भाकृ अनुप
ICAR

वार्षिक रिपोर्ट
Annual Report
2016-17

भा.कृ.अनु.प.– राष्ट्रीय अनार अनुसंधान केन्द्र
सोलापुर – 413 255

ICAR - National Research Centre on Pomegranate
Solapur - 413 255

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

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PREFACE

The ICAR-National Research Centre on Pomegranate (ICAR-NRCP), Solapur, Maharashtra was established by ICAR in 2005 to augment the production, productivity and utilization of pomegranate through basic, strategic and applied research. In the recent past, India witnessed a quantum jump in production and export and became the world leader in area and production of pomegranate. Due to its highest return on investment, Pomegranate has become the means of livelihood security of approximately more than 90,000 farmers dwelling in dryland regions of India viz., Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Telengana, Madhya Pradesh, Himachal Pradesh, Rajasthan and other non-traditional areas.

In 2015-16, the area under pomegranate has increased sizably from 1.81 lakh ha to 1.93 lakh ha whereas the production from 17.89 lakh tonnes to 21.98 lakh tonnes with average productivity from 9.86 t/ha to 11.38 t/ha. The area under pomegranate in Maharashtra state alone has increased to 1.29 lakh ha. This was possible only due to creation of awareness on various horticultural technologies instilling confidence among the growers supported by organized marketing by various stakeholders including ICAR-NRCP, Solapur. It is heartening to note that one of the progressive pomegranate growers from Gujrat was felicitated with the national honour of "Padma Shri" by Govt. of India.

Several significant milestones have been achieved by ICAR-NRCP, Solapur during the year 2016-17 with respect to research, development of infrastructure and outreach extension activities. Some of the most significant achievements are mentioned below.

The progress of research work of ICAR-NRCP during the period of 2011-2016 was reviewed by a high level QRT constituted by ICAR. The team had observed and recorded a comment mentioning that "The committee was pleased to see the rapid growth of the Centre in a short span, it has made its visibility at the national level".

A final patent application on protocol for extraction of virgin seed oil with retention of bioactive components from pomegranate was filed. Minimal processing protocol was also standardized for freshly extracted pomegranate arils with 14 days storage life at 5^0C as against less than 1 day without processing at ambient. The new initiatives of ICAR-NRCP covers: Development of the new version of Mobile-app named as **'Solapur Anar'** in 6 languages viz. English, Hindi, Marathi, Kannada, Gujarati & Telugu; Development of pomegranate hybrids- 'Solapur Lal' for table purpose & 'Solapur Anardana' for processing purpose; Establishment of pilot plant for processing and total utilization of pomegranate fruit in juice, RTS beverage, wine, pomegranate seed oil and pomegranate peel powder; Layout of 9.9 km long underground pipeline for installation of lift irrigation system; Construction of 43 bed trainees hostel with furnishing within a record time of 15 months and well within the allocated AA&ES. Apart from these other activities include Mera Gaon Mera Gaurav; m-Kisan; Interactive touch screen kiosk in Marathi, Hindi and English language; new experiment on organic cultivation of pomegranate; Preparation of triggers for crop insurance of pomegranate, production of video film on NRCP profile; analysis of soils for development of soil health cards, Marathi version of technical bulletin entitled "Pomegranate :Cultivation, marketing and utilization", Preparation of bilingual LED display boards (24 nos.) on various technologies of ICAR-NRCP, etc. were successfully completed during this period. Besides, in-house research projects, the ICAR-NRCP has attracted research grants through ICAR extramural funding for three additional research projects. Similarly ICAR-NRCP was also successful in obtaining research grants from NMPB (Ministry of AYUSH) and NHB.

Scientists and technicians were deputed for training in various research institutes to strengthen the HRD activities and capacity building. During this year, Dr. Trilochan Mohapatra, Hon'ble Secretary (DARE) & DG (ICAR) visited ICAR-NRCP on 23.10.2016 and inaugurated the 'Pilot plant for processing of pomegranate' having capacity of 100 l/h for processing of juice/RTS and 'Lift irrigation system for supply of irrigation water @ 1 lakh l/day to ICAR-NRCP's research farm at Hiraj, Solapur.

During the period under report, technologies viz., "*In vitro* propagation of pomegranate cultivar Bhagwa including biohardening" and 'Development of pomegranate juice and RTS beverage' were transferred to one commercial firm and two promising entrepreneurs. Technical consultancy services were provided for establishment and rejuvenation of pomegranate orchard in Kanpur, U.P. Similarly technical consultancy was also provided to establish a start-up unit at Nashik, Maharashtra on minimal processing and packaging of pomegranate arils for export. The ICAR-NRCP also has made significant intervention in the tribal areas of Maharashtra and West Bengal for improving livelihood security of tribal farmers.

I wish to place on record my sincere gratitude to Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his constant guidance and kind support in achieving the various goal of ICAR-NRCP, Solapur. I express my heartfelt thanks to Dr. A.K. Singh, DDG (HS), Dr. W.S. Dhillon, ADG (HS-I) and Dr. T. Janakiram, ADG (HS-II) for their unwavering support and timely help in executing the proposed activities. My sincere gratitude to all the staff members of SMD (HS) for their kind cooperation and support offered to this centre. Thanks are due to Dr. Y.S. Nerkar, Chairman, 2nd QRT of ICAR-NRCP for the period 2011-2016 and Dr. R.B. Deshmukh, former VC, MPKV, Rahuri and Chairman, RAC for their keen interest on 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 cooperation and sincere efforts in successfully accomplishing the above mentioned activities.

May 30, 2017
Solapur

(R.K. Pal)
Director

कार्यकारी सारांश

अनार सुधार कार्यक्रम बहुत हद तक उपलब्ध जननद्रव्यों के गुण भिन्नता पर निर्भर करता है। 'काबुल कांधारी' एवं 'कांधारी सीडलेस' नामक दो किस्में डा.य.सिं.प.उ.वा.वि. से तथा एक थ्री वे क्रास संकर ''(गणेश x नाना) x दारू'', भा.कृ.अनु.प.-भा.बा.अनु.सं. से 2016-17 में एकत्रित की गई। वर्तमान में इस केंद्र के प्रक्षेत्र जीन बैंक में 375 जननद्रव्यों का संग्रह है।

26 जननद्रव्यों के 24 परिमाणात्मक गुणों के मूल्यांकन से यह प्रतीत हुआ की कुल घुलनशील ठोस (ब्रिक्स), 100 दानों का वजन (ग्रा.) छिल्का मोटाई (मि.मी.), दाना लम्बाई (मि.मी.), दाना चौड़ाई (मि.मी.), फल रस प्रतिशत, इत्यादि में भिन्नता ज्यादा है जो आगे भी किस्म सुधार कार्यक्रम में चयन की गुंजाईश दर्शाता है।

तैंतालीस जननद्रव्यों (23 जननद्रव्यों व्यवसायिक किस्में तथा 20 जंगली जननद्रव्य) के आण्विक भिन्नता अध्ययन ने दर्शाया की आईसी-318712, गुल-ए-शाह रेड, आईसी-318724, केआरएस एवं 1182 जननद्रव्य अनुवांशिक रूप से भिन्न हैं। इनका इस्तेमाल नये सेग्रिगेटिंग जीनोटाइप के विकास में संकरण कार्यक्रम के जरिए किया जा सकता है। अनार प्रजनन कार्यक्रम में चयन प्रक्रिया को सुगम करने के लिए पालीमार्फिक आण्विक चिन्हकों की पहचान की गई है।

शुष्क क्षेत्र बागवानी में फल फटाव एक गंभीर समस्या है। सात व्यवसायिक किस्मों में मृग बहार के दौरान फल फटाव की सीमा 1.80-4.41% दर्ज की गई। सर्वाधिक फल फटाव 'गणेश' किस्म तथा न्यूनतम 'भगवा' में दर्ज किया गया।

भगवा x (गणेश x नाना) x दारू के संकरण से विकसित सात मीठे सकंरों के मूल्यांकन के दौरान एक खाने योग्य संकर, एनआरसीपी एच-६ की पहचान हुई जिसका नाम 'सोलापुर लाल' (जल्द परिपक्वता, अधिक उपज एवं लौह तथा जस्ता संपन्न) रखा गया। तेरह खट्टे संकरों के मूल्यांकन में एनआरसीपी एच-12 (''सोलापुर अनारदाना'') की पहचान की गई जिसकी अम्लता 4.8% दर्ज की गई।

संशोधित एमएस मिडियम + एडनिन सल्फेट + अर्जिनिन + बीएपी + एनएए युक्त एमएम 13 मिडियम में औसतन 4.85 साइड शूट्स प्रति मायक्रोशूट्स की दर से गुणन पाया गया। अठ्रह एसएसआर, 13 आईएसएसआर एवं दस पालीमार्फिक आरएपीडी चिन्हको की पहचान क्लोनल फिड्लटी परीक्षण हेतु की गई, यह सभी चिन्हक 'भगवा' को इसके पेरेन्ट्स तथा अन्य नजदीकी किस्मों से अलग करने में सक्षम पाये गए । गुणात्मक तथा परिमाणात्मक फल गुण जैसे फल से छिल्के का अनुपात, कार्यिकीय फल भार हानि, फल भार तथा कुल घुलनशील ठोस/अम्लता अनुपात यह दर्शाते हैं की सूक्ष्म प्रवर्धित पौधों तथा गूटी कलम एवं दृढ़काष्ठ कर्तित पौधों में कोई सार्थक भिन्नता नहीं है।

दस में से पाँच अंत:पादप नामत: टीसी 4, 6, 130, 137 एवं 310 जिनका वियोजन इन विट्रो में प्रसारित अनार के प्ररोहों एवं नोडल खण्डों से किया गया है तथा जो जैन्थोमोनास एक्सोनोपोडिस पीवी प्यूनकी की वृद्धि को इन विट्रो अवस्था में 45.46-60.14% तक नियंत्रित करने में सक्षम पाये गए।

पेनीसिलियम पिनोफायलम के कोनिडिया के बड़े पैमाने पर उत्पादन हेतु प्रक्रिया का मानकीकरण किया गया तथा टैल्क आधरित जैव फार्मुलेशन पोटाश ऊर्वरक की पूरकता के लिए विकसित किया गया। इस फार्मुलेशन के प्रयोग से मृदा में उपलब्ध पोटाश एवं फास्फेट की मात्राओं तथा फल ऊपज एवं गुणवता में सार्थक सुधार दर्ज किया गया। इसका अधिकतम प्रभाव 100 मि.ग्रा./कि.ग्रा. मृदा अघुलनशील पोटाश के इस्तेमाल के साथ प्राप्त हुआ।

30x30 से.मी. एवं 40x40 से.मी. पर दो लेटरल के साथ ऊपसतहीय बूँद सिंचन तथा लेटरल ज्यामिति में दो लेटरल के साथ चार ड्रीपर और इसके बाद गोलाकार सूक्ष्म सिंचन पद्धति बेहतर पायी गई। गन्ने की खोई; (जैविक पलवार) तथा पर्वियस मल्च; (अजैविक पलवार) पुष्पन तथा फल ऊपज की दृटि से बेहतर पाये गए। विभिन्न पौध घनत्व में बूंद सिंचन 40,50,एवं 60 प्रतिशत वेटेड मृदा आयतन के साथ क्रमश: 3, 4 एवं 5 वर्षों के पौधों के लिए श्रेष्ठ पाया गया। पार्शियल रूट जोन ड्रयिंग तथा डेफिसिट सिंचन में मृदा नमी 17.29-32.59% के

बीच रही जबकि पत्ती की सापेक्षिक पानी मात्रा 60.3 से 80.5% रही। विभिन्न ट्रेनिंग पद्धतियों में से चौथे साल में सर्वाधिक फल स्थापन (55.05%) एकतना कटाई पद्धति और सबसे कम कंट्रोल (40.55%) में पाया गया।

अनार मे फल चूषी पतंगे (यूडोसिमा मेटरना) के प्रबन्धन हेतु भा.कृ.अनु.प.-रा.कृ.की.सं.ब्यु., बंगलूरू की सहायता से ११ फिरोमोन यौगिकों की पहचान की गई है। किटों के ट्रैप हेतु स्यूलूर युक्त बकेट ट्रैप, बी. कूकरबीटी के लिए तथा मिथायल यूजीनॉल युक्त मैकफैल ट्रैप, बी. डोरसेलिस के लिए श्रेष्ठ पाया गया। सभी सात प्रकार के फल ढ़कने वाले बैग, फल भेदक एवं फल चूषी पतंगे के प्रबन्धन में 100% प्रभावशाली पाये गए जबकि कंट्रोल में क्रमशः 13.55 एवं 16.66 प्रतिशत फल संक्रमित थे।

इन्टीरोकोकस केसिलिफलेक्स, स्यूडोमोनास स्पीसीज एवं बेसिलस सिरस नामक तीन रोगजनक जीवाणुओं का वियोजन फल भेदक के बीमारीग्रस्त ढ़ोले से किया गया तथा इनकी पहचान भा.कृ.अनु.प.-रा.कृ.की.सं.ब्यु., बंगलूरू की सहायता से की गई । 'भगवा' किस्म में फूल किड़े (थ्रीप्स) के प्रबन्धन के लिए थॉयक्लोप्रिड 21.7 एस सी आपतन घटाने में सबसे प्रभावशाली पाया गया (85.59%) जबकि फल भेदक के लिए सायन्ट्रोनिलिप्रोल 10 ओडी सबसे प्रभावशाली पाया गया (95.54%)। अनार बीज तेल के निष्कर्षण एवं गुणवत्ता के लिए 720 वॉट के मायक्रोवेव ओवन में 60 सेकेंड का पूर्वउपचार तथा चार घण्टे का निष्कर्षण समय उपयुक्त पाया गया। शीत गृह वातावरण में (5^0 एवं 90.1% सा.आ.) 90 दिनों तक फलों को रखने के बाद फलों की शीत गृह उपरान्त शेल्फ लाइफ ४ दिन साधारण तापमान पर एवं पाँच दिन मॉल की परिस्थितियों में पायी गई।

सात व्यवसायिक किस्मों में से अरक्ता में सबसे ज्यादा रस निष्कर्षण प्रतिशत (49.22) पाया गया। इन सात व्यवसायिक किस्मों में मृग बहार के फलों के श्रेणीकरण में सबसे ज्यादा फल प्रींस श्रेणी में, 300-400 ग्रा.(35.41%) तथा उसके बाद 200-300 ग्रा. की श्रेणी (29.37%) में पाये गए ।

सौ जननद्रव्यों की जाँच में एसीसी 10 एवं आईसी-1267 जीवाणु झुलसा, फल सड़न, स्कैब एवं एथ्रैक्नोज विमुक्त पाये गए, जबकि इसी-677023 थ्रीप्स आपतन से विमुक्त पाया गया । फल सड़न, फल धब्बे, उकठा रोग जनकों के आण्विक चरित्रिकरण एवं पहचान के लिए जाति विशिष्ट आयटीएस प्रायमर जोड़ी आयटीएस I-F/आयटीएस 4-R ने 600-650 बेस पेयर के बीच एम्पलीफिकेशन दर्शाया है। कार्बेन्डाजिम़ 12% + मेन्कोजेब 62% डब्लु.पी., हेक्साकोनाजोल 4% + जायनेब 68% डब्लु.पी., ट्रायसायक्लाजोल 18% + मेन्कोजेब 62% डब्लु.पी. एवं प्रोपीकोनाजोल 25% डब्लु.पी. फार्मुलेशन 0.15-0.20% की दर से फल सड़न एवं काले धब्बे जनने वाले जीवाणुओं को पूरी तरह निषेध करने में सक्षम पाये गए।

हिमाचल प्रदेश में सर्वेक्षण से पता चला की किन्नौर में जंगली अनार जीवाणु झुलसा विमुक्त हैं। 24 एक्सएपी वियोजनों से ग्यारह जीन के जीन अनुक्रमणों को जेनबैंक में संग्रहीत किया गया। एबी 1 फाइल के साथ 9 हाऊसकिपिंग जीन के अनुक्रमणों को भी पीएएमडीबी डेटाबेस में संग्रहीत किया गया। एसएआर रसायनों (K_2HPO_4, सेलिसायलिक एसिड, क्लोव ऑयल, जस्मोनिक एसिड) के 300 पीपीएम की दर से छिड़काव से जीवाणु झुलसा में 46.36-72.41% तक कमी पायी गई। सभी सहयोग केंन्द्र पर 14 अंत:पादप एवं फायलोस्फियरीक अधिपादप जीवाणु झुलसा को 41.00 से 56.07% तक कम करने में सक्षम रहे। ईथलिन, सेलिसायलिक एसिड, एनएए एवं पैक्लोब्यूट्राज़ोल नामक वृद्धि नियामक जीवाणु झुलसा को नियंत्रित रखने में सर्वाधिक सक्षम रहे।

एक तना तथा 4 x 4 मी. की दूरी पर कांधारी काबुली में सबसे कम बीमारी पायी गई। भा.कृ.अनु.प-रा.अ.अनु.कें. पर जैवफार्मुलेशन के साथ संशोधित सामेकित रोग प्रबन्धन सूची के इस्तेमाल से जीवाणु झुलसा प्रथम वर्ष में 97.75% एवं द्वितीय वर्ष में 100% तक नियंत्रित रहा तथा साथ ही साथ उत्पादकता में 29.50% की वृद्धि दर्ज़ की गई ।

