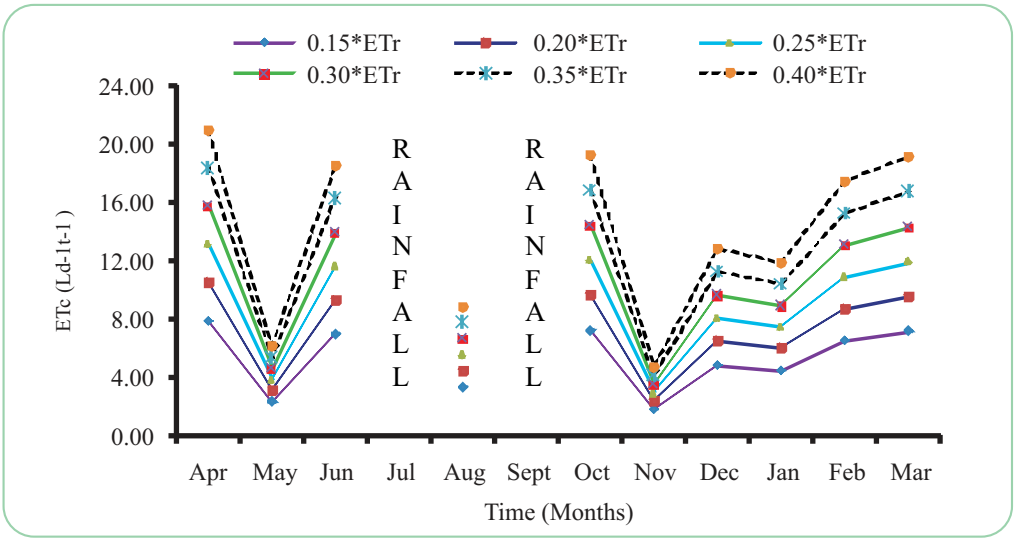
Mean monthly variation of wind speed and sunshine hours

3.3.2. Comparison of various irrigation methods with sub-surface drip irrigation system

The experiment was conducted on comparative performance evaluation of micro-irrigation methods to find out the effect of growth performance of 2nd year pomegranate orchard. Six treatments were replicated four times in RBD during 2014-2015. Various micro-irrigation treatments encouraged plant growth, reduced moisture evaporation and also regulated soil temperature. Maximum plant height, flowers, branches and stem diameter were recorded in SDI with double laterals (30*30 cm) followed by SDI with double laterals (30*40 cm), SDI with double laterals (30*50 cm), DI with double laterals (4D), SDI with single laterals (30 cm) and DI with single lateral (2D). Soil moisture withholding was also higher in the SDI with double laterals (30*30 cm).

In lateral geometry experiment, 3 main treatments and 6 sub-treatments in split plot design were conducted to find out the effect of two years old pomegranate orchard during 2013-2015. The seasonal values of water requirement to be applied to pomegranate plant ranged from 367 to 978 liters/year/plant for 2nd year pomegranate plant. The 0.30*ETr is the best treatment having double laterals with 4 drippers followed by ring type and single lateral (2D). The maximum plant height, flowers, branches and stem diameter was recorded in 0.30*ETr.

SDI at 30 cm spacing system



Pomegranate evapotranspiration, ETp (liter/month/tree)

Monthly shaded area, wetted area and leaf area index

Months	APP(m^2)	SA (m^2)	WA (%)	TA (m^2)	LAI_{SN}
April,2014	9.0	1.25	15.00	4.56	3.64
May	9.0	1.28	15.80	5.60	3.67
June	9.0	1.30	16.00	5.89	3.76
July	9.0	1.32	16.20	6.46	3.84
August	9.0	1.34	17.00	6.79	3.98
September	9.0	1.36	17.98	7.45	4.12
October	9.0	1.38	18.50	7.98	4.22
November	9.0	1.40	19.50	8.34	4.33
December	9.0	1.43	21.20	8.60	4.44
January	9.0	1.45	22.50	9.10	4.54
February	9.0	1.48	23.98	10.00	3.54
March,2015	9.0	1.50	24.50	10.54	3.65

(**Note:** APP-Area per plant (m^2), SA – Shaded area (m^2), WA-Wetted area(%), TA-Total area of leaves (m^2) and LAI_{SA}- Leaf area index at Solar noon hour (m^2/m^2)), **(**Spacing-4.5 x 2 m**)**

3.3.3. Effect of mulches and irrigation level on yield, quality and WUE of pomegranate

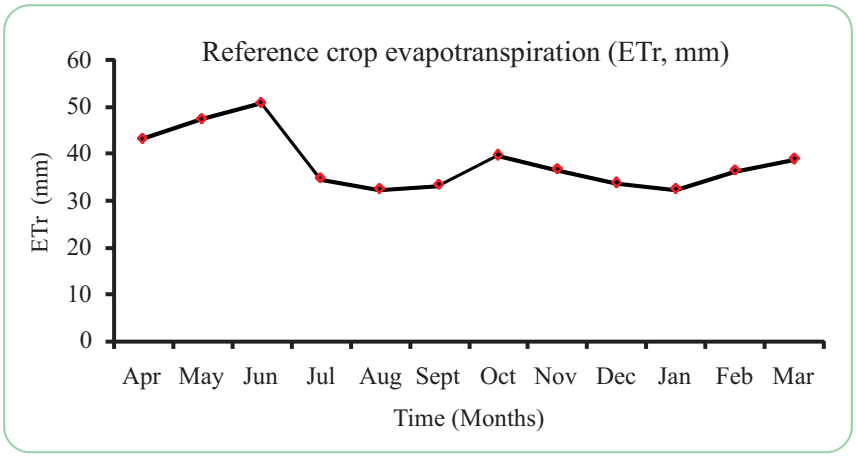
Climatic parameters at experimental site

The daily climatic parameters required for the estimation of ET_r is mentioned below.

Estimation of reference crop evapotranspiration (ET_r, mm)

Reference crop evapotranspiration (ET_r, mm) is the major component of pomegranate water requirement. It is the quantity of water transpired by

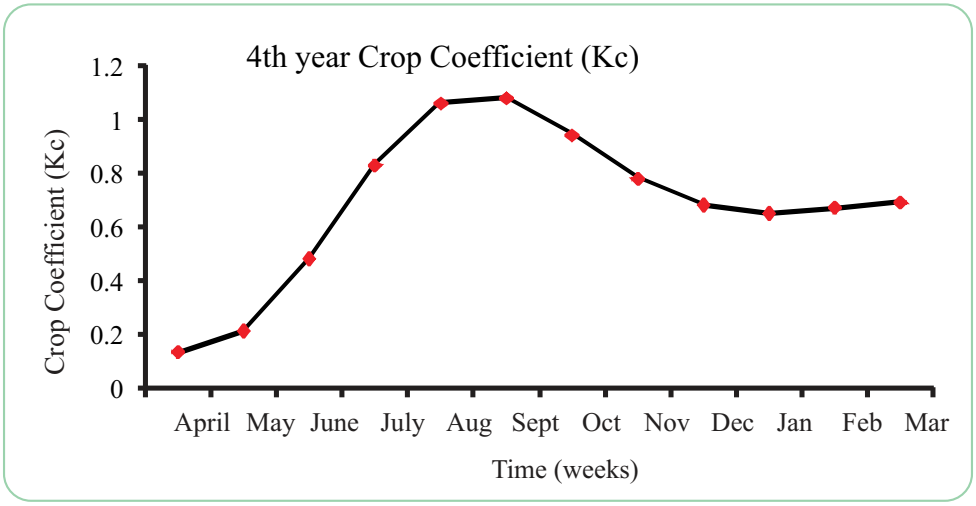
plants during their growth or retained in the plant tissue and the moisture evaporated from the surface of soil and vegetation. It is used to describe the atmospheric "demand" for water. The major factors affecting reference crop evapotranspiration are climatic parameters. Consequently, reference crop evapotranspiration is a climatic parameter and can be computed from weather data. Reference crop evapotranspiration expresses the evaporative power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors. Hence, the daily climatic data for the period of April, 2014 to March, 2015 were used to determine daily and weekly reference crop evapotranspiration (ET_r) by using Penman-Monteith Method. The monthly ET_r values showed that the trend of variation of average ET_r values over the year. The yearly reference crop evapotranspiration (ET_r) obtained are 1992.30 mm. The ET_r was maximum in June and minimum in January (35-39 SMW). The monthly minimum and maximum ET_r ranged from 32.30 to 50.80 mm.



Monthly ETr (mm) values from April, 2014 to March, 2015 at experimental site

Development of crop coefficient (K_c) values

Crop coefficients are needed to estimate pomegranate evapotranspiration (ET_p) with reference crop evapotranspiration (ET_r). These coefficients are dimensionless numbers that are multiplied by the ET_r values to know pomegranate evapotranspiration in mm. It varies with crops, age, phenological stages, location, by time of the years and specific cultural or management practices. Therefore, the weekly crop coefficient value was computed by using equation (K_c=0.014x+0.08) and converted in monthly basis. The monthly crop coefficient curve for pomegranate plant in 4th year was recorded. It indicated that the values of crop coefficient increases from 0.13 to 1.08 due to the development, maturation of the leaf surface, increased number of leaves, foliage, water sprout, flowers and fruits of the plant during 4th year. The Kc values increases linearly from April to August months due to increases in number of leaves, water sprout, luxors, flowers, fruits and shaded area as observed from the representative plant and decreases from October to January months due to removing of water sprout, leaf drop and harvesting of fruits. The crop coefficient (0.65-0.70) increases in the month of Januay to March due to increases excess water sprout, foliage and management practices.



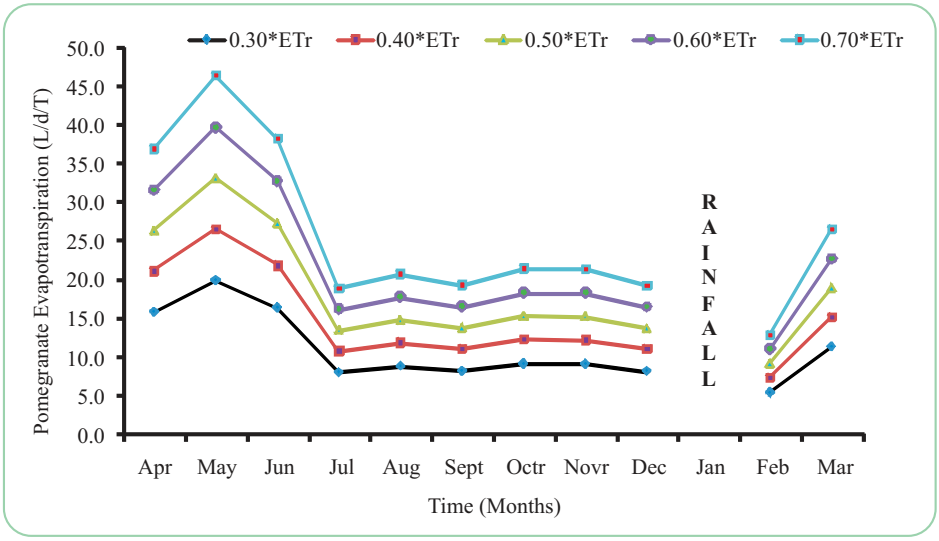
Crop coefficient curve for 4th year pomegranate plant

Estimation of Pomegranate Evapotranspiration (ETp, litres / day / plant)

The daily water to be applied through drip irrigation system at 90 % efficiency from April, 2014 to March, 2015 ranged from 6–35 liters/day/plant for 4th old age of pomegranate plant at 0.50*ETr is the best. It gradually increases or decreases during different development stages of pomegranate plant due to the variation of reference crop evapotranspiration, pan coefficient, wetted area and crop coefficient values. Lower Kc values represent slower plant growth and lower plant canopy cover, indicating lower ETp. The annual pomegranate evapotranspiration is 12123 litres/year/plant and water to be applied to pomegranate plant ranged from 3637 to 8486 liters/year/plant based on different irrigation levels 0.30 to 0.70 * ETr. The critical stages wise water requirement in $Lstage^{-1}t^{-1}$ including number of days for pomegranate Bhagawa cv. (*i.e.* new leaf initiation, crop development, maturity and harvesting) were identified and recorded.

Critical pomegranate plant stages for irrigation in *hasta* bahar

Sl. No.	Critical stages for Irrigation	Nos. of days	WR ($LStage^{-1}t^{-1}$)
1.	New leaf initiation	22-25	154-175
2.	Crop development (Flowering to fruit Setting	70-80	1400-1600
3.	Mid (Fruit development)	60-70	1620-1890
4.	Harvesting (Fruit removal)	45-60	1800-2400



Monthly ETr (mm) values from April, 2014 to March, 2015 at experimental site

Pomegranate Evapotranspiration for Inorganic and Organic Mulches (ETp, litres/day/plant)

An experiment on different organic (i.e. Wheat, Safflower and Sugarcane bagasse) and inorganic mulches (i.e. Black and White, Black and Pervious) was conducted to find out the effect of mulches on soil properties and growth of pomegranate. Eight treatments including control were replicated four times in split plot design. Various-mulching treatments encouraged plant growth, reduced moisture evaporation and also regulated soil temperature. Depletion of soil moisture was very high in untreated plants. Maximum number of fruits was recorded in sugarcane and pervious mulches with 0.50*ETr, followed by wheat, safflower and black and white and black. Soil moisture retention was also higher in the black mulch treated plants.

Growth parameters

Pomegranate cv. Bhagawa was evaluated for their growth parameters in organic and inorganic. Plant height, plant spread (EW & SE), stem diameter, stem girth, thorn length, flowers and number of fruits ranged from 112 to 165 cm, 120 to 169 cm, 115 to 139 cm, 3.0 to 4.7 cm, 2.6 to 2.9 cm , 2.7 to 3.9 cm, 70 to 208 and 40 to 85 respectively.

Organic mulch

Inorganic mulch

Growth performance of organic and inorganic experimental plots

Mulching Material	Plant height (cm)	Plant spread (cm)		Stem diameter (cm)	Stem girth (cm)	Thorn length (cm)	No. of flowers/ plant	No. of fruits/ plant
		EW	NS					
Organic mulch (0.30 to 0.70*ETr)								
OT1	112	120	115	3.3	2.6	2.7	140	48
OT2	135	127	137	3.8	2.9	3.4	170	56
OT3	160	143	134	4.7	2.8	3.6	208	76
OT4	134	124	127	4.2	2.7	3.9	70	43
Inorganic mulch (0.30 to 0.70*ETr)								
IT1	125	150	130	3.4	2.7	2.6	158	40
IT2	146	158	139	3.5	2.9	2.9	150	55
IT3	165	169	138	4.1	2.6	3.5	240	85
IT4	138	143	132	3.9	2.8	3.8	120	50

(Organic- OT_1- Wheat, OT_2-Safflower, OT_3-Sugarcane bagasse, OT_4-Control;
Inorganic-IT_1-Black and White, IT_2-Black, IT_3-Pervious, IT_4-Control)

4. CROP PROTECTION

4.1. Bacterial blight

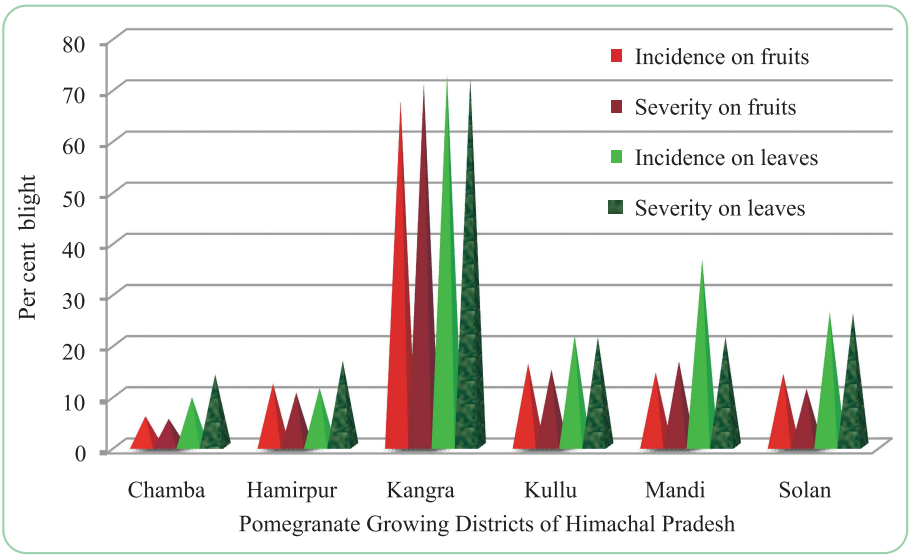
The work highlighted here on bacterial blight of pomegranate, was carried out under the Project titled, 'Flagship Project on Integrated Approach to Eradicate Pomegranate Bacterial Blight.' The study was done by the Nodal agency National Research Centre on Pomegranate (NRCP), Solapur (Maharashtra) and coordinating Centers- Indian Institute of Horticultural Research (IIHR), Bengaluru (Karnataka), Indian Agricultural Research Institute (IARI), New Delhi, University of Horticultural Sciences, Bagalkot (UHS) Karnataka, Dr. YS Parmar University of Hort. and Forestry (Dr.YSPUHF), Nauni, Solan (HP).

4.1.1. Status of pomegranate bacterial blight in Himachal Pradesh

Surveys were conducted by Dr. YS Parmar University of Horticulture and Foresty, Nauni, Solan in six districts of Himachal Pradesh viz. Chamba, Kangra, Hamirpur, Mandi, Kullu, and Solan to record status of bacterial blight of pomegranate caused by *Xanthomonas axonopodis* pv. *punicae* (*Xap*). A total of 30-50 plants in 1-5 orchards were surveyed depending on area of orchard and number of orchards present in each district and the diseased samples were collected for isolation of the pathogen.

The analysis of survey data revealed that the maximum disease incidence on fruits was at Jachh in Kangra district on Bhagawa (81.37 %) where as it was minimum at Thrass in Kullu district on Kandhari Hansi (7.55%). The maximum disease severity on fruits was recorded at Jachh in Kangra district on Mridula (76.47 %), while the minimum disease severity on fruits was found at Seobag in Kullu district (7.67%). The fruits of Kandhari Kabuli, at Mehla, Sarru in Chamba district and that of Mridula in Gharsa did not reveal symptoms of bacterial blight.

On leaves the maximum disease incidence was recorded at Jachh in Kangra on Ganesh (79.23%), while at Mehla in Chamba district growing Kandhari Kabuli variety was free from bacterial blight symptoms. Further, the maximum disease severity on leaves was registered (75.48 %) at Jachh in Kangra on Kandhari Kabuli.



Incidence and severity of bacterial blight of pomegranate in different districts of Himachal Pradesh

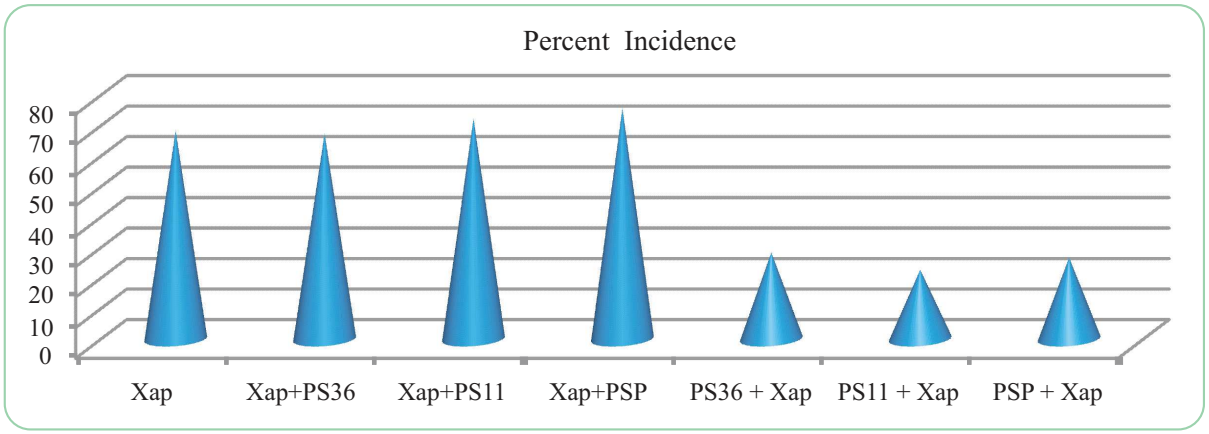
4.1.2. Evaluating biological agents and novel chemicals for bacterial blight management

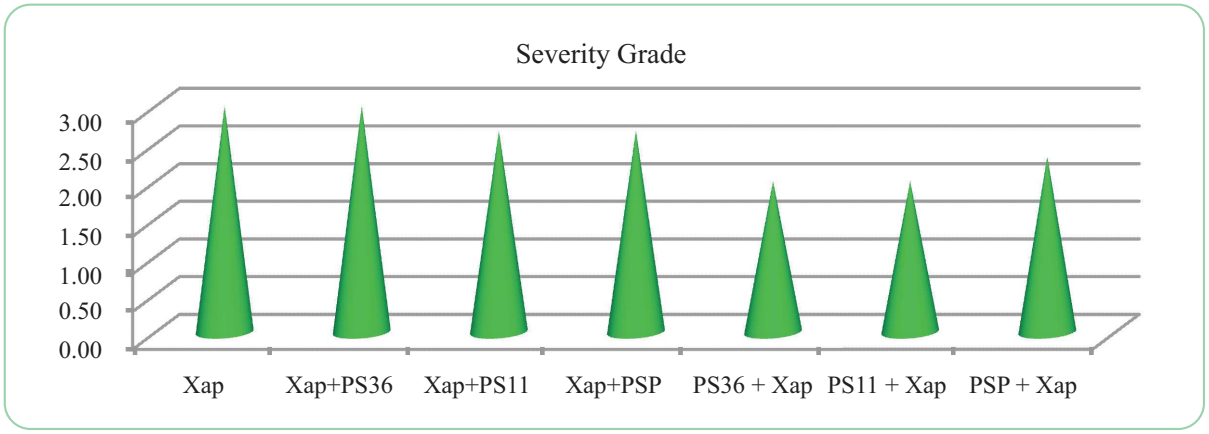
a) Isolation and evaluation of bioagents against bacterial blight pathogen

Soil samples were collected from different agroclimatic regions of pomegranate growing areas in Karnataka and Maharashtra for developing inventory of bio-agents and the antagonists by University of Horticulture Science, Bagalkot (Karnataka). A total of 204 *Trichoderma sp.,* 177 *Pseudonomas sp.* and 158 *Bacillus sp* were isolated and *in vitro* efficacy studies against bacterial blight pathogen Xap were conducted.

Two effective new species for controlling blight were identified to be *Pseudomonas geniculata* and *Pseudomonas plecoglossicidia* and the 16S sequence of the same have been submitted to NCBI-GenBank. The other effective isolates of *Pseudomonas* and *Bacillus* are being identified by 16S rRNA sequence and *Trichoderma* species by ITS sequences.

In a pot culture trial at NRCP, Solapur three isolates of *Pseudomonas fluorescens* from UHS Bagalkot (PS36, PS11) and Solapur (PSP) were tested against Xap. All three isolates effectively checked BB when sprayed twice 15 and 7 days before *Xap* inoculation. The isolates reduced BB incidence by 58.54-66.83% and severity by 22.23-33.33 per cent over control (BB incidence 68.33% and severity grade 3). The isolates were however, not able to reduce BB when sprayed after symptom development.

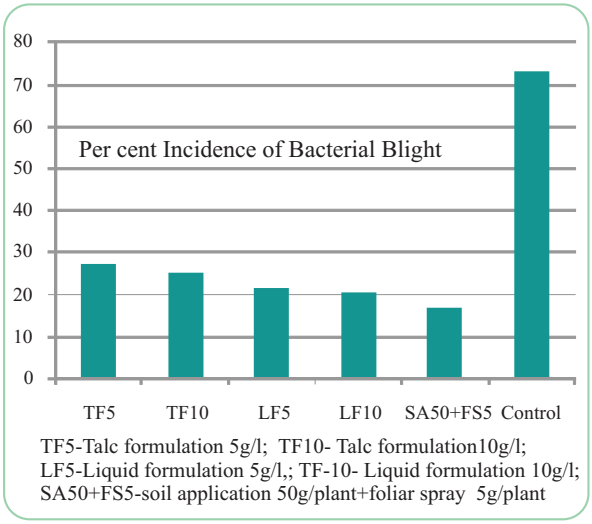




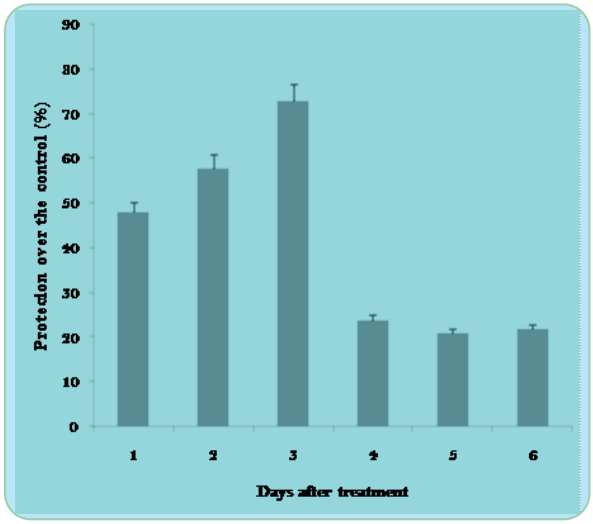
Efficiency of *Pseudomonas fluorescens* isolates (PS36, PS11 & PSP) in reducing bacterial blight caused by *X. axonopodis* pv. *punicae* isolate (Xap)

Promising *P. fluorescens* isolates was evaluated in greenhouse using both talc and liquid formulations for sprays. All formulations resulted in significant reduction in bacterial blight incidence by 62.7-77.1%. Soil applications of *P. fluorescens* followed by foliar sprays, offered the maximum protection of 77.1 % over the control which recorded 73.4% incidence. Studies also revealed that liquid formulations were significantly better than talc formulations.

A spatio- temporal pattern experimentation was conducted to know the nature of resistance offered by the *P. fluorescens* through temporal separation of pathogen and biological treatment. The results revealed that, resistance development was transiently improved beginning from the treatment and maximum was attained, when pathogen was challenge inoculated 3-days after treatment of *P. fluorescens*, which recorded maximum protection of 73%.



Effect of *Pseudomonas fluorescens* treatments on bacterial blight in greenhouse



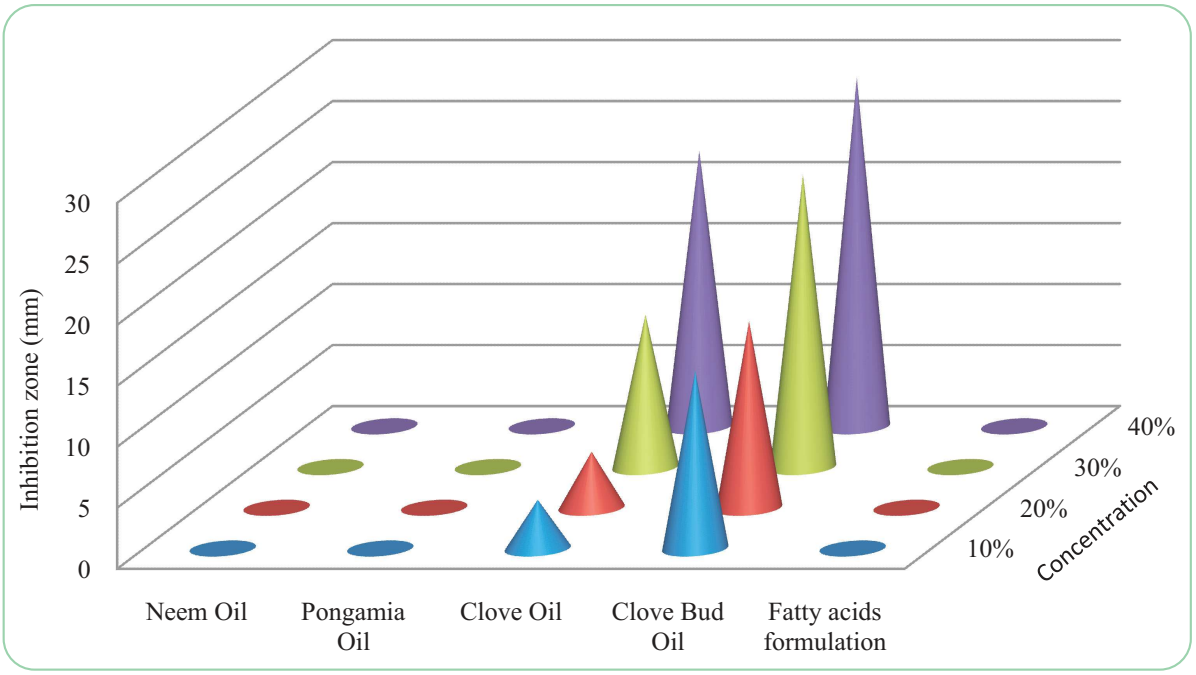
Nature of resistance by *P. fluorescens* species

b) Sensitivity of *Pseudomonas fluorescens* to other molecules

Potential *Pseudomonas fluorescens* was screened for sensitivity to micronutrients and other chemicals generally used in pomegranate crop production. It was found compatible with micronutrients and fungicides but not against bactericides *viz.* copper oxy chloride, streptomycin sulphate (90%) + tetracycline hydrochloride(10%) and 2-bromo-2-nitro-1,3-diol. The study also indicated that minimum of 4 days gap is required for application of *Pseudomonas* species after the spray.

c) Development of delivery systems

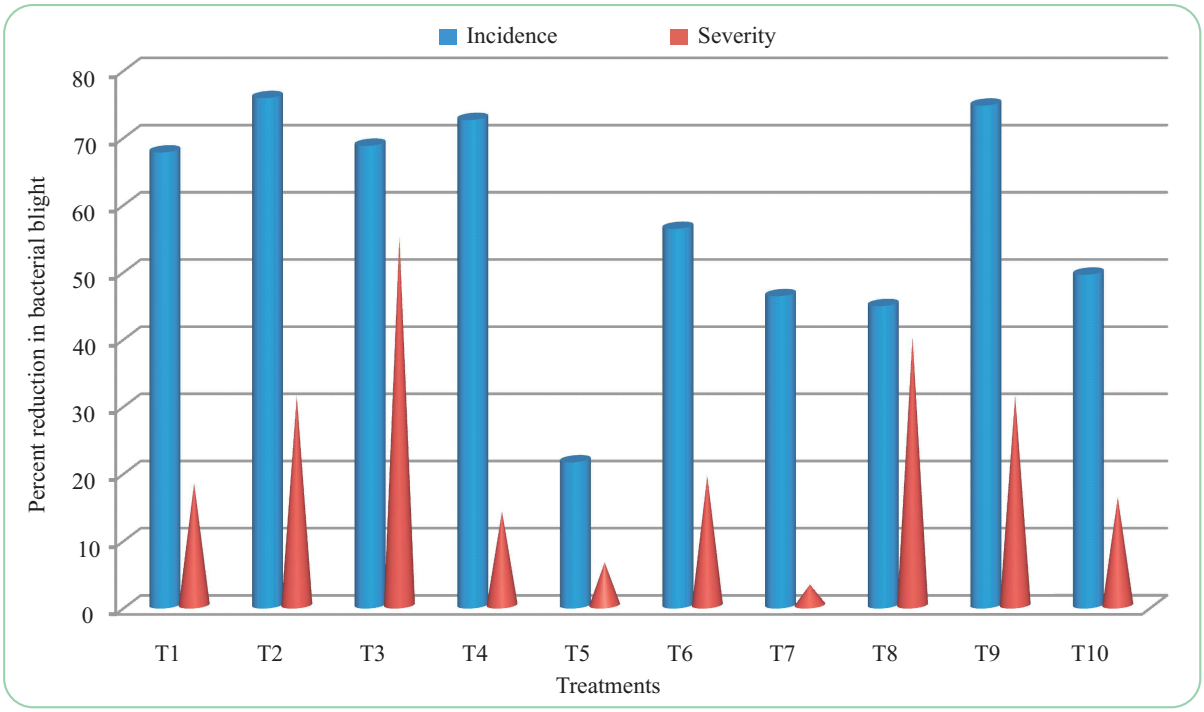
Bioagents are less persistent under field conditions due to desiccation of propagules under adverse conditions. Hence plant oils and fatty acids were tested as delivery systems for *P. fluorescens* for their prolonged survival and establishment of bioagents in field conditions for effective control. Results indicated that neem oil, pongamia oil and fatty acids are compatible with *P. fluorescens* and same can be used for developing the delivery systems with enhanced efficacy. Clove and clove bud oil were inhibitory to *P. fluorescens* at tested concentration of 10-40%, which formed 4.0-22.6 mm and 14.6 to 28.6 mm inhibitory zones respectively in dual diffusion test.



***In vitro* sensitivity of *Pseudomonas fluorescens* to different concentration (10-40%) of plant oils and fatty acids formulation**

d) Evaluation of novel chemicals

Molecules known for inducing biochemical resistance against diseases along with chemicals in vogue for management of pomegranate bacterial blight were evaluated in polyhouse against bacterial blight pathogen *Xanthomonas axonopodis* pv. *punicae* in challenge inoculation. Lowest BBD incidence was recorded in salicylic acid treatment, which was at par with spray treatments with formulations containing silicone polyether, copper sprays and chitosan derivative. Reduction of BBD incidence in these treatments was from 67.87-75.97% over control having 33.50% incidence. Among other 5 molecules, significant reduction was recorded in mancozeb, carbendazim, ziram and streptocycline from 45-56%, however Fosetyl-Al did not show significant control of bacterial blight. Reduction in blight severity over control was recorded from 39.82 to 54.75% with sprays of copper formulations and streptocycline that are at par with each other.

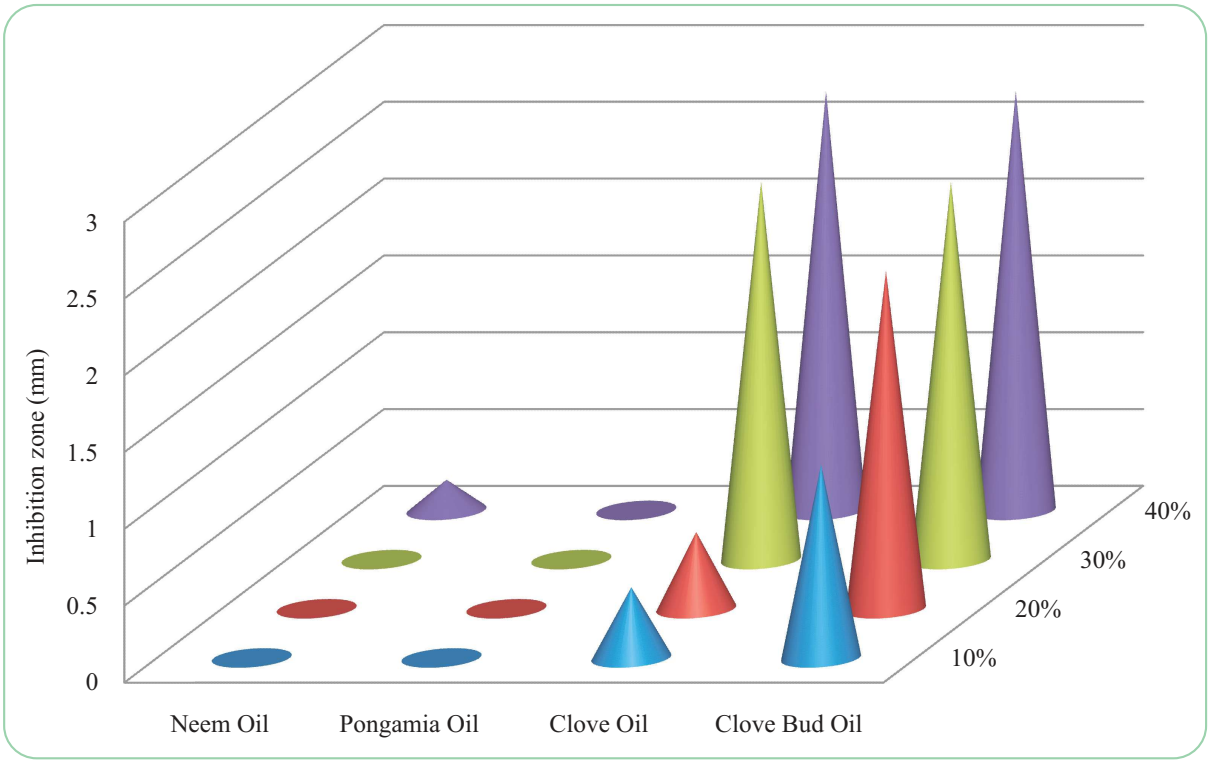


Efficacy of different molecules in reducing pomegranate bacterial blight pot culture trials
T1:Silicone poly ether; T2: Salicylic acid; T3: Copper Hydroxide/Copper oxy chloride in alteration; **T4**: Chitosan derivative; **T5**: Fosetyl- Al 80%WP; **T6**: Mancozeb; **T7**: Ziram; **T8**: Streptocycline **T9**: 2-bromo-2-nitro-2-propane-1,3-diol, **T10**: Carbendazim

In a test for disease resistance potential against BBD in coded samples, surface wash after 10 days of last spray showed highest potential in plants sprayed with carbendazim followed by chitosan derivative and salicylic acid. The extract at 1:8 dilution showed highest potential in chitosan followed by salicylic acid, 2-bromo-2-nitropropane-1,3-diol (bronopol) treated plants. Concentration of antimicrobial components was highest in chitosan followed by salicylic acid and bronopol.

e) Evaluation of plants oils against *Xap*

Different plant oils were evaluated *in vitro* at 10-40% for their efficacy against *Xap*. Clove oil and clove bud oil were most effective with inhibition zone of 27.3 mm in 40% oil. Clove bud oil was effective even at 10% concentration with larger inhibition zone. Neem oil recorded 2mm inhibition at 40% concentration and pongamia oil did not record any inhibition.



***In vitro* sensitivity of *X .axonopodis* pv. *punicae* to different concentration (10-40%) of plant oils**

f) Effect of Potassium on bacterial blight

Sulphate of potash (SOP) was applied in both soil and foliar sprays in three splits after flowering. Results indicated that application of potash as SOP and current package of practices played highly significant role in reducing bacterial blight, fruit cracking and increasing number of fruits /yield, whereas, additional application of potash as SOP had positive influence over the fruit cracking rather than blight incidence as well as on number of fruits/plant. Potash has positive influence on water use efficiency thus helping overcome water stress and hence, reduces fruit cracking.

4.1.3. Studies on host pathogen interaction

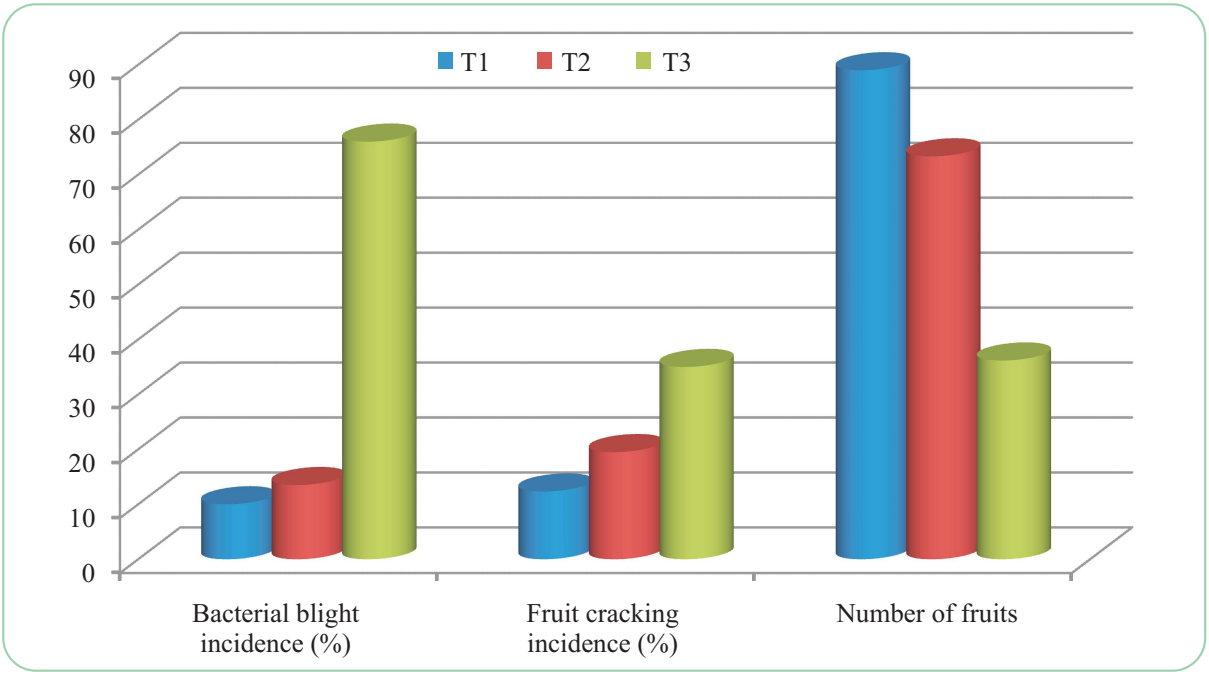
***a) In silico* detection of *X. axonopodis* pv. *punicae* interacting genes in pomegranate**

Understanding the genetic mechanism of host-pathogen interaction is important for successful crop improvement. The present study was undertaken by NRCP Scientist at ICAR-IIHR, Bengaluru, to identify the interacting genes from both host and pathogen side.

One-hundred and fourteen *Xanthomonas* interacting gene sequences irrespective of the crop species were downloaded from National Center for Biotechnology Information (NCBI, http://www.ncbi.nlm.nih.gov/) database and BLAST aligned with pomegranate database (2,397 ESTs and 75,887 Nucleotide) sequences. Out of 114, eight genes have showed 67-84 per cent homology with the pomegranate sequences. These genes are known to come in the way of cell-wall recognition, molecular interaction and biological processes required for the pathogen interaction to cause the infection. Primers were designed for the same gene sequences from their conserved region by using the Primer3 program

(http://frodo.wi.mit.edu/primer3/). Meanwhile, primers were also designed for *Xa21* gene, from the homologous region of the aligned *Oryza sativa* Indica group, *Oryza longistaminata*, *Oryza rufipogon*, *Oryza nivara*, *Oryza glumipatula* and *Oryza meridionalis* sequences.

The PCR amplification was carried out using the *in silico* developed primers for the selected genotypes of pomegranate i. e., Bhagawa, Nana, Daru and Ganesh. The amplified products on agarose gel (1.2%) electrophoresis was analyzed for the presence or absence of the *Xanthomonas* interacting gene homologous sequence. Out of eight genic primers, six have amplified in the pomegranate samples. Thus, confirms the presence of *Xanthomonas* interacting genes in pomegranate which were acting at the molecular level. These genes would be very useful to regulate them at their genetic level for effective control of *Xanthomonas* invasion.



Effect of sulphate of potash (SOP) application on blight incidence and fruit cracking

T1- SOP 25g/plant soil drenching + 4g/plant foliar spray, 3 times at 15-days interval after flowering + with current POP; T2- Package of practices with no additional supply of SOP; T3-Control

4.1.4. Standardization of techniques for mass production of disease (BB) free planting material of commercial varieties

a. Sanitization of planting material for producing blight free plantlets :

Apparently healthy stem cuttings were taken from farmer's orchard at Dongaon, which was heavily infected with bacterial blight, for standardizing sanitization protocol. The cuttings were taken twice from same orchard, first on March 31, 2013 before Monsoon and second time on Nov. 21, 2013 after Monsoon. These were planted after giving different treatments under shade net. In cuttings taken before monsoon nodal blight developed only in small percentage (5.57%) of cuttings hence treatments could not be evaluated. Evaluation of treatments was

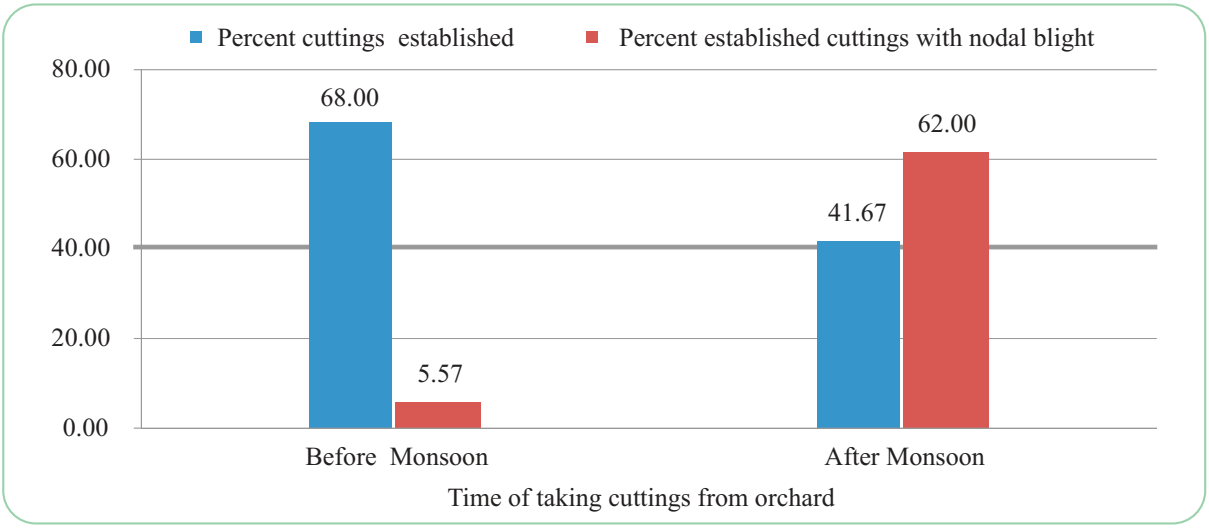
done in cuttings taken after monsoon where nodal blight was expressed in 62% cuttings. Establishment of stem cuttings was higher (68%) when they were taken prior to monsoon and only 41.67% when taken after monsoon. Thus cuttings taken after rest period, before monsoon was advantageous as they established better with very low percentage of nodal blight.

Score	Expect	Identities	Gaps	Strand	Frame
538 bits(596)	6e-154()	432/521(83%)	0/521(0%)	Plus/Plus	

Features:

```
Query  23   ATGCCAAACCCCAAAGTGTTCTTCGACATGACCGTCGGCGGTCAGCCCGCCGGCAGGATC  82
Sbjct  77   ATGGCGAACCCGAGGGTCTTCTTCGACATGACGATCGGCGGCCAGCCGGCCGGCCGGATT  136
Query  83   GTGATGGAGCTCTTCGCCGATGTCACCCCCCGAACCGCCGAGAACTTCCGCGCCCTCTGC  142
Sbjct  137  GTGATGGAGCTCTACGCTGACACCACCCCCCGCACCGCGGAGAACTTCCGCGCCCTCTGC  196
Query  143  ACCGGCGAGAAAGGCATCGGCAAGTCCGGCAAGCCACTCCACTACAAGGGCTCGTCCTTC  202
Sbjct  197  ACCGGCGAGAAGGGCGTTGGCCGCTCCGGCAAGCCCCTCCACTACAAGGGGTCGACCTTC  256
Query  203  CACCGTGTGATCCCCGGATTCATGTGCCAGGGGGGAGACTTCACCGCCGGAAACGGAACC  262
Sbjct  257  CACCGTGTGATCCCGGGGTTCATGTGCCAAGGTGGTGACTTCACCGCCGGGAACGGCACC  316
Query  263  GGAGGCGAATCAATCTACGGCTCAAAATTCGCCGATGAGAACTTCGTGAAGAAGCACACC  322
Sbjct  317  GGTGGCGAGTCGATCTACGGGGCGAAGTTCGCCGACGAGAACTTCATCAGGAAGCACACC  376
Query  323  GGCCCCGGAATCCTCTCCATGGCGAATGCCGGACCCGGAACCAACGGATCTCAGTTCTTC  382
Sbjct  377  GGCCCGGGAGTGCTGTCCATGGCGAACGCCGGCCCAGGGACGAACGGGTCCCAGTTCTTC  436
Query  383  GTCTGTACGGCCAAGACCGAGTGGCTCGATGGGAAGCACGTTGTGTTCGGTCAAGTCGTC  442
Sbjct  437  GTCTGCACTGCCAAGACCGAGTGGCTGGACGGGAAGCACGTGGTGTTCGGGCAGATCGTG  496
Query  443  GAAGGAATGGACGTCGTCAAGGCCATCGAGAAAGTGGGGTCCAGCTCCGGAAGGACCAAC  502
Sbjct  497  GAGGGGATGGACGTGGTGAAGGCGGTGGAGAAGGTGGGGTCGAGCTCCGGCAGGACCTCG  556
Query  503  AAGCCCGTCGTGATCGCTGATTGCGGTCAATTGTCTTAGAT  543
Sbjct  557  AAGCCGGTGGTTGTCGCGGACTGCGGCCAGCTGTCTTAAAT  597
```

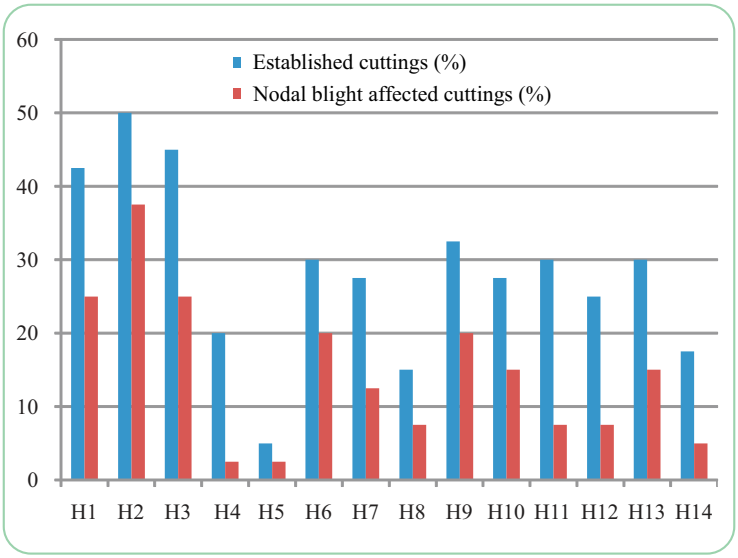
NCBI-BLAST alignment showing the homology between the citrus and pomegranate EST sequence



Effect of season on establishment of cuttings and nodal blight development

In an experiment with different doses (0.5, 1, 2, 3, 4, and 5 g/l) of Trichlosan quick dip treatment, dose of 1 and 2 g/l significantly improved establishment of cuttings but treatments failed to check expression of nodal blight

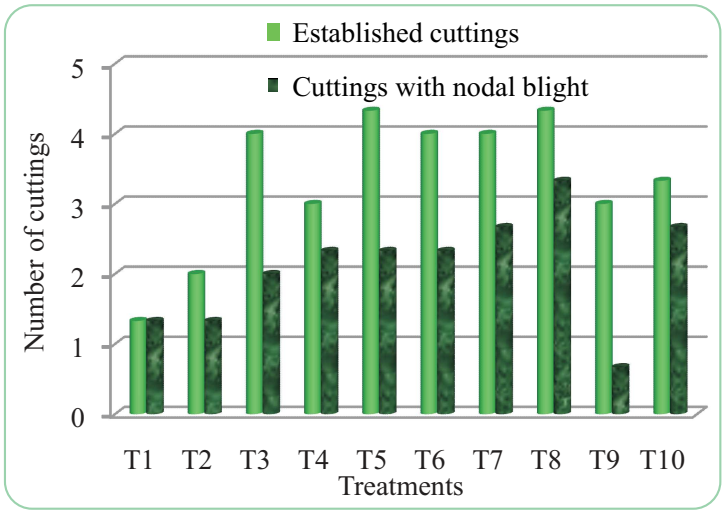
In second set with different heat treatments all heat treatments except hot water treatment at 53°C for 15 sec and 5 minutes reduced establishment of cuttings. Hot water treatment at 53°C for 15 sec improved survivability by 17.64% but could not check nodal blight development. Treatments that checked nodal blight expression in cuttings by 50-90% reduced establishment of cuttings drastically.



Effect of heat treatments on establishment of stem cuttings and development of nodal bacterial blight

H1	Control (no treament)
H2	Hot water 53°c for 15 sec
H3	Hot water 53°c for 5 min
H4	Hot water 53°c for 10 min
H5	Hot water at 60°c for 15 sec
H6	Hot air dry at 53°c for 15 sec
H7	Hot air dry at 53°c for 5 min
H8	Hot air dry at 53°c for 10 min
H9	Hot air 53°c for 15 sec., wrapped in moist cloth
H10	Hot air 53°c for 5 min., wrapped in moist cloth
H11	Hot air 53°c for 10 min., wrapped in moist cloth
H 12	U.V light for 10 min
H 13	U.V light for 20 min
H 14	Hot air 53°c for 5 min. + freezing at - 4 °c for 5 min.

Different chemical treatments used for quick dip significantly improved establishment of cuttings between 55.67% to 69.28%, except one treatment with kocide and streptocycline. None of the chemical treatments resulted in significant control of nodal blight. Sodium hypochlorite 1% treatment however, reduced nodal blight by 49.62%.



Effect of chemical treatments on establishment of stem cuttings and development of nodal blight

Treatments	
T 1	control only water streptocycline 0.5+kocide
T 2	2 g/l streptocycline
T 3	0.5+carbendizim 1g/l
T 4	Bronopol 0.5+Kocide 2g/l Bronopol
T 5	0.5/l+carbendizim 1g/l
T 6	Rose Bengal 0.1g/l
T 7	Rose Bengal+kocide g/l Rose Bengal+carbendizim
T 8	1g/l Sodium hypochlorite
T 9	10ml/l
T 10	Boric acid 30g/l

4.1.4. Phenotyping and genotyping of *X. axonopodis pv. punicae* strains

a) Phenotypic Characters

Five key phenotypic characters have been found by IARI, New Delhi for identification of *X. axonopodis* pv. *punicae* and eliminating the yellow coloured bacterial saprophytes being isolated from the leaf and other samples. The 5 phenotypic characters are:

i. Inherent slow growth rate

X. axonopodis pv. *punicae* isolates take 72-96 hours to appear like a recognizable pin head size colony, saprophytes grow within 24 hrs.

ii. Temperature sensitivity

X. axonopodis pv. *punicae* isolates grow at 28°C and growth absent at 37°C.

iii. Fuscan pigment

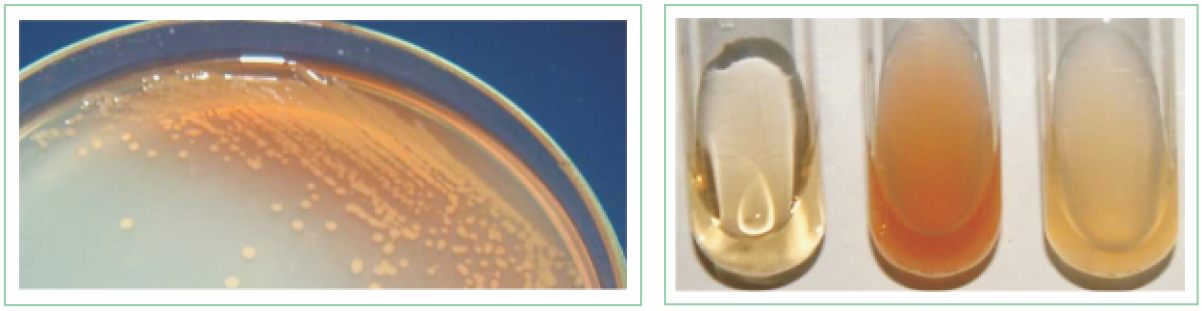
X. axonopodis pv. *punicae* isolates produce a brown pigment-Fuscan in medium especially Luria Bertani's Agar in 5 days.

iv. pH sensitivity

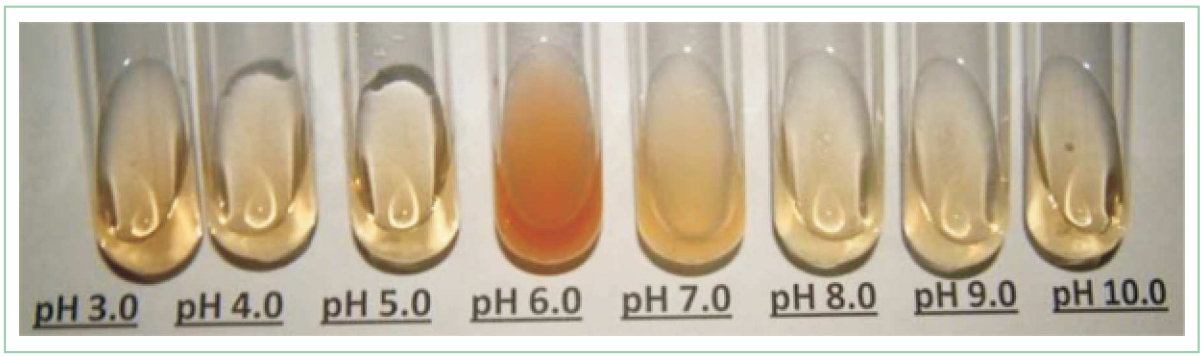
X. axonopodis pv. *punicae* isolates grow between at 6-8 pH, growth is absent at pH 5 and 8.

v. Salt sensitivity

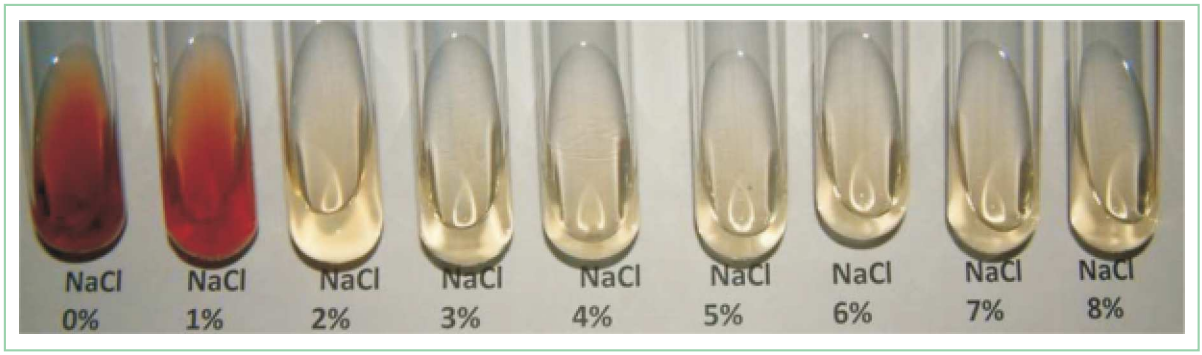
X. axonopodis pv. *punicae* isolates grow at 1% NaCl but do no grow at or above 2% salt concentration.