जीवाणु झुलसा के संदर्भ में अनार के पत्तों के फायलोस्फियरीक सूक्ष्म जीवों के मेटाजीनोमिक विश्लेषण से यह ज्ञात हुआ की रोगग्रस्त पत्तीयों की तुलना में स्वस्थ पत्ती 5-10 गुना ज्यादा विविध सूक्ष्म जीवों को हार्बर करती है । मेटाजीनोम को एम जी रास्ट एवं एनसीबीआय में जमा किया गया है । अनार के फायलोस्फियर से वियोजित कुल

26 जीवाणु पूर्ण रूप से एक्सएपी एवं सी. फिम्ब्रीयाटा को नियंत्रित रखने में सक्षम पाये गए। इन 26 जीवाणुओं में से 19 ने जीवाणुनाशक एवं फंफुदनाशक क्रियाऐं दर्शायी तथा 7 ने फफूंदरोधक क्रिया दर्शायी। बैसिलस सबटीलिस एवं मासिलिया वैरियन्स ने सबसे अधिक जीवाणुनाशक क्रिया दिखाई। जीसीएमएस विश्लेषण में बेसिलस सबटीलिस एवं मासिलिया वैरियन्स में क्रमशः 50 एवं 22 वाष्पशील यौगिक पाये गए। होस्ट-पॅथोजन इन्टेरेक्शन में 7 रक्षा सम्बन्धित जीन्स का चरित्रिकरण करके इनका इस्तेमाल विभिन्न इलिसिटर द्वारा उत्प्रेरित प्रतिरोधक क्षमता का आँकलन करने में किया गया।

डॉ.य.सिं.प.उ.वा.वि. के प्रक्षेत्र परीक्षण में विभिन्न जैवकारकों ने फलों पर जीवाणु झुलसा के प्रभाव को 54.38 - 80.54% तक कम किया तथा ऊपज को 4.37 - 46.50% तक बढ़ाया जबकि स्यूडोमोनास ट्यूटज़ेरी पी 1 का नाकारात्मक प्रभाव रहा तथा बेसिलस एमायलोलिक्यूफेसियन्स पी 2 का प्रभाव कंट्रोल की तुलना में सार्थक रुप से बेहतर नहीं पाया गया। जैवकारक एवं एलिसिटर्स संक्रमण पूर्व छिड़काव के रुप में प्रभावशाली पाये गए तथा जीवाणु झुलसा को 80% तक या उससे ज्यादा कम किया, रसायनिक छिड़काव संक्रमण उपरान्त छिड़काव के रुप में बेहतर पाये गए तथा जीवाणु झुलसा को 40.45 - 74.90% तक कम करने में सक्षम रहे।

भा.कृ.अनु.प.-रा.अ.अनु.कें. द्वारा अनार के एक विशाल ट्रान्सक्रिप्टोम डेटा (89.58 जीबी) की उत्पत्ती इलूमिना एसबीएस वी 4 कमेस्ट्री के इस्तेमाल से किया गया। इसमें से 87.64 जीबी क्लीन डेटा था जिसमें सभी नमूनों का Q30 स्कोर 92% से ज्यादा पाया गया तथा ज्यादातर नमूनों का Q30 स्कोर 94% से ज्यादा पाया गया, 2 केबी से ज्यादा बड़े यूनीजीन्स की संख्या 34626 पायी गई तथा 85% यूनीजीन्स सात में से किसी एक डेटाबेस में एनोटेटेड पाये गए जबकि 11% यूनीजीन्स सभी सात महत्वपूर्ण डेटाबेस (एन आर, एन टी, के ओ, स्वीस प्राट, पी फैम, जी ओ, कौग) में एनोटेटेड पाये गए।

भा.कृ.अनु.प.-रा.अ.अनु.कें. के कुछ नए पहलः 'सोलापूर अनार' नामक नये मोबाइल एप्लीकेशन का 6 भाषाओं नामतः अंग्रेजी, हिन्दी, मराठी, कन्नड़, गुजराती एवं तेलगु में विकास; खाने योग्य किस्म 'सोलापूर लाल' तथा प्रसंस्करण योग्य किस्म 'सोलापूर अनारदाना' का विकास; अनार रस, आर.टी.एस. पेय पदार्थ, मदिरा, अनार बीज तेल एवं अनार के छिल्के का पावडर निर्माण, प्रसंस्करण एवं पूर्ण उपयोग हेतु पायलट प्लांट की स्थापना; 9.9 कि.मी. लम्बी भूमिगत पाइपलाइन का लिफ्ट सिंचाई पद्धति हेतु संस्थापन; 43 बेड क्षमता वाले पूर्ण रुप से सुसज्जित एवं 15 महीनों के रिकार्ड समय तथा आवंटीत बजट में तैयार प्रशिक्षणार्थी निवास। इसके अलावा मेरा गाँव मेरा गौरव, एम-किसान; मराठी, हिन्दी, अंग्रेजी भाषाओं में इन्टरक्टीव टच स्क्रिन कियास्क, अनार में जैविक खेती पर आधारित नया प्रयोग, अनार में फसल बीमा के लिए ट्रिगर्स की तैयारी, भा.कृ.अनु.प.-रा.अ.अनु.के. के प्रोफाइल विडिओ फिल्म का निर्माण, मृदा स्वास्थ्य कार्ड निर्माण हेतु मृदा विश्लेषण, तकनीकी बुलेटीन ''अनारः खेती, विपणन एवं उपयोग'' का मराठी रुपान्तरण, भा.कृ.अनु.प.-रा.अ.अनु.के की विभिन्न तकनीकों पर द्विभाषीय एल ई डी प्रदर्शन बोर्ड (24 संख्या) का निर्माण, इत्यादि अन्य सफलतापूर्वक सम्पन्न कार्य हैं।

संस्थागत शोध परियोजनाओं के अलावा इस केन्द्र ने भा.कृ.अनु.प. के तीन बाह्य परियोजना अनुदान को भी आकर्षित किया। इसी प्रकार भा.कृ.अनु.प.-रा.अनु.के. ने रा.औ.पौ.बो. (आयुष मंत्रालय) तथा राष्ट्रीय बागवानी बोर्ड से भी शोध अनुदान सफलतापूर्वक प्राप्त किये ।

EXECUTIVE SUMMARY

Pomegranate improvement programme is highly dependent on exploring the variability of characters existing in the germplasm. Two varieties viz., "Kabul Kandhari" and "Kandhari Seedless" from YSPUHF and one three-way cross hybrid- "(Ganesh x Nana) x Daru" from ICAR-IIHR were collected in 2016-17. Currently, 375 germplasm were maintained at the FGB of the institute.

Evaluation of 26 germplasm for 24 quantitative characters revealed that TSS (°B), 100 arils weight (g), rind thickness (mm), aril length (mm), aril width (mm), fruit juiciness (%), etc have shown wider range of variability indicating the scope for making selection in further varietal improvement programme.

Further molecular diversity study of 43 genotypes (23 cultivated and 20 wild) revealed that IC-318720, Gul-e-Shah Red, IC-318724, KRS and 1182 genotypes are genetically dissimilar. They can be used for developing new segregating genotypes through hybridization programme. Polymorphic markers have been identified for facilitating selection process in pomegranate breeding programme.

Fruit cracking is a serious issue in dry land horticulture. Study of seven commercial cultivars during mrig bahar crop recorded fruit cracking ranging from 1.80 to 4.41%. The highest incidence of fruit cracking was observed in cv. Ganesh while cv. Bhagwa recorded least fruit cracking.

The performance evaluation of seven sweet type hybrids developed from the crossing of Bhagwa with '(Ganesh x Nana) x Daru' led to identification of a promising hybrid suitable for table purpose: NRCP H-6 named as "Solapur Lal" (early maturity, high yielding and rich in Fe and Zn). Evaluation of thirteen sour type hybrids led to identification of NRCP H-12 ("Solapur Anardana"), suitable for processing purpose (4.80% acidity).

A medium "MM13" comprising of modified MS medium + Adenine sulphate, arginine, BAP and NAA resulted in production of 4.85 number of side shoots per micro shoot. Further eighteen SSR markers, twelve ISSR markers and ten polymorphic RAPD markers were identified for clonal fidelity testing to differentiate cv. Bhagwa from its parents and other closely related cultivars. Qualitative and quantitative analysis of fruit traits viz. fruit to rind ratio, PLW, fruit weight, brix-acid ratio, revealed that tissue culture raised plants did not differ significantly from air-layer and hard wood cutting raised plants.

Five endophytes viz. TC-4, TC-6, TC-130, TC-137 and TC-310 out of ten endophytes isolated from *in vitro* raised shoot tips and nodal segment of Bhagwa were highly effective in restricting the growth of *Xanthomonas axonopodis* pv. *punicae* by 45.46 to 60.14% *in vitro*.

The process for mass production of *Penicillium pinophilum* conidia was standardized and a talc based novel bio-formulation for potassium fertilizer supplement was developed. The application of the formulation significantly improved soil available K and P status, fruit yield and quality showing maximum impact when applied along with insoluble source of K@100mg/kg soil.

SDI with double line inline lateral at 30 cm * 30 cm followed by 40 cm * 40 cm and in lateral geometry experiment, two laterals with four drippers followed by ring type micro-irrigation system were found best. Sugarcane bagghas (organic mulch) and pervious mulch (inorganic mulch) were found best for better flowering and fruit yield. The performance evaluation of DI systems at different plant spacing and wetted soil volume at 40, 50, and 60 % for 3, 4 and 5 years old pomegranate orchards was found best. Under partial root zone drying and deficit irrigation , the moisture content ranged from 17.29 to 32.59 % while the relative leaf water content varied from 60.3 to 80.5 % respectively. Evaluation of pomegranate cv. Bhagwa under different training systems during 4th year revealed highest fruitset (55.05%) under single stem training system whereas it was lowest (40.55%) under control (>5 stems/plant).

For the control of fruit piercing moth *(Eudocima materna)* pomegranate, 11 sex pheromone compounds were identified with the help of NBAIR, Bengaluru. For trapping insects, bucket trap with cuelure for *B.cucurbitae* and McPhail trap with methyl eugenol for *B. dorsalis* were found best. All 7 different bagging materials used provided 100% protection against the fruit borer and fruit sucking moths as compared to control (13.55 and 16.66%) fruit sucking moth and fruit borer damage respectively.

Three different types of pathogenic bacteria were isolated and identified as *Enterococcus casseliflavus*, *Pseudomonas sp*. and *Bacillus cereus* from the diseased larvae of pomegranate fruit borer at Molecular Entomology laboratory of NBAIR, Bengaluru. For control of thrips, Thiacloprid 21.7SC was most effective in reducing the thrips incidence (84.59%) whereas for control of fruit borer, Cyantroniliprole 10%OD was most effective (95.54%) in Bhagwa.

For pomegranate seed oil recovery and quality, the optimum conditions for microwave pretreatment were 720 watt, pretreatment time of 60 s and extraction time of 4 h. The post cold storage shelf life of fruits stored in cold store (5±0.5 ℃ at 90± 1% RH) and removed on 90th day was found to be 4 and 5 days respectively for storage at room temperature and mall condition respectively.

Among 7 commercial cultivars, Arakta recorded the highest juice recovery of 49.22%. Grading the fruits of seven commercial cultivars in *mrig bahar* revealed that largest proportion of fruits belonged to prince size of 300-400g (35.41%) followed by 200-300g grade (29.37%).

Out of 100 germplasm screened, Acc.10 and IC-1267 were found free from bacterial blight, fruit rot, scab and anthracnose while EC-677023 was free from thrips incidence. Molecular characterization and identification of the pathogens causing fruit rot, fruit spot, heart rot and wilt done by employing genus specific ITS universal primer pair ITS1-F/ ITS4-R revealed their amplification at 600-650bp. Formulations viz., carbendazim 12%+mancozeb 62%WP, hexaconazole 4%+zineb 68% WP, tricyclazole 18%+mancozeb 62% WP and propiconazole 25%WP @ 0.15-0.20% were effective in completely inhibiting the growth of fruit rot and black spot pathogen.

Survey of pomegranate in Himachal Pradesh revealed that wild pomegranates growing in Kinnaur were free from bacterial blight. Gene sequences of 11 genes were submitted to GenBank from the 24 *Xap* ioslates collected. Also, sequences of 9 housekeeping genes with AB1files submitted to PAMDB database. SAR chemicals (K_2HPO_4, Salicylic acid, clove oil, jasmonic acid) @300ppm effectively reduced the bacterial blight by 46.36-72.41%. Fourteen promising endophytes and phyllospheric epiphytic microorganisms from all collaborating Centers, effectively reduced bacterial blight by 41.00%to 56.07%. Growth regulators viz., ethylene, salicylic acid, NAA, paclobutrazol were most effective in controlling bacterial blight.

Kabuli Kandhari recorded minimum disease incidence at 4x4m spacing under single stem system. The modified IDM schedule at NRCP, using bioformulations was found to reduce BB by 95.75% in first year of fruiting and 100 % in second year along with improvement in productivity by 29.50%.

Metagenomic analysis of the phyllosphere microbiome of pomegranate leaves in relation to BB revealed that healthy leaves harbour 5-10 times more diverse microbes in comparison to symptomatic leaves. Metagenome deposited in Mg RAST and NCBI. A total of 26 bacteria isolated from phyllosphere of pomegranate completely inhibited *Xap* and *C. fimbriata*. Out of 26, 19 bacteria had bactericidal and fungicidal activity while 7 had fungistatic activity. The bacteria *Bacillus subtilis* and *Massilia varians* had highest bactericidal activity. A total 50 VOCs were detected through GC-MS analysis of *Bacillus subtilis* and 22 VOCs were detected in *Massilia varians.* A total of 7 defense genes in host pathogen interactions were characterized and used for assessing the level of resistance induced by different elicitors.

In field trials at YSPUHF blight reduction on fruits with different bioagents was 54.38-80.54%. Yield increase was 4.37-46.50%, however *Pseudomonas stutzeri* P1 had negative effect and *Bacillus amyloliquefaciens* P2 was not significantly better than control with respect to yield. Bioagents and elicitors were effective as prophylactic sprays reducing blight by 80% or above and chemical sprays worked better as therapeutic treatments checking blight by 40.49-74.90%.

Large transcriptome data of 89.58 GB has been generated in pomegranate by ICAR-NRCP, using Illumina SBS V4 chemistry. The clean data is 87.64 GB with more than 92 % Q30 score for all the 12 samples analysed and more than 94 % for most of the samples. The number of unigenes with size more than 2 kb was 34626 and more than 85 % of the unigene were annotated at least in one of the seven databases *namely*, NR, NT, KO, Swiss Prot, PFAM, GO, KOG and 11 % were annotated in all the seven databases.

The new initiatives of ICAR-NRCP covers: Development of the new version of Mobile-app named as **'Solapur Anar'** in 6 languages viz. English, Hindi, Marathi, Kannada, Gujarati & Telugu; Development of pomegranate hybrids- 'Solapur Lal' for table purpose &'Solapur Anardana' for processing purpose; Establishment of pilot plant for processing and total utilization of pomegranate fruit in juice, RTS beverage, wine, pomegranate seed oil and pomegranate peel powder; Layout of 9.9 km long underground pipeline for installation of lift irrigation system; Construction of 43 bed trainees hostel with furnishing within a record time of 15 months and well within the allocated AA&ES. Apart from these other activities include Mera Gaon Mera Gaurav; m-Kisan; Interactive touch screen kiosk in Marathi, Hindi and English language; new experiment on organic cultivation of pomegranate; Preparation of triggers for crop insurance of pomegranate, production of video film on ICAR-NRCP profile; analysis of soils for development of soil health cards, Marathi version of technical bulletin entitled "Pomegranate :Cultivation, marketing and utilization", Preparation of bilingual LED display boards (24 nos.) on various technologies of ICAR-NRCP, etc. which were successfully completed during this period.

Besides, in-house research projects, the centre has attracted research grants through ICAR extramural funding for three additional research projects. Similarly ICAR-NRCP was also successful in obtaining research grants from NMPB (Ministry of AYUSH) and National Horticulture Board.