Fuscan pigment production by *X. axonopodis* pv. *punicae* in LB agar medium within five days



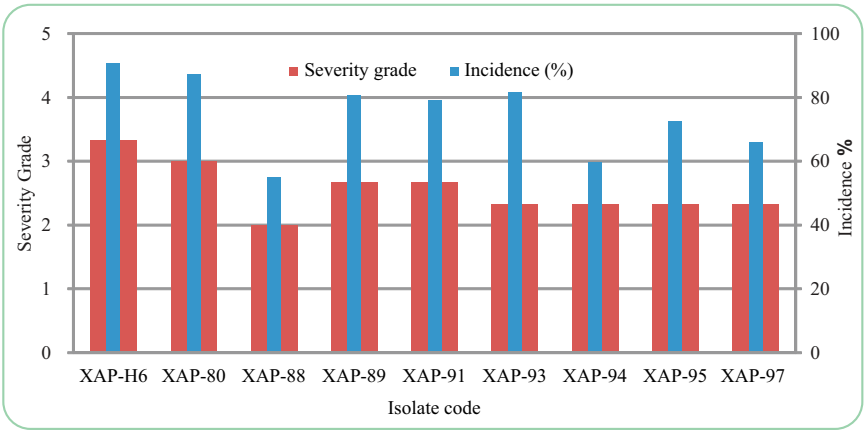
Growth of *X. axonopodis* pv. *punicae* in LB agar medium at different pH



Growth of *X. axonopodis* pv. *punicae* in LB agar medium at different salt concentration

b) Storage of *X. axonopodis* pv. *punicae*

The *X. axonopodis* pv. *punicae* isolates collected over time from different locations need to be stored for long period for various genomic and other studies. *Xap* isolates collected for last two years were stored in deep freezer at -80°C in 20% glycerol. Out of these nine stored isolates including check isolate of *X. axonopodis* pv. *punicae* were tested for viability and virulence of cultures stored in ultralow temperature freezer for 30 to 101weeks at NRCP, Solapur. Fresh Isolate *Xap*-97 maintained at 4°C served as check. All 9 isolates recorded high incidence of BB above 60% except one isolate with 55% incidence and severity grade was above 2 (>25% severity) in all. Hence, long term storage of *Xap* isolates at ultra low temperature of -80°C in 20% Glycerol was found effective.



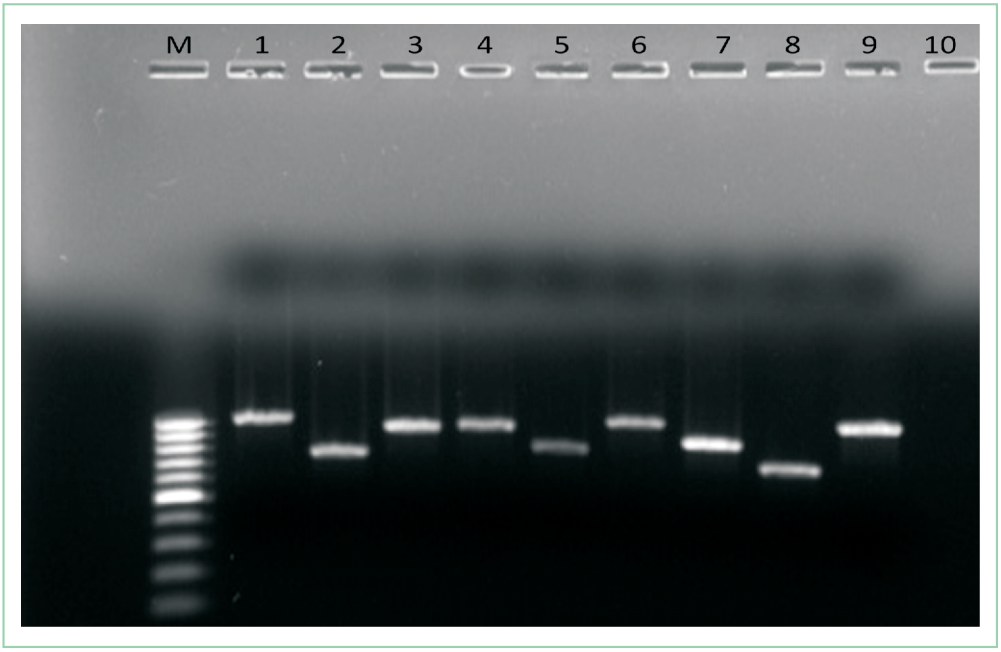
Isolate code	Storage period (weeks)
XAP-H6	30
XAP-80	99
XAP-88	101
XAP-89	101
XAP-91	30
XAP-93	30
XAP-94	30
XAP-95	30
XAP-97	Fresh

Incidence and severity of *X. axonopodis* pv. *punicae* isolates after storage at -80°C

Pathogenicity of *X. axonopodis* pv *punicae isolate Xap*-H6 and *Xap*-89

c) Genotyping

Genotyping based on Multilocus Sequence Typing was standardized by IARI, New Delhi for population genetics studies. Multilocus Sequence Typing, a powerful genotypic technique for inferring evolutionary relationships at the inter-specific and intra-specific levels was adopted for the bacterium isolated from bacterial blight infected samples collected from states of Maharashtra, Andhra Pradesh, Karnataka, Himachal Pradesh and Delhi. The analysis specifically targets the "core" genome when slowly evolving housekeeping genes encoding for proteins essential for the survival of microorganism were analyzed. Genome wide analysis of the plant pathogenic bacterium is essential to decipher its evolutionary dynamics. Housekeeping genes like *dnaK, fyuA, gyrB, rpoD, fusA, gltA, gapA, lepA* etc were amplified, sequenced and analysed. The gene sequences were analysed for Indels and SNPs and allelic variants were identified and assigned allele numbers. The analysis clearly revealed its genetic similarity with *Xanthomonas axonopodis* pv. *citri* (~*Xanthomonas citri* pv. *citri*) and *Xanthomonas axonopodis* pv. *malvacearum* (*Xanthomonas citri* pv. *malvacearum*) respectively, causing bacterial canker in citrus and bacterial blight in cotton. It may be speculated that the close proximity of these crops in the same ecological niche in central Indian subcontinent would have played a major role in selection of respective pathovars on these hosts. The relatively less genetic distance as observed in the MLST data is a pointer for such a probability.



Amplification of housekeeping genes (1-10) in *Xanthomonas axonopodis* pv. *punica:* M: 100bp DNA ladder as marker; 1:*dna*K; 2: *fyu*A; 3: *gyr*B1; 4: *rpo*D; 5: *fus*A; 6: *gap*1; 7: *glt*A; 8: *gyr*B2; 9: *lep*A; 10: Negative control.

A limited population of the pathogen representing major pomegranate growing regions in India including the isolate collected in 1950s and preserved in National Collection of Plant Pathogenic Bacteria under FERA, UK were analysed in this study. The data revealed that the isolates obtained from diverse geographical location and distant time points were identical as they shared same allele profiles. Identical allele profile found for the isolates further indicate its narrow genetic base or low genetic diversity and the strain responsible for bacterial blight epidemics in central India could be due to wide spread horizontal transmission of the bacterial pathogen from one place to another and passed on to seasons through, a safe carrier most likely, the vegetatively propagated planting material. Coupled with the practice of mono culturing of one or few elite cultivars for good harvest in vast stretch of land, the pathogen has aggravated and accelerated the epidemics that we witnessed in our country. However, the study needs to be expanded to large collection of isolates of *Xanthomonas axonopodis* pv. *punicae* representing unconventional growing regions where the new disease outbreak has been observed.

4.1.4. Developing cultivar/s resistant to pomegranate bacterial blight

a) Introduction and evaluation of germplasm

Indigenous and exotic germplasm was introduced at IIHR Bengaluru. Eight pomegranate accessions were collected for their unique traits from Solan-Shimla region in Himachal Pradesh and 32 accessions from NBPGR-Phagli, Himachal Pradesh. In addition 132 accessions of pomegranate were introduced from USDA, of which 120 accessions were planted in the field at IIHR.

Collections of pomegranate accessions from Himachal Pradesh

Acc. No.	Place of collection	Remarks/Specific traits
1.	Devidhar, Shimla	Tall, growing on rocky & steep sloppy land
2.	Bagdevoli, Shimla	Tall, growing on mild sloppy land
3.	Dhami, Shimla	Tall, growing on mild sloppy land
4.	Khetlighat, Shimla	Tall &Vigorous, growing on steep sloppy land
5.	DarooDevaria, Sirmaur	Tall, growing on mild sloppy and rocky land
6.	Shothi, Sirmaur	Tall and vigorous, dark red aril with high TSS
7.	Jatoli, Solan	Spreading and vigorous growth
8.	Jatoli, Solan	Tall & vigorous, dark pinkish arils with high TSS

A set of 14 genotypes collected from sub Himalayan region were screened for their resistance to bacterial blight. The results showed that, no germplasm was resistant, 4 showed high susceptibility, but 2 were tolerant to bacterial blight. A total of 209 germplasm lines were screened under various groups viz., Exotic (105), cultivated (15), hybrids (23) and sub-himalayan types (66). Among the germplasm lines screened, IC 318374 and Cv. Ruby were selected as tolerant and susceptible lines respectively for further biochemical and molecular studies.

Screening of pomegranate accessions collected from sub-Himalayan region for bacterial blight resistance

Acc. No.	Lesion diameter (mm)	Disease Scoring
IC 318766	0.85	R
IC 318784	2.28	MS
IC 318775	5.1	HS
IC 318776	0.5	R
IC 318787	3.7	S
IC 318741	2.5	MS
IC 318717	6.0	HS
IC 318736	1.1	MR
IC 318752	5.2	HS
IC 318705	2.8	MS
IC 318754	3.0	MS
IC 318798	6.7	HS
IC 318700	1.9	MR
IC 318790	2.2	MS

b) Screening of Pomegranate (Daru) progenies for Bacterial blight resistance:

Over 1000 pomegranate (Daru) progeny plants were subjected to rigorous inoculation by repeatedly spraying the plants with bacterial (*X. axonopodis* pv. punicae) suspension at 10^8cfu/ml concentration under glasshouse condition for screening against bacterial blight resistance. Twenty leaves were selected randomly from each plant for observations on symptom expression. Disease incidence was scored and percent disease index (PDI) was worked out based on 0 – 5 scale. Results showed that all but two plants expressed susceptible reaction ranging from 45.0 to 100.0 per cent.

c) Screening of germplasm for bacterial blight resistance

Germplasm maintained at the Field Gene Bank of NRCP at Kegaon and Hiraj blocks was screened for bacterial blight resistance under natural conditions during 2014-15. In all 126 germplasm collections at Kegaon and 31 at Hiraj were screened for blight development during the months of July to November 2014, when blight pressure was high and incidence and severity remained above 40%. Blight incidence/severity varied from 0-75% in different

germplasm.

Out of 126 pomegranate germplasm collection screened, 6 were found free from blight and 14 showed slight susceptibility/tolerance reaction with ≤5% blight severity and rest were found moderate to high susceptible categories. Among 14 slightly tolerant germplasm accessions, 4 accessions - IC-318793, IC-318743, IC-318716 and 1181- were found slightly susceptible in 2010 screening also.

Bacterial blight free or tolerant germplasm at NRCP

Group	Blight Severity (%)	Germplasm	
		Number	Name
Disease Free/ tolerant	0.0	6	Mukteswar, , IC -318973, IC -1280, IC -1276, IC -1256 and IC-1253
Slightly susceptible	≤5.5	14	Acc. No.4, EC -676951, 1181, IC -318793, IC -318776, IC -318724, IC-318743, IC-318716, IC-1279, IC -1281, IC -1274, IC -1258, IC -1254, IC -1278

d) Disease resistance potential in different varieties

Four varieties with different susceptibility to bacteria blight were tested for morphological and anti-microbial and disease resistance potential against *Xap*. Significant differences were not observed in stomatal number or size, however, tolerant varieties Nana and Daru showed highest EC (0.23ds/m and 0.12 ds/m respectively). Coded samples of 4 varieties were sent for analysis of disease resistance potential (biochemicals). Surface wash showed highest potential in leaves of variety Daru, followed by Ganesh and, Nana. Variety Bhagawa showed lowest disease resistance potential among 4 varieties. The leaf extract of 4 varieties at 1:8 dilution showed similar trend for disease resistance potential. Relative concentration of antimicrobial components was also maxium in variety Daru followed by Ganesh, Nana and Bhagawa. This is supported by the fact that variaety 'Daru' showed highest disease resistance whereas, Bhagawa exhibited highly susceptible disease reaction in field under high disease pressure.

e) Hybridization studies

Studies were carried out at ICAR-NRCP, Solapur and ICAR-IIHR, Bengaluru. At IIHR, blight tolerant accessions and Bhagawa were used for hybridization programme. A total of 45 flowers of Bhagawa were control pollinated with pollen collected from two different sub-himalayan accessions. The seeds from the hybridized fruits are since been extracted for raising seedlings. At ICAR-NRCP, the crosses were made with the commercial varieties i.e. Bhagawa, Ganesh and some of bacterial blight tolerant varieties – Daru, Acc. 5, Acc.6, Acc.8, Patna-5 and Nana. Fruits of these hybrids (5-15 per cross) were harvested for future studies.

f) Association mapping in pomegranate

In this investigation by NRCP analyzed publicly available microsatellites and identified a robust set of 44 SSRs that are polymorphic with eighty-eight cultivated and wild genotypes of pomegranate and used them to generate molecular data. The phenotyping of genotypes for different traits

were done during 2013-14 to proceed for association mapping. The P matrix for 3 principal components of principal component analysis (PCA) was calculated from 112 SSR alleles with use of TASSEL 5.0 (http://www.maizegenetics.net). The Q matrix was adapted from the K-4 cluster for association mapping to control spurious results arising from population stratification. The generalized linear model (GLM) and mixed linear model (MLM) of TASSEL 5.0 was used for association mapping. The GLM approach identified 3 markers linked with acidity, fruit weight, and bacterial blight across the season. The PGCT001 association with fruit weight was significant after Boniferroni correction during both seasons and was also significant by the MLM approach. PGCT001 was associated with both fruit weight and bacterial blight.

Level of significance, marker effect and distribution of associated alleles revealed by association mapping

Locus	Trait	Year	GLM P value	MLM P value	R2 Value	Distribution of Accessions			Allelic sizes (bp)	GLM Alleic estimate	MLM Alleic effect
						Cluster I&II	Cluster III	Cluster IV			
PGCT043	Acidity	2013	0.01600	NS	0.0611	13	7	35	232:232	1.859	1.822
						25	1		232:241	0.776	0.92
PGCT043	Acidity	2014	0.0268	NS	0.0567	13	7	35	232:232	1.723	1.192
						25	1		232:241	0.3778	0.785
PGCT001	Fruit Weight	2013	0.04	NS	0.0876	22	3	10	153:101	5.689	-0.288
						6	4	21	101:101	37.023	29.096
						6			153:153	-19.355	-9.422
PGCT001	Fruit Weight	2014	1.89E-04	0.00807	0.1312	22	3	10	153:101	8.909	5.807
						6	4	21	101:101	61.60	54.63
						6			153:153	-19.667	-27.151
PGCT001	Bacterial blight	2013	0.02285	NS	0.09147	22	3	10	153:101	3.869	2.255
						6	4	21	101:101	0.0126	-1.232
						6			153:153	-0.911	-0.826
PGCT001	Bacterial blight	2014	0.0246	NS	0.10966	22	3	10	153:101	5.409	3.425
						6	4	21	101:101	-0.735	-0.380
						6			153:153	0.364	-1.15
PGCT020	Bacterial blight	2013	0.0015	0.01844	0.0941	21	1	6	152:241	-3.984	-4.876
						4	1	24	152:152	-10.863	-9.376
						12	8	7	241:241	-3.0219	-3.584
PGCT020	Bacterial blight	2014	0.00292	0.0604	0.10445	21	1	6	152:241	-0.413	-1.155
						4	1	24	152:152	-9.474	-8.487
						12	8	7	241:241	-2.672	-1.885

GLM-generalized linear model; MLM-mixed linear model; NS: Not significant

4.1.5. Development of blight prediction model

a) Bacterial blight development *vis-a-vis* meteorological factors in 2014

Bacterial blight incidence and severity on different plant parts was recorded at weekly intervals in a fixed plot at NRCP and correlated with weather parameters. Among various weather parameters influencing bacterial blight in field, temperature from 25-35°C accompanied with humidity above 50%, was the most important parameter significantly influencing bacterial blight incidence. Among the other factors significantly and positively influencing bacterial blight were wind speed, rainfall and number of rainy days. RH below 30% significantly but negatively influenced bacterial blight. Severity was influenced most significantly with only temperature from 25-35°C + humidity above 50% and RH below 30%.The regression models developed on these parameters can explain 83.4% variability (R^2=0.834) in incidence and 100% variation in severity (R^2=1.000) with 91.2% (R=0.912) and 100% (R=1.000) reliability respectively. Increase in the number of hours with temperature between 25-35°C combined with RH >50%, the incidence and severity of blight also increases in the same or following week. The number of hours with these conditions of temperature and RH started increasing from 16th week (April) and remained high till 42nd week (October/-November) of the year, hence recorded increased BBD during this period. Similarly, in 2014 blight was high from 22nd week (June) to 45th week (November), which was the period with rainfall when incidence recorded was respectively, 38.04% and 46.63% and severity grade was 2.31 to 3.00 on scale of 5. The highest incidence and severity grade recorded were 74.21% and 3.00 respectively, in 32nd week (August).

Apparent infection rate (r) of blight spread from April to September was 0.01/unit/day, whereas from June to September month 'r' was 0.02/unit/day indicating rapid spread of blight during the period.

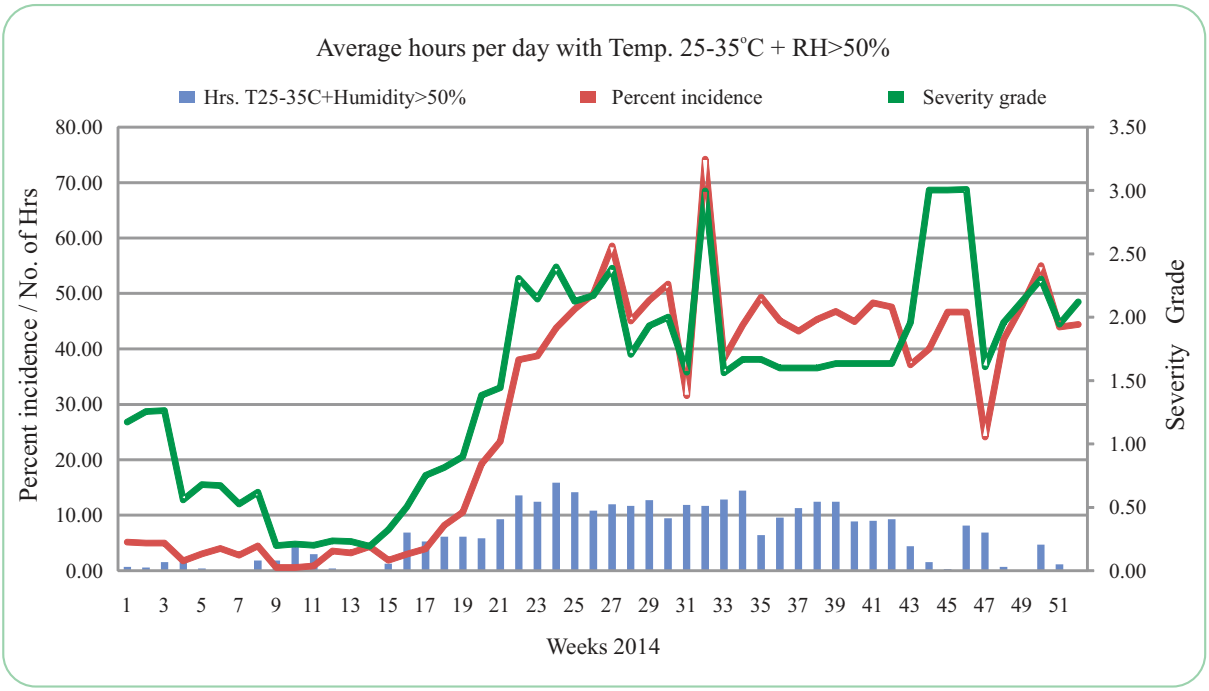
	Weather Parameters	Correlation coefficient (r) with	
		V1	V2
		BB Incidence	BB Severity grade
V3	Hrs. with Temp.25-35°C+ RH>50%	0.608*	0.448*
V4	Wind speed (m/s)	0.279*	0.181
V5	Total Rainfall/week	0.320*	0.247
V6	No of rainy days/week	0.400*	0.277
V7	Hrs temp<20C	-0.170	0.002
V8	Hrs. Rh<30%	-0.553*	-0.534*

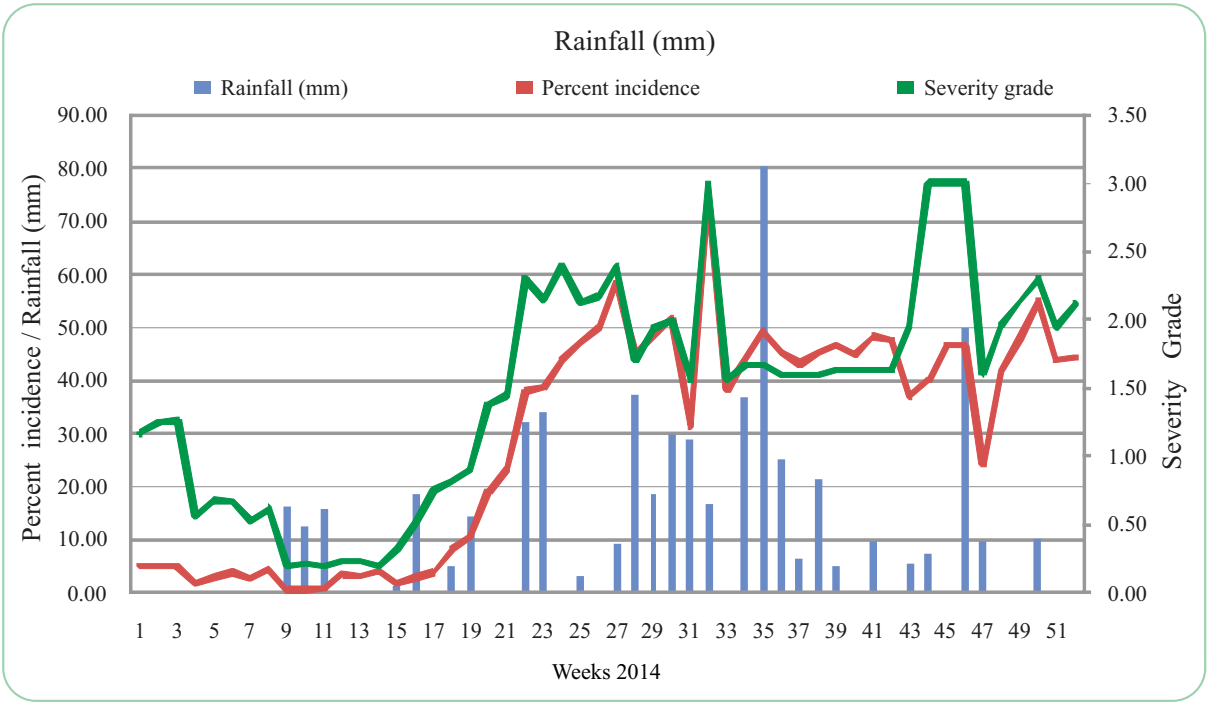
***Significant at 5%**

Regression Models for bacterial blight

(1) Incidence: V1 = -6.606 + (19.658) **x** V3+ (1.038) **x** V4+ (-0.595) **x** V5+ (-0.158) **x** V6 + (2.683) **x** V8+9
Intercept (a) = -6.606
Coefficient of determination (R Square) = 0.834
Multiple Correlation Coefficient (R) =0.912
Standard Error = 9.000

(2) Severity V2 = 9.990 + (1.000) **x** V3+ (9.365) **x** V4+ (-4.321) **x** V5+ (-7.637) **x** V6+ (6.663) **x** V8+ 3.725
Intercept (a) = 9.990
Coefficient of determination (R Square) = 1.000
Multiple Correlation Coefficient (R) =1.000
Standard Error = 3.725





Bacterial blight development in relation to weather conditions during 2014

b) Studies on bacterial blight initiation and development in respect of time and space

In a newly planted experimental plot (8 months old cv. Bhagawa) at Hiraj farm, blight was first observed around II[nd] week of September (around 9[th] September, 2014) on one plant in centre of the plot). Infected plant revealed fruit and twig infection. Periodical observations on blight build-up revealed that on 1.10.2014 blight incidence in the plot had reached 25.5% and on 20.10. 14 incidence was 30.0% and intensity 13.16%. Blight spread was more towards the north-east direction of the infected plant probably due to wind borne rain splashes accompanied by South-west monsoon during the period.

There was no blight in the adjacent plot in the eastern side till 1.10.14 when blight incidence in infected plot was 25.5%. However, blight was first observed in adjacent plot on 10.10.2014 on one plant of border row just adjacent to the infected plot. Infections were mostly on foliage after initiation, blight progressed rapidly more towards north-eastern direction evidently due to wind borne rain splashes occurring because of south-west monsoon. By 20.10.14, disease incidence in newly infected plot increased to 4.0% when it was 30% in already infected plot. In the beginning further spread of the disease in newly infected plot was mainly on first 1-5 rows from the initially infected plant in the border row of the plot.

From the above study it can be concluded that in newly established orchard blight usually initiates from apparently healthy plant(s) carrying latent infections and secondary spread takes place through wind borne rain splashes or water droplets under favorable weather conditions. In present study it took almost 21 days for the blight to attain 25.5% incidence from the time of onset (9.9.14). Initially further spread of the blight was around primary focus. It is also possible that before 9[th] September blight infections on some plants might have gone unnoticed due to extremely low level of infection.