RESEARCH PROGRAMMES AND PROJECTS

Institute Research Projects

S. No.	Project Title	Principal Investigator	Status
1.	Conservation, characterization and sustainable use of diversity in pomegranate	Dr. (Mrs.). Shilpa Parashuram	Ongoing
2.	Genetic improvement of pomegranate	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	Mr. Mallikarjun	Ongoing
6.	Postharvest management value addition and improving knowledge of stakeholders for increasing production and marketing of pomegranate	Dr. Nilesh N. Gaikwad	Ongoing
7.	Draft genome sequencing and *denovo* assembly of pomegranate (*Punica granatum* L.)	Ms. Roopa Sowjanya P.	Ongoing
8.	Biological control of wilt complex problem in pomegranate	Dr. U. R. Sangle	Ongoing
9.	Flagship project on integrated approach to eradicate bacterial blight	Dr. (Mrs.). Jyotsana Sharma	Completed

Externally funded projects

S. No.	Funding Agency	Project Title	Principal Investigator	Status	Amount Rs. in Lakh
1.	RKVY	Horticultural crop pest surveillance and advisory project for mango, pomegranate and banana	Dr. (Mrs.) Jyotsana Sharma	Ongoing	10.76
2.	ICAR-IPTM	Intellectual property management and transfer/commercialization of Agriculture Technology scheme	Director, ICAR-NRCP	Ongoing	6.40
3.	PPV & FRA, Govt. of India	Establishment of DUS centre at NRC on Pomegranate	Director, ICAR-NRCP	Ongoing	6.00
4.	Bayer Crop Science Limited, Mumbai	Contract research project on Performance evaluation of Fosetyle –Al 80WP (Aliette) and other protection range chemicals on pomegranate health and productivity	Dr. (Mrs.). Jyotsana Sharma	Ongoing	11.00

5.	NHB, Gurugram, Govt. of India	Mechanization in pomegranate cultivation and its demonstration	Dr. N.V. Singh	Ongoing	41.62
6.	NHB, Gurugram, Govt. of India	Standardization and demonstration of propagation and production technologies for protected cultivation of pomegranate (*Punica granatum* L.)	Dr. N. V. Singh	Ongoing	16.84
7.	NMPB and Ministry of AYUSH, Govt. of India	Utilization of pomegranate for development of functional medicinal ingredients	Dr. R. K. Pal Dr. Nilesh N. Gaikwad	Ongoing	41.77
8.	M/s. MOSCOS Food processing Pvt. Ltd., Nashik	Technical consultancy for establishment of minimal processing and packaging unit for pomegranates	Dr. Nilesh N. Gaikwad, Dr. R K Pal	Ongoing	6.90
9.	M/s. Sanjeevni Fertilizers and Chemicals (P) Ltd. (Raghuvansh Agro Farms, Bhognipur, Kanpur	Implementation of total orchard management practices for pomegranate plantation	Dr. N.V. Singh	Ongoing	2.50
10.	ICAR CRP on Water	Response of pomegranate to deficit irrigation and partial root zone drying	Dr. D.T. Meshram	Ongoing	56.00
11.	ICAR	All India Coordinated Research Project on Arid Zone Fruits	Dr. K. Dhinesh Babu Dr. N.V. Singh	Ongoing	1.50
12.	ICAR CRP Platform	Consortia research platform on borer pests	Dr. Mallikarjun	Completed	7.45
13.	ICAR	Outreach programme on management of sucking pests in horticultural crops	Dr. Mallikarjun	Completed	7.32
14.	ICAR	Consortia Research Platform on Agro biodiversity	Dr. R.K. Pal	Completed	3.50
15.	ICAR Network Project	Micronutrient management in pomegranate for enhancing yield and quality	Dr. Ashis Maity	Completed	20.76
16.	Swasti Agro &Bioproducts Pvt. Ltd., Pune	Evaluation of chitosan derivatives and chitosan based formulation XANSIL to control bacterial blight of pomegranate	Dr. (Mrs.). Jyotsana Sharma	Completed	8.85
17.	NHB, Gurugram, Govt. of India	Demonstration of model pomegranate production practices for effective management of bacterial blight disease	Dr. R.K. Pal	Completed	21.25
18.	ICAR-Extramural research project	Trait specific characterization of indigenous and exotic pomegranate accessions to arrive at core collection for genetic improvement programme	Dr. B.N.S. Murthy ICAR-IIHR, Dr. K. Dhinesh Babu	Completed	24.82
19.	ICAR-Extramural research project	Development of fruit based carbonated drink from pomegranate and grapes	Dr. Nilesh N. Gaikwad	Completed	25.71
20.	ICAR-Extramural research project	SNP marker based mapping of bacterial blight genes in pomegranate (*Punica granatum* L.)	Dr. Shilpa Parashuram	Completed	37.09

Tribal Sub-Plan

S.No.	Project title	Principal Investigators	Status
1.	Introduction of pomegranate cultivation (*Punica granatum* L.) to tribal farmers of Gadchiroli dstrict	Dr. R. K. Pal, Dr. D. T. Meshram Dr. Ashis Maity	Ongoing
2.	Introduction of pomegranate cultivation in Bankura and Purulia districts of West Bengal for livelihood security of tribal population	Dr. R. K. Pal, Dr. D. T. Meshram Dr. Ashis Maity	Ongoing

Inter-institutional collaborative projects

S. No.	Project Title	Collaborative Institutes	Principal Investigator	Status
1	Delineation of potential areas for pomegranate cultivation in India using remote sensing and GIS techniques	ICAR-NRCP, Solapur, NBSSLUP, Nagpur	Dr. D.T. Meshram ICAR-NRCP	Ongoing
2	Development of a smart sprayer for young pomegranate orchard	ICAR-CIAE,Bhopal	Dr. Nilesh N.Gaikwad ICAR-NRCP	Ongoing

RESEARCH ACHIEVEMENTS

1. CONSERVATION, CHARACTERIZATION AND SUSTAINABLE USE OF DIVERSITY

Project Title : Conservation, characterization and sustainable use of diversity in pomegranate
PI : Dr. Shilpa Parashuam
Co-PI : Dr. (Mrs.) Jyotsana Sharma, Dr. K. Dhinesh Babu, Dr. D. T. Meshram, Dr. N. V. Singh, Dr. Ashis Maity, Dr. Nilesh Gaikwad, Ms. Roopa Sowjanya, Mr. Mallikarjun

Experiment 1.1 Germplasm collection and conservation

With the objective of collecting germplasm of pomegranate, a survey was made at Y. S. Parmar University of Horticulture and Forestry (YSPUHF), Solan, Himachal Pradesh and ICAR-IIHR, Bengaluru, Karnataka during 2016-17. Hardwood cuttings (HWC) of two varieties "Kabul Kandhari" and "Kandhari Seedless" from YSPUHF whereas HWC of three way cross hybrid "(Ganesh x Nana) x Daru" were collected from ICAR-IIHR besides the seeds of three hybrid crosses i.e., "(Ganesh x Nana) x Daru"; "(Bhagwa x Daru) x Nana" and "(Bhagwa x Double Flower) x Nana". Currently, 375 pomegranate collections have been maintained at ICAR-NRCP, Solapur. Important breeding materials consisting of hybrids, mutant population (M1 generation) of Ganesh and Bhagwa, selected advanced lines with desirable characteristics were also conserved at the field gene bank.

Experiment 1.2 Germplasm characterization

1.2.1 Evaluation of pomegranate germplasm

Twenty six pomegranate germplasm were evaluated for 24 physico-chemical characters with three replications during mrig bahar in 2016-17. The measured data has shown the presence of a significant variability for various morphological and physico-chemical characters. In ANOVA, significant differences between the germplasm accessions was observed at both 5% and 1% level of significance, indicating adequate variability among the genotypes for all characters. In comparison with check variety Bhagwa, it is found that among 16 targeted economically important traits, the characters like TSS (°B), 100 arils weight (g), rind thickness (mm), aril length (mm), aril width (mm), fruit juiciness (%), etc have showed wider range of variability showing the scope for making selection in further varietal improvement programmes.

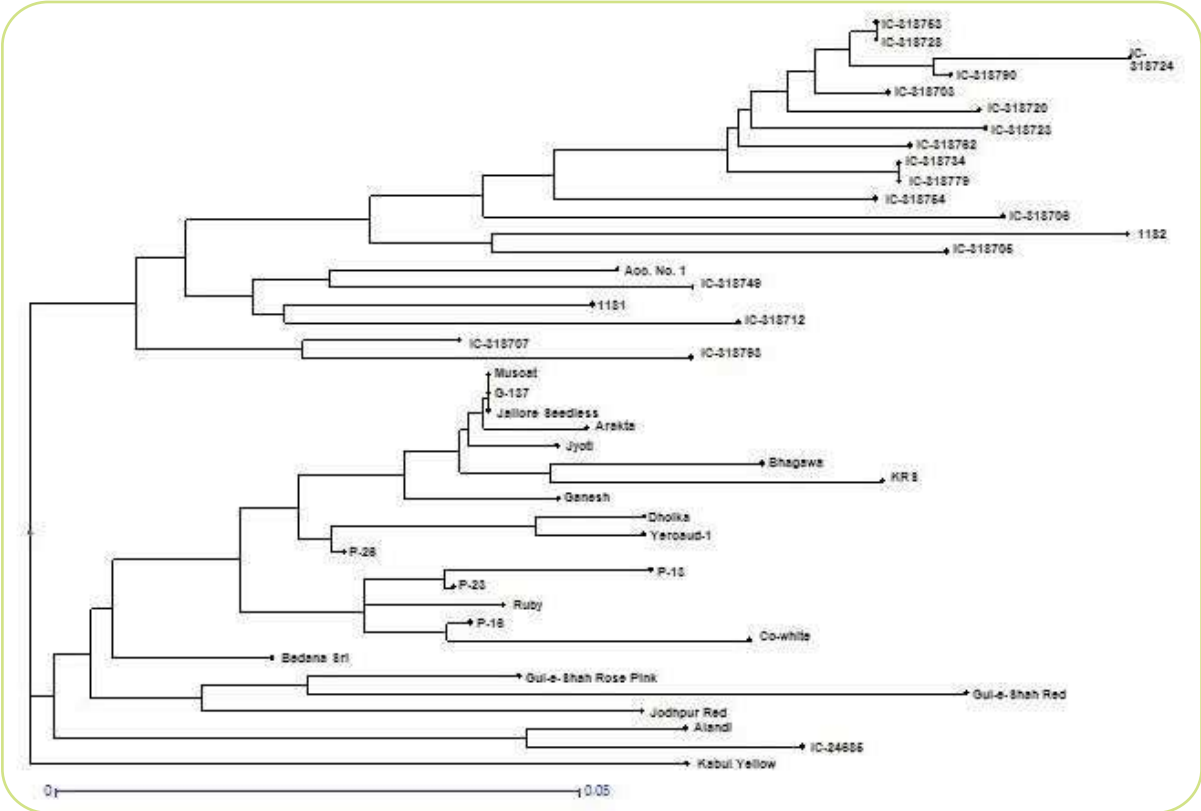
Morphological and physico-chemical variability among 25 pomegranate accessions

Sl. No.	Characters	Mean	Range	SEm	CV (%)	Check variety (Bhagwa) Mean
1.	TSS (^{0} Brix)	17.36	15.86-18.98	0.31	3.14	15.65
2.	100 arils weight (g)	30.60	18.77-42.91	1.31	7.40	34.05
3.	Rind thickness (mm)	2.60	1.88-3.34	0.19	12.38	2.71
4.	Aril length (mm)	9.83	8.58-11.21	0.30	5.29	10.50
5.	Aril width (mm)	6.58	5.77-7.76	0.30	8.02	6.96
6.	Fruit Juiciness (%)	37.97	26.01-52.02	1.52	6.95	41.59
7.	100 seed weight (g)	2.30	1.86-2.73	0.03	2.36	1.58
8.	Seed length (mm)	6.26	5.81-7.22	0.15	4.12	6.47
9.	Seed width (mm)	2.67	2.36-3.10	0.10	6.58	2.33
10.	Seed texture (%)	83.11	73.10-100.24	3.12	6.49	34.15

1.2.3 Molecular diversity analysis in pomegranate

In the present study molecular diversity among forty three pomegranate genotypes including cultivated varieties (23) and wild germplasm (20) was assessed the by using simple sequence repeats (SSR) markers. Plant genomic DNA was isolated using modified CTAB method. Total forty four SSR markers reported from the previous studies were screened across the selected pomegranate germplasm to understand their diversity pattern at molecular level, out of these 29 SSR primers were found to be polymorphic. These polymorphic primers have generated 96 SSR marker alleles, with an average number of 1.84 alleles per locus. Polymorphic information content (PIC) values ranged from 0.04 to 0.56 with an average of 0.25 per marker. The observed heterozygosity value ranged from 0.05 to 0.63, with the mean value of 0.30.

DARWIN software was used to study the phylogenetic relationship among the selected germplasm from the scored data. Maximum genetic dissimilarity was observed between 'IC-318720' and 'Gul-e-Shah Red' (0.21), 'IC- 318724' and 'KRS (0.20), '1182' and 'KRS (0.20). Neighbor Joining cluster analysis gives the three separate clusters. All the wild accessions were grouped into cluster I, while cultivated varieties in cluster II. Single accession (Kabul Yellow) was formed a unique cluster as it is having fruit traits in between cultivated and wild types. A Principal Co-ordinate analysis based on the Euclidean Distance Matrix revealed that the first axis comprised of Eigen value of 0.003 and percentage variance of 32.69 per cent, whereas second axis comprised of 0.001 and 10.3 per cent with a cumulative variance of 42.99 per cent. Thus indicating that making selection of diverse genotypes having maximum dissimilarity co-efficient will be more useful in generating new segregating genotypes through hybridization programmes. Also the identified polymorphic markers will complement the selection process in pomegranate breeding programmes.



Dendrogram showing phylogenetic relationship among 43 pomegranate genotypes

1.2.4 Heat unit requirement for pomegranate germplasm

Growing degree days (GDD), photo thermal unit (PTU), photo thermal index (PTI) and heat use efficiency (HUE) are frequently used as an indicator for crop phenology. All growth and development stages of crop are estimated more accurately on the basis of GDD. The photo thermal indices provide a reliable index for the progress of the crop that can be used to predict the yield of crops. The GDD is used to quantify effect of temperature and describe the timing of different biological process.

The total GDD, photo-thermal index and heat use efficiency were estimated for Bhagwa, Patna-5, P-13, P-16, IC-1201, IC-318753, IC-318779, IC-318740, IC-318702, Acc-1 and IC-318712) during 2016-2017 in *mrig bahar*. Total GDD accumulations of all the varieties ranged from 2650to 3575 ^{0}D from defoliation to harvesting period. The growing degree days ranged from1101 to 1656 ^{0}D at flowering stage and 426 to 1308 ^{0}D at reproductive stage. The lowest and highest GDD from defoliation to harvesting period build up of 2650 ^{0}D for IC-1201 and 3575 ^{0}D for Bhagwa. Photo-thermal index (PTI) ranged from 18.20 to 19.9 ^{0}D/day whereas heat use efficiency (HUE) ranged from 0.70 to 8.4 degree days at flowering and reproductive stages.

Days to attain total growing degree, fruit set physiological maturity, photo-thermal index and heat use efficiency

Varieties	TD (days)	Y (t/ha)	TGDD (^{0}D)	NLI (^{0}D)	FS (^{0}D)	M (^{0}D)	H (^{0}D)	PTI (^{0}D)	HUE (^{0}D)
Bhagwa	185-190	11.0	3575	319.4	1358	1308	1522	19.9	1.2
Patna-5	145-150	3.0	2754	319.4	1319	567	784	18.3	0.9
P-13	140-145	11.4	2663	319.4	1201	545	560	18.3	1.3
P-16	135-147	12.5	2700	319.4	1119	529	525	18.2	2.7
IC-1201	130-145	4.8	2650	319.4	1119	425	652	18.4	8.4
IC-318753	140-145	19.6	2663	319.4	1439	736	525	18.4	0.7
IC-318779	160-165	26.9	3012	319.4	1538	904	875	18.4	2.4
IC-318740	150-155	3.5	2840	319.4	1101	725	787	18.4	4.3
IC-318702	165-170	8.20	3093	319.4	1656	736	956	18.4	4.6
Acc-1	145-150	1.88	2755	319.4	1420	567	767	18.4	2.5
IC-318712	160-165	2.70	3012	319.4	1326	904	782	18.4	7.4

(TD-Total duration; ^{0}D-Degree days; Y-Yield; TGDD-Total growing degree days; NLI-New leaf initiation; FS-Fruit set; M-Maturity; H-Harvesting; PTI-Photo-thermal index and HUE-Heat use efficiency)

IC-318779 recorded the highest yield of 26.9 t/ha with total growing degree days requirement of 3012^{0}D. This was followed by IC-318753 which recorded 19.6 t/ha TGDD requirement of 2663^{0}D.

Experiment 1.3. Studies on biochemical parameters of selected germplasm

The important biochemical parameters of 11 varieties harvested in the month of October 2016 were evaluated for TSS (°B), acidity (%), antioxidant capacity (mg/100ml of AAE), total phenol content (ml/l GAE), anthocyanin content (mg/100ml of cyanidine), ascorbic acid (mg/100ml), aril bioyield point (N), seed rupture point (N), and aril colour (l*, a*, b*). Among these eleven were cultivated types namely (Bhagwa, Ganesh, Arakta, Mridula, G137, Jyoti, Kandhari, P-13, Kabul Yellow, China Orange, Kalpitiya). The results revealed that Arakta recorded the highest total phenol (1874.33 mg/l GAE)) and anthocyanin (43.44mg/100ml of cynidine) besides lowest value for seed rupture point (31.38N).

Among nine wild types (EC-24686, IC-318705, IC-318707, IC-318720, IC-318728, IC-318749, IC-318754, IC-318779, IC-318790) evaluated, EC-24686 recorded highest acidity (4.18%), antioxidant (39.48mg/10ml AAE) and anthocyanin (8.72mg/100ml of cynidine).

Biochemical composition of selected germplasm

Germplasm	Antioxidant capacity (mg/100ml of AAE)	Total phenol (mg /l GAE)	Anthocyanin content (mg/100ml of cynidine)	Ascorbic acid (mg/ 100 ml)	Aril Bio-yield point (N)	Seed Rupture point (N)	Aril colour		
							l*	a*	b*
Cultivated Type									
Bhagwa	38.48	1567.33	22.18	13.75	5.46	39.62	29.81	32.59	16.00
Ganesh	37.25	1147.67	1.53	12.08	5.42	34.21	52.39	7.79	22.91
Arakta	38.48	1874.33	43.44	11.25	5.11	31.38	22.44	26.85	12.07
Mridula	38.49	1663.33	37.05	10.75	5.90	33.55	20.00	21.57	9.23
G137	37.52	918.67	2.75	12.08	4.59	35.64	47.28	17.29	17.91
Jyoti	35.67	636.33	2.55	11.88	3.72	38.17	42.37	18.90	16.17
Kandhari	38.47	1029.67	0.71	10.00	4.56	38.88	41.68	22.65	16.71
P-13	38.48	1142.00	1.33	11.00	4.78	44.46	50.79	16.41	16.26
Kabul Yellow	38.08	954.00	0.25	10.83	8.28	75.36	54.50	6.57	21.88
China Orange	35.31	929.00	4.41	12.08	4.93	38.02	33.35	23.05	14.06
Kalpitiya	36.99	1500.67	2.09	11.25	5.57	49.02	52.98	10.79	18.99
Wild Type									
EC-24686	39.48	2236.33	8.72	11.67	7.19	101.03	41.94	26.06	16.57
IC-318705	22.69	1549.00	0.54	10.42	5.53	87.53	51.18	6.96	20.27
IC-318707	28.16	1374.33	0.52	9.58	4.97	83.58	40.00	20.72	16.86
IC-318720	31.39	1359.33	0.65	10.42	5.29	83.84	49.87	17.45	17.57
IC-318728	26.43	2569.00	1.01	10.83	5.33	89.98	49.55	16.37	16.35
IC-318749	27.15	1844.67	1.37	10.42	4.52	71.72	41.28	19.04	15.70
IC-318754	27.76	1325.33	0.34	9.58	6.23	83.45	47.55	12.06	17.37
IC-318779	25.37	1265.00	0.24	10.00	5.28	81.72	46.47	12.39	16.57
IC-318790	32.95	1211.33	0.25	10.42	4.43	83.83	58.38	3.50	23.93

Experiment 1.4. Reaction of field germplasm to different diseases and insect pests

In all 100 germplasm accessions were screened for bacterial blight, fungal spots and rots and thrips. The germplasm lines found disease free or tolerant with less than 10% incidence are summarized below.

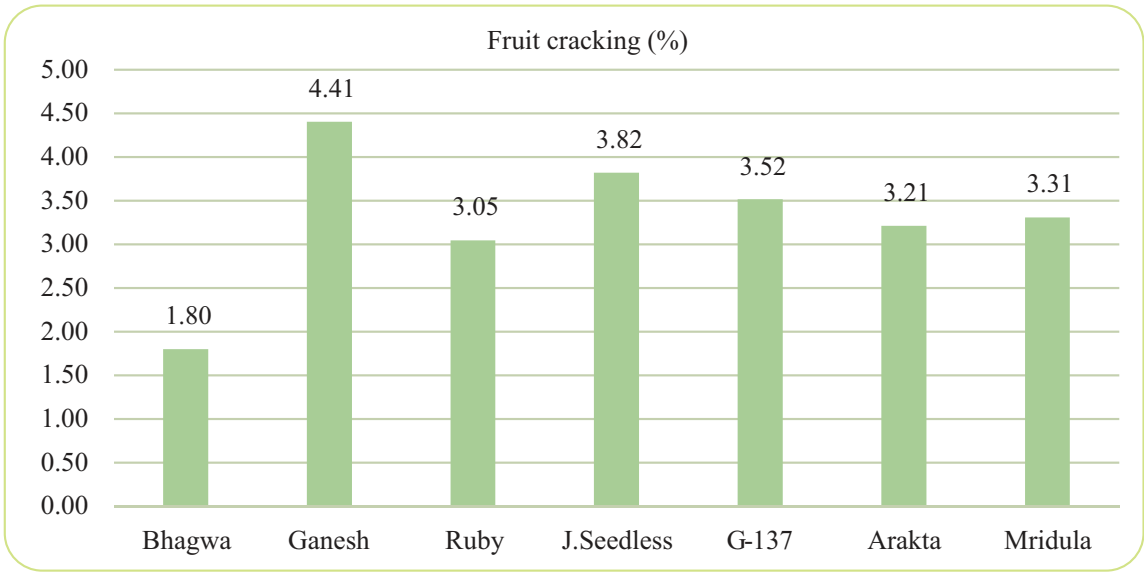
Germplasm lines found disease free or tolerant	
Bacterial Blight (*Xanthomonas axonopodis* pv. *punicae*)	
Blight free (20)	ACC.10, IC-318723, IC-318753, IC-318718, IC-1254, IC-1256,IC-1257, IC-1258, IC-1259, IC-1260, IC-1261, IC-1263, IC-1265, IC-1266, IC-1267, IC-1269, IC-1270, IC-1271, EC-676961, EC-677006
Tolerant (31)	ACC.9, EC-676947, EC-676959, EC-676963, EC-676965, EC-676985, EC-676987, EC-676997, EC-676998, EC-677005, EC-677007, EC-677008, EC-677009, EC-677010, EC-677012, EC-677013, EC-677015, EC-677022, EC-677023, EC-677027, EC-677028, IC-1182, IC-1196, IC-1203, IC-1253, IC-318703, IC-318705, IC-318728, IC-318754, IC-318779, IC-318790
Fruit Rot (*Colletotrichum gloeosporioides*)	
Disease free (40)	ACC.10, ACC.9, EC -676931, EC-676944, EC-676960, EC-676963, EC-676993, EC-676994, EC-676998, EC-676999, EC-677000, EC-677003, EC-677004, EC-677005, EC-677011, EC-677012, EC -677015, EC -677016, EC -677017, EC -677019, EC -677020, EC -677023, EC -677025, EC -677026, EC -677027, EC -677029, G R Pink, IC -1182, IC -1253, IC -1254, IC -1257, IC-1259, IC-1261, IC-1263, IC-1265, IC-1266, IC-1267, IC-1269, IC-1271, P-16
Tolerant (15)	EC-677021, IC-1196, IC-1201, IC-1203, IC-1256, IC-1258, IC-1260, IC-318703, IC-318707, IC-318718, IC-318723, IC-318728, IC-318753, IC-318754, ShirinAnar
Scab (*Sphaceloma punicae*)	
Disease free (34)	ACC.10, ACC.9, EC -676930, EC-676931, EC-676944, EC-676960, EC-676963, EC-676992, EC-676993, EC-676994, EC-676998, EC-676999, EC-677000, EC-677003, EC-677004, EC-677005, EC -677011, EC -677012, EC -677015, EC -677016, EC -677017, EC -677019, EC -677020, EC-677021, EC-677023,EC-677025, EC-677026, EC-677027, EC-677029, IC-1182, IC-1201, IC-1253 , IC-1260, IC-1267
Tolerant (5)	G R Pink, IC-1258, IC-1265, IC-318707, IC-318718
Anthracnose (*Colletotrichum* sp.)	
Disease free (26)	ACC.10, EC -676930, EC -676931 , EC -676944, EC -676960, EC -676963, EC -676992, EC -676993 , EC -676994, EC -676998, EC -676999, EC -, 77000, EC -677003, EC -677004, EC -677011, EC -677012, EC -677017, EC -677019, EC -677020, EC -677021, EC -677023, EC -677025, EC-677027, IC-1253, IC-1267, IC-1270
Tolerant (19)	ACC.9, EC-677005, EC-677016, EC-677026, IC-1201, IC-1254, IC-1256, IC-1258, IC-1259, IC-1260, IC -1261, IC-1263, IC -1265, IC -1266, IC -1271, IC -318707, IC -318718, P -16, ShirinAnar
Thrips damage	
Free (1)	EC-677023
Tolerant (0)	-

Experiment 1.5. Determination of fruit cracking in pomegranate

The incidence of fruit cracking in seven commercial cultivars was assessed during the mrig bahar of eight year old orchard. Fruit cracking ranged from 1.80 to 4.41%. Cracking (%) was lowest in Bhagwa (1.80%). This was followed by Ruby (3.05%) and Arakta (3.21%). The fruit cracking was highest in Ganesh (4.41%). The highest incidence of cracking in Ganesh might be attributed to the lowest rind thickness.

Rind thickness of pomegranate cultivars

Cultivar	Rind thickness (mm)
Bhagwa	3.40
G-137	2.88
Ruby	2.80
Arakta	2.60
Mridula	2.60
Jalore Seedless	2.25
Ganesh	1.90



Fruit cracking (%) in commercial cultivars of pomegranate

2. GENETIC IMPROVEMENT

Project Title : Genetic improvement of pomegranate
PI : Dr. K. Dhinesh Babu
Co-PI : Dr. N. V. Singh, Dr. Jyotsana Sharma, Dr. Shilpa Parashuram, Ms. Roopa Sowjanya P.

Experiment 2.1. Hybridization for bacterial blight tolerance

With the objective of developing new hybrids tolerant to bacterial blight disease through hybridization, crossing was done between commercial cv. Bhagwa and four genotypes of bacterial blight tolerance. Out of four crosses undertaken, the fruitset was successful in all the four crosses. The fruitset ranged from 45.0 to 53.5 percent and was highest (53.5%) in 'Bhagwa x (Nayana x Ruby)'. The seeds of these crosses are being used for raising the F1 hybrid population. These F1 hybrid population would be screened against bacterial blight disease of pomegranate.

Hybridization for bacterial blight tolerance

Cross	No. of flowers crossed	No. of fruits obtained	Fruitset (%)	Germination (%)
Bhagwa x Daru	40	21	52.5	70
Bhagwa x Hybrid-A*	43	22	51.2	75
Bhagwa x Nayana	40	18	45.0	90
Bhagwa x (Nayana x Ruby)	43	23	53.5	82

*Hybrid-A: {Bhagwa x[(Ganesh x Nana) x Daru}


Bhagwa x Daru


Bhagwa x Hybrid-A


Bhagwa x Nayana

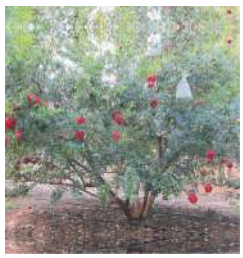

Bhagwa x (Nayana x Ruby)

Hybridization for bacterial blight tolerance

Hybrid progenies of BhagwaxDaru, Bhagwa x Hybrid-A, Bhagwa x Nayana and Bhagwa x (Nayana x Ruby)

Experiment 2.2. Evaluation of NRCP hybrids

Evaluation of seven sweet type hybrids during eighth year of planting in mrig bahar resulted in identification of the promising hybrid NRCP H-6, named as Solapur Lal for table purpose. "Solapur Lal' has early maturity (160-165 days), higher yield (23-27 t/ha), better quality (TSS 17.5-17.7°B, vitamin-C 19.4-19.8 mg/100g, anthocyanin 385-395 mg/100g, iron 5.6-6.1 mg/100g of fresh arils, zinc 0.64-0.69 mg/100g of fresh arils compared to Bhagwa.



Solapur Lal

Solapur Lal	Characters	Bhagwa
Medium (2.0-2.3)	Tree height (m)	Medium (1.8-2.1)
Red	Calyx colour	Red
160-165	Fruit maturity (days)	180-185
23-27	Yield (t/ha)	16-20
280-290	Fruit weight (g)	287-297
Red	Fruit colour	Red
Medium (3.3-3.5)	Rind thickness (mm)	Medium (3.3-3.5)
40-41	100 Aril weight (g)	35-36
Red	Aril colour	Red
Medium	Seed Texture	Soft
45-50	Juice % (ml/100g)	43-48
17.5-17.7	TSS (°Brix)	15.7-15.9
19.4-19.8	Vitamin-C (mg/100g)	14.2-14.6
385-395	Anthocyanin (mg/100g)	355-365
5.6 – 6.1	Iron (mg/100g of fresh arils)	2.7-3.2
0.64 – 0.69	Zinc (mg/100g of fresh arils)	0.50-0.54

Comparative performance of Solapur Lal vs. Bhagwa

Bhagwa

Evaluation of thirteen sour type hybrids during eighth year of planting in mrig bahar resulted in identification of the most promising hybrid NRCP H-12 suitable for processing purpose. NRCP H-12 named as 'Solapur Anardana' has higher yield (22-24 t/ha), titrable acidity (4.7-4.9%) and anthocyanin (457-467 mg/100g) compared to Amlidana.



Solapur Anardana	Characters	Amlidana
Medium (2.0 -2.3)	Tree height (m)	Small (1.4-1.5)
Red	Calyx colour	Red
135-140	Fruit maturity (days)	140-145
22-24	Yield (t/ha)	9-11
290-298	Fruit weight (g)	225-230
Red	Fruit colour	Yellow
Medium (3.3-3.5)	Rind thickness (mm)	Thin (1.8-2.0)
33-34	100 Aril weight (g)	35-36
Red	Aril colour	Light-Pink
Medium	Seed Texture	Medium
45-50	Juice % (ml/100g)	43-48
16.6-16.8	TSS (°Brix)	15.7-15.9
18.0	Vitamin-C (mg/100g)	14.2-14.6
457-467	Anthocyanin (mg/100g)	45-55
4.7-4.9	Acidity (%)	4.1-4.3



Solapur Anardana

Comparative performance of Solapur Anardana vs. Amlidana

Amlidana

3. PROPAGATION AND BIO-HARDENING

Project Title : Propagation, bio-hardening and mass multiplication of elite planting material in pomegranate (*Punica granatum* L.)
PI : Dr. N. V. Singh
Co-PI : Dr. K. Dhinesh Babu, Dr. Jyotsana Sharma, Dr. Shilpa Parashuram, Ms. Roopa Sowjanya

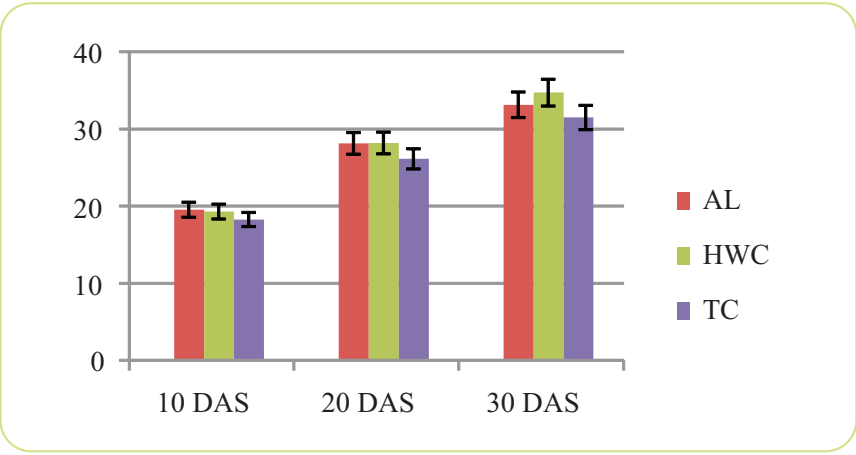
Experiment 3.1. Comparative evaluation of different planting material

Qualitative and quantitative fruit traits including rind thickness, fruit to rind ratio, physiological loss in weight at room temperature (25 °C±2 at 35 % RH) and under cold storage conditions (5 °C at 80 % RH), average fruit weight and brix/acid ratio were found at par among the fruits harvested from plants raised through different propagation methods.

Comparative evaluation of fruits of cv. Bhagwa harvested from plants raised through different propagation methods

Planting material	Avg. Fruit wt. (g)	Rind Thickness (mm)	Fruit to rind ratio	TSS/Acid ratio (Brix /Acid ratio)	100 Aril weight (g)	Bioyield Point (N)	Seed Rupture Point (N)
AL	213.684	3.118	2.621	31.756	36.000	6.213	39.205
HWC	222.540	3.581	2.261	33.230	38.000	5.016	39.207
TC	207.527	3.696	2.714	33.152	34.667	4.773	33.417
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

(AL: air layered, HWC: hardwood cutting, TC: tissue culture)



Physiological loss in weight (%) at room temperature storage

Experiment *3.2. In vitro* propagation

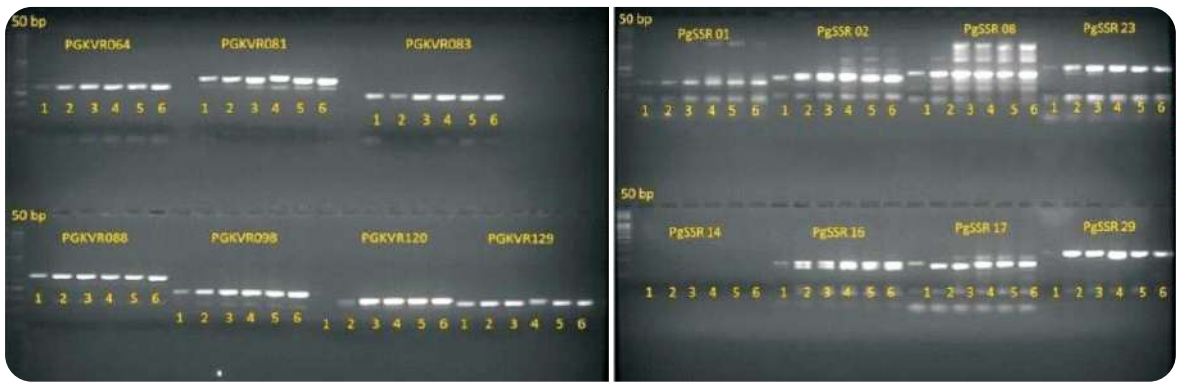
More than 30 media and growth regulator combinations were tried to improve multiplication of microshoots and rooting of shoots. The MM 13 (Modified MS medium + Adenine Sulphate, Arginine, BAP and NAA) produced on an average 4.85 number of side shoots per microshoot with range of 3 to 8 side shoots.