4.2. Wilt

a. Frequency of wilt organisms associated with wilt

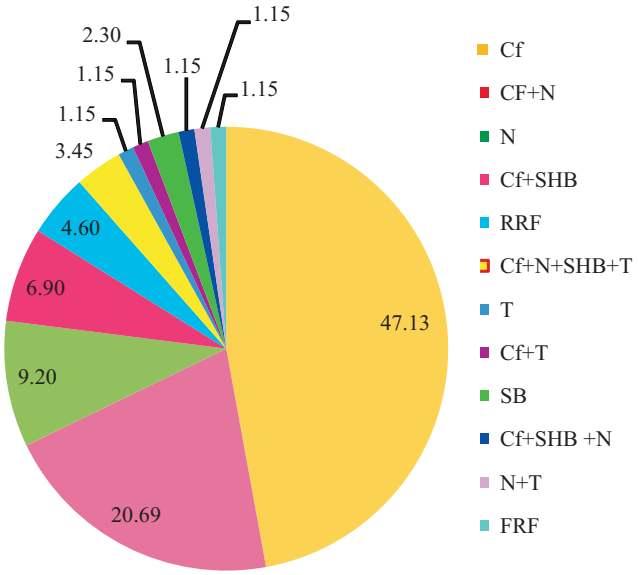
In all, 87 wilt samples brought to NRCP from different states of Maharashtra including 2 samples from Karnataka and Telangana were analysed for association of various wilt organisms. *Ceratocystis fimbriata* was found associated with 80.46% sampleas either alone or in association with other organisms. *C. fimbriata* alone was present in 47.13% samples and nematode *Meloidogyne incognita in* 9.2% *samples,* whereas in 20.69% samples, nematode was found associated with *C. fimbriata*. Short hole/ pin hole borer damage was found in 6.9% samples along with wilt of *C. fimbriata*. Stem borer, termites, foot rot due to *Rhizoctonia solani*, and root rot due to *Macrophomina sp*. were found in only 1-2 samples.

Initiation and development of bacterial blight from source of infection

Blight development in blocks	Blight incidence and severity (%) on different dates									
	9.9.14		1.10.14		10.1014		20.10.14		30.10.14	
	*Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.
Plot 1	1.0	5.5	25.5	26.5	28.0	18.71	30.0	13.16	NR	NR
Plot 2	0.0	0.0	0.0	0.0	1.0	5.5	4.0	8.62	6.0	7.58

*Inc.: Incidence; Sev.: Severity; NR: Not Recorded

Percent wilt samples associated with different organisms



Associated Wilt Organisms	
Cf	*Ceratocystis fimbriata*
N	Nematode
T	Termite
SB	Stem borer
SHB	Shot hole borer
FRF	Foot rot Fungus
RTF	Root Rot Fungus

Frequency of different organisms associated in wilt samples

Ceratocystis fimbriata was observed the major cause of wilt in pomegranate. In another analysis of 12 diseased samples collected from Hiraj farm, 11 samples revealed association of *Ceratocystis fimbriata* and only one sample showed presence of *Fusarium* spp.

b. Survivability of *C. fimbriata* in soil

In a pot culture study, pomegranate plants wilted in artificially inoculated *C. fimbriata* soils , were removed after complete wilting and soils were analysed periodically for presence of *C. fimbriata*. Isolations made on July 22, 2014 from infested soil on to carrot slices and then PDA medium revealed the growth of *C. fimbriata,* thereby, suggesting the survivability of *C .fimbriata* in infested soil at least upto 19 months.

c. Population of parasitic nematodes in pomegranate orchards

Soil samples from eighteen pomegranate plantation were sent to Division of Nematology, IARI, New Delhi to know status of parasitic nematodes. Analysis revealed presence of 4 parasitic species *Meloidogyne incognita (0-84 count./ml), Rotylenchulus* sp.(0-31 *count/ml*), *Aphelenchus* sp. (0-3 *count* ml), *Helicotylenchus* sp. (3 *count*./ml in 1 sample only). *M. incognita* and *Rotylenchulus* sp. respectively were present in 15 and 14 out of 18 soil samples analysed and were the major species. Among free living species *Dorylaimid* sp. (2-10 *count*./ml) was found. This study highlights the need to investigate methods to manipulate soil microflora and fauna through improved integrated practices to reduce parasitic nematodes, as wilt due to root knot nematode *M. incognita* is the second major wilt causing organism after fungal pathogen *C. fimbriata*.

d. Progress of wilt due to *Meloidogyne incognita*

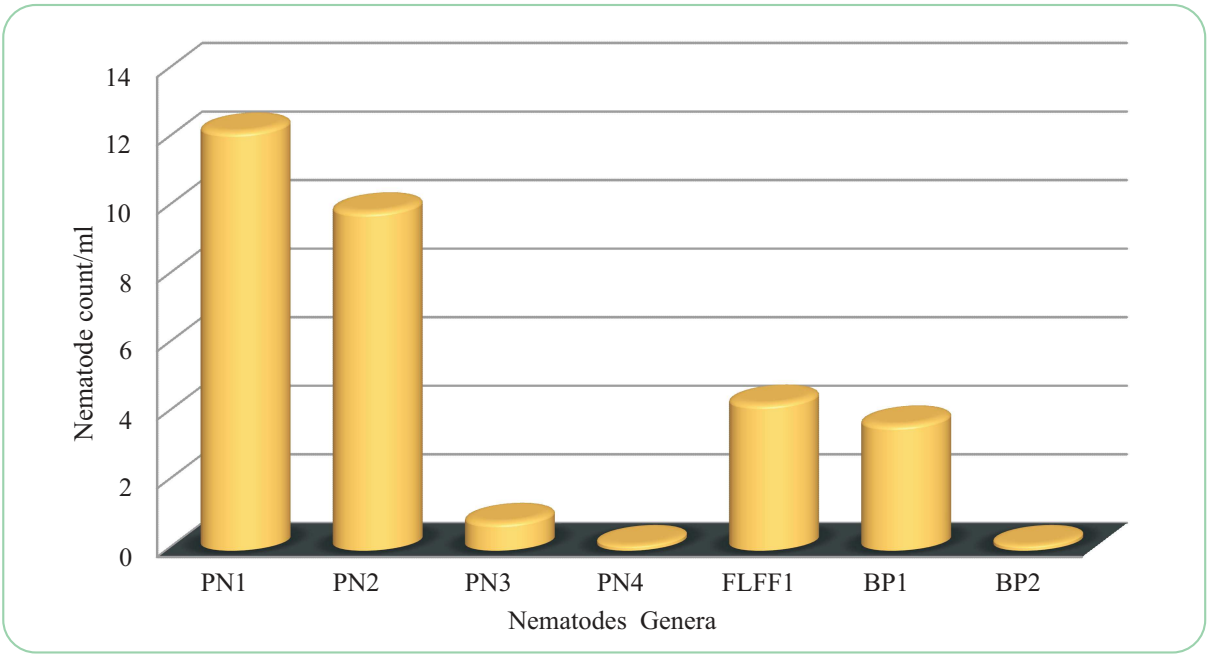
Potted plants (cv. Bhagawa) were inoculated with root-knot nematode (*M. incognita*) galls in June 2013 from nematode infested samples brought from Amravati (MS). One plant wilted and exhibited complete drying and browning of the foliage by July 2014. The roots of the wilted plant on observation was found to have abundant galls exhibiting eggs and adult nematodes under the microscope. During the present study it took almost a year for the nematode

inoculated plant to show complete drying and killing of plants. In orchards also it is observed, nematode infected plants result in slow death unlike *Ceratocystis fimbriata* which caused wilt within a week under favourable conditions.

e. Management of pomegranate wilt

Biological control

Four fungal bioagents –*viz.* BA6(1), BA7(1), BA6 (7D), and BA 6(2) were evaluated in pot culture. Soil was made sick with *C. fimbriata* culture. When plants started wilting, old plants were removed and new plantation was done. Bioagents were added after 3 weeks of plantation. All bioagents delayed incidence of wilt by 12-16 weeks and BA6(1) was most promising with delay of 8weeks and maximum wilt reaching to 50% in 24 weeks. The isolate BA6(1) giving best control will be screened in field and also identified.



Status of Nematode population (Count/ml) in soil of pomegranate orchards

parasitic nematodes **:** PN1- *M. incognita*, PN2-*Rotylenchulus* sp., PN3- *Aphelenchus* sp., PN4 - *Helicotylenchus* sp.; Free living fungal feeder : FLFF1- *Dorylaimid* sp.; bacteriophages : BP1- *Rhabditids* sp. and BP2 - *Acrobeles* sp.

Management of *Ceratocystis fimbriata* with bioagents

Bioagent	Wilt initiation (WPI)	Maximum wilt recorded (WPI)	% Wilt
BA6(1)	10	24	50
BA7(1)	4	24	75
BA6 (7D)	2	20	100
BA 6(2)	2	28	75
Control	1	8	100

Control of *C. fimbriata* with different bioagents (BA) after 8 weeks

f. Screening of germplasm for wilt resistance

All five germplasm (IC-318705, IC-318779, IC-1204, IC-1182 and Sirin Anar) screened for wilt resistance through artificial inoculation with *C. fimbriata* were found susceptible to wilt pathogen by the end of September, 2014.

g. Severity of fungal leaf and fruit spots and rot

Severity of various leaf and fruit spot and rot diseases caused by different fungal pathogens was recorded in germpasm block at Hiraj farm during the months of July and September 2014. Most of the time spot diseases were observed overlapping. Among various spot pathogens scab due to *Sphaceloma punicae*, was the most prevalent followed by fruit rot due to *Colletotrichum gloeosporioides*. Other spots due to *Pseudocercospora punicae* and *Alternaria alternata* were of minor importance. During July month leaf spots severity ranged between 1.83 to 7.83% where as in September month, spot and rot severity was upto 54.6 %. The following 4 germplasm were found free from various fungal spot and rot pathogens:- IC-1272, IC-1289, IC-1256 and IC-1253.

h. Effect of different irrigation systems on diseases and insect pests incidence

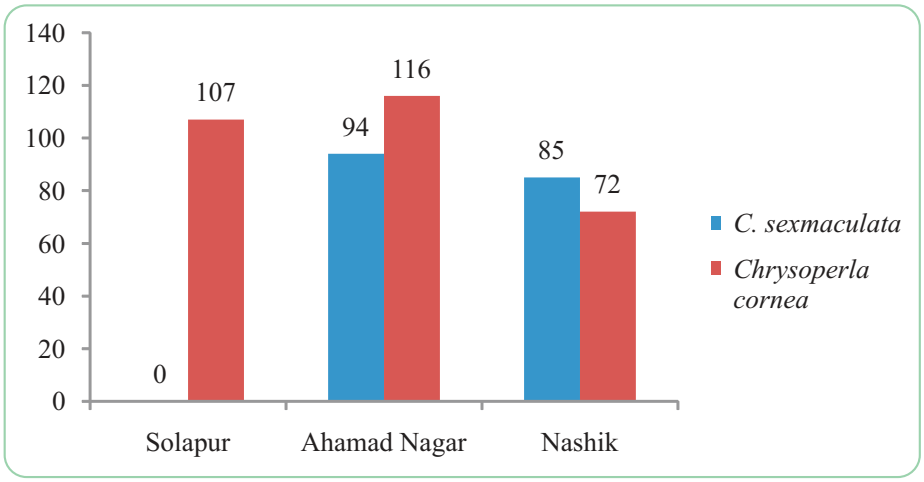
Different drip and subsurface irrigation systems under study did not show significant differences in severity of diseases and insect pest infestation. Average blight severity ranged from 34.06% to 35.49% in the three irrigation systems. Fungal leaf spots were of minor importance and insect-pests were not observed. Among the various leaf spots, spots caused by *Alternaria alternata* were most common followed by spots due to *Sphaceloma punicae* and *Pseudocercospora punicae.*

Severity of diseases and insect-pests under different irrigation systems in 2014

S. No	Irrigation system	Severity/Infestaion (%)		
		Bacterial blight	Leaf spots	Insect-pests
1	Single lateral drip	34.06	0.39	0.0
2	Double lateral drip	35.49	0.19	0.0
3	Subsurface drip	35.70	0.90	0.0

4.3. Sucking pests

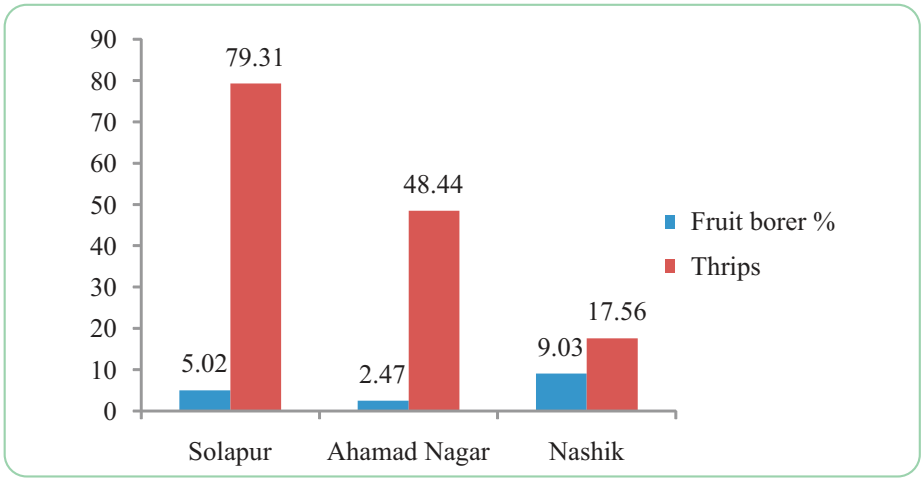
Survey were conducted under 'Outreach programme on management of sucking pests in horticultural crops' in 3 talukas covering 3 District of Maharashtra (Solapur, Ahmednagar, Nashik) during March, 2015. In all 13 orchards having 28 acres area were surveyed. On an average thrips incidence was highest in Solapur district it was about 79.31%. As compare to thrips, the fruit borer incidence was low i.e 5.02% and *Chrysoperla* natural enemies activity was found in orchards of Solapur district. In Ahmednagar district the thrips incidence was moderate and fruit borer was very negligible and natural enemies activity was the highest. The natural enemies were *Coccinella sexmaculata* and *Chrysoperla cornea.* In Nasik district incidence of thrips and fruit borer was very less but natural enemies activity was high compare to pest incidence.



Population /plant of natural enemies of sucking pests in pomegranate orchards of Maharashtra

4.4. Borer pests

Under 'Consortium research platform on borers in network mode', it was found that among other pests, stem borer to the tune of 10% was found in Nashik area. No infestation of shot hole borer, bark eating caterpillar, mealy bugs, mites was observed in surveyed orchards.



Per cent infestation of fruit borer and thrips in Maharashtra

Population dynamics of Insect-pests was also studied during 2014-15. Observations were recorded on the incidence and severity of various insect-pests prevalent on the germplasm at Hiraj farm during months of July and September 2014. The major damage was observed to be caused by thrips (*Scrirtothrips dorsalis*) and fruit borer (*Deudorix isocrates*) where as mite (*Tenuipalpus punicae*) and fruit moth (*Othreis* sp) infestation was in traces. During July, thrips average infestation on fruits varied between 1.83-3.66% where as in September thrips average infestation was upto 12.0%. Fruit borer average infestation in July was between 1.6 – 20% and in September it decreased and varied between 1.6-13.3 % probably due to adoption of sanitation measures. During the month of October, insect-pests infestation in newly planted (8 months old cv. Bhagawa) experiment at Hiraj Farm (H-25, H-27) was recorded as follows: Mite incidence on plants was 40%, fruit borer incidence was 6.0% and fruit moth incidence recorded only upto 1.0%.

5. POST HARVEST TECHNOLOGY

5.1 Thermal processing of juice

Effect of the thermal processing parameters viz. temperature, time and method of juice extraction on the pomegranate juice quality was studied. Main objectives of the study were to determine optimum thermal processing time-temperature combination and method of juice extraction. The method of juice extraction used included juice extraction from arils and juice extraction using mechanical hand press from halved fruits. Processing temperatures of 70, 80, 90 and 100 °C and processing time of 2, 5 and 10 minutes were selected for studies.

5.1.1 Process of thermal processing

Fruits of pomegranate cv. Bhagawa were harvested from fields of National Research Centre on Pomegranate, Solapur. Fruits were transported on the same day to the cold storage at 5 °C until used for experimentation. The healthy fruits of uniform size and appearance were washed with chlorinated water (200 ppm sodium hypochlorite solution) for 10 minutes. The fruits were again washed twice with the fresh water and mopped. Thus, the initial microbial inoculum load was reduced. The fruits were then separated in to two batches for mechanical juice extraction and juice extraction from arils. The juice was extracted directly from arils or pressing halved fruits. Both the batches of extracted juice were immediately stored at 5°C in the dark for 24 h for settlement of sediments. The separated juice was siphoned and filtered through muslin cloth. The pomegranate juice batches were heat treated (pasteurized) at 70, 80, 90, and 100°C ± 1°C for 2, 5, and10 minutes and packaged in glass bottles while still hot. The bottles were then allowed to cool down at ambient. The juice bottles were stored in a cold room (5°C) until used for analysis. The quality parameters such as total soluble solids in °Brix, titrable acidity, reducing, non-reducing, total sugars, ascorbic acid content, anthocyanin, total phenol content, colour were determined and sensory score was also assessed using trained panelist on nine point hedonic scale.

5.1.2 Effect of thermal processing on quality parameters of juice

Total soluble solid content for juice extracted from arils and machine was 16.50 and 16.63 °B respectively. With increase in thermal processing time and temperature it increased from 16.53 to 18.57 °B for juice extracted from arils and for machine extracted juice it increased from 16.69 to 18.67 °B. At any time temperature combination the juice extracted with machine from halved fruits recorded higher TSS compared to that from arils. Reducing, non-reducing and total sugars showed increasing trend with increasing time and temperature of thermal processing. The per cent acidity values for pomegranate juice from arils are found to be decreasing with increase in time and temperature of thermal processing while similar trend was not observed in case of juice extracted by machine.

Heat treated juice packaged in bottles

Effect of thermal processing temperature and time combination on juice TSS, acidity and sugar

Treatments	Total soluble solids (°B)	Acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
A00	16.50	0.38	13.51	1.13	14.64
A12	16.80	0.35	14.02	1.85	15.87
A22	17.13	0.35	14.29	2.30	16.59
A32	17.97	0.32	14.85	3.29	18.14
A42	18.21	0.35	15.63	3.93	19.56
M00	16.63	0.31	12.93	0.91	13.84
M12	16.87	0.32	13.51	1.42	14.93
M22	17.00	0.32	14.15	1.40	15.55
M32	17.70	0.31	14.71	1.86	16.57
M42	18.50	0.33	15.63	2.12	17.75

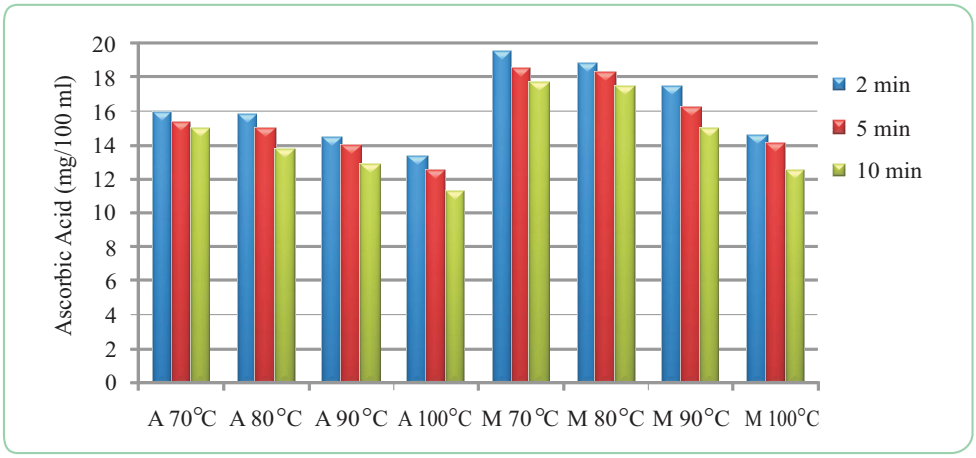
(A: Aril extracted juice, M: Machine extracted juice, first numeral refers to temperature of processing 0: control; 1:70°C; 2:80°C; 3:90°C; 4:100°C, second numeral refers to time of processing 0: control; 1:2 minutes; 2:5 minutes; 3:10 minutes)

The ascorbic acid being thermo labile was found to be decreasing with increase in time and temperature. The juice extracted from halved fruits had shown higher ascorbic acid compared to that from arils indicating that pomegranate peel extract might be contributing to ascorbic acid content in juice extracted from halved fruits by mechanical hand press. The unprocessed juice samples extracted from arils and halved fruits had ascorbic acid content of 16.67 and 20.42 mg/100 ml respectively which has been degraded with increase in processing time and temperature. The ascorbic acid degradation was higher at 90 and 100 °C as compared to 70 and 80 °C. The total anthocyanin content in unprocessed juice from arils and mechanical extraction from halved fruits was 121.05 and 129.67 mg/100 ml respectively. The anthocyanin content in pomegranate was found to be heat stable with very little degradation with increase in time and temperature of thermal processing. The effect of thermal processing on total phenols, anthocyanin and ascorbic acid is shown in graphs. The total phenol content was found to be higher in juice extracted from halved fruit by mechanical pressing (2340 mg/l of GAE) as compared to (2100 mg/l of GAE) from arils. This is because of peel has contributed to the total phenol of juice extracted by pressing halved fruits. The thermal treatment reduces phenol content in juice and is clearly seen from graph.

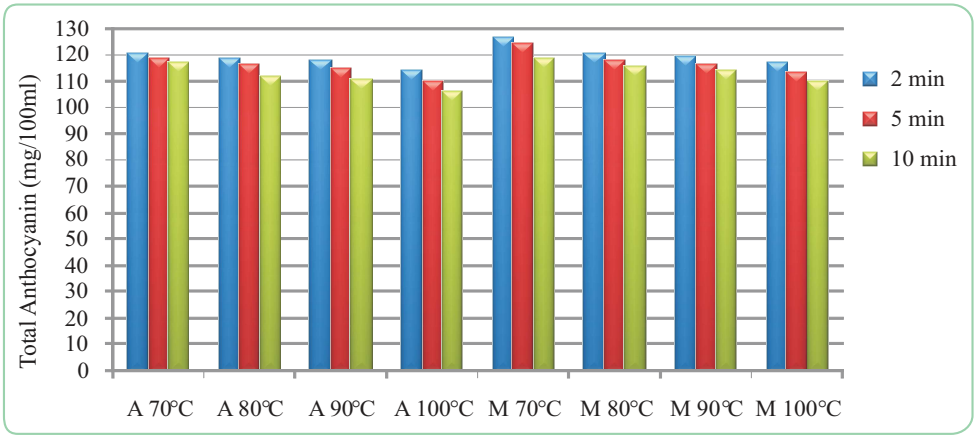
Total phenol, total anthocyanin and ascorbic acid in pomegranate juice extracted from arils and halved fruits

Treatment	Total phenol (mg/l GAE)	Total anthocyanin (mg/100ml)	SD	Ascorbic Acid (mg/100 ml)	SD
A00	2100	121.05	0.62	16.67	0.72
M00	2340	129.67	1.18	20.42	0.72

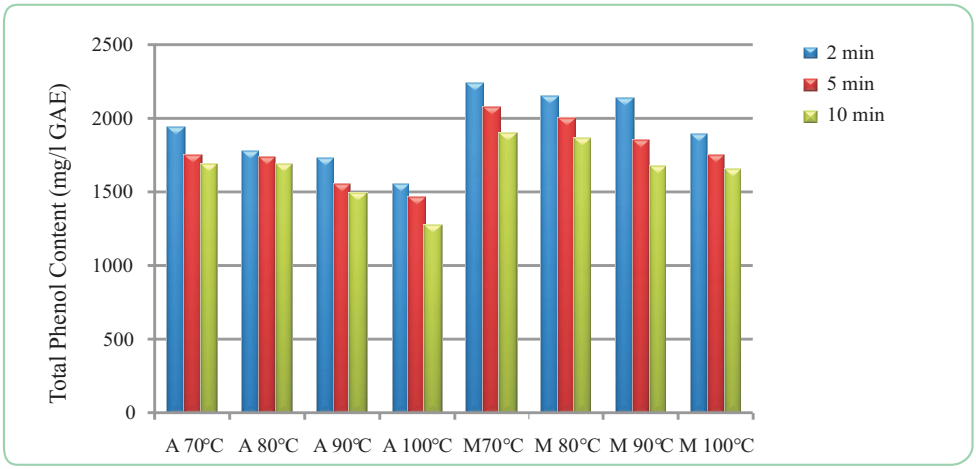
(A: Aril extracted juice, M: Machine extracted juice, first numeral refers to temperature 0 : Control, second numeral refers to time 0: control)



Effect of thermal processing and method of juice extraction on ascorbic acid



Effect of thermal processing and method of juice extraction on total anthocyanin



Effect of thermal processing and method of juice extraction on total phenol content
(A refers: aril extracted juice, and M refers: Machine extracted juice from halved fruits)

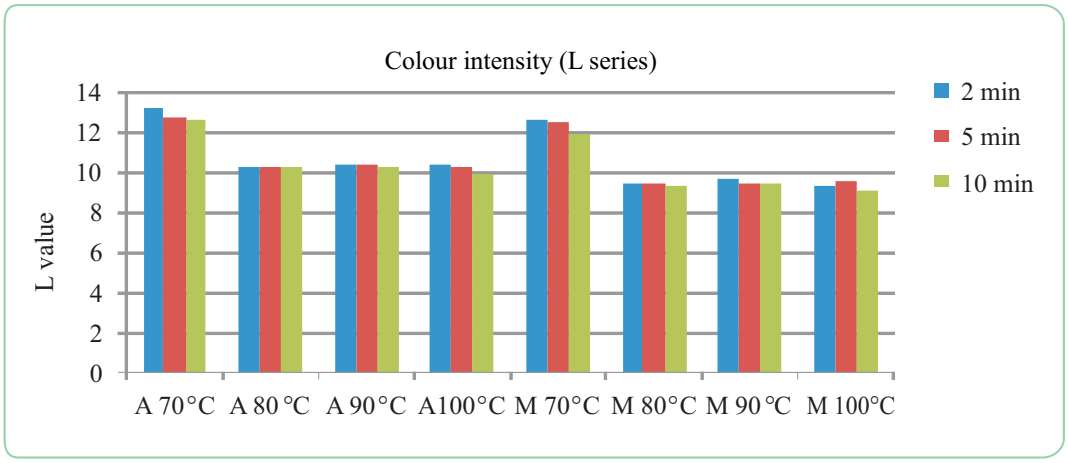
The colour of juice was measured using colorimeter Lab Scan XE, of Hunter Lab, USA in L, a, and b scale where values of L- indicate darkness to lightness, while a-indicates greenness to redness and b- indicates from yellowness to blueness. The average values of triplicate readings were reported for each sample. The unprocessed juice samples extracted from halved fruits had lower lightness 'L' values and redness 'a' values than that from arils. Effect of thermal treatment was pronounced at 80, 90 and 100 °C. It is also very clear from graphs that major degradation of lightness occurs at and above 80°C. There was not much variation in L values with increase in time or temperature of thermal processing above 80°C. The 'a values' representing redness, shown degradation at and above 80°C of temperature does not affect much the colour values.

Sensory evaluation was carried out with trained panelist. It was found that juice extracted from arils had higher scores of colour, taste and overall acceptability as compared to that from halved fruits owing to contribution of phenols and other components from peel in later. It was observed that thermal processing up to 80°C for 2 minutes did not affect sensory attributes of pomegranate juice and it was similar to freshly extracted juice from both arils as well as halved fruits.

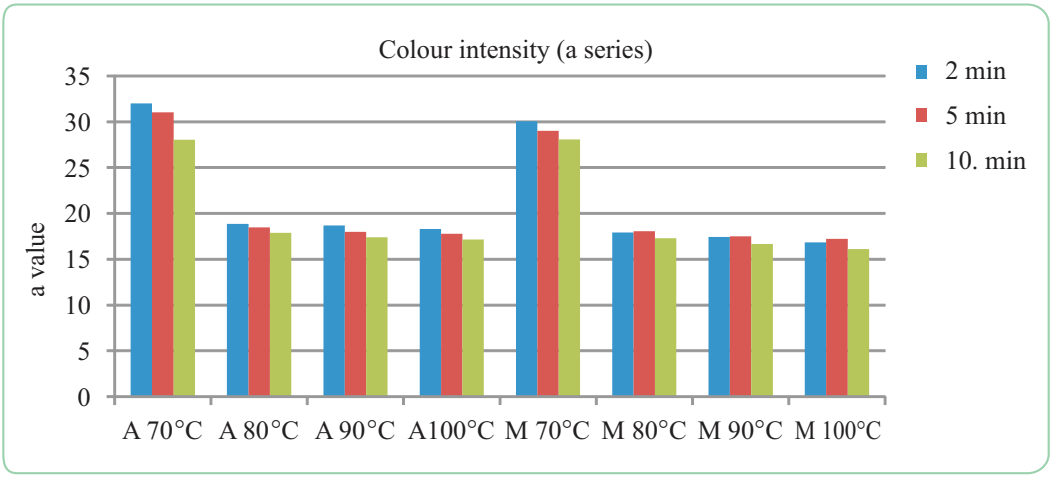
Keeping in mind the effect of thermal treatment parameters such as time and temperature on quality the time temperature combination of 80 °C and 2 minutes can be recommended for juice pasteurization. The quality of juice from halved fruit was found to be better compared to juice from arils except for colour and sensory properties.

Effect thermal treatment and method of juice extraction on juice colour

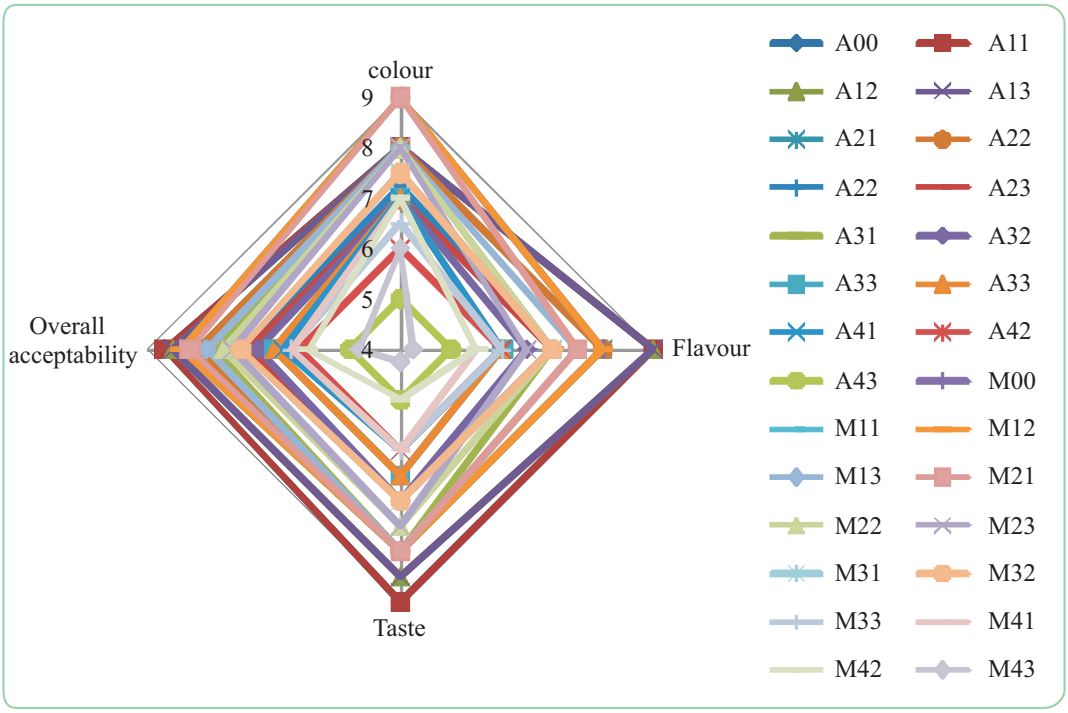
Treatment	L	a	b
A00	15.87	33.93	10.30
M00	11.49	26.97	7.43



Effect of thermal processing and method of juice extraction on colour values 'L'



Effect of thermal processing and method of juice extraction on colour values 'a'



Radar plot for sensory score

5.2 Post harvest quality parameters

5.2.1 Process for extraction of pomegranate seed oil

Process for extraction of pomegranate seed oil was developed at ICAR-NRCP, Solapur during 2014-15 using the cold press for oil extraction.

5.2.2 Determination of seed oil content in pomegranate germplasm

Commercial cultivars and germplasm of pomegranate were studied for their seed oil content. The soxhlet method of oil extraction was used with petroleum benzene a non-polar solvent for extraction.

The results of the oil extraction experiments which were conducted with three replications and mean values were depicted for oil recovery and density.

Pomegranate seeds

Cabinet dryer for pomegranate seed

Grinder

Ground pomegranate seeds

Cold Press for oil

Pomegranate seed oil

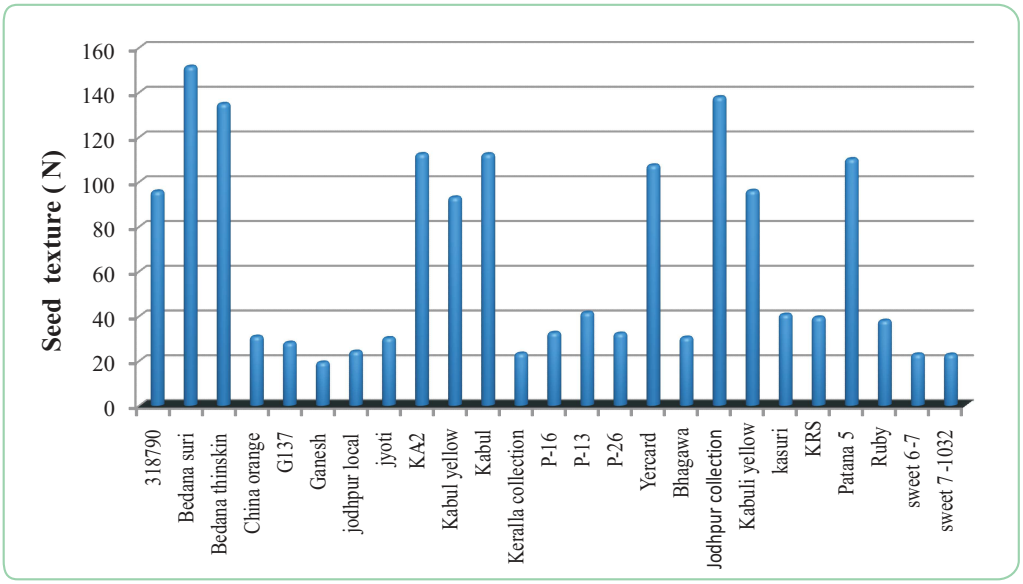
Pomegranate seed oil extraction unit established at ICAR-NRCP, Solapur

Seed oil content in pomegranate germplasm

Sl. No.	Variety	Avg. oil recovery % (w/w)	Avg. oil recovery % (v/w)	Avg. oil density (g/cc)
1	Bhagawa	28.00	31.00	0.90
2	Ganesh	26.43	28.75	0.92
3	Arakta	23.70	25.67	0.92
4	Kalpitiya	10.30	12.00	0.86
5	Tabesta	13.27	14.50	0.91
6	Co- White	11.77	13.67	0.86
7	Yercard	12.83	15.33	0.84
8	Bedana Suri	14.33	16.6 7	0.86
9	Bedana Thinskin	11.97	15.00	0.80
10	318790	17.15	20.50	0.84
11	Kabul	16.40	20.00	0.82

5.2.3 Seed texture in pomegranate germplasm

Texture is a critical quality attribute in the consumer acceptability of arils. Particularly seed texture affects consumer's preference. The seeds of different pomegranates germplasm were studied for seed texture. Seeds were dried at 50°C for 12 h prior to texture analysis for removal excess moisture. The seed texture is measured using texture analyzer (TA-XT Plus, stable Micro systems, surrey, England), with 2mm diameter needle probe. Seed texture (Bioyield point) was expressed as minimum compression force (N) required for penetration of needle probe in seed and results were shown in graph. The most promising germplasm with respect to mellowness of seed texture as suitable genetic material for breeding of varieties for table purpose were Ganesh, Sweet 6-7, Sweet 7-1032, Kerala Collection, Jodhpur Local, G137, Jyoti, Bhagawa, and China Orange.



Seed texture for different pomegranate germplasm

5.3 Minimal processing of pomegranate arils

The pomegranate is consumed mainly fresh, but the difficulty encountered in separating the edible arils from the fruit have its share in its lower consumption unlike the other fruits e.g. Oranges, banana, grapes etc. Hence, minimal processing of pomegranate is of great importance for convenience of the consumers. Commercialization of minimally processed and "ready-to-eat" fresh arils is the good alternative.

The aim of the current study was to investigate the application of passive MAP and different pretreatments like aloe vera gel (AG), salicylic acid (SA), ascorbic acid: citric acid (AA:CA), pomegranate seed oil (PSO) on shelf life and quality of the arils. The quality changes in physicochemical parameters such as total soluble solids, titrable acidity, total phenol content, ascorbic acid, anthocyanin, microbial quality, textural properties, colour and sensory qualities during storage were studied.

5.3.1 Process of minimal processing and packaging

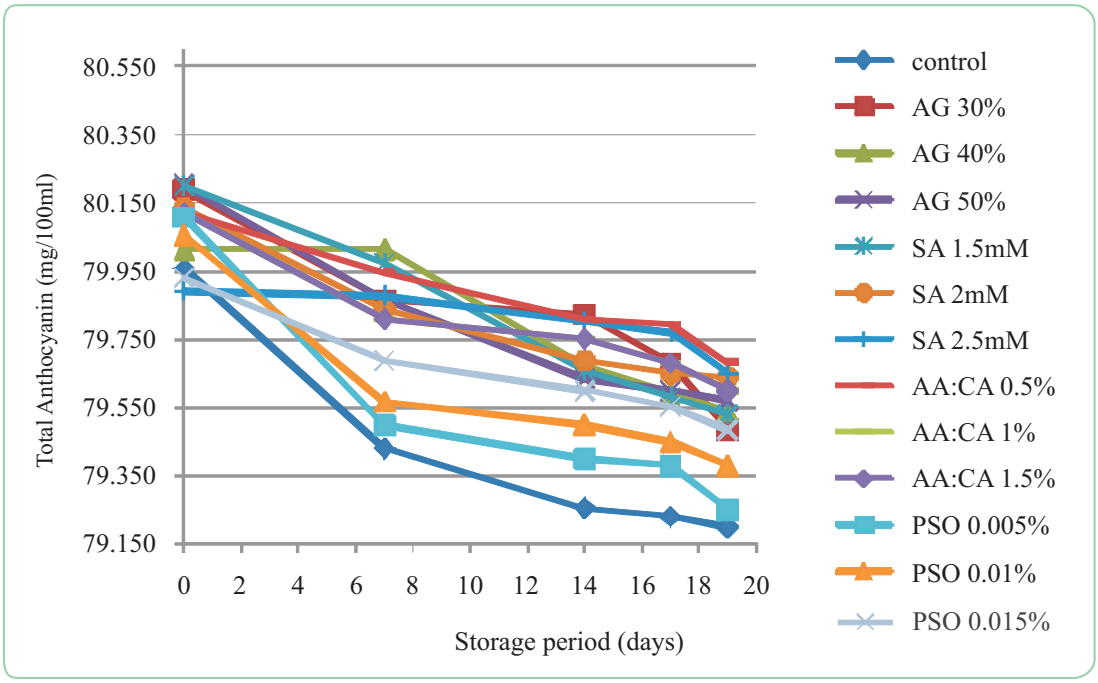
The matured and healthy fruits of uniform size and appearance of Bhagawa variety were treated with chlorinated water (sodium hypochlorite solution 200ppm) for 10 minutes. The fruits were then washed twice with the fresh water and mopped. The disinfection is carried out to reduce the initial inoculum load. The arils were separated manually at 16°C by peeling fruits with knife. The pretreated arils were packed in plastic punnet which was heat sealed with biaxially oriented polypropylene film. All the processing operations were carried out at 16 °C.

The pomegranate arils were analyzed for total soluble solids, titrable acidity, anthocyanin, ascorbic acid, total phenol content during storage of pomegranate arils. The changes in colour and texture parameters were also studied during storage using the colour difference meter and texture analyzer. The sensory evaluations of pretreated pomegranate arils were also carried out during storage period. The results for storage studies were tabulated or shown in graphical form.

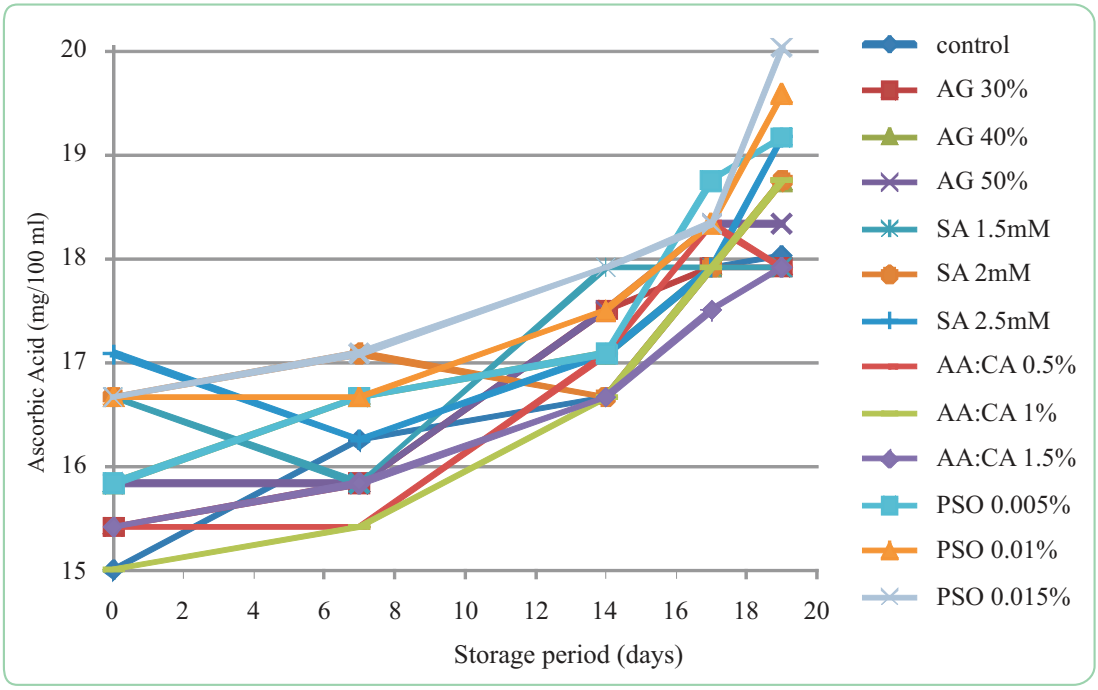
Effect of pretreatments on total soluble solids TSS (°Brix) and titrable acidity (%) in minimally processed pomegranate arils over the storage period

Treatments	Storage period (Days)			
	0th		19th	
	TSS (°Brix)	Acidity (%)	TSS (°Brix)	Acidity (%)
Control	17.13	0.38	19.53	0.52
AG 30%	16.67	0.39	18.97	0.46
AG 40%	16.67	0.38	20.07	0.46
AG 50%	16.70	0.43	18.27	0.44
SA 1.5mM	16.83	0.38	17.93	0.45
SA 2mM	16.90	0.41	18.03	0.43
SA 2.5mM	16.95	0.43	19.23	0.45
AA:CA 0.5%	16.67	0.42	18.57	0.50
AA:CA 1%	16.83	0.42	19.87	0.48
AA:CA 1.5%	16.85	0.42	18.23	0.46
PSO 0.005%	16.77	0.36	18.03	0.40
PSO 0.01%	16.60	0.34	19.03	0.40
PSO0.015%	16.67	0.33	18.57	0.40

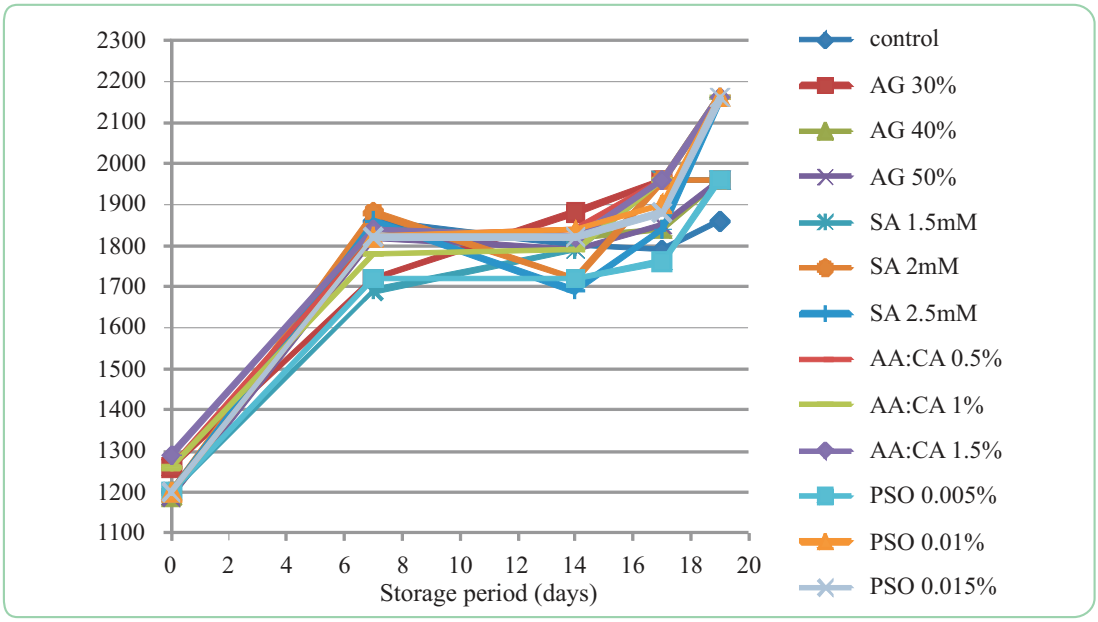
(AG: Aloe vera gel, SA: Salicylic acid, AA:CA = ascorbic acid : citric acid, PSO: pomegranate seed oil)



Effect of pretreatment and storage period on anthocyanin content of minimally processed pomegranate arils

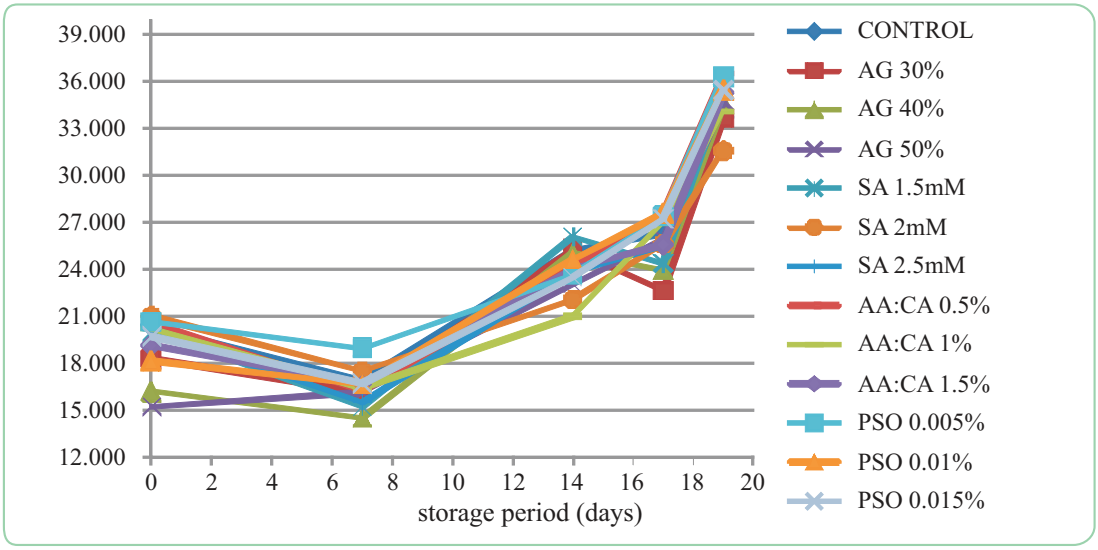


Effect of pretreatment and storage period on ascorbic acid content of minimally processed pomegranate arils



Effect of pretreatment and storage period on total phenol content of minimally processed pomegranate arils

The colour parameters were studied using colour difference meter. The colour was expressed in dimensions of L*, a*, b*. L* values were decreased over the storage period for the arils showing increase in darkness of the arils during storage. The pomegranate lightness was maintained in arils treated with oil, salicylic acid 2.5mM, AG 50% and Ascorbic acid : citric acid 1.5%. In case of a* values overall increase was observed in redness values the higher values of redness were observed in oil treated arils, besides that salicylic acid treated and AA:CA treated arils shown higher redness values. The texture of the arils was not affected much due to pretreatment, or storage period.



Effect of pretreatment and storage period on L* values of minimally processed pomegranate arils

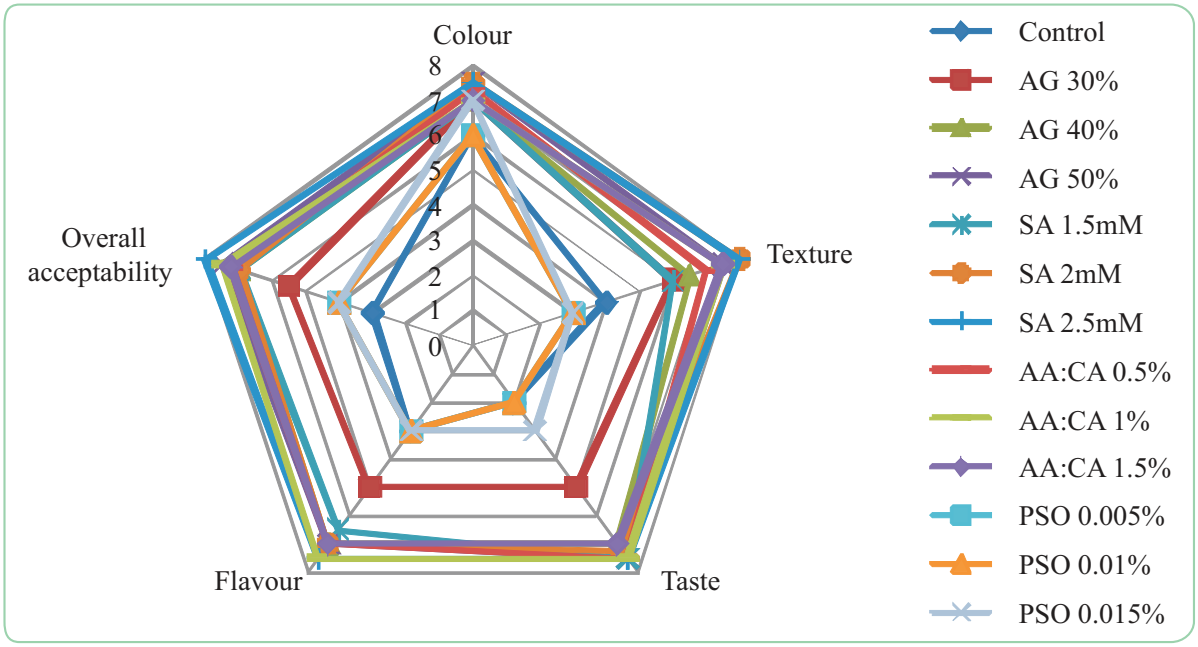
Effect of pretreatments on texture/bioyield point (N) for minimally processed pomegranate arils over the storage period

Pretreatments	Texture or bioyield point of arils (N)				
	Days of Storage				
	0th	7th	14th	17th	19th
Control	5.12	6.39	5.91	6.70	6.52
AG 30%	4.64	6.66	5.20	5.86	4.73
AG 40 %	5.35	6.72	6.20	6.18	6.07
AG 50 %	6.52	6.93	6.96	6.14	6.56
AA:CA 0.5%	5.52	6.48	6.21	6.71	6.87
AA:CA 1%	6.20	7.32	7.75	5.61	7.33
AA:CA 1.5%	6.31	6.53	6.36	7.79	7.13
PSO 0.005%	5.22	6.59	5.91	5.99	6.37
PSO 0.01%	5.63	6.68	6.47	6.58	5.13
PSO 0.015%	6.66	7.14	6.13	7.20	6.40
SA 1.5 mM	6.18	6.07	6.96	7.20	6.30
SA 2 mM	6.83	7.22	4.67	6.36	7.24
SA 2.5 mM	6.60	6.60	6.62	6.84	6.51

Sensory score after 19 days storage for different pretreatments in minimally processed arils

Pretreatments	Sensory score for 19th day of storage				
	Sensory Parameters				
	Colour	Texture	Taste	Flavour	Overall acceptability
Control	6.00	4.00	2.00	3.00	3.00
AG 30%	7.00	6.00	5.00	5.00	5.50
AG 40%	7.00	6.50	7.00	7.00	7.00
AG 50%	7.50	7.50	7.50	7.00	7.50
SA 1.5M	7.00	6.00	7.50	6.50	7.00
SA 2M	7.50	8.00	7.25	7.00	7.00
SA 2.5M	7.50	8.00	7.50	7.50	8.00
AA:CA 0.5%	7.25	7.00	7.50	7.00	7.25
AA:CA 1%	7.00	7.50	7.50	7.50	7.50
AA:CA 1.5%	7.00	7.50	7.00	7.00	7.25
PSO 0.005%	6.00	3.00	2.00	3.00	4.00
PSO 0.01%	6.00	3.00	2.00	3.00	4.00
PSO 0.015%	7.00	3.00	3.00	3.00	4.00

Sensory evaluation was carried on nine point hedonic scale by trained sensory panelist. The average scores for sensory evaluation for arils stored for 19 days are tabulated below. The sensory score revealed that there was not much variation in colour scores over the storage period however other paramaters such as taste, texture, flavor and overall acceptability varied much over storage period. On 19th day of storage highest sensory score was observed for arils treated with SA 2.5 mM, followed by AG 50%, and AA: CA 1 %. The least sensory score was found for control and pomegranate seed oil treated samples. The control and PSO treated samples shown degradation in sensory score from 7th day onwards.



Radar plot for sensory score of arils with different pretreatments

Total microbial count in log CFU/g was determined for minimally processed and packaged arils over the storage period for all the pretreatments. The safe maximum limit set by Spanish legislation for minimally processed produce is 7 log cfu/g is considered for storage studies continuance. On 19th day of storage the least microbial count was observed for samples treated with pomegranate seed oil, followed by SA 2.5 mM, AA:CA 1.5%, AG 50% and AA:CA 1%.

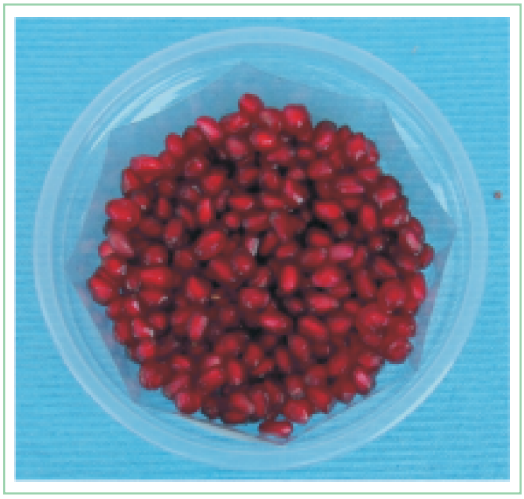
Effect of selected pretreatments on microbial quality during storage for minimal processed arils

Treatments	Total microbial count (log cfu/g) during storage				
	0 day	7 day	14 day	17 day	19 day
Control	3.00	5.30	7.51	8.30	9.05
AG 50%	2.51	2.67	3.58	4.75	5.28
SA2.5mM	0.00	2.00	4.56	5.03	5.20
AA:CA1%	0.00	3.78	4.02	4.69	5.49

Based on microbial count, sensory score and other quality parameters the pretreatment of salicylic acid 2.5 mM followed by AG 50% and AA:CA 1 % was found to be best and these three treatments can be recommended for commercial minimal processing of pomegranate arils.

Pretreated with salicylic acid 2.5 mM

Pretreated with aloe vera gel 50 %



Pretreated with AA:CA 1.5 %

Control

Minimally processed arils pretreated with selected treatments on 19th day of storage

5.4. Pomegranate wine

5.4.1 Protocol for pomegranate sparkling wine preparation

Protocol was standardized for preparation of sparkling quality pomegranate wine from Ganesh and Bhagawa cultivars. Shake flask culture method was adopted. The juice was extracted from the fruits of pomegranate and poured to two third volume of conical flasks of 0.5-1.0 litre capacity. The total soluble solid content of the juice was measured through refractometer and adjusted to above 22° Brix by supplementing the required quantity of cane sugar. The pasteurized juice was pre-treated with enzymes at desired concentration for few hours. The juice was filtered and inoculated with the starter culture yeast and the fermentation process was carried out for about

10-12 days. The wine was clarified using fining agents and other means.