Multiplication of Shoots on MM 13 medium

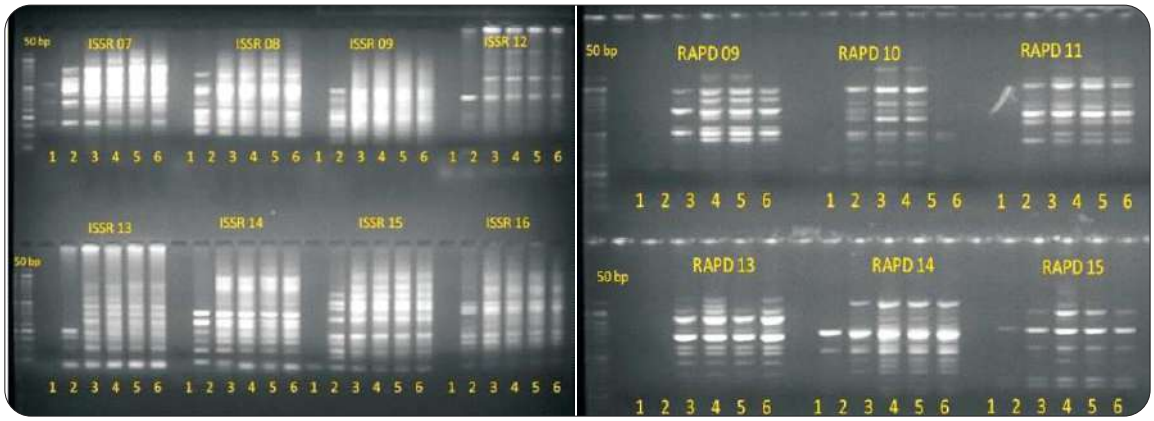
Experiment 3.3. Clonal fidelity testing of tissue culture raised Bhagwa plantlets

During 2016-17, 27 SSR markers, 16 ISSR and 16 RAPD markers were screened on 6 pomegranate varieties namely Ganesh, Arkata, Mridula, Gul-e-Shah Red, Bhagwa and Super Bhagwa. In this study, we could able to find out markers which can differentiate Bhagwa plantlets from other closely related genotypes including its parents, these identified markers will be involved in fieldility testing programme.

Out of 27 SSR markers 18 were found polymorphic which were showing differences among the genotypes, out of 16 ISSR and RAPD markers, we found 12 polymorphic ISSR and 10 polymorphic RAPD markers for further use in clonal fidelity testing. Jaccard's similarity coefficients for ISSR and RAPD markers were estimated at 1.00 but similarity coefficients were 0.66 (RAPD), 0.83 (ISSR) and 0.83 (SSR). Many-a-times somaclonal variations are due to hyper and hypo methylation of DNA because of elevated level of ROS (Reactive Oxygen Species). It warrants exploitation of Methylation sensitive markers like Methylation Sensitive Amplified Polymorphism (MSAP).



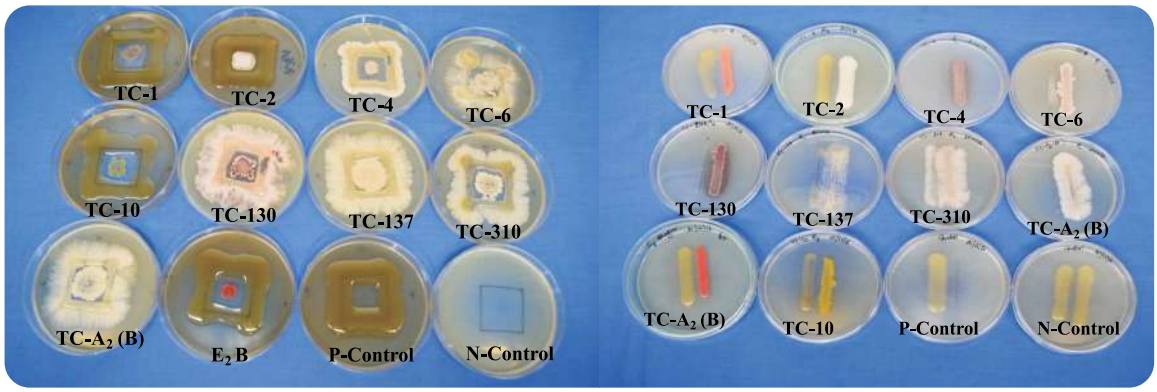
Amplification of SSR markers on selected pomegranate genotypes



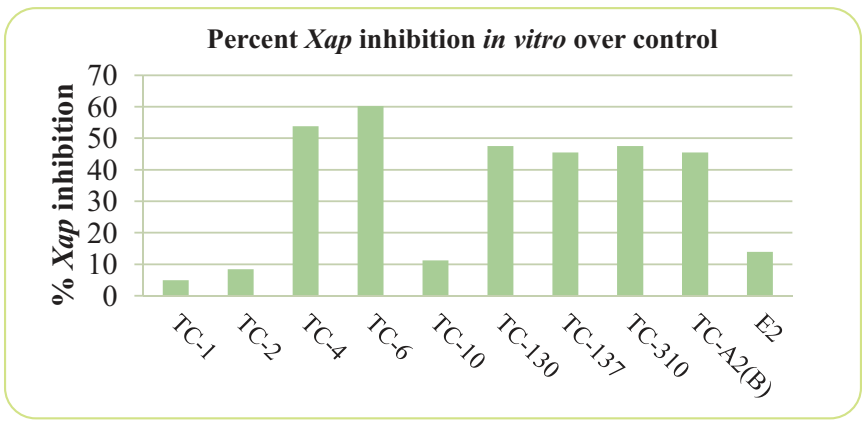
Amplification of ISSR and RAPD markers on selected pomegranate genotypes

Experiment 3.4. Isolation of evaluation of pomegranate endophytes

Ten endophytes were isolated from *in vitro* raised shoot tips and nodal segments of Bhagwa culture. Endophytes TC-4, TC-6, TC-130, TC-137 and TC-310 were found effective in reducing the *Xap* growth by 45.46 to 60.14 % *in vitro*. In a pot culture experiment, TC-6 and TC-310 were found to reduce the bacterial blight incidence by 20.32 and 29.72 % and severity by 30.23 and 37.23%, respectively.



Anti *Xap* activity of endophytes isolated from *in vitro* cultures of pomegranate



Percent *Xap* inhibition *in vitro* over control

4. INTEGRATED CROP PRODUCTION TECHNOLOGIES

Project Title	:	Development and refinement of integrated production technologies for improved productivity
PI	:	Dr. D. T. Meshram
Co-PI	:	Dr. Ashis Maity, Dr. K. Dhinesh Babu

Experiment 4.1. Nutrient management

Experiment 4.1.1. Effect of novel bio-formulation for potassium fertilizer supplement on fruit yield and quality attributes of pomegranate

The process of mass production of conidia of *Penicillum pinophilum*, potassium solubilizing fungi was standardized and a talc based formulation was developed with spore count ranging from 5-6 x 10^{10} CFU g^{-1} formulation. This formulation was evaluated in 3 years old pomegranate cv. Bhagwa plantation during mrig bahar. The application of said bio-formulation significantly increased fruit yield, average fruit weight and juice content of fruit. The highest increase in fruit yield, average fruit weight was noted when this bio-formulation was applied along with insoluble source of K@100 mg K kg^{-1} soil. It was further observed that application of this bio-formulation could supplement about 79% of potassium requirement of the crop. And when applied along with insoluble source of K @ 100 mg K kg^{-1}, it could supplement 100% potassium requirement of the crop. This bio-formulation also improved the size of arils as indicated by the increase in 100 arils weight.

Application of this bio-formulation also had impact on quality attributes of pomegranate fruit. Significant improvement in ascorbic acid, phenol and sugar content particularly reducing sugar was recorded upon application of said bio-formulation. The highest improvement in fruit quality attributes was obtained when the said bio-formulation was applied along with insoluble source of K @ 100 mg K kg^{-1} soil. It was interesting to note that significant decrease in non-reducing sugar was recorded upon application of this bio-formulation.

Soil bioavailable K and P content was measured at three critical phonological stages viz. fruit set (0-60 days after full bloom, DAFB), fruit enlargement (60-120 DAFB) and fruit maturity (120-180 DAFB). And the results indicated that there was significant improvement in available K and P content of soil all through the fruit growth stages. The highest increase in available K and P at different fruit growth stages was evident when the said bio-formulation was used along with insoluble source of K @ 100 mg K kg^{-1} soil. Plant K and P status was also assessed through leaf tissue analysis after harvest of the crop. The results also indicated the plant inoculated with bio-formulation had significantly higher concentration of K and P in their leaf tissue. Here also the highest concentration of K and P were notice in plant inoculated with bio-formulation plus insoluble source of K @ 100 mg K kg^{-1} soil.

The impact of application of the said bio-formulation on soil biological activity was assessed through measuring enzymatic assays viz. alkaline and acid phosphatase, dehydrogenase and microbial biomass carbon content of soil. The results indicated that significant improvements in alkaline and acid phosphatase enzyme activity which are involved in mineralization of organic P were recorded upon the application of said bio-formulation. Maximum improvement in alkaline and acid phosphatase activities were noticed when the said bio-formulation was applied along with insoluble source of potassium @ 100 mg K kg^{-1}.

There was significant increase in biological activity as evidenced by enhancement in dehydrogenase enzyme activities and also increase in

microbial biomass carbon content of soil. Here also maximum increase in dehydrogenase enzyme activity and microbial biomass carbon content of soil were recorded when the said bio-formulation was applied along with insoluble source of K @ 100 mg K kg^{-1} soil.

Experiment 4.2. Water management

Experiment 4.2.1. Comparison of various irrigation methods with sub-surface drip irrigation system for pomegranate production

The experiment was conducted on comparative performance evaluation of micro-irrigation methods to find out the effect of growth performance of 4th year pomegranate orchard. Six treatments were replicated four times in RBD during 2016-17. Various micro-irrigation treatments encouraged plant growth, reduced moisture evaporation and also regulated soil temperature. Maximum plant height, flowers, branches and stem diameter was recorded in SDI with double laterals (30*30 cm) followed 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 4th year old age pomegranate orchard during 2016-17. The seasonal values of water requirement to be applied to pomegranate tree ranged from 955.60 to 2866.95 liters/year/tree for 4th year pomegranate tree. The 0.40*ETr is the best treatment having double laterals with 4 drippers followed by ring type and single lateral (2D) and maximum plant height, flowers, branches and stem diameter was recorded in 0.40*ETr. Monthly shaded area (m^2), wetted area (%), total area leaves (m^2) and leaf area index at solar noon hours is mentioned.

SDI system at 30 cm x30 cm spacing

Ring type DI with six drippers

Cumulative growth performance and water use in various micro-irrigation methods during Dec, 2016 to March,2017

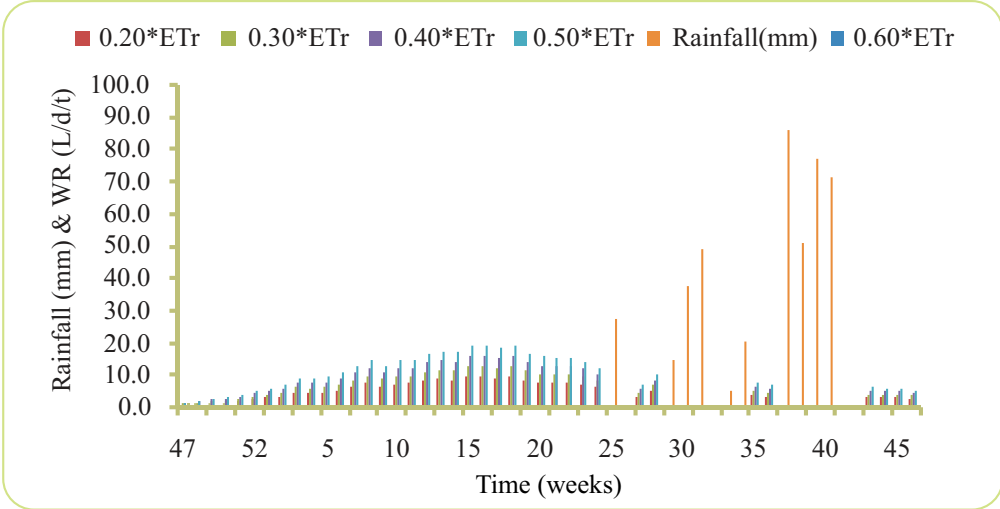
Treatments	Water use (litres)	Plant height (cm)	Plant spread (cm)		Stem diamete-r (cm)	Stem girth (cm)	Thorn length (cm)	Flowers (Nos.)
			EW	SE				
T_1	895	125	109	109	2.3	2.6	2.3	110
T_2	1119	132	120	125	2.5	2.8	2.8	119
T_3	1342	134	132	130	3.6	3.0	3.6	130
T_4	1566	125	120	118	2.8	2.9	3.4	112
T_5	1790	122	110	108	2.5	2.3	2.5	115
T_6	3580	129	125	120	2.6	2.6	2.6	122

(T_1-SDI with single lateral (30 cm), T_2 - SDI with double laterals (30*30 cm), T_3-SDI with double laterals (30*40 cm), T_4- SDI with double laterals (30*50 cm), T_5-DI with single lateral (2D) and T_6-DI with double laterals (4D)) (Spacing-4.5 x 2 m).

Cumulative growth performance in lateral geometry experiment (Dec, 2016 to March, 2017)

Treatments (0.20 to 0.70 * ETr)	Plant height (cm)	Plant spread (cm)		Steam diameter (cm)	Steam girth (cm)	Thorn length (cm)	Flowers (Nos.)
		EW	SE				
T_1	126	120	110	2.6	2.8	2.5	112
T_2	132	135	130	3.6	2.9	3.7	140
T_3	128	119	110	2.8	2.7	2.9	98

(T_1- Single lateral (2D), T_2 - Double laterals (4D), T_3-Ring type (6Di)), (Spacing-4.5 x 2 m)



Pomegranate evapotranspiration, ETp (liters/day/tree)

Monthly shaded area, wetted area and leaf area index

Months	APP(m2)	SA (m2)	WA (%)	TA (m2)	LAI_{SN}
December, 2016	9.0	1.55	26.35	5.60	3.60
January, 2017	9.0	1.85	28.25	6.85	3.72
February, 2017	9.0	1.93	30.25	7.53	3.86
March, 2017	9.0	2.30	32.25	8.96	3.89

(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)

Experiment 4.2.2. Effect of mulches and irrigation level on yield, quality and WUE of pomegranate

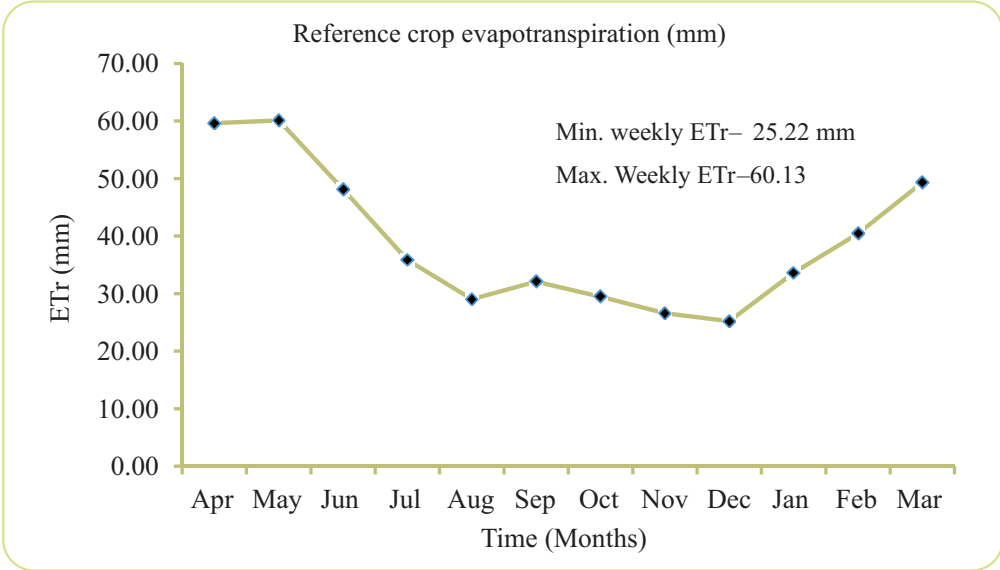
Climatic parameters at experimental site

The daily climatic parameters which is required for the estimation of ET_r, has been worked out.