Among the sparkling wine obtained from Ganesh and Bhagawa varieties, the sparkling wine from Ganesh was more transparent compared to Bhagawa.

Important characteristics of Bhagawa and Ganesh wine

Parameters	Bhagawa	Ganesh
TSS (°Brix)	12.7	13.0
Colour Intensity		
L*	14.96	46.37
a*	30.46	18.77
b*	24.46	59.42

Sparkling wine from Bhagawa

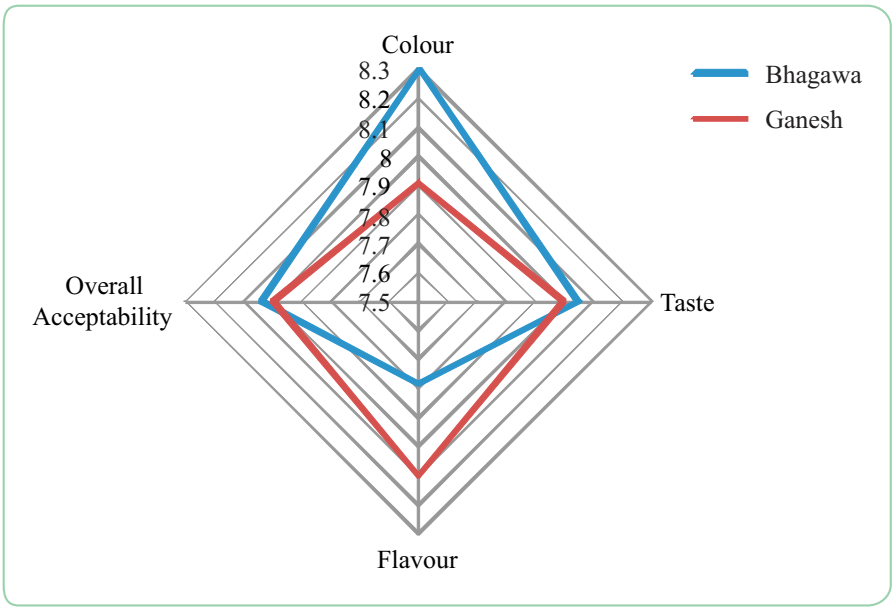
Sparkling wine from Ganesh

Organoleptic scoring of pomegranate wine

	Bhagawa sparkling wine				Ganesh sparkling wine			
S.No.	Colour	Taste	Flavour	Overall acceptability	Colour	Taste	Flavour	Overall acceptability
1	9.00	9.00	9.00	9.00	8.00	8.00	9.00	8.33
2	9.00	9.00	8.00	8.67	9.00	8.00	8.00	8.33
3	9.00	9.00	6.00	8.00	8.00	9.00	7.00	8.00
4	9.00	8.00	8.00	8.33	8.00	9.00	9.00	8.67
5	8.00	6.00	5.00	6.33	6.00	7.00	7.00	6.67
6	8.00	7.00	7.00	7.33	9.00	8.00	8.00	8.33
7	7.00	7.00	7.00	7.00	6.00	8.00	7.00	7.00
8	9.00	9.00	9.00	9.00	8.00	8.00	9.00	8.33
9	9.00	9.00	8.00	8.67	8.00	8.00	9.00	8.33
10	9.00	9.00	9.00	9.00	9.00	8.00	8.00	8.33
11	7.00	6.00	6.00	6.33	8.00	8.00	9.00	8.33
12	7.00	8.00	8.00	7.67	8.00	8.00	8.00	8.00
13	9.00	9.00	9.00	9.00	8.00	8.00	9.00	8.33
14	7.00	8.00	8.00	7.67	8.00	6.00	6.00	6.67
15	9.00	9.00	9.00	9.00	8.20	8.00	8.00	8.07
16	8.00	8.00	8.50	8.17	9.00	9.00	8.00	8.67
17	9.00	6.00	6.00	7.00	9.00	9.00	9.00	9.00
18	8.00	9.00	9.00	8.67	7.00	8.00	9.00	8.00
19	8.00	9.00	9.00	8.67	7.00	8.00	8.00	7.67
20	8.00	7.00	7.00	7.33	7.00	7.00	7.00	7.00
Mean	8.30	8.05	7.78	8.04	7.91	8.00	8.10	8.00

5.4.2 Organoleptic scoring of sparkling wine from Bhagawa and Ganesh varieties

Organoleptic scoring of pomegranate sparkling wine obtained from Bhagawa and Ganesh varieties of pomegranate was done on hedonic scale of 1-9 by a team of experts. It was revealed that sparkling wine from Bhagawa and Ganesh were highly acceptable with an overall acceptability of 8.04 and 8.00 respectively.



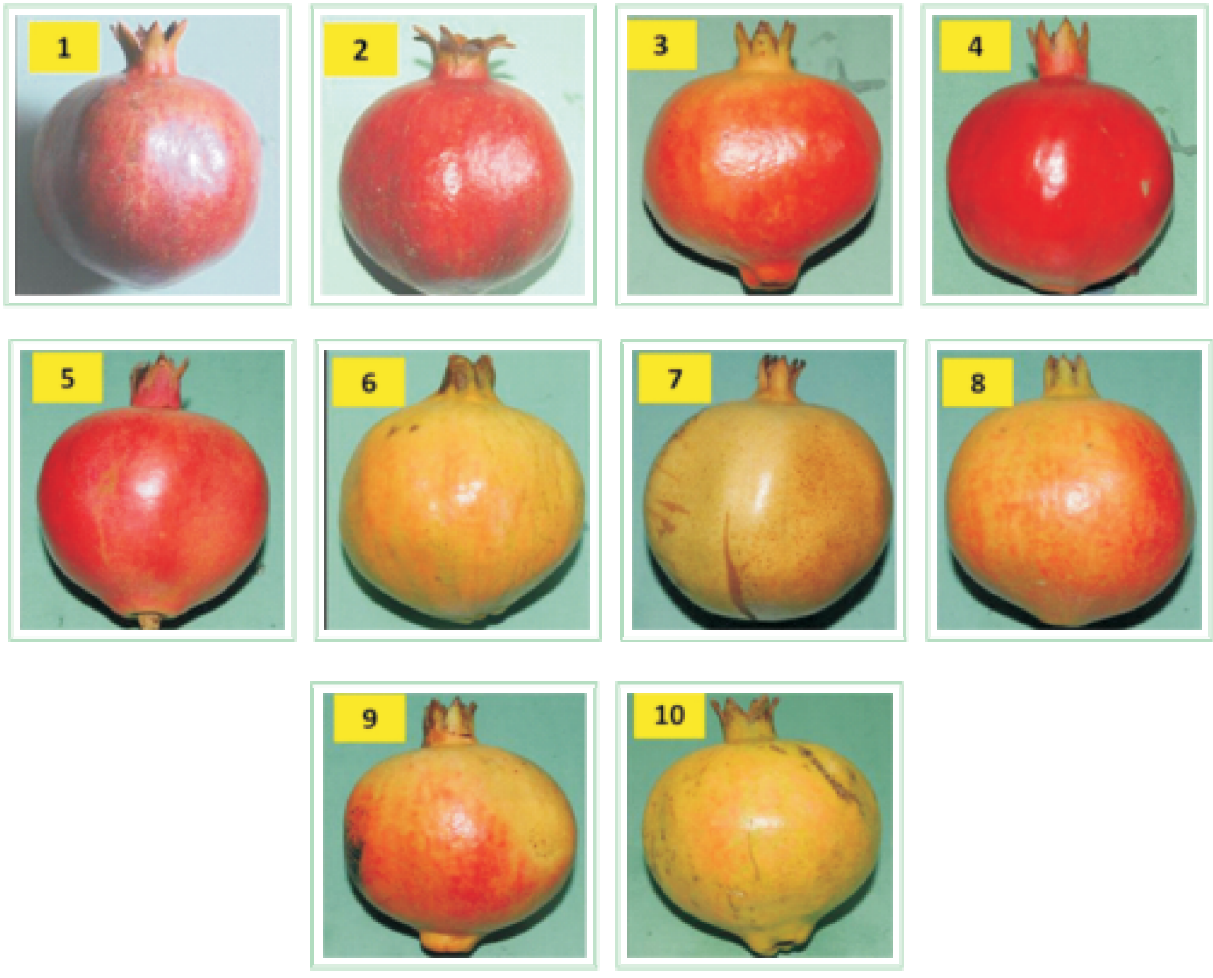
Sensory evaluation of sparkling wine of Bhagawa and Ganesh varieties

6. EXTERNALLY FUNDED PROJECTS

Project: Establishment of DUS Center at ICAR-National Research Center on Pomegranate

(Project funded by PPVFRA, New Delhi)

Three hundred and four germplasm of indigenous and exotic types were presently maintained in the field gene banks of ICAR-NRCP, Solapur. Database of 10 varieties covering thirty six characters including morphological, chemical and physical traits have been recorded and compiled in the form of compendium. For preparation of photolibrary, digital photographs of visible plant, leaf, flower and fruit characters of all ten cultivars were taken and maintained.



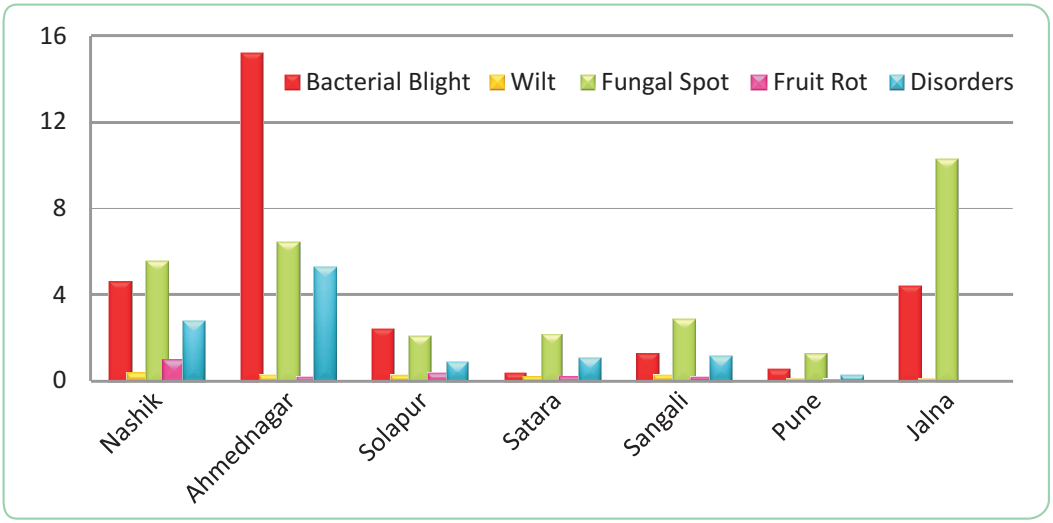
External fruit morphological variability among ten pomegranate germplasm
(1-Mridula; 2- Arakta; 3-Bassein Seedless; 4- Bhagawa; 5- Dholka; 6- G-137; 7-Kabul Yellow; 8- Ganesh; 9- Jyoti; 10- Kandhari)

Internal fruit morphological variability among ten pomegranate germplasm
(1-Mridula; 2- Arakta; 3-Bassein Seedless; 4- Bhagawa; 5- Dholka; 6- G-137; 7- Kabul Yellow; 8- Ganesh; 9- Jyoti; 10- Kandhari)

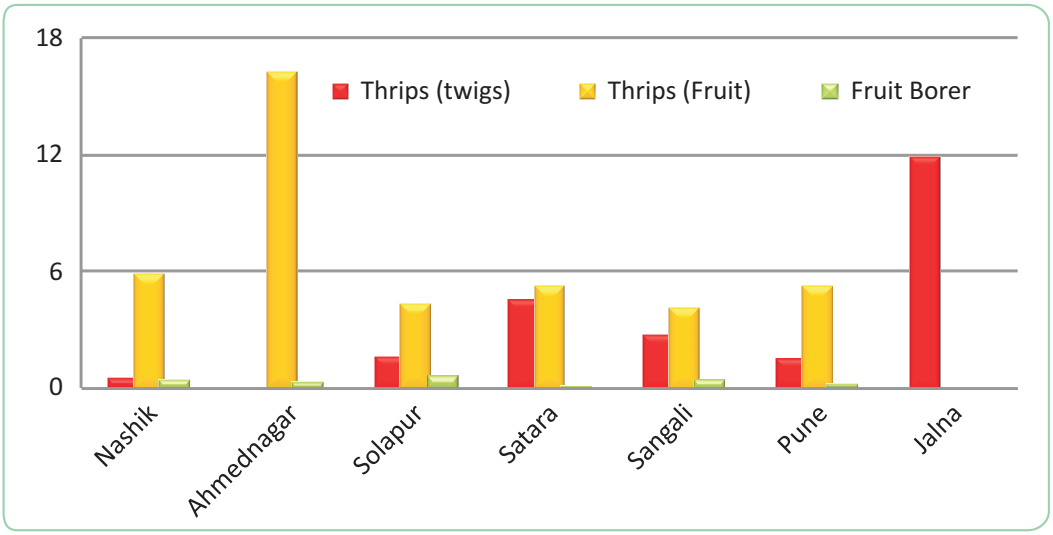
Project: Horticultural crop pest surveillance and advisory project for Mango, Pomegranate and Banana (HORTSAP)

(Externally funded project under State Agriculture Department, Maharashtra)

Survey of pomegranate orchards was conducted in the year 2014. In all, 258 orchards in 161 villages under 27 taluks of 7 districts covering 295 ha area were surveyed. Highest average incidence of bacterial blight recorded was 15.25% in Ahmednagar whereas it was found lowest in Pune (0.50%) during 2014. Fruit spots were highest in Jalna (10.27%). Wilt and fruit rots incidence was less than 1%. Disorders were highest upto 5.28%. Among insect pests, highest thrips damage was observed upto 16.25% in Ahmednagar. Fruit borer incidence was less than 1%.



Status of pomegranate diseases and disorders in different districts of Maharashtra (2014)



Status of pomegranate insect pests in different districts of Maharashtra (2014)

Project: Evaluating performance of poly propylene non-woven bags with respect to diseases, insect pests, physiological disorders and quality of pomegranate fruits

(Contract research trial, Reliance Industries Pvt. Ltd.)

Trial conducted with Reliance Polypropylene, Non - Woven (RPPNW) bags (closed and open types), in all the three seasons viz. *mrig, hasta* and *ambe bahar* at two locations- Doangaon and Kegaon. Data on diseases, disorders and insect pests were recorded for all the three seasons and average of all three bahars was used for analysis of data on disease, disorders and insect pests. Fruits of only *ambe bahar* were analyzed for quality parameters. A brief report on observations is given below.

Diseases

1. Bacterial blight was more in both closed (57.32%) and open (51.68 %) type RPPNW bags when compared to uncovered fruits (39.17%).
2. Fungal spots were equally present in uncovered and PPNW bagged fruits
3. Fruit rot increased significantly in closed RPPNW bags (15.33%) but was at par in open type (3.01 %) RPPNW bags and uncovered (5.12%) fruits.

Insect pests

1. PPNW bags gave 100 per cent protection against Fruit sucking moth.
2. Fruit borer Infestation was less in both type of RPPNW bags (around 2%) when compared to control (5.95%).
3. Thrips infestation was more in covered RPPNW bags (30.46%) and little less in open type RPPNW bags (21.58%) and control (24.47). However, they appear at par.

Disorders

1. No significant differences were recorded in physiological disorders - sunscald and fruit cracking in uncovered and bagged fruits

Fruit quality

1. The aril sack, in the fruits covered with either type of RPPNW bags was tougher than fruits in uncovered bags. Arils and juice were reddish in RPPNW, however more red in closed bags.
2. The fruits in RPPNW bags when compared to uncovered fruits had lower TSS, non-reducing sugar, anthocyanins, but had high Vitamin-C content in cv. Ganesh as well as Bhagawa when compared with unbagged ones.

   Reliance Polypropylene, Non-Woven bags were found effective in controlling fruit sucking moth most effectively and fruit borer infestation to some extent; however, it increased bacterial blight and hence should be avoided in blight affected orchards. Closed types bags increased rots. Better colour of aril, juice and vitamin C content were recorded in bagged fruits as compared to unbagged ones.

Covered with RPPNW bags-closed

Covered with RPPNW bags- Open

Uncovered

Effect of RPPNW bags on Bacterial Blight

Covered with RPPNW bags

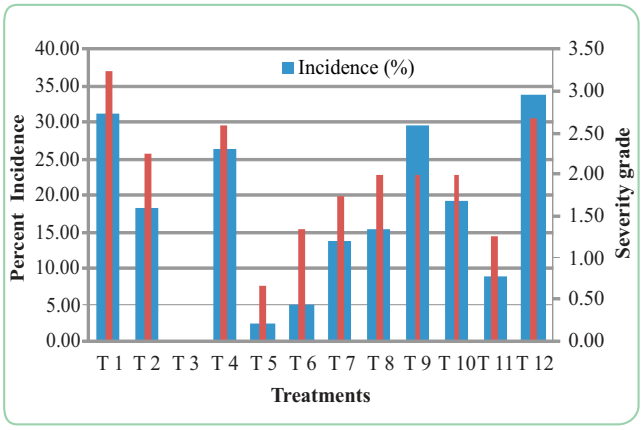
Uncovered

Effect of RPPNW bags on attack of Fruit Sucking Moth

Project: Evaluating bioefficacy of formulations Avtar and Merger in the management of fungal leaf/fruit spots and rots of pomegranate

(Contract research trial, Indofil Chemicals Limited)

Sixteen different treatments were evaluated for fungal spots and rots in a farmer's field including Merger (Tricyclazole 18%+Mancozeb **62% WP) and** Avtar (Hexaconazole 4%+Zineb 68% WP). Fungal spots caused by *Cercospora* and *Sphaceloma* sp. and *Colletotrichum* rot were significantly reduced with Merger (2.5-3.0g/l), mancozeb (2.5g/l), Avtar (2-2.5g/l) and OHM schedule. Fungal fruit spots were checked completely with sprays of Merger (0.3%) followed by Mancozeb 75% WP(0.25%) (92.42% reduction in fungal spots). Sprays of Avtar and Bordeaux solution (0.5%) altered with Kocide (0.2%) / COC (0.25%)/ Carbendazim (0.1%) / Thiophanate Methyl (0.15%) also checked disease between 74-86%. Hexaconazole also reduced spots by 74%. All these treatments also reduced severity significantly by 50-100%.



Effect of fungicidal sprays on incidence and severity of fungal fruit spots

Treatments	
T 1	Merger (Tricyclazole 18%+Mancozeb 62% WP)
T 2	Merger (Tricyclazole 18%+Mancozeb 62% WP)
T 3	Merger (Tricyclazole 18%+Mancozeb 62% WP)
T 4	Tricyclazole 75% WP
T 5	Mancozeb 75 % WP
T 6	Avtar (Hexaconazole 4%+Zineb 68% WP)
T 7	Avtar (Hexaconazole 4%+Zineb 68% WP)
T 8	Avtar (Hexaconazole 4%+Zineb 68% WP)
T 9	Zineb 75% WP
T 10	Hexaconazole 5% EC Altering Bordeaux Mix.(0.5%) With Kocide (0.2%), COC (0.25%)/Carbendazim (0.1%)
T 11	Thiophanate Methyl(0.15%)
T 12	Control

Project: Demonstration of model pomegranate production practices for effective management of bacterial blight disease

(Funded by National Horticulture Board, New Delhi)

Model pomegranate production practices were implemented in five farmers' orchards in the village Ankoli and Shejbabhulgaon, Mohol taluka, Solapur District. Out of five demonstration, fruits have been harvested in two demonstration plots and in three demonstration plots, fruits are at developing stage.

There was significant increase in yield in the adopted orchards by 29.31% to 48.96% as compared to non-adopted orchards. Significant reduction in fruit cracking, sunscald, rotting and bacterial blight infection was also observed in adopted orchards.

Orchard I

Orchard II

Bearing in pomegranate cv. Bhagawa in adopted orchards

Fruit yield obtained from two demonstration plots at village Ankoli, Mohol

Capacity building

'Pomegranate field day' was organized at the demonstration site to share the results of model pomegranate production practices for effective management of bacterial blight disease among pomegranate growers. About 60 pomegranate growers from nearby villages participated in result demonstration programme and they were impartedwith technical knowledge on pomegranate production practices by ICAR-NRCP experts through hands-on training at the demonstration plot. Pomegranate growers regained their confidence in effective management of bacterial blight disease to maximize the fruit yield.

Capacity building of pomegranate growers through result demonstration at site and celebration of pomegranate field day

7. RESEARCH PROGRAMMES AND PROJECTS

Institute Research Projects

Sl.No.	Project Title	Principal Investigator (PI)	Status
1.	Conservation, characterization and sustainable use of diversity in pomegranate	Dr. Ram Chandra	Ongoing
2.	Genetic improvement of pomegranate for yield, quality and resistance to biotic and abiotic stresses through conventional breeding and biotechnological approaches.	Dr. K. Dhinesh Babu	Ongoing
3.	Development and refinement of integrated production technologies for improved productivity.	Dr. D. T. Meshram	Ongoing
4.	Propagation, bio-hardening and mass multiplication of elite planting material in pomegranate (*Punica granatum* L.)	Dr. N. V. Singh	Ongoing
5.	Development and refinement of integrated crop protection technologies for improved productivity of pomegranate	Dr. K. K. Sharma	Ongoing
6.	Post harvest management value addition and improving knowledge of stakeholders for increasing production and marketing of pomegranate	Dr. Nilesh N. Gaikwad	Ongoing
7.	Propagation of pomegranate through conventional and non-conventional methods	Dr. N. V. Singh	Completed

Eternally Funded Projects

Sl. No.	Programmes	Project Title	Principal Investigators (PI)	Status
1	Project under RKVY	Horticultural crop pest surveillance and advisory project for Mango, Pomegranate & Banana	Director, ICAR-NRCP	Ongoing
2	Intellectual Property Right	Intellectual property management and transfer/commercialization of Agriculture Technology scheme	Director, ICAR-NRCP	Ongoing
3	Technology development and transfer scheme of NHB	Demonstration of model pomegranate production practices for effective management of bacterial blight disease	Director, ICAR-NRCP	Ongoing
4	DUS project	Extablishment of DUS centre at NRC on Pomegranate	Director, ICAR-NRCP	Ongoing
5	Contract research service (Paid up trial)	Evaluating bioefficacy of formulations Avtar and Merger in the management of fungal leaf/fruit spots and rots of pomegranate (Funded by Indofil Chemicals Limited)	Dr. (Mrs.) Jyotsana Sharma	Ongoing
6	Contract research service (Paid up trial)	Evaluating performance of poly propylene non-woven bags with respect to diseases, insect pests, physiological disorders and quality of pomegranate fruits (Funded by Reliance Industries Pvt. Ltd.)	Dr. (Mrs.) Jyotsana Sharma	Ongoing

Tribal Sub Plan

Sl. No.	Project Title	Principal Investigators (PI)	Status
1	Introduction of pomegranate cultivation (*Punica granatum* L.) to tribal farmers of Gadchiroli district	Dr. D. T. Meshram	Ongoing

Inter-institutional Collaborative Projects

Sl.No.	Project Title	Collaborative Institutes	Principal Investigators (PI)	Status
1.	Delineation of potential areas for pomegranate cultivation in India using remote sensing and GIS techniques	NBSSLUP, Nagpur	Dr. D. T. Meshram	Ongoing
2.	Flagship project on integrated approach to eradicate bacterial blight	ICAR-NRCP, Solapur , IARI, New Delhi, UHS, Bagalkot, YSPUHF, Solan ICAR-IIHR, Bangalore ICAR-NRCG, Pune	Dr. (Mrs.) Jyotsana Sharma, ICAR-RCP	Ongoing

Project: Introduction of pomegranate cultivation to tribal farmers of Gadchiroli district

Two self help group of farmers were selected for demonstration of pomegranate cultivation in black and light texture soil at Potgaon and Dongarsawangi villages, Tal.-Wadsa & Armori, Dist-Gadchiroli. These groups were provided with healthy pomegranate saplings, fertilizers and other inputs. Technical know-how was also given to them through practical demonstration. Borewell and drip irrigation facility was also created at these sites. The performance of pomegranate plantation in black and light soil is shown below. Activities initiated for 10 acres of pomegranate cultivation for improving the livelihood security of tribal farmers at Bamani, Ranggapalli, Gumalkonda, Pochanpalli and Venkatpura villages of Gadchiroli district and work is in progress.

Plantation in black soil at Dongarsawangi

Planting of pomegranate in black soil

Plantation in light soil at Potgaon

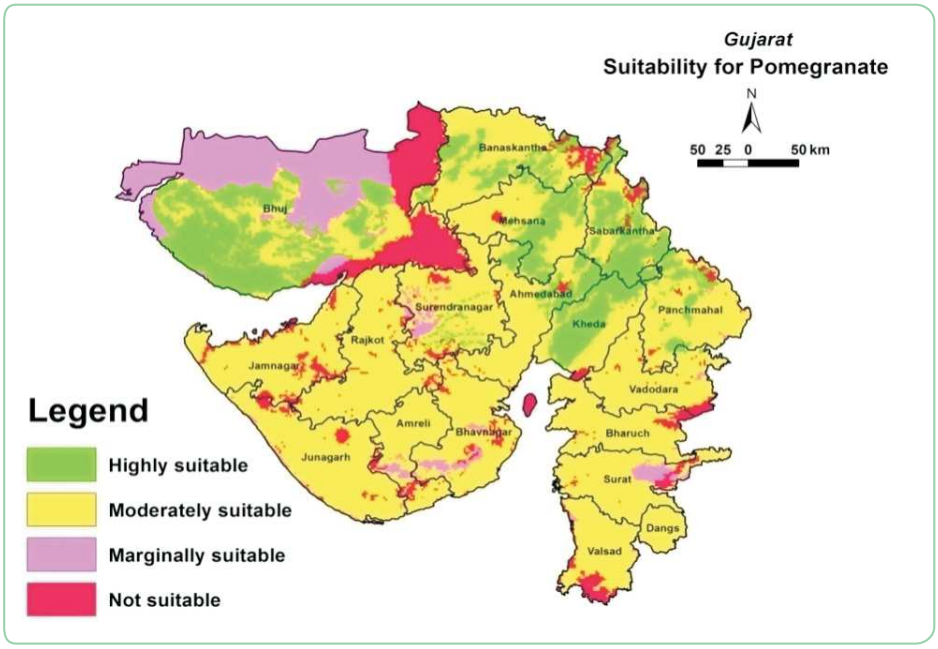
Planting of pomegranate in light soil

Three training programmes were organized for improving livelihood security of tribal farmers from Gadchiroli, Dhule and Nandurbar Districts. The themes of training were as follows.

i. Pomegranate Cultivation and Production of Low Cost Planting Materials, 18-20th Aug., 2014
ii. Pomegranate Cultivation and Production of Low Cost Planting Materials, 30th Aug., 2014
iii. Pomegranate Cultivation for Improving the Sustainable Livelihood Security, 23-25th Feb, 2015

Project: Delineation of potential areas for pomegranate cultivation in India using Remote Sensing and GIS Techniques

This collaborative project between ICAR-NBSS & LUP, Nagpur and ICAR-NRCP, Solapur has been initiated. Potential areas of Gujarat state were identified and categorized as highly suitable, moderately suitable, marginally suitable and unsuitable areas for pomegranate cultivation.