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

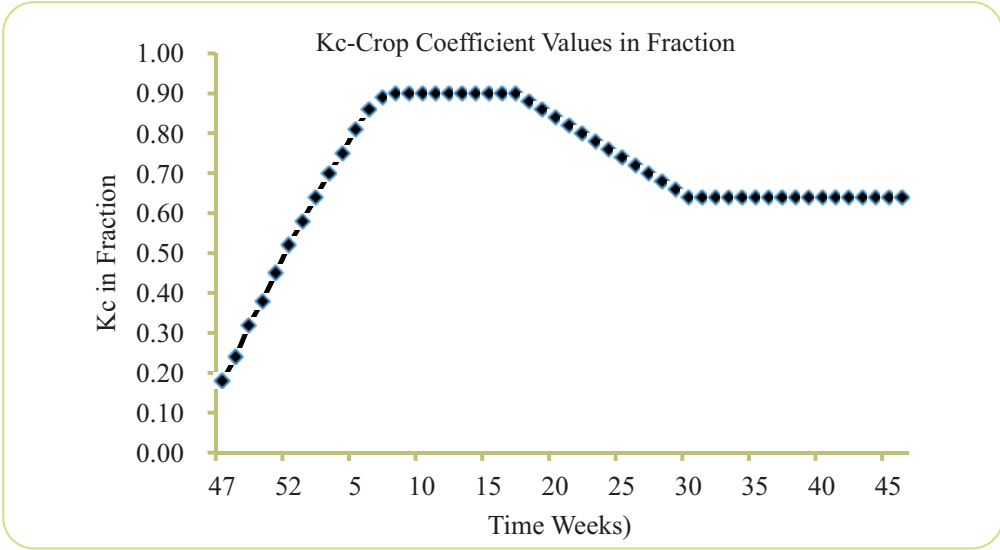
soil and vegetation. It is used to describe the atmospheric "demand" for water. The major factors affecting reference crop evapotranspiration are climatic parameters. Consequently, reference crop evapotranspiration is a climatic parameter and can be computed from weather data. Reference crop evapotranspiration 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 Dec, 2016 to Mar, 2017 were used to determine daily, weekly and monthly reference crop evapotranspiration (ET_r) by using Penman-Monteith Method. The monthly ET_r values are presented**.** The trend of variation of average ET_r values over the year was studied. The yearly reference crop evapotranspiration (ET_r) obtained was 2009.25 mm. The ET_r was maximum in May (19-21 SMW) and minimum in September (35-39 SMW). The weekly minimum and maximum ET_r ranged from 25.22 to 60.13 mm



Monthly ETr (mm) values from April, 2016 to March, 2017 at experimental site

Development of crop coefficient (K_c) values

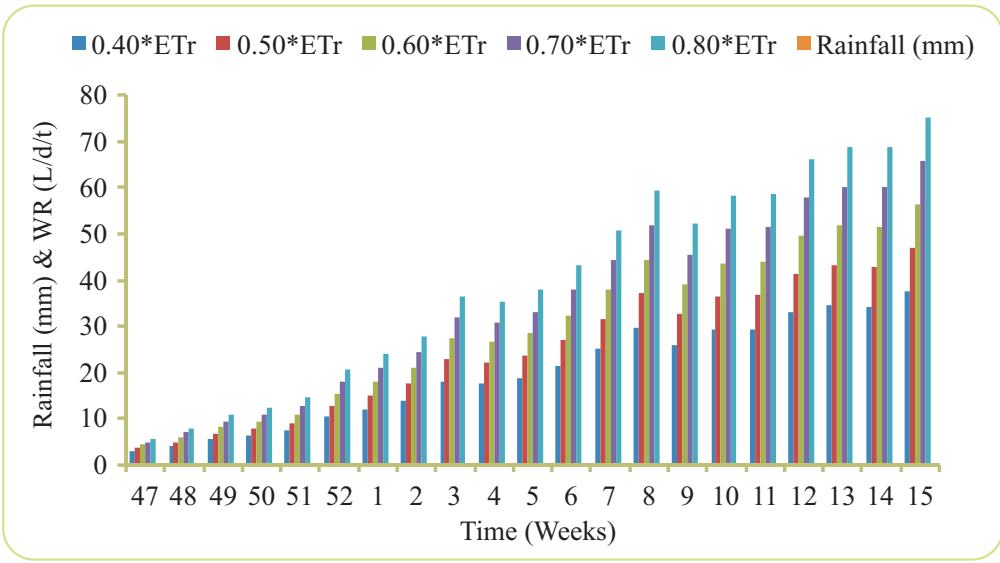
Crop coefficients are needed to estimate pomegranate evapotranspiration (ET_p) with reference crop evapotranspiration (ET_r). These coefficients are dimensionless numbers that are multiplied by the ET_r values to know pomegranate evapotranspiration in mm. It varies with crops, age, phenological stages, location, by time of the years and specific cultural or management practices. Therefore, the weekly crop coefficient values were computed by using equation (Kc=0.14x + 0.18) and converted in monthly basis. The monthly crop coefficient curve for pomegranate tree in 6th year was presented. It indicated that the values of crop coefficient increased from 0.18 to 0.90 due to the development, maturation of the leaf surface, increased number of leaves, foliage, water sprout, flowers and fruits of the tree during 6th year. The K_c values increases linearly from January to March months due to increases in number of leaves, water sprout, luxors, flowers, fruits and shaded area as observed from the representative trees and decreases from October to December months due to removing of water sprout and leaf drop. The crop coefficient (0.70-0.90) increases in the month of February to May due to increases excess water sprout, foliage and management practices.



Crop coefficient curve for 6th year pomegranate tree

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

The daily water to be applied through drip irrigation system at 90 % efficiency from December, 2016 to March, 2017 ranged from 5–43 liters/day/tree for 6th old age of pomegranate tree at 0.60*ETr is the best. It gradually increases or decreases during different development stages of pomegranate tree 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 four months pomegranate evapotranspiration are 4387 Litres/tree and water to be applied to pomegranate tree ranged from 731 to 1462 liters/month/tree based on different irrigation levels from 0.40 to 0.80. The critical stages wise water requirement in $Lstage^{-1}t^{-1}$ including number of days for pomegranate Bhagwa cv. (*i.e.* new leaf initiation, flowering to fruit set, fruit development) were identified.



Daily pomegranate evapotranspiration (liters/day/tree) for 6th year pomegranate tree

Critical pomegranate plant stages for irrigation in *hasth bahar*

Sr.No.	Critical stages for Irrigation	Nos. of days	WR ($LStage^{-1}t^{-1}$)
1.	New leaf initiation	22-25	84-175
2.	Flowering to fruit set	70-80	1449-2905
3.	Fruit development	60-70	1386-2772

Pomegranate Evapotranspiration under inorganic and organic Mulches (ETp, litres / day / tree)

An experiment on different organic (i.e. Wheat, Safflower and Sugarcane baggas) and inorganic mulches (i.e. Black and White PE, Black PE and Pervious mulch (weed mat)) 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 0.60*ETr, followed by wheat, safflower and black and white and black polythene. Soil moisture retention was also higher in the black mulch treated plants.

Growth parameters

Bhagwa cv. of pomegranate 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 115 to 165 cm, 127 to 148 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.

Organic mulch

Inorganic mulch

Growth performance under organic mulching and inorganic mulching

Treatment	Plant height (cm)	Plant spread (cm)		Stem diameter (cm)	Stem girth (cm)	Thorn length (cm)	Flowers/ plant	Fruits/ plant
		EW	SE					
Organic (0.30 to 0.70*ETr)								
T1	115	127	118	3.5	2.9	2.9	145	48
T2	140	130	141	3.9	3.2	3.7	176	54
T3	165	148	138	4.8	3.0	3.9	212	78
T4	137	130	132	4.5	2.8	3.8	90	58
Inorganic (0.30 to 0.70*ETr)								
T1	130	155	135	3.8	2.9	2.8	195	47
T2	150	165	142	3.9	3.0	3.2	158	58
T3	171	172	140	4.5	2.8	3.8	250	49
T4	142	148	138	4.2	2.7	4.10	156	52

(**Organic**- T_1- Wheat, T_2-Safflower, T_3-Sugarcane baggas, T_4-Control and **Inorganic**-T_1-Black and White PE, T_2-Black PE, T_3-Pervious,T_4-Control)

Experiment 4.2.3. Response of pomegranate to partial root zone drying and deficit irrigation

Field experiment was conducted during 2016-2017 on light texture soil at National Research Center on Pomegranate, Solapur (latitude 17^0 10", longitude $74^0$42" and 483.5 m msl) in the Western Part of Maharashtra to assess the deficit and partial root zone drying irrigation system at different phenological stages (i.e. new leaf initiation period, development, maturity, harvesting and rest period) of Pomegranate. The soil of the experimental site is tight texture soil throughout the soil profile. The physical and chemical properties of soil of the experimental field was recorded.

Spacing 4.5 x 2.0 m | Spacing 4.5 x 3.0 m | Spacing 4.5 x 4.0 m

Layout of experiment on PRZDI under different spacing

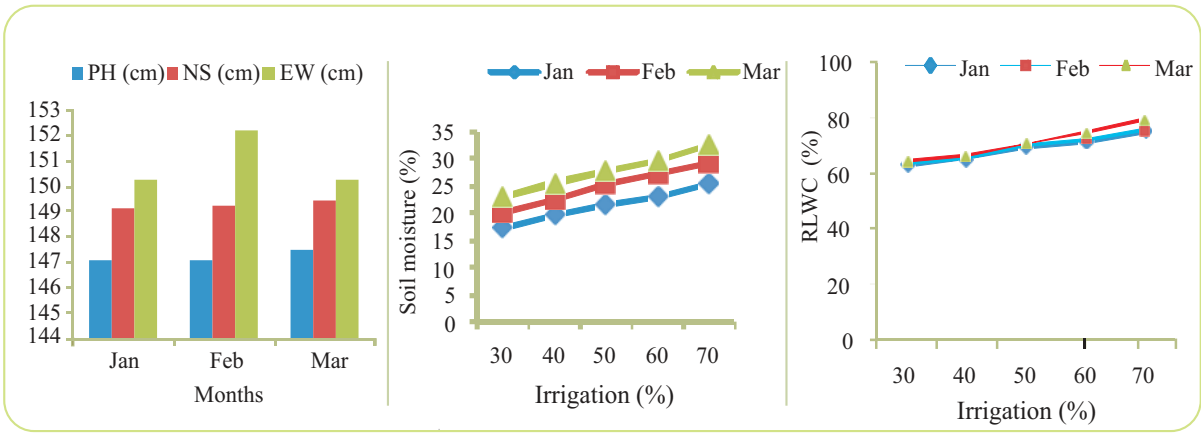
Chemical and physical soil properties of the plots of experiment orchards

Chemical properties of soil			
Properties	Depths (cm)		
Depths (cm)	30	60	90
pH	8.45	8.96	8.22
EC(dSm^{-1})	0.32	0.34	0.27
OC (%)	0.96	0.47	0.42
$CaCo_3$ (%)	5.45	4.67	11.3
Available major nutrients (kg/ha)			
N	298	225	140
P	110	72	52
K	785	720	430
Available micro nutrients (ppm)			
Fe	3.14	3.58	4.45
Mn	9.15	6.44	6.95
Zn	4.56	1.38	1.16
Cu	15.5	4.57	5.65

Physical properties of soil	
Sand (%)	35.61
Silt (%)	19.60
Clay (%)	14.58
Bulk density (Mg/m^3)	1.50
Field Capacity (mm/m)	145
PWP (mm/m)	40

Effect of DI on vegetative growth performance, soil moisture, RLWC and root geometry

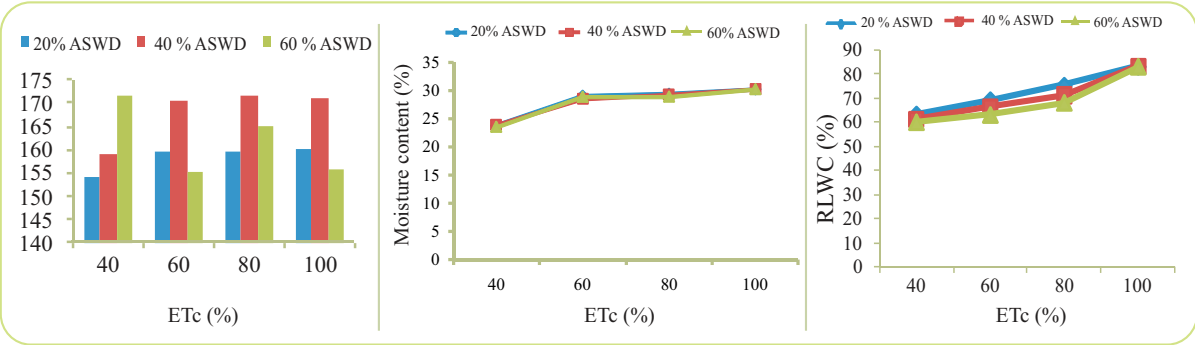
The result showed that, the performance evaluation of DI systems at different plant spacing and wetted soil volume at 40, 50, and 60 % for 3rd, 4th and 5th year's old pomegranate orchards was found best. DI reduced moisture content and maximum plant height, branches and flowers were recorded in having WSV at 40, 50 & 60 %**.** Soil moisture content and relative leaf water content under deficit irrigation were calculated. The moisture content and relative leaf water content in percentage varied between 17.29 to 32.59 and 62.9 to 79.3 percent, respectively.



Vegetative growth (cm) **Soil moisture (%)** **RLWC (%)**

Effect of PRZDI on vegetative growth performance, soil moisture, RLWC and root geometry

The performance evaluation of PRZDI systems at 40 %*ET_c, 60 %*ET_c, 80 %*ET_c and 100 %*ET_c (control) having 20, 40, and 60 % ASWD at drying side showed that less water produced good performance of vegetative growth. PRZDI reduced moisture content and maximum plant height, branches and flowers were recorded in having WSV at 100 % * ET_c with 20% ASWD**.** Soil moisture content and relative leaf water content under deficit irrigation were presented. The moisture content and relative leaf water content varied between 23.5 to 31.8 and 62.9 to 79.3 percent, respectively. The moisture content and relative leaf water content varied between 17.29 to 32.59 percent and 60.3 to 80.5 percent, respectively.



Vegetative growth (cm) **Soil moisture (%)** **RLWC (%)**

Effect on root geometry

Observations on root geometry was recorded and results showed that, the higher and lower root length, weight and density (69.44 cm, 89.91 gm and 1.48 kg/m^3) and (40.66 cm, 40.80 grams and 0.67 kg/m^3) were observed in 100 % ET_c and 40 % ET_c

Root sampling

40% ETc

60% ETc

80% ETc

100% ETc

Collected Roots

Effect of PRZDI on root geometry

Experiment 4.3. Crop management

Experiment 4.3.1. Evaluation of pomegranate under different training systems

Preliminary evaluation of pomegranate during fourth year under different training systems (single, double, triple, four, five and >5 stems / plant) revealed that the fruitset was highest (55.05%) under single stem training system whereas it was lowest (40.55%) under control (>5stems/plant). The yield was highest under four stem training system (13.1 kg/ plant) followed by triple stem (12.2 kg/plant) where as it was lowest under control.

Under single stem training system, pruning is easier while the penetration of spray fluid and light is optimum. However, the risk of loss of plant is higher due to bacterial blight on main stem, insect pest damage or wind pressure.

Under multi-stem training system, when one stem is lost due to bacterial blight, insect pest damage etc, it becomes possible for the plant to survive through other stems. However, pruning is tedious while the penetration of spray fluid and light is not optimum.

Single Stem

Double Stem

Triple Stem

Four Stem

Five Stem

Control (>5 stems)

Evaluation of pomegranate under different training systems

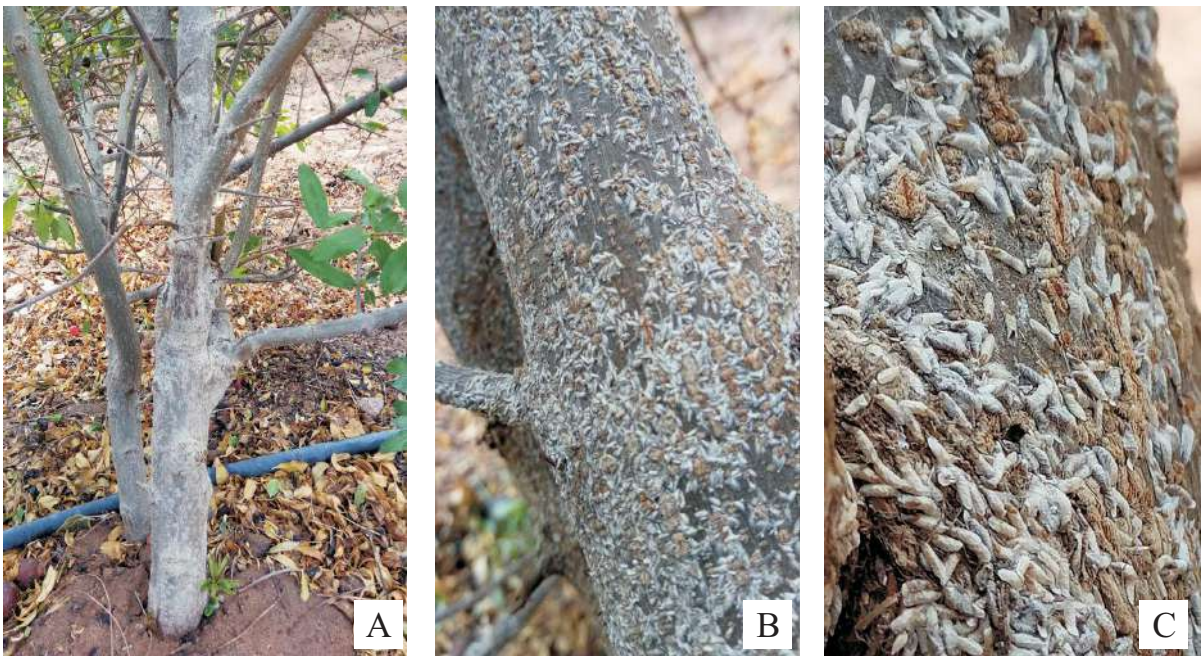
5. INTEGRATED CROP PROTECTION TECHNOLOGIES

Project Title	:	Development and refinement of integrated crop protection technologies for improved productivity of pomegranate
PI	:	Mr. Mallikarjun
Co-PI	:	Dr. Jyotsana Sharma, Dr. U.R. Sangle

Experiment 5.1. Insect pests

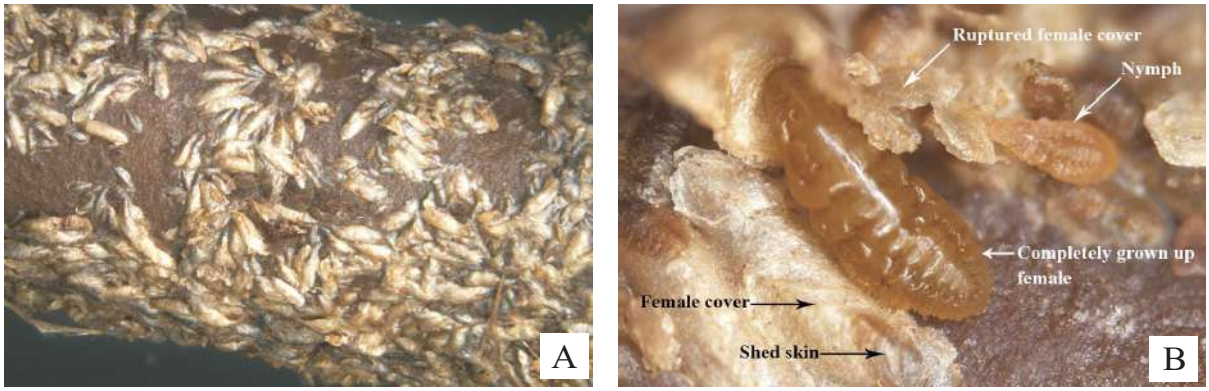
Experiment 5.1.1. First record of invasive scale insect *Lopholeucaspis japonica* (Cockerell)

Japanese maple scale, *Lopholeucaspis japonica* (Hemiptera: Diaspididae) was reported for the first time on pomegranate (*Punica granatum*) from Gujarat, It was found infesting pomegranate crop in Nakhatrana village, Kutch District of Gujarat during March 2016, on single pomegranate plant and its incidence gradually increased during the July-August covering 38-40, five year old plants with yellowing of the leaves, stunted growth and poor fruit bearing. Specimens were identified at NBAII, Bengaluru. The scale covers complete branches with the colony containing males and females. Normally it was observed on bark of main stem and branches.



***Lopholeucaspis japonica* infestation on pomegranate bark at Gujarat**

(A. White encrustation on all aerial parts B. White specks developed by the stages of the scale C. Magnified image showing raised male and females on the stem)



Microphotograph of scale insects

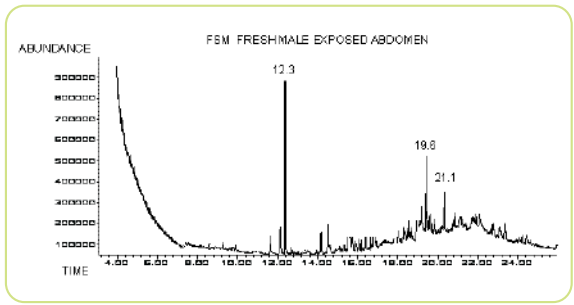
(A. Scale colony on the branch showing females and male scales B. Different stages of the scale)

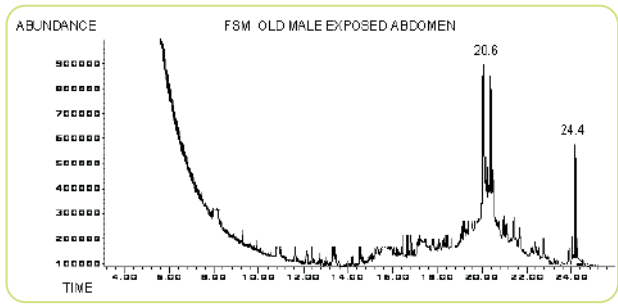
Experiment 5.1.2. Isolation and identification of sex pheromone compounds against fruit piercing moths.

The isolation of sex pheromone compounds from fruit piercing moth *Eudocima materna* was done at NBAIR, Bangalore. Laboratory reared freshly emerged virgin adult male and females kept in separate cages, were used for the purpose. Abdominal tip of 4 different pairs of male and female moths, that had freshly emerged and after 48 hours of emergence were used for isolation of pheromone compounds and detected using Gas chromatography coupled with Electro Anttenogramm Detector (GC-EAD). Total 11 detected compounds were identified with the help of Gas chromatography and mass spectrometry (GC-MS); these are tabulated below.

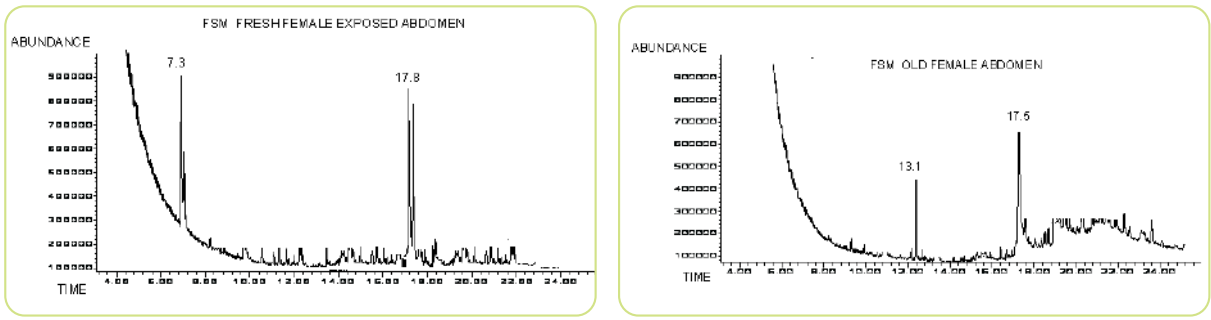
Sex pheromone compounds detected and identified in **fruit piercing moth *Eudocima materna* in GC-EAD**

(a) Old female exposed to freshly emerged male			(b) Freshly emerged female exposed to freshly emerged male		
Retention time (RT)	**Compound**	**Percent Match**	**Retention time (RT)**	**Compound**	**Percent Match**
12.3	Phenol 2,4, BIS (1,1 Dimethyl Ethyl)	98	7.3	Alpha Dodecene	84
19.6	1-Docosene	93	7.3	1-Nonadecene	95
21.1	1-Docosonol	94	7.3	9-Eicosene	91
			17.8	1-Octadecanol	91



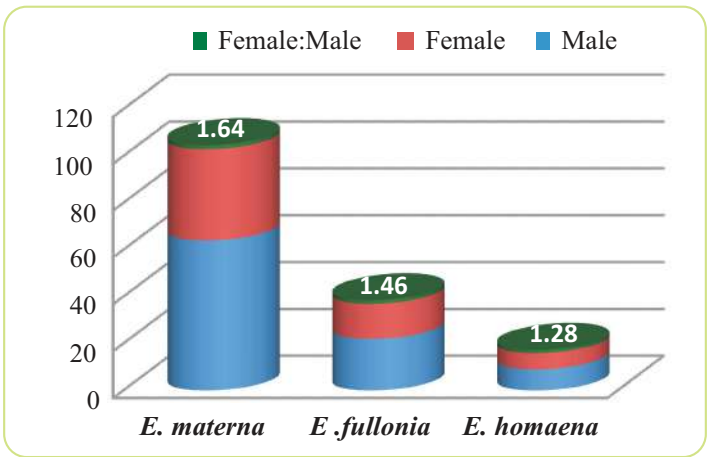


(c) Old male exposed to freshly emerged female			(d) Old male exposed to old female		
Retention time (RT)	**Compound**	**Percent Match**	**Retention time (RT)**	**Compound**	**Percent Match**
20.6	Tricosane	45	13.1	1-Hexadecene	96
24.4	Eicosane	94	17.5	1-Nonadecanol	94



Experiment 5.1.3. Population dynamics of fruit sucking moths

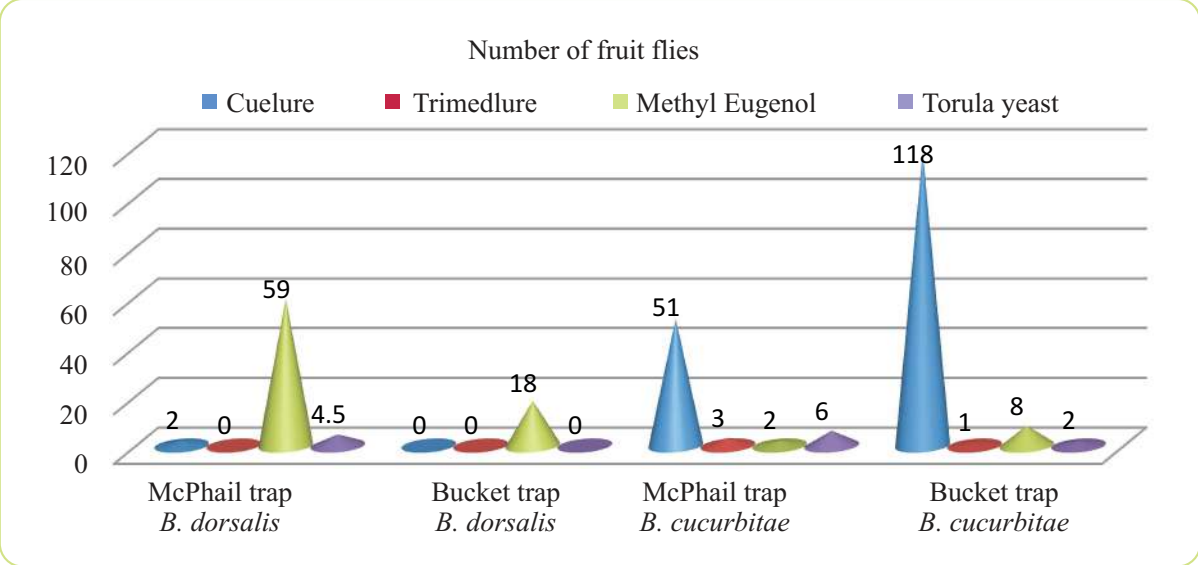
Population of fruit sucking moths was monitored from August till October 2017. Three different species of fruit sucking moth were collected during the season with dominance of *E. materna.* Among the collected adults the male moth was predominant in all three species. The peak activity of the moth was from 7.30 pm to till 11.30 pm and from the first week of August to September, though it was observed with reduced activity till 2.00 am and till November end.



Population dynamics of fruit sucking moths

Experiment 5.1.4. Evaluation of traps and lures for fruit fly

McPhail and Bucket traps charged with four types of attractants/lure sources *viz.* Methyl eugenol (ME), Cue lure (CL), Torula yeast (TY) and Trimed lure (TL), were installed in pomegranate ecosystem at NRCP research block, to evaluate their efficacy in attracting different species of fruit flies. Bucket trap with Cue lure was best for trapping the *Bactrocera cucurbitae* adults and McPhail trap with methyl eugenol, for *Bactrocera dorsalis* with highest catch of 118 and 59 adults respectively. No catches of *Ceratitis capitata* were found.



Trapping of fruit fly species *Bactrocera dorsalis* and *Bactrocera cucurbitae* trapped on different lures in McPhail and bucket traps

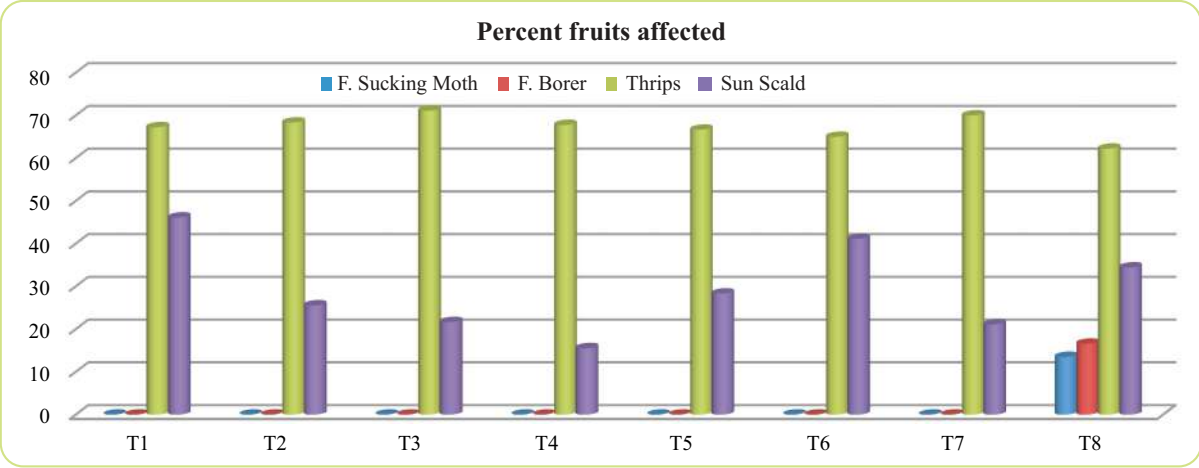
McPhail trap

Bucket type trap

Traps used for fruit fly

Experiment 5.1.5. Evaluation of different types of bagging materials against insect pest damage

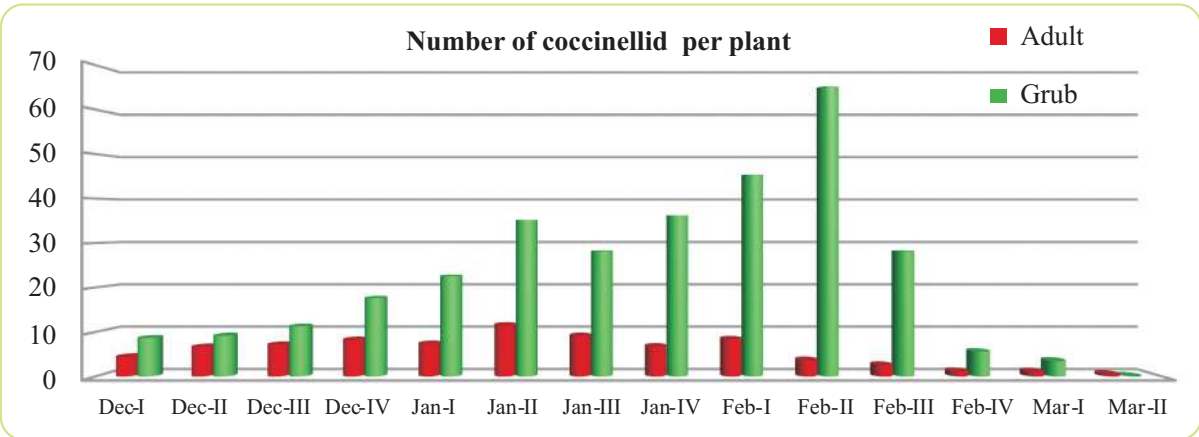
All the seven types of bagging material gave 100% protection against fruit borer and fruit sucking moths in comparison to control with 13.55% fruit borer and 16.66% FSM damage. Bagging was ineffective for thrips damage. Paper bags (butter, brown and news paper) gave some protection against sun scald.



Effect of bagging on fruit damage due to insect pests and sun scald: T1: Poly propylene non woven UV stabilized; T2: Muslin cloth; T3: Butter paper;T4: Brown Paper; T5: Muslin cloth white; T6: Green net; T7: News paper; T8: control

Experiment 5.1.6. Population dynamics of coccinellid predator (*Cheilominus sexmaculata*) and its hyperparasitoid complex

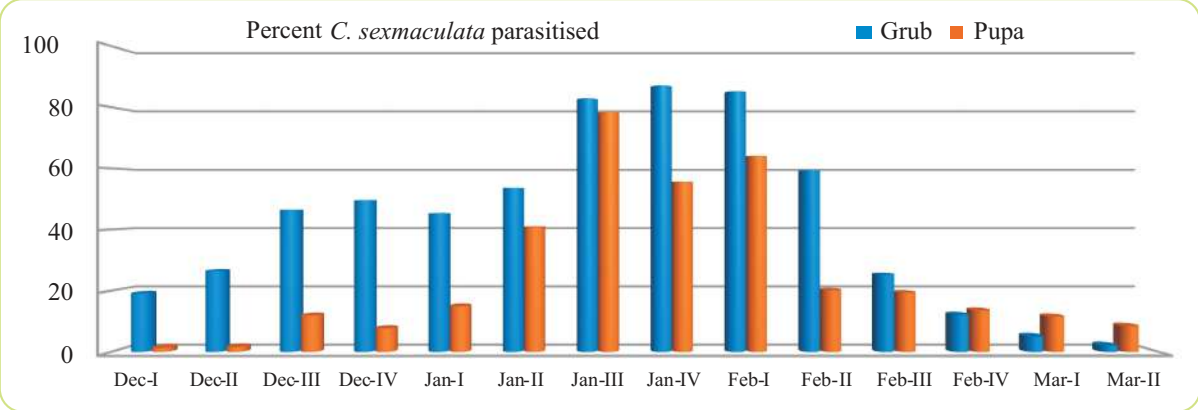
Seasonal occurrence of coccinellid predator lady bird beetle (*Cheilomenes sexmaculata* Fab.) –a beneficial insect predator of sucking pests aphids and mealy bugs- was recorded at weekly intervals. The population of grubs increased consistently from December first week (8.65/plant) to February second week, when it was highest (65.22/plant), thereafter, the population drastically fell down to 5.6/plant in February third week and was not found by March first week. Highest adult population of 11.6/plant was recorded in January second week and nil in March first week.