Potential areas for pomegranate cultivation in Gujarat state

8. TRANSFER OF TECHNOLOGY

Organization of training programmes by ICAR-NRCP, Solapur

S. No.	Name of Training programme	Venue	No. of Participants/ Beneficiaries	Date
1.	NABARD sponsored three days training programme on pomegranate production and value addition	ICAR-NRCP, Solapur	21 farmers of Sehore and Dewas districts of Madhya Pradesh	7-9th May 2014
2.	Training programme on model pomegranate production practices	ICAR-NRCP, Solapur	Officials of Bayer crop sciences Ltd.	29-30th May 2014
3.	Mentor for Professional Attachment Training of ARS Scientist, Mr. Chandrakant Mahadev Awachare	ICAR-NRCP, Solapur	1scientist	12th May- 11th August, 2014
4.	Three days training programme on model pomegranate production practices and value addition	ICAR-NRCP, Solapur	Officials of Tata Chemicals Ltd.	12-14th January 2015
5.	FET programme of 100th FOCARS batch of ARS Scientists (P)	ICAR-NRCP, Solapur and Village Sawleshwar, Solapur	6 scientists	19th August-9th Sept, 2014
6.	One day Workshop on Entrepreneurship Development in Pomegranate for Rural Youth	ICAR-NRCP, Solapur	20 rural youths of Solapur	25th September 2014
7.	Pomegranate for Nutrition, Livelihood security	ICAR-NRCP,	35 farmers	05-07th December, 2014
9.	Training programme for tribal farmers of Dhule district on "Pomegranate Cultivation and Production of Low Cost Planting Materials"	ICAR-NRCP, Solapur	25 farmers	18-20th August, 2014
8.	Three months training on "*In vitro* propagation in pomegranate cv. Bhagawa and genetic diversity study in pomegranate genotypes"	ICAR-NRCP, Solapur	1 student	29th Dec, 2014- 28th March, 2015
10.	Three months training on "*In vitro* propagation and Bio-hardening of pomegranate " and "Assessment of Genetic diversity in Pomegranate Germplasm (*Punica granatum* L.) using SSR markers".	ICAR-NRCP, Solapur	2 students	16th Jan, 2015- continued

S. No.	Name of Training programme	Venue	No. of Participants/ Beneficiaries	Date
11.	Model pomegranate production practices	ICAR-NRCP, Solapur	26 farmers from Beed, MS	16-18th February, 2015
12.	Pomegranate Cultivation for Improving the Sustainable Livelihood Security for Dhule and Nandurbar tribal farmers	ICAR-NRCP, Solapur	50 farmers	23-25th Feb, 2015
13.	Training Programme on Isolation and Identification of Pomegranate Bacterial Blight Pathogen, SRF and RA Orientation under Flagship project on 'Integrated Approach to Eradicate Pomegranate Bacterial Blight'	ICAR-NRCP, Solapur	10 SRF &RA	16-25th March 2015
14.	Awareness cum training programme on 'PPV & FR Act, 2001 and model pomegranate production	ICAR- NRCP	14 farmers 6 KVK SMSs	8-10th April 2015

On site training programmes participated and organized

Sr. No.	Name of Training programme	Venue	No. of Participants/ Beneficiaries	Date
1.	Training programme on Pomegranate cultivation and production of low cost planting materials for improving livelihood security for tribal farmers of Gadchiroli district, sponsored by ICAR-NRCP, Solapur	Village Bamani, Ta-Sironcha, Dist-Gadchiroli	200 farmers	31st August 2014
2.	Training programme for the Jat pomegranate farmers sponsored by ATMA, Jat	Jat	250 farmers	27th August 2014
3.	Training programme for Phaltan pomegranate farmers sponsored by ATMA, Phaltan	Phaltan	280 farmers	17th January 2015
4.	Training Programme on Pomegranate Cultivation practices for farmers of Shreegonda, Ahamadnagar,	KVK Shreegonda, Ahamadnagar,	300 farmers	11th July 2014

Sr. No.	Name of Training programme	Venue	No. of Participants/ Beneficiaries	Date
5.	Training programme on Pomegranate Cultivation	Sakal International Learning Centre, Pune	100 progressive growers	18th July 2014
6.	Training programme on Pomegranate Cultivation	Maharashtra Pomegranate Growers Association, Pandharpur	350 farmers	21th August 2014
7.	Training Programme for Pomegranate Growers of Jalana (Maharashtra)	KVK, Jalna	250 farmers	5th October 2015
8.	Training Programme on Model Pomegranate Production Practices for Farmers of Gujarat	APMC, Tharad, Banaskantha	150 farmers	7th March 2015
9.	Technology week celebrations at KVK, Mohol	KVK, Mohol, Maharashtra	Pomegranate growers of Solapur, Maharashtra	12th February 2015
10.	Model pomegranate production practices	Bhimapur, Tharad taluka, Gujarat	230 farmers of Gujarat state	7th March 2015
11.	Training Programme on Model Pomegranate Production Practices for SHO, NHM Gujarat	Centre of Excellence on Pomegranate Deesa (Gujarat)	70-80 Horticultural officers	8th March 2015
12.	Workshop on pomegranate production and value addition organized by Mahatma PhuleKrishi Vidhnyan Kendra Indapur, MS in collaboration with Maharashtra State Agrl. Dept. and NRCP	Indapur, Maharashtra	Pomegranate growers from Indapur Taluk	26th June 2014

Participation in Exhibitions / Krishi Mela

Sl.No.	Name of Exhibition	Venue	Date
1.	National Conference on 'Challenges and opportunities for production and supply chain of pomegranate'	Univ. of Hort. Sciences Bagalkot, Karnataka	17-19th Jun 2014
2.	Kisan Mela-cum exhibition on Pomegranate	Pandharpur, MS	21st Aug 2014
3.	National Seminar-cum-Exhibition on 'Pomegranate for Nutrition, livelihood Security and Entrepreneurship Development'	ICAR- NRCP, Solapur, MS	7-8th Dec 2014
4.	Rashtriya Kisan Mela	ICAR-NRCC, Nagpur, MS	29-30th Dec2014
5.	Krushi Pradarshan 2015	KVK Narayangaon, MS	6th January 2015
6.	Krushi Pradarshan 2015	Siddheshwar fair Home ground, Solapur, MS	January, 2015

Pomegranate advisory provided by ICAR-NRCP, Solapur to farmers groups

Sr. No	Date	Area	No. of Pomegranate Growers /Visitors
1	15.09.2014	Tumkur, Karnataka	26
2	15.09.2014	Students of Marathwada University, Aurangabad, Maharashtra	13
3	09.10.2014	Vijapur, Karnataka	50
4	09.10.2014	Sangli, Maharashtra	50
5	10.10.2014	Phaltan, Satara, Maharashtra	50
6	10.10.2014	Indapur, Pune, Maharashtra	50
7	14.11.2014	Guntakkal,Telangana	45
8	10.12.2014	Rajura, Chandrapur, Maharashtra	50
9	10.12.2014	Jalgaon, Maharashtra	50
10	12.12.2014	Nagpur, Maharashtra	22
11	13.10.2014	Raisen, Madhyapradesh	90
12	22.12.2014	Daryapur , Amaravati, Maharashtra	35
13	22.12.2014	Dharur , Beed, Maharashtra	35
14	31.12.2014	Babhulgaon , Yavatmal, Maharashtra	45
15	03.01.2015	Indapur, Pune, Maharashtra	22
16	03.01.2015	Darva ,Yavatmal, Maharashtra	22
17	07.01.2015	Karad ,Sangli, Maharashtra	45
18	08.01.2015	Phalthan, Pune, Maharashtra	45
19	19.01.2015	Dayananad college Solapur, Maharashtra	80
20	21.01.2015	Deola, Nasik, Maharashtra	35
21	22.01.2015	Chakur , Latur, Maharashtra	34
22	23.01.2015	Nijamabad, Telanagana	24

Sr. No	Date	Area	No. of Pomegranate Growers /Visitors
23	20.02.2015	Chitradurga ,Telangana	50
24	25.02.2015	Biotech. College Latur, Maharashtra	40
25	26.02.2015	Dayanand college solapur, Maharashtra	80
26	11.03.2015	Siddhalghatta , Karnataka	45
27	16.03.2015	Badavni , Madhya Pradesh	44
28	17.03.2015	Petha, Nasik, Maharashtra	55
29	19.03.2015	PG students of UHS Bagalkot	20
30	21.03.2015	Chandrapur	20
31	26.03.2015	Chikkanhalli,Tumkur, Karnataka	55
32	26.03.2015	Tiptur, Karnataka	90

9. INSTITUTIONAL ACTIVITIES

The following events concerned with 'Research and Development' activities of the National Research Centre on Pomegranate were conducted during the year 2014-15.

a. Research Advisory Committee Meeting

The VIIIth meeting of Research Advisory on 26 April, 2014 at ICAR-NRCP, Solapur under the chairmanship of Dr. C. D. Mayee, Former Chairman, ASRB, New Delhi. The constitution of the VIIIth RAC of ICAR-NRCP was as follows:

Sl. No.	Name	Designation &Address
1.	Dr. C.D. Mayee - Chairman	Former Chairman, ASRB, New Delhi
2.	Dr. O.P. Pareek - Member	Former Director CIAH, Bikaner, Rajasthan
3.	Dr. B.B. Vashistha - Member	Former Director, NRCSS, Ajmer, Rajasthan
4.	Dr. V. Rajagopal - Member	Former Director, CPCRI, Kasaragod
5.	Dr. RK Jain - Member	Jt. Director (Education) and Dean, IARI, New Delhi
6.	Dr. RK Pal - Member	Director, NRC on Pomegranate, Solapur
7.	Dr. SK Malhotra - Member	ADG (Hort. Sci. I), ICAR, New Delhi
8.	Shri. Baburao Ramchandra Gaikwad - Member	Progressive Farmer, Sangola, Dist. Solapur, Maharashtra
9.	Shri Prabhakar Chandane - Member	President, All India Pomegranate Growers Association, Pune, Maharashtra
10.	Dr. Jyotsana Sharma - Member Secretary	Principal Scientist, NRC on Pomegranate, Solapur

The members of RAC along with the Director and Scientists of ICAR-NRCP visited Kegaon and Hiraj research farms of the Centre in the morning and 'Bio-hardening and Propagation Unit in the evening and interacted with the concerned scientists. The committee appreciated the developments during the year 2013-14 and also advised on various issues for further improvement. After the field visit, the scientists of the centre presented their individual contributions to meet the goals of ICAR-NRCP. At the outset Dr. RK Pal, Director, ICAR-NRCP, extended warm welcome to RAC members and gave a brief account of the developments of the Centre during the past one year through his brief presentation, 'ICAR-NRCP 2013-14: An Overview.' This was followed by presentation of 'Action Taken Report' on the recommendations of seventh RAC meeting held on June 7, 2013 by member secretary, Dr. (Mrs) Jyotsana Sharma. The committee appreciated that the scientists had acted upon most of the recommendations satisfactorily. The principal investigators (PI) of the projects presented the work-done during 2013-14. In all, work done under three programmes in ten projects was presented. The recommendations of VIIIth RAC approved by ICAR are summarized below.

RECOMMENDATIONS of VIIIth RAC

1. Indexing, cataloguing and documentation of entire pomegranate germplasm may be done for developing profile of each germplasm for various horticultural traits, processing and table purpose attributes, reaction to various biotic and abiotic stresses etc. This may be done in phased manner and a catalogue may be published for germplasm indexed and catalogued in 2014-15, before the next RAC meeting.
2. Large number of crosses be made involving wild types and desirable cultivars, seedling population may be planted in close spacing and screened. The plants showing desirable horticultural traits with resistance to bacterial blight and/or wilt may be multiplied and planted directly in the field.
3. Exploitation of non-host resistance for bacterial blight should receive attention
4. Marker assisted breeding for bacterial blight resistance may be done in collaboration with other ICAR institutes.
5. Attempts should be made for developing a fool proof sanitization protocol for production of bacterial blight free nursery plants.
6. An early warning system for bacterial blight be developed with environmental factors most contributing to bacterial blight progress so as to take appropriate mitigation strategies
7. New formulations/agents may be tried for bacterial blight control.
8. Differences in surface microflora on leaves and fruits of pomegranate cultivars with different bacterial blight susceptibility be enumerated and correlated with bacterial blight severity
9. Modification of PCR diagnostic kit/ Bio-PCR and sampling methodology/size be standardized for detection of latent infections of bacterial blight in planting material may be worked out in collaboration with IARI, New Delhi.
10. In the changing scenario where pomegranate crop is being regulated any time of the year, studies on plant growth promoting substance for manipulation of flowering (including sex ratio) and fruiting behaviour of pomegranate may be taken on priority. Further pruning and training systems and other parameters contributing to good flowering and fruit set may be standardized for getting flowering as per choice of season.
11. Critical stages of irrigation in pomegranate, should be identified, so that farmers with limited water resources may irrigate to get maximum benefit
12. It was suggested to prepare a map showing regions suitable for pomegranate cultivation in India by superimposing rainfall map on soil characteristics map.

Research Advisory Committee Meeting

b. Institute Research Committee Meeting

The IX[th] IRC meeting of ICAR-NRCP was held on 23.06.2014 and was attended by following members.

Sl. No.	Name	Designation
1.	Dr. R.K. Pal, Director, ICAR-NRCP, Solapur	Chairman
2.	Dr. (Mrs.) Jyotsana Sharma, Principal Scientist (Plant Pathology), NRCP, Solapur	Member
3.	Dr. K.K. Sharma, Principal Scientist (Plant Pathology), NRCP, Solapur	Member
4.	Dr. K. Dhinesh Babu, Senior Scientist (Fruit Science), NRCP, Solapur	Member
5.	Dr. D.T. Meshram, Scientist SS (SWCE), NRCP, Solapur	Member
6.	Dr. Ashis Maity, Scientist (Soil Science), NRCP, Solapur	Member
7.	Dr. N.V. Singh, Scientist (Fruit Science), NRCP, Solapur	Member
8.	Dr. Nilesh Gaikwad, Scientist (ASPE), NRCP, Solapur	Member
9.	Dr. Ram Chandra, Principal Scientist (Hort.), NRCP, Solapur	Member Secretary

c. Institute Management Committee Meeting

The XI[th] IMC meeting of NRCP was held on August 8, 2014 and was attended by following members.

Sl. No	Name	Designation
1.	Dr. R. K. Pal – Chairman	Director, NRC on Pomegranate, Solapur
2.	Dr. A. K. Mishra – Member	Project Coordinator (STF), CISH, Lucknow
3.	Dr. D. P. Waskar – Member	Director of Research, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
4.	Dr. Ram Chandra – Member	Principal Scientist, ICAR-NRCP, Solapur
5.	Shri Ram Avtar Parashar – Member	Finance & Accounts Officer, ICAR-NIASM, Baramati
6.	Shri Prabhakar Chandane – Member	Farmer's representative
7.	Shri Baburao Ramchandra Gaikwad – Member	Farmer's representative
8.	Dr. (Mrs.) Jyotsana Sharma _ Invitee Member	Principal Scientist, NRCP, Solapur
9.	Shri V. A. Shinde – Invitee Member	Assistant Finance & Accounts Officer, NRCP, Solapur
10.	Shri R. B. Rai – Invitee Member	Assistant Administrative Officer, NRCP, Solapur
11.	Shri A. A. Goswami, Member Secretary	Administrative Officer, NRCP, Solapur

A brief account of ongoing research projects and action taken report on VIII[th] IRC meeting held on 30.09.2013 was presented by Dr. Ram Chandra. This was followed by the presentation of the achievements of 10 ongoing research projects by respective PI. The action plan under different projects were critically reviewed and suggestions for improvement were put forward.

The following issues were discussed and recommended by the Institute Management Committee.

1. Recommendation for the Distribution of Incentive/Benefits share to the scientific /Technical/Administrative and Supporting Staff as per the ICAR Guidelines for the ICAR Guideline for the Intellectual Property Management Technology Transfer/ Commercialization.
2. Execution of the Misc. farm development viz. construction of temporary sheds for tractor/vehicle, storing farm implements and other agricultural is puts as reconstruction of main gate, security cabin etc. (in case of demolition by NHAI)
3. Recommendation for the minor correction in the list of equipment for R&D pilot plant on post harvest management and processing of pomegranate in the approval equipment in XII plan EFC/SFC.

IMC meeting of ICAR - NRCP

Visit to PHT lab by IMC members

d. Independence Day Celebration

Independence Day

e. *Hindi Chetna Mass,* ICAR-NRCP, Solapur

ICAR-NRC on Pomegranate has celebrated *"Hindi Chetna Mass"* from 15th September, 2014 to 14th October, 2014. Various competitions were organized during the period and all the members of this centre participated in these events. To mark the end of these competitions, a prize distribution ceremony was organized on 14th October, 2014. Dr. Eresh Swamy, former Vice-Chancellor, Solapur Vidyapeeth, Solapur attended the ceremony as Chief Guest and the programme was chaired by Dr. R. K. Pal, Director, ICAR-NRCP, Solapur. In his speech, honorable chief guest highlighted the importance of Hindi in bringing unity in diversity and congratulated the staff of ICAR-NRCP for organizing very useful commemorative programme as *"Hindi Chetana Mass"*. The chairman emphasized upon the importance of Hindi in bringing cultural and linguistic unity of India. The event was managed by Mr. A. A. Goswami, Hindi Officer in cooperation with all the Scientific, Technical, Administrative and Supporting Staff of ICAR-NRC on Pomegranate.

Prize distribution ceremony on conclusion of *Hindi Chetna Mass*

f. Foundation Day Celebration

ICAR- NRCP organized 'Foundation Day Celebration' on 25.09.2014. As part of the event, one day training programme was organized for 25 progressive farmers. The training programme was formulated in such a way that it focused on value addition and enterprise development. Few lectures and demonstration on propagation of planting material, bio-hardening, value addition, wine making, etc were arranged.

g. Clean India Mission (*Swach Bharat Abhiyan)*

Clean India Mission *(Swach Bharat Abhiyan)* was launched at ICAR-NRCP, Solapur on 02.10.2014. In this connection, Oath was undertaken by all staff members to keep the campus and the premises clean. This was followed by cleaning of all laboratories, experimental blocks, hi-tech polyhouses, shadenet houses and the connecting roads, main gate and adjoining areas. It was also decided to dispose off the biodegradable and non-biodegradable waste materials in dust bins of different colour codes so as to make use of the decomposing material.

Oath undertaking in connection with Clean India Mission

Campus cleaning activity under Clean India Mission

h. Filed Day

A field day was organized on 07.01.2015 at Ankoli village, Mohol Taluka of Solapur District in the farmer's field adopted under the NHB project on demonstration of Model pomegranate production practices. The scientific management practices for pomegranate cultivation were discussed with a farmers group of 100 members.

Field day organized under NHB project on Model pomegranate production practices

i. Republic Day Celebration

Republic Day

ICAR-NRC on Pomegranate celebrated the 66th Republic day of the Nation on 26th January, 2015. On the occasion, Dr. (Mrs.) Jyotsana Sharma, Principal Scientist, ICAR-NRCP hoisted the national flag and addressed the staff of this centre highlighting the importance and strength of Indian constitution and its role in building up the nation.

j. National Seminar-cum-Exhibition

Three day (Dec. 05-07, 2014) National Seminar-cum-Exhibition on 'Pomegranate for Nutrition, livelihood Security and Entrepreneurship Development' Jointly Organized by ICAR-National Research Centre on Pomegranate, Solapur & Society For Advancement of Research on Pomegranate (SARP), Solapur was inaugurated by Dr. TA More, Hon'ble Vice Chancellor, Mahatama Phule Krishi Vidyapeeth, (MPKV), Rahuri. The dignitaries on the dais were Dr. VT Jadhav, Former Director, ICAR-NRCP, Dr. P. Kumar, Former Director, NRCP, Dr. NN Maldar, VC, Solapur, University, Dr. NP Singh, Director, ICAR Research Complex, Goa, Dr. DP Waskar, Director of Research, VNMKV, Parbhani, Shri Prabhakar Chandane, President, All India Pomegranate Growers Association, Dr. RK Pal, Director ICAR-NRCP and President, SARP and Dr. NV Singh, Organizing Secretary and Secretary, SARP. The dignitaries also released 4 publications *viz.* (i) Souvenir of the Seminar, (ii) Technical

Bulletin on Pomegranate: Cultivation, Marketing and Utilization, (iii) ICAR-NRCP at a Glance and (iv) DVD on Management of Bacterial Blight in three languages Hindi, Marathi and English. Selected progressive pomegranate farmers from Maharashtra, Karnataka, Rajasthan and Gujarat were facilitated during the Seminar. Five Technical Sessions, an Exhibition of Agri Products, a Farmer-Scientist-Entrepreneurer interaction and a Plenary session were organized during the National Seminar-cum-Exhibition from 5th -7th Dec, 2014.

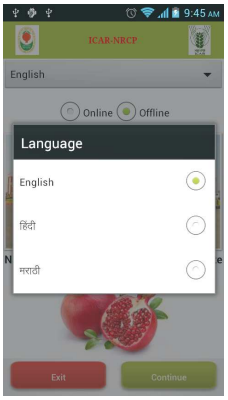
Inaugural ceremony of the National Seminar

Inauguration of exhibition

k. Launching of 'mobile application' for Pomegranate Growers

To adapt to this changing world, ICAR-National Research Centre on Pomegranate took one step forward with launch of ICAR-NRCP android based Mobile App to make the life of pomegranate growers easy. The mobile application was launched by Dr. N. K. Krishnakumar, DDG (HS) on 7th December, 2014 and has been downloaded by 5299 pomegranate growers and other stakeholders all over the world. This application can be used through online and offline mode. The most salient feature of this app is that it is available in three different languages English, Hindi and Marathi. Currently supported features by NRCP app are pomegranate production information which includes topics from establishment of pomegranate orchard, production of quality planting material, nutrient management in pomegranate, water management in pomegranate, diseases and pest management, post-harvest management of pomegranate and processing and value addition of pomegranate. The other icons on applications included publications for download, weather forecast, on the go Market rates of pomegranate across the country, announcements, contact with ICAR-NRCP scientists with just one click. Mobile app can be downloaded by searching ICAR-NRCP on google play store.

Launching of ICAR-NRCP *mobile app* by Hon. Dr. N K Krishnakumar, DDG, Hortl. Science



Screen shots ICAR-NRCP mobile app

I. Commercialization/ Transfer of Technologies

1. ICAR-NRC on Pomegranate, Solapur entered into technology licensing agreement for "*In vitro* Propagation of pomegranate cultivar Bhagawa including biohardening"

ICAR-National Research Centre on Pomegranate, Solapur has entered into memorandum of agreement with M/s HortiFloral Biotech, Tembhurni and M/s K. F. Bioplants Pvt. Ltd., Pune for production of tissue cultured and bio-hardened planting material of cultivar Bhagawa on 3rd June, 2014 and 9th Jan, 2015, respectively. Notably, ICAR-NRCP is the only public sector organization to come up with tissue culture and bio-hardening protocol of pomegranate which can be scaled upto commercial level. The technology licensing agreement has paved way for *in-vitro* production of elite planting materials on mass scale by M/s Horti Floral Biotech. With the exponential increase in the area under pomegranate in the country the demand for disease free planting material is rising rapidly. The technology licensing from ICAR-NRCP for commercial production of elite and disease free planting material to meet the huge demand of pomegranate growers is step in right direction.

Director ICAR-NRCP Dr. R K Pal handing over memorandum of agreement to M/s. Horti Floral Biotech for production tissue cultured and bio-hardened planting material of cultivar Bhagawa

2. ICAR-NRC on Pomegranate, Solapur signed a MOU with GK 1 Farm Fresh for technology licensing of Ready-to-Serve (RTS) beverage from Pomegranate

ICAR-National Research Centre on Pomegranate,Solapur has signed a memorandum of understanding with M/s GK 1 Farm Fresh for technology licensing of Ready-to-Serve (RTS) beverage from pomegranate on 24th July 2014. G Krishna Reddy the proprietor of GK 1 Farm Fresh was trained on production technology of RTS beverage from pomegranate. He is basically a farmer with 10 acres of pomegranate orchard and was concerned about the utilization of fruits which does not fetch good price in the market due to smaller size, cracking, surface blemishes, blight affected split fruits etc. He said that he gets around 1 tonne of pomegranate of this kind per acre. After getting training on development of RTS beverage, he started processing pomegranate for RTS beverage.

Director ICAR-NRCP Dr. R K Pal handing over technology of Ready-to-Serve (RTS) Beverage from Pomegranate to Mr. Krishna Reddy of GK1 Farm Fresh

Director ICAR-NRCP Dr. Pal along with team of inventors handing over licencing agreement to officials of KF Bioplants

3. ICAR-NRC Pomegranate entered in Technology License Agreement with M/s Bhosale Nursery and M/s. Hariyali Hitech for production of low cost planting materials using hardwood cutting and Bio-hardening

ICAR-National Research Centre on Pomegranate, Solapur has signed a memorandum of agreement with Bhosale Nurseries for "Two step hardwood cutting protocol of pomegranate including bio hardening" on 1st August, 2014 and 5th Sept, 2015, respectively. The technology enables production of healthy planting material using various antibiotic, fungicidal and hot water treatments throughout the year under protected structures. This is cheap, less labour intensive and farmer's friendly technology where farmers can take regular yield and utilize resultant pruned wood including water shoots for the preparation of healthy planting material for sale or for self-use.