Population of *C. sexmaculata* during different meteorological weeks

The grubs and adults of *C. sexmaculata* collected from pomegranate orchard, were found parasitized by different parasitoids. Out of 75 infested grubs and 50 pupae four different hyperparasitoids were recorded. The parasitoids identified at NBAII, Bangalore were *Tetrastichus sp.* (pupal parasitoid), *Homalotylus* sp. (larval and pupal parasitoid), *Pteromalid* sp. and *Anastatus acherontiae* (larval parasitoid). Data on extent of parasitization by two major hyperparasitoids *viz. Homalotylus and*

Tetrastichus sp. were recorded. Maximum parasitization of grubs with *Tetrastichus sp.* was from 3rd week of January to first week of Fenruary with 82.82%-87.02% parasitization and 78.39 percent in pupae during third week of January. Average parasitism due to *Homalotylus* sp. was found to be 42.83 percent in grubs and 24.96 in pupae.



Percent *C. sexmaculata* grub and pupae parasitized by *Homalotylus sp.* during different meteorological weeks

Grub

Parasitized grubs of *C. sexmaculata* beetle by *Homalotylus sp*

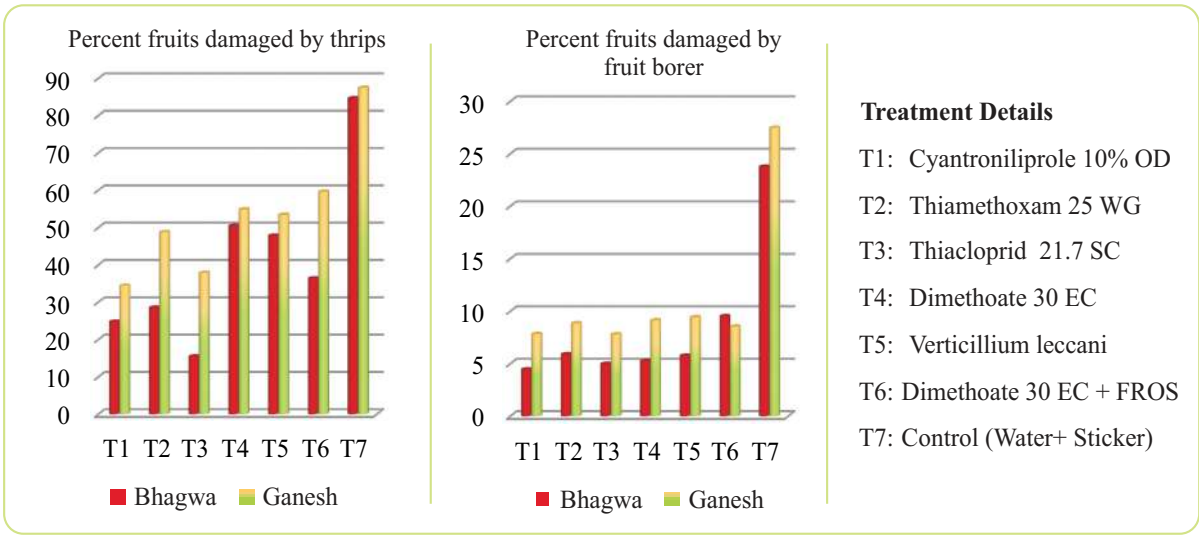
Experiment 5.1.7. Isolation and identification off entomopathogens from the infested larvae of pomegranate fruit borer

A variety of organisms including *Enterococcus casseliflavus*, *Pseudomonas sp.* and *Bacillus cereus* were found parasitizing fruit borer larvae, these were isolated, identified, sequenced and submitted to Gen bank through Molecular Entomology Laboratory of NBAIR, Bangalore. The accession Nos. of these entomopathogens are respectively KU669032, KU669033 and KU669034. These organisms will be used for the ecofriendly management of fruit borer in pomegranate.

Experiment 5.1.8. Management of borer and thrips

Six insecticide and biopesticide treatments were evaluated against fruit borer and thrips *Scirtothrips dorsalis* infestation. Thiacloprid 21.7 SC provided the best protection from thrips and fruit

borer with respectively 84.59% and 95.02% fruits free in Bhagwa variety and 62.16% and 92.22% in Ganesh. Cyantroniliprole 10% OD and Thiamethoxam 25 WG were also effective. The treatments were very effective for borer pests as fruit borer damage in the best treatment was reduced by 81.23% in Bhagwa and 68.95% in Ganesh in comparison to control.



Efficacy of different pesticides against thrips and fruit borer

Experiment 5.1.9.Effect of weather parameters on occurrence of borer and sap sucking pests

Fruit borer, showed positive correlation on var. Ganesh and Bhagwa with temperature, rainfall and negative correlation with relative humidity on both the varieties. Thrips showed negative correlation with all the weather parameters on both the varieties.

Correlation of weather parameters with thrips and fruit borer population dynamics

Pest and Variety	Correlation Coefficient		
	Mean of Min. & Max. Temp.	Mean of Min. & Max. R.H.	Rainfall
Fruit Borer (G)	0.79	-0.48	0.79
Fruit Borer (B)	0.87	-0.53	0.87
Thrips (G)	-0.26	-0.40	-0.26
Thrips (B)	-0.45	-0.31	-0.45

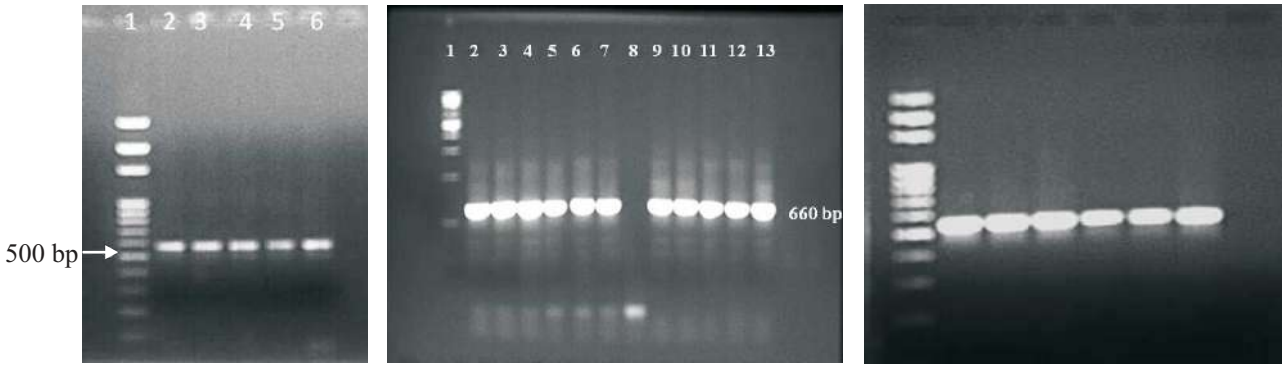
Experiment 5.2. Fungal pathogens

Experiment 5.2.1.Isolation of organisms associated with various diseases

In all 14 new fungal isolates including 3 *Ceratocystis fimbriata* isolates causing wilt, 6 *Sphaceloma punicae* isolate causing scab, 6 *Colletotrichum gloeosporioides causing* fruit rot and 3 *Alternaria alternata* isolates causing heart rot of pomegranate have been added to NRCP culture collection from, Gujarat, Karnataka, Uttar Pradesh and Maharashtra.

Experiment 5.2.2. Molecular identification and characterization of major fungal pathogens

Molecular identification and characterization of major fungal pathogens was done employing genus specific internal transcribed spacer ITS) universal primer pair ITS1-F/ITS4-R. The isolated fungal pathogens *Colletotrichum gloeosporioides* isolated from fruit rot, *Cercospora* spp. from fruit spot, *Alternaria alternata* from heart rot and fruit spot, *Ceratocystis fimbriata* from wilt, amplified at 600-650bp.



C. gloeosporioides
1= 0.1kb DNA ladder
2 = Col-13, 3 = Col-14
4 = Col-15, 5 = Col-16, 6 = Col-17

Ceratocystis fimbriata
1=1kb DNA ladder, 2=CF4, 3=CF18, 4=CF28a), 5=CF28b), 6=CF31, 7=CF33, 8= -VE control, 9=CF1, 10=CF2, 11=CF24, 12=CF28, 13=CF33

Cercospora punicae
1: 100 bp DNA ladder, 2. CR-24, 3. CR-30, 4. CR-31, 5. CR-23, 6.CR-32, & 7.CR-33

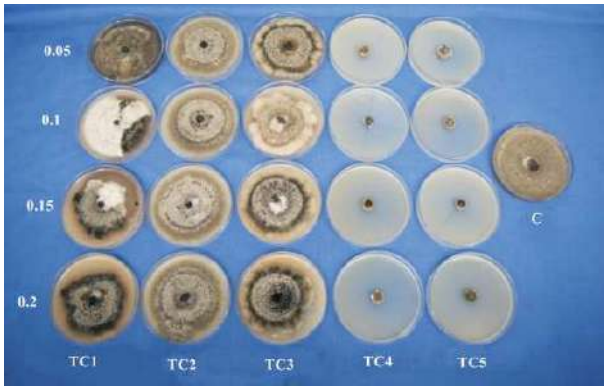
Molecular detection of fungal pathogens using ITS primers

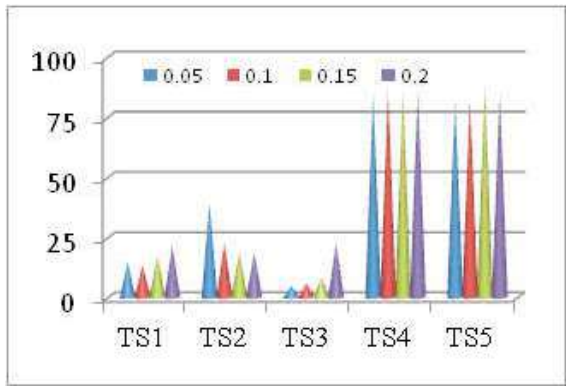
Experiment 5.2.3. Evaluation of fungicides against fungal rot and spot pathogens

Experiment 5.2.3.1. Evaluation of systemic and contact fungicides

Five systemic and 6 contact fungicides were evaluated through poisoned food technique in vitro against leaf spot fungus *Alternaria alternata* and fruit rot fungus *Colletotrichum gloeosporioides*. Systemic fungicides were superior to contact fungicides in inhibiting both the pathogens. Propiconazole and hexaconazole were the most effective systemic fungicides with 100% control of *C. gloeosporioides* and respectively more than 86% control of *A. alternata* even at lowest dose of 0.05%. Azoxystrobin and carbendazim were not very effective in inhibiting the growth of *A. alternata* even at 0.2% dose,however, *C. gloeosporioides* growth was inhibited by 76.38% with azoxystrobin and 60.0% by carbendazim. Thiophanate methyl was not very effective in inhibiting both the pathogens at any of the tested concentrations.

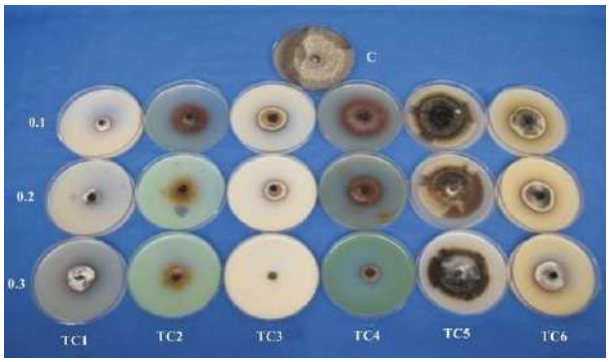
Among the contact fungicides evaluated propineb was the most effective chemical with 100% inhibition of *C. gloeosporioides* and 85.85% inhibition of *A. alternata at all doses.* Chlorothalonil was second best contact fungicide for *C. gloeosporioides w*ith 92.28% inhibition but was not effective against *A. alternata.* All other fungicides *viz.* copper hydroxide and captan and copper oxychloride inhibited both the pathogens between 60.49 to 87.65%.

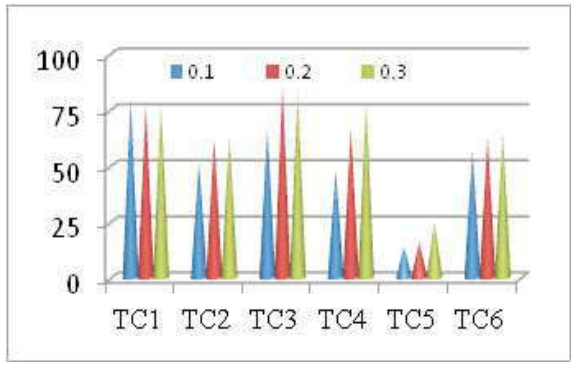




***In vitro* inhibition of *Alternaria alternata* with different systemic fungicides**

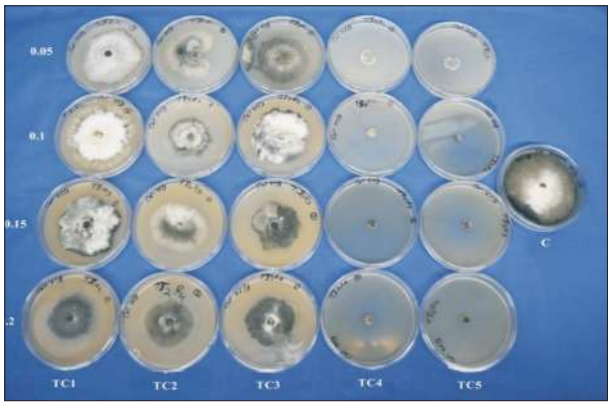
TS1: Thiophanate methyl 70% WP; **TS2:** Azoxystrobin 23% SC; **TS3:** Carbendazim 50% WP; **TS4:** Hexaconazole 5% EC; **TS5**: Propiconazole 25% EC; **C:** Control

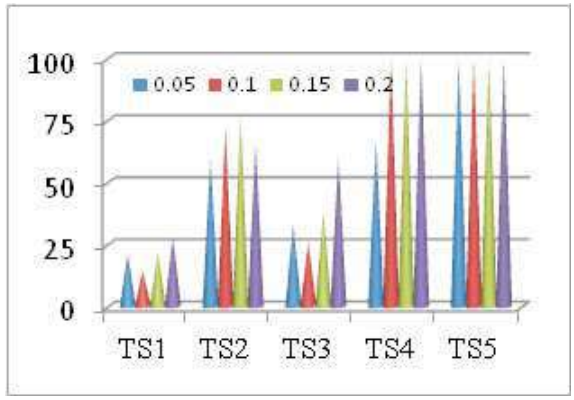




***In vitro* inhibition of *Alternaria alternata* with different contact fungicides**

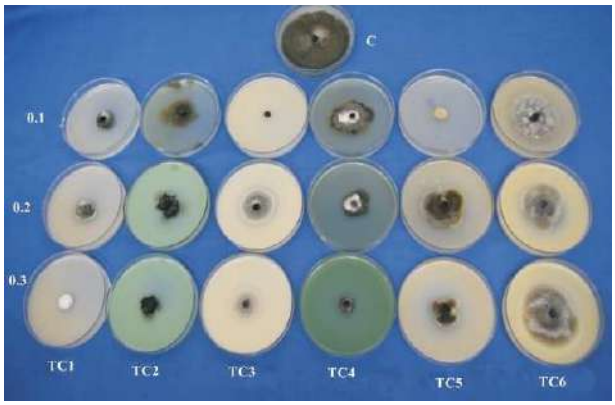
TC1: Captan 50% WP; **TC2:** Copper Oxy Chloride (COC) 50% WP; **TC3:** Propineb 70 %WP; **TC4:** Copper hydroxide 77% WP;**TC5:** Chlorothalonil 75% WP; **TC6:** Mancozeb 75% WP; **C:** Control

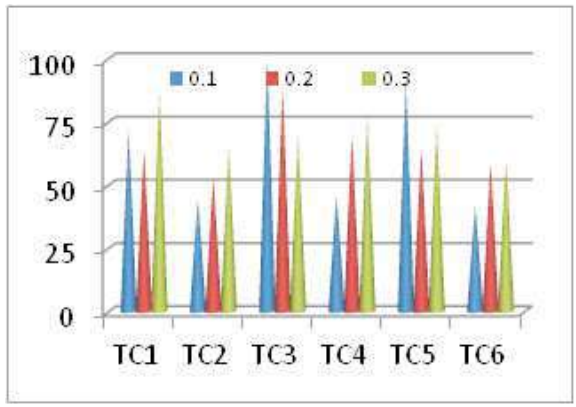




***In vitro* inhibition of *Colletotrichum gloeosporioides* with different systemic fungicides**

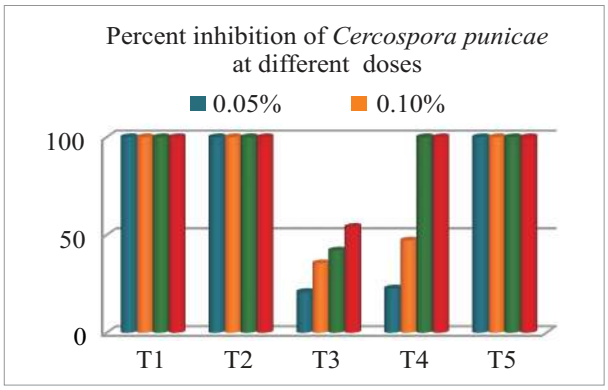
TS1: Thiophanate methyl 70% WP; **TS2:** Azoxystrobin 23% SC; **TS3:** Carbendazim 50% WP; **TS4:** Hexaconazole 5% EC; **TS5**: Propiconazole 25% EC; **C:** Control