Hardwood cutting technology

Director ICAR-NRCP Dr. R.K. Pal along with team of inventors handing over licencing agreement to Mr.Bhosale

Director ICAR-NRCP Dr. R.K. Pal along with team of inventors handing over licencing agreement to Mr.Wackchaure of M/s Hariyali Hitech

m. Other important occasions of ICAR-NRCP

Visit of Agricultural Commissioner Sh. Umakant Dangat on 04.08.2014

Agreement with BSNL for construction of Trainees Hostel, 30.01.2015

Agreement with Maharasthra Jeevan Pradhikaran for Lift Irrigation System

n. Infrastructure created

Texture analyzer

Colour difference meter

Walk-in cold room

A view of pilot plant

A view of pilot plant

A view of pilot plant

Newly constructed shadenet house at ICAR-NRCP, Solapur

10. TRAINING AND CAPACITY BUILDING

Participation of Scientists /Staff in Conference /Refresher Courses / Meetings / Symposia / Workshop / Trainings

Sl. No	Title	Date	Venue	Name of the participants
1.	State Level "Joint Agresco-2014" org. by Dr Bala Saheb Sawant Konkan Krishi Vidyapeth, Dapoli -and Maharashtra Council of Agricultural Education and Research (MCAER), Pune	12-13th May, 2014	Dr Bala Saheb Sawant Konkan Krishi Vidyapeeth	Dr. (Mrs). Jyotsana Sharma
2.	National Seminar-cum-workshop on physiology of flowering in perennial fruit crops	24-26th May, 2014	CISH, Lucknow	Dr. R.K.Pal (Member, National Steering Committee), Dr. K. Dhinesh Babu
3.	National Seminar: Challenges and Opportunities for Production and Supply Chain of Pomegranate	17-19th June, 2014	University of Hort. Sciences, Bagalkot.	Dr. RK Pal Dr.(Mrs). Jyotsana Sharma Dr. Ram Chandra Dr. K. Dhinesh Babu Dr. D. T. Meshram Dr. Nilesh Gaikwad Sh. D. T. Chaudhari Sh. Mahadev Gogaon
4.	Management Development Programme on Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects	4-8th Aug, 2014	NAARM, Hyderabad	Dr. D. T. Meshram
5.	Summer school on Food Quality and Safety: Recent Advances in Evaluation Techniques	5-25th Aug, 2014	Central Institute of Post-harvest Engineering and Technology, Ludhiana, Punjab	Dr. Nilesh Gaikwad
6.	Annual workshop of KVKs of Zone V	29th Sep, 2014	KVK Baramati, Maharshtra	Dr. Nilesh Gaikwad
7.	New dimension of Agro-Meteorology for Sustainable Agriculture	16-18th Oct, 2014	GBPUAT Pantnagar, Uttarakhand	Dr. D.T. Meshram
8.	23rd meeting of ICAR Regional Committee No. VII	17-18th Oct, 2014	Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh)	Dr. RK Pal Dr. (Mrs). Jyotsana Sharma

Sl. No	Title	Date	Venue	Name of the participants
9.	6th Indian Horticulture Congress on 'Horticulture for Inclusive Growth- An International Event'	6 -9th Nov, 2014	CODISSIA Trade Fair Complex, Coimbatore.	Dr. R. K. Pal Dr. K. Dhinesh Babu Dr. D. T. Meshram Dr. Ashis Maity Dr. N V Singh
10.	Meeting of the Nodal Officers of Institutes of Horticultural Science Division on review of RFD achievement	24th Nov, 2014	NASC Complex, New Delhi	Dr. Nilesh Gaikwad
11.	National Seminar-Cum-Exhibition, conducted by ICAR-NRCP and SARP, Solapur on "Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Development"	5-7th Dec. 2014	ICAR-NRCP, Solapur	Dr. R. K. Pal Dr. Ram Chandra Dr. Jyotsana Sharma Dr. K. Dhinesh Babu Dr. D. T. Meshram Dr. Ashis Maity Dr. N. V. Singh Dr. Nilesh Gaikwad Mrs. Prativa Sahu Dr. H. B. Shilpa
12.	Mega Exhibition, University of Hort. Sciences, Bagalkot	13-15th Dec, 2014	University of Hort. Sciences, Bagalkot.	Dr. (Mrs). Jyotsana Sharma Sh. Mahadev Gogaon
13.	National Meet on Distant hybridization for horticultural crop improvement,	21-23th Jan, 2015	IIHR, Bangalore	Dr. K. Dhinesh Babu Dr. H. B. Shilpa
14.	KVK Technology Week Jan 22-24, 2015, Krishi Vigyan Kendra, Solapur	23rd Jan, 2015	KVK Farm, Hiraj	Dr. (Mrs). Jyotsana Sharma
15.	National Seminar and Exhibition on Pomegranate (Silver Jubilee of Maharashtra Pomegranate Growers Research Association, Pune)	2nd Feb, 2015	Shirdi, Dist. Ahamadnagar (Maharashtra)	Dr. R. K. Pal Dr. Jyotsana Sharma Sh. Vijay Lokhande
16.	Meeting for Cluster Development for Pomegranate by APEDA in Maharashtra	9th Feb, 2015	Maharashtra State Agriculture Marksting Board (MSAMB), Pune	Dr. R. K. Pal Dr. Jyotsana Sharma Dr. Nilesh Gaikwad
17.	Workshop for Status of work done under HORTSAP	13th Feb, 2015	Department of Horticulture, Commissionerate of Agriculture, Pune	Dr. (Mrs).Jyotsana Sharma
18.	Workshop of HRD Nodal Officers from ICAR institutes for Human Resource Management	26th Feb, 2015	NAARM, Hyderabad	Dr. (Mrs). Jyotsana Sharma
19.	Meeting with State Horticulture Mission, Ahmedabad	3rd Mar, 2015	State Horticulture Mission, Ahmadabad	Dr. RK Pal Dr. (Mrs). Jyotsana Sharma Dr. K Dhinesh Babu Dr. Ashis Maity

Sl. No	Title	Date	Venue	Name of the participants
20.	National Workshop on Protected cultivation for Vegetable Crops	11th Mar, 2015	PFDC, Dept. of IDE MPKV, Rahuri. Maharashtra	Dr. Nilesh Gaikwad
21.	State level Steering Committee Meeting on HORTSAP 2014-15- and 2015-16	13th Mar, 2015	Commissionerate of Agriculture, Sakhar Sankul, Shivaji nagar, Pune	Dr. (Mrs). Jyotsana Sharma
22	Exhibition organized in connection with National Meet on Horticultural Crops	14th Mar, 2015	RRS (TNAU), Paiyur	Dr. R. K. Pal Dr. K. Dhinesh Babu Sh. M. S. Gogaon
23.	Investigation on Response of Pomegranate Production to Deficit and Irrigation Partial Root Zone Drying Scheduling using Micro-Meteorology Techniques	25-26th Mar, 2015	ICAR-IIWM, Bhubaneswar, Orissa	Dr. D.T. Meshram
24.	First General Body Meeting of Society for Advancement of Research on Pomegranate (SARP)	25th Mar, 2015	NRCP, Solapur	Dr. R. K. Pal Dr. (Mrs). Jyotsana Sharma Dr. K. Dhinesh Babu Dr. D. T. Meshram Dr. Ashis Maity Dr. N. V. Singh Dr. Nilesh Gaikwad Mrs. Prativa Sahu
25.	ICAR-Sponsored winter School on Integrated Pest Management and Meeting with PI HORTSAP Project	28th Feb, 2015	NCIPM, New Delhi	Dr. (Mrs). Jyotsana Sharma

Glimpses of training programmes organized by ICAR - NRCP, Solapur

Workshop on Entrepreneurship Development in Pomegranate for Rural Youth on the occasion of institute foundation day, 25.09.2014

Training programme on model pomegranate production practices for officials of Bayer Crop Science Ltd. May 29-30, 2014

NABARD sponsored three days training programme on pomegranate production and value addition for farmers from MP, May 7-9, 2014

Three days training programme on model pomegranate production practices and value addition for officials of Tata Chemicals Ltd. January 12-14, 2015

Workshop on pomegranate production and value addition organized by Mahatma Phule Krishi Vigyan Kendra at Indapur, MS in collaboration with Maharashtra State Agril. Dept. and ICAR-NRCP, June 26, 2014

Orientation training for SRF/RA of Flagship Project March 16- 25, 2015

Training Programme of Madhya Pradesh farmers on 07.05.2014

Training programme on Model Pomegranate Production Practices, February 16-18, 2015

Training programme for employee of Tata Chemicals Ltd., January 12-14, 2015

Workshop on Entrepreneurship Development in Pomegranate for Rural Youth September 25, 2014

Training programme for Tribal farmers of Dhule and Nandurbar Districts February 23-25, 2015

11. PUBLICATIONS

I. Research papers

A. International Journal

1. Singh, N.V., Abburi, V.L., Ramajayam, D., Kumar, R., Chandra, R., Sharma, K.K., Sharma, J., Babu, K.D., Pal, R.K., Mundewadikar, D.M., Saminathan, T., Cantrell, R., Nimmakayala, P. and Reddy, U.K. 2015. Genetic Diversity and association mapping of bacterial blight and other horticulturally important traits with microsatellite markers in pomegranate from India. *Molecular Genetics and Genomics.* doi:10.1007/s00438-015-1003-0
2. Pandey, R., Gupta, A., Chowdhary, A., Pal, R.K., and Venkat, R.M., 2014. Over-expression of mouse ornithine decarboxylase gene under the control of fruit-specific promoter enhances fruit quality in tomato. *Plant Mol Biol,* DOI 10.1007/sl1103-014-0273-y

B. National Journal

1. Meshram, D.T. and Gorantiwar, S.D. 2015. Evaluation of pan coefficient for estimating reference crop evapotranspiration in Solapur station, Maharashtra. *Mausam*. 62(2):551-556.
2. Meshram, D.T., Gorantiwar, S.D., Mittal, H.K. and Jain, H.K. 2015. Forecasting of Pomegranate (*Punica granatum* L.) Evapotranspiration by using Seasonal ARIMA Model. *Indian Journal of Soil Conservation*. 43(1):255-264.
3. Suroshe, S.S., Sharma, J., Singh, N.V. and Pal, R.K. 2015. New report of insect pests and their natural enemies from Pomegranate (*Punica granatum* L.). *Indian Journal of Horticulture*. (Accepted – In Press).
4. Gaikwad, N.N., Samuel, D.V.K., Grewal, M.K. and Manjunatha, M. 2014. Development of Orange Grading Machine on Weight Basis. *Journal of Agricultural Engineering, 51 (3): 1-8.*
5. Babu, K.D., Singh, N.V., Chandra, R., Sharma, J., Maity, A. and Sarkar, P.C. 2014. Effect of surface coating with lac based formulations on post harvest quality of pomegranate (*Punica grantum* L.) fruits. *International Journal of Tropical Agriculture*, 32 (3-4): 835-839.
6. Sharma, R.R., Pal, R.K., Sagar, V.R., Parmanick, K.K., Paul, V., Gupta, V.K., Kumar, K. and Rana, M.S. 2014. Impact of pre-harvest fruit-bagging with different coloured bags on peel colour and the incidence of insect pests, disease and storage disorders in 'Royal Delicious' apple. *Journal of Horticultural Science & Biotechnology,* 89 (6):613-618

II. Review articles

1. Pal, R.K., Babu, K.D., Singh, N.V., Maity, A. and Gaikwad, N.N. 2014. Pomegranate Research in India – Status and future challenges. *Progressive Horticulture*, 46(2):184-201

III. Books

1. Chadha, K.L. and Pal, R.K. 2015. Managing post harvest quality and losses in horticultural crops. Vol-1: General Issues, Astral International (P) Ltd., New Delhi, 1-231p.
2. Chadha, K.L. and Pal, R.K. 2015. Managing post harvest quality and losses in horticultural crops Vol-2: Fruit Crops, Astral International (P) Ltd., New Delhi, 253-561p.
3. Chadha, K.L. and Pal, R.K. 2015. Managing post harvest quality and losses in horticultural crops. Vol-3: Vegetables, Flowers and Plantation Crops, Astral International (P) Ltd., New Delhi, 581-727p.

IV. Book chapters

1. Meshram, D.T., Jadhav, V.T., Gorantiwar, S.D. and Chandra, R. 2015. Modeling of Weather Parameters using Stochastic Methods in Climate Change Modeling, *In*: Planning and Policy for Agriculture. Springer publisher.
2. Pal, R.K. and Babu, K.D. 2015. Pomegranate (*Punica granatum* L.). *In*: Managing postharvest quality and losses in horticultural crops (Eds. Chadha, K.L. & Pal, R.K.), Vol.2 Fruit Crops. Daya Publishing House, New Delhi, pp.735-752.
3. Ranpise, S.A., Sankaran, M., Babu, K.D., Jai Prakash, Hiwale, S.S. 2014. Pomegranate. *In*: Tropical and subtropical fruit crops. Crop Improvement and varietal wealth (Ed, Ghosh, S.N.), Jaya Publishing House, Delhi, pp: 549-580.
4. Rawal, R.D. and Sharma, J. 2015. Post harvest Diseases. *In*: Managing Postharvest Quality and Losses in Horticultural Crops Vol. I: General Issues, (KL Chadha and RK Pal Ed.) Publ. Daya Publishing House®, *A Division of* Astral International Pvt. Ltd. New Delhi, pp: 111-146.
5. Singh, N.V., Sharma, J. and Pal, R.K. 2015. Biological control of pre and post disease of fruits. *In*: Microbial empowerment in agriculture-a key to sustainability and crop productivity (ed. B.K. Sharma). Biotech Books, New Delhi (ISBN 978-81-7622-331-7). pp. 141-172.

V. Popular articles

1. Babu, K.D., Sharma, J. and Pal, R.K. 2014. Ornamental Pomegranates. *In*: *Punikesara Souvenir,* National Conference on Challenges and Opportunities for Production and Supply Chain of Pomegranate, June 17-19, University of Horticultural Sciences, Bagalkot, 105-107.
2. Sharma, J. 2015. *Europian desamadhya dalimb niryatichaya drishtikonatoon rog wa kidichya niyanthranasathi sifarishkeleli kitnashake Dalimbvruth* 1:21-25 (Marathi).
3. Singh, N.V., Chandra, R. and Pal, R.K. 2014.*In vitro* propagation protocol and bio-hardening of pomegranate cultivar Bhagawa.*ICAR News*. 21(1): 1-2.
4. Singh, N.V., Chandra, R. and Pal, R.K. 2014.Two stage hardwood cutting protocol for pomegranate. *ICAR News*. 20 (4):20-22.
5. Singh, N.V., Chandra, R., Singh, S., Pal, R.K., and Singh, G. 2014. "Anar me upaj sudhar ke liyae chatra prabandhan. *Vindhya Krishi. 9(1):68-76.*

VI. Presentation of research papers/ abstracts in conference/ symposia/ seminars/ workshop/other fora

A. Lead papers

1. Gorantiwar, S.D. and Meshram, D.T. 2014. Water requirement for Pomegranate (*Punica granatum* L). *National Seminar-cum-Exhibition on Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Development*, 05-07th December, 2014 at ICAR-NRCP, Solapur
2. Meshram, D.T. and Gorantiwar, S.D. 2014. Forecasting the Model of Reference Crop Evapotranspiration for Solapur Station, Maharashtra, India. *International Symposium on New Dimensions in Agro-meteorology for Sustainable Agriculture, conducted by Association of Agro-meteorologist and GBPUAT,* 16-18th October, 2014 at *GBPUAT, Pantnagar,* (Abstract No.7 .7) pp.247.
3. Pal, R.K. and Babu, K.D. 2014. Post harvest management and total utilization of pomegranate (*Punica granatum* L.). *National Seminar-cum-Exhibition on 'Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Development*' from December 05-07th, 2014 at ICAR-NRCP, Solapur, pp. 252-261.

4. Pal, R.K. and Gaikwad, N.N. 2014. Post harvest management and value addition in pomegranate. *National Conference on Challenges and Opportunities for Production & Supply Chain of Pomegranate*, 11-13th April, 2014 at University of Horticultural Sciences, Udyangiri, Bagalkot.
5. Sharma, J. and Sharma, K.K. 2014. Pomegranate diseases and their management, In: *Souvenir, National Seminar-cum-Exhibition on 'Pomegranate for Nutrition, livelihood Security and Entrepreneurship Development'* December 05-07th, 2014 at ICAR-NRCP, Solapur, pp. 184-190.
6. Sharma, J. 2014. Diseases and Disorders in Pomegranate and their Management. *In*: *Punikesara- Souvenir*, *National Conference on Challenges and Opportunities for Production and Supply Chain of Pomegranate* June 17-19th, 2014 Univ. Hort. Sci., Bagalkot:86-98.
7. Sharma, J. 2014. Diseases and Disorders in Pomegranate and their Management. In: *Anar Sampada: Lead Papers and Abstracts, National Conference on Challenges and Opportunities for Production and Supply Chain of Pomegranate* June 17-19th, 2014 UHS, Bagalkot: 55-66.
8. Sharma, J. 2015. Pathogens threatening pomegranate cultivation In: *Souvenir and Abstracts, National Symposium (IPS West Zone) on Plant Pathology: Disease Diagnosis and management for sustainable agriculture*, Organized by Indian Phytopathological Society, New Delhi held on January 24-25th, 2015 at Botany Department, Maharashtra Mahavidyalaya Nilanga Dist. Latur: 81.

B. Oral presentations

1. Babu, K.D. and Pal, R.K. 2014. Induction of flowering in pomegranate through foliar spray of chemicals and hormones. In: *Abstracts of National Seminar-cum-workshop on physiology of flowering in perennial fruit crops*, 24-26th May 2014, CISH, Lucknow (3.13 Oral / pp.42).
2. Babu, K.D., Sharma, J., Murthy, B.N.S., Chandra, R., Singh, N.V. and Pal, R.K. 2014. Development of pomegranate varieties through breeding. In : *Anar Sampada- Lead papers & Abstracts of National Conference on Challenges and opportunities for production & supply chain of pomegranate*, 17-19th, June 2014, UHS, Bagalkot (Oral /pp.28).
3. Maity, A., Chandra, R., Singh, N.V., Meshram, D.T. and Pal, R.K. 2014. Effect of elemental sulphur on solubility of micronutrients and their uptake by pomegranate. In: *Souvenir, National Seminar–Cum–Exhibition on Pomegranate for nutrition, livelihood security and entrepreneurship development, jointly organized by ICAR-NRCP and Society of Advancement of Research on Pomegranate (SARP), Solapur, 5-7th December, 2014 (Oral) pp. 101-107.*
4. Meshram, D.T., Maity, A., Singh, N.V., Chandra, R. and Pal, R.K. 2014. Effect of in-organic mulches on yield, quality and WUE in Pomegranate *(Punica granatum* L.*), Oral research paper presented in National Seminar-Cum-Exhibition on Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Development*, *ICAR-NRCP and SARP, Solapur*, 5-7th December, 2014 at ICAR-NRCP, Solapur, pp.76.
5. Gaikwad, N. N., Pal, R.K. and Babu, K.D. 2014. Entrepreneurship development in pomegranate through value addition. Oral Paper presented at *National Seminar On 'Pomegranate For Nutrition, Livelihood Security and Entrepreneurship Development,* 5-7th December 2014 at NRC on Pomegranate Solapur.
6. Sharma, J. 2015. Integrated management of pomegranate diseases, insect pests and disorders. In: *Course Compendium for ICAR-Sponsored Winter School on Recent Advances in Integrated Pest Management held at NCIPM*, New Delhi, Feb 26th - March 18th, 2015.
7. Singh, N.V., Babu, K.D., Chandra, R., Sharma, J., Sahu, P. and Pal, R.K. 2014. Production of quality planting material in pomegranate. In: *Souvenir, National Seminar–Cum–Exhibition on Pomegranate for nutrition,*

livelihood security and entrepreneurship development, jointly organized by ICAR-NRCP and Society of Advancement of Research on Pomegranate (SARP), Solapur, 5-7th December, 2014 (Oral), pp. 84-93.

VII. Technical /Extension bulletins

1. Pal, R.K., Sharma, J., Chandra, R., Sharma, K.K., Babu, K.D., Meshram, D.T., Maity, A. Singh, N.V. and Gaikwad, N.N. 2014. Pomegranate Cultivation, Marketing & Utilization, Technical Bulletin No. NRCP/2014/3 ICAR-NRC on Pomegranate, Solapur.
2. Sharma, J. and Chandra, R. 2014. *ICAR-NRCP at a Glance*, Publ.NRCP, Solapur. 23p.
3. Sharma, J. Suroshe, S.S., Shinde, Y.R., Chaudhari, D.T. 2014. *Daalimbavaril rog va keednidana ani vyavasthapan*, NRCP/VistarPustika 2014/1, NRCP, Solapur: 65p (Marathi).

VIII. Annual Report

1. Pal, R.K., Babu, K.D., Maity, A., Singh, N.V. and Gaikwad, N.N. 2014. NRCP Annual Report 2013-14, National Research Centre on Pomegranate, Solapur, p89.
2. Singh, N.V. 2014.Translation, compilation and editing of Annual Report (Hindi), 2012-13 of NRC on Pomegranate.

IX. Souvenir

1. Pal, R.K., Chandra, R., Sharma, J., Babu, K.D., Meshram, D.T., Maity, A., Singh, N.V., Gaikwad, N.N, Sahu, P. and Shilpa, H.B. 2014. Souvenir (of Lead paper, oral & poster abstracts) – *National Seminar cum Exhibition on Pomegranate for Nutrition, Livelihood Security and Entrepreneurship Development*, Dec 5-7th, 2014, ICAR-NRC on Pomegranate, Solapur -413 255, 307p.

X. Manual/ compendium

1. Meshram, D.T., Pal, R.K., Chandra, R. Sharma, J., Sharma, K.K., Babu, K.D., Maity, A. and Singh, N.V. 2014. Compendium on pomegranate cultivation and production of low cost planting material for tribal farmers of Dhule, Maharashtra.47p.
2. Gaikwad, N.N. Pal, R.K., Sharma, J., Chandra, R., Sharma, K.K., Babu, K.D., Meshram, D.T. and Singh, N.V. 2014. Compendium of lectures in Training program on Pomegranate production and value addition for farmers of Madhya Pradesh. 07-09 May 2014, 46p.

XI. DVD

1. Sharma J. and Shinde, Y.R. 2014. Management of Bacterial Blight. DVD in three languages (Hindi, Marathi and English) 9-12 minutes each

12. BUDGET ESTIMATE

Financial Outlay 2014-15

Head of Account	Rupees in lakhs			
	Plan		Non-Plan	
	RE	Expenditure	RE	Expenditure
A. Recurring				
Estt. Charges	0.00	0.00	230.52	189.27
T.A	8.00	7.05	5.00	4.97
Other Charges	144.00	141.48	185.35	183.14
Total A	152.00	148.53	420.87	377.38
B. Non-Recurring				
Equipment	50.00	49.82	4.40	4.00
Major Works	218.00	218.00	0.00	0.00
Library	0.00	0.00	2.03	2.03
Furniture	0.00	0.00	3.69	3.69
Total B	268.00	267.82	10.12	9.72
C. P. Loans & Advances	0.00	0.00	2.20	2.20
D. Pension	0.00	0.00	30.01	26.97
E. Vehicles and Vessels	0.00	0.00	12.00	0.00
Grand Total (A+B+C+D)	420.00	416.35	475.20	416.27

Revenue Receipts 2014-15

Sl. No.	Items	Amount (Rs.)
1	Income from Farm Produce	167465/-
2	Income from Royalty and Publications	485550/-
3	Income from other sources	1051413/-
4	Interest on loans and advances	16555/-
5	Interest earned on short term deposits	761813/-
6	Recovery of loans and advances	539735/_
7	Application fees from candidates	40000/-
	Total Revenue Receipt	3062531/-

13. STAFF POSITION

(As on 31.03.2015)

Category	Sanctioned during XIIth Plan	Staff in position	Vacant
RMP	01	01	0
Scientific	14	10	4
Technical	06	06	0
Administrative	11	06	5
Supporting	02	02	0
Total	34	25	9

14. JOINING / PROMOTION / RELIEVING

Sl.No	Joining
1	Mrs. Prativa Sahu joined as Scientist at ICAR- NRC on Pomegranate on 09.04.2014
2	Mr. Vipin Dagar joined as Lower Division Clerk at ICAR -NRC on Pomegranate on 21.08.2014
3	Dr. (Mrs.) Shilpa H. B. joined as Scientist at ICAR- NRC on Pomegranate on 01.10.2014

Appendix I

a. Institute Management Committee of ICAR-NRCP

(As on 31.03.2015)

Chairman

1. Dr. R. K. Pal, Director
ICAR-NRCP, Solapur

Members

2. Dr. Ram Chandra
Principal Scientist
ICAR-NRCP, Solapur

3. Dr. A. K. Srivastava
Principal Scientist
NRC for Citrus, Nagpur

4. Dr. Abraham Verghese
Principal Scientist,
IIHR, Bangalore

5. Dr. A. K. Mishra
PC (STF) CISH, Lucknow

6. ADG (Hort.-I)
ICAR, New Delhi

7. Director of Horticulture
Govt. of Maharashtra
Shivaji Nagar, Pune

8. Director of Horticulture
Govt. of Rajasthan
Jaipur, Rajasthan

9. Dr. D. P. Waskar
Director of Research
VNMKV, Parbhani

10. Shri Ram Avtar Parashar
F&AO, NIASM
Baramati-413 115

11. Shri Prabhakar Chandane,
PO. Ekhatpur, Tal. Sangola,
Dist. Solapur

12. Shri Baburao Ramchandra
Gaikwad, Ramkrishna Niwas,
Shivaji Nagar, Sangola,
Dist. Solapur

Member Secretary

13. Shri A. A. Goswami
Administrative Officer,
ICAR-NRCP, Solapur

b. Research Advisory Committee of NRCP

(As on 31.03.2015)

Chairman

1. Dr. C. D. Mayee
50 K, Bharat Nagar, Amravati Road,
Nagpur -33

Member

2. Dr. O. P. Pareek
A-239, Kranti Nagar, Lalgarh, Bikaner

3. Dr. B. B. Vashistha
Former Director, NRCSS
C-107, Vidhuth Nagar, Jaipur, Rajasthan

4. Dr. V. Rajagopal
Former Director, CPCRI
Flat No.102, Sreekarkasham Street
A18-4-60, Railway Colony, Thirupathi

5. Dr. R. K. Jain
Head, Plant Pathology & Biotechnology
Indian Agricultural Research Institute
Pusa, New Delhi -12

6. Dr. R. K. Pal, Director
ICAR-NRC on Pomegranate,
Solapur

7. Dr. T. Janakiram
ADG (Hort.II), ICAR
KAB-II, Pusa, New Delhi

8. Shri Prabhakar Chandane,
PO. Ekhatpur, Tal. Sangola,
Dist. Solapur

9. Shri Baburao Ramchandra Gaikwad,
Ramkrishna Niwas, Shivaji Nagar,
At. Post. Sangola, Dist. Solapur

Member Secretary

10. Dr. (Mrs.) Jyotsana Sharma
Principal Scientist,
ICAR-NRC on Pomegranate,
Solapur 413255 (MS)

Appendix II

a. Institute Research Council of NRCP

(As on 31.03.2015)

Chairman

1. Dr. R. K. Pal
   Director

Member

2. Dr. (Mrs.) Jyotsana Sharma
   Pr. Scientist (Plant Pathology)
   NRCP, Solapur
3. Dr. K. K. Sharma
   Pr. Scientist (Plant Pathology)
   NRCP, Solapur
4. Dr. K. Dhinesh Babu
   Sr. Scientist (Hort.-Fruit Science)
   NRCP, Solapur
5. Dr. D. T. Meshram
   Sr. Scientist (SWCE.)
   NRCP, Solapur
6. Dr. Ashis Maity
   Scientist (Soil Science-Pedology)
   NRCP, Solapur
7. Dr. N. V. Singh
   Scientist
   (Hort.-Fruit Science)
8. Dr. N. N. Gaikwad
   Scientist (ASPE)
   NRCP, Solapur
9. Dr. (Mrs.) Prativa Sahu
   Scientist (Hort. – Fruit Science)
   NRCP, Solapur

Member Secretary

10. Dr. Ram Chandra
    Pr. Scientist (Horticulture)
    NRCP, Solapur

b. Institute Joint Staff Council of ICAR-NRCP

(As on 31.03.2015)

Chairman

1. Dr. R. K. Pal
   Director,
   ICAR-NRC on Pomegranate,
   Solapur

Members (Official side)

2. Dr. K. Dhinesh Babu,
   Sr. Scientist,
   NRCP, Solapur
3. Dr. Ashis Maity
   Scientist,
   NRCP, Solapur
4. Dr. N. V. Singh
   Scientist,
   NRCP, Solapur
5. Shri V. A. Shinde,
   Assist. Fin. & Acc. Officer
   NRCP, Solapur

Member Secretary (Official Side)

6. Sh. A. A. Goswami
   Admin. Officer
   NRCP, Solapur

Member (Staff side)

7. Shri D. T. Chaudhari
   Sr. Tech. Assistant
   NRCP, Solapur

Member (CJSC)

8. Shri. R. B. Rai
   Asstt. Admin. Officer
   NRCP, Solapur

Member Secretary (Staff side)

9. Shri Y. R. Shinde
   Tech. Assistant
   NRCP, Solapur

Appendix III

Personnel
(As on 31.03.2015)

RMP

Dr. R. K. Pal
Director

Scientific Staff

Dr. Ram Chandra
Pr. Scientist
(Horticulture)

Dr. (Mrs.) Jyotsana Sharma
Pr. Scientist
(Plant Pathology)

Dr. K. K. Sharma
Pr. Scientist
(Plant Pathology)

Dr. K. Dhinesh Babu
Sr. Scientist
(Hort.-Fruit Science)

Dr. D. T. Meshram
Sr. Scientist
(Soil and Water Conservation Engg.)

Dr. Ashis Maity
Scientist
(Soil Science-Pedology)

Dr. N. V. Singh
Scientist
(Hort.-Fruit Science)

Dr. N. N. Gaikwad
Scientist
(Agril. Structures and Process Engg.)

Mrs. Prativa Sahu
Scientist
(Hort. – Fruit Science)

Dr. (Mrs.) Shilpa H. B.
Scientist
(Genetics & Plant breeding)

Technical Staff

Sh. D. T. Chaudhari
Sr. Tech. Asstt.

Sh. Yuvraj Shinde,
Tech. Asstt.

Sh. Diwakar Sawaji
Tech. Asstt.

Sh. M. S. Gogaon
Sr. Technician

Sh. Govind Salunke
Technician

Sh. Vijay Lokhande
Technician

Administrative Staff

Sh. A. A. Goswami
Admin. Officer

Sh. Shinde V. A.
AFAO

Sh. R. B. Rai
AAO

Sh. Kiran Khatmode
LDC

Sh. A. S. Babar
LDC

Sh. Vipin Dagar
LDC

Supporting Staff

Sh. Shailesh Bayas
SSS

Sh. Vishal Gangane
SSS

प्रमाण पत्र • Certificado • Certificat • Zertifikat • شهادة

CERTIFICATE OF REGISTRATION

Quality Management Systems

NATIONAL RESEARCH CENTRE ON POMEGRANATE

Solapur- Pune, National Highway- 65, Kegaon,
Solapur- 413255, Maharashtra, India

Equalitas Certifications Limited Certifies that the Management System of the above mentioned Company has been assessed and meets the requirements established by the following rules:

ISO 9001:2008

The Management System Includes :

Augment the Production, Productivity and Utilization of Pomegranate through Basic, Strategic and Applied Research

Certificate No: **Q-01140603**

Date of Initial Registration: **03 Jun 2014**

Latest Issue Date: **03 Jun 2014**

Valid Till: **02 Jun 2015***

***Certificate is Valid for 3 Years From the Date of Initial Registration (03 Jun 2014 to 02 Jun 2017).**

*** After successful completion of surveillance audit, new certificate shall be issued.**

In the course of validity of the present certificate the enterprise management system must permanently satisfy the requirements of the international regulations. The fulfilment of these regulations will be regularly controlled by Equalitas Certifications Limited.

www.jas-anz.org/register

Director

Equalitas Certifications Limited

URL: www.theecl.com

Accreditation by Joint Accreditation System of Australia and New Zealand (Accreditation No. M4410210II)

817, Ansals Kirti Shikhar, 11 District Centre, Janakpuri, New Delhi-110058, India

For precise and updated information concerning possible changes occurred in the certification objective of the present certificate, please contact- info@theecl.com

The Certificate of Registration remains the property of Equalitas Certifications Ltd. and shall be returned immediately upon request.

Rev: 11

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किसानों का हमसफर

भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch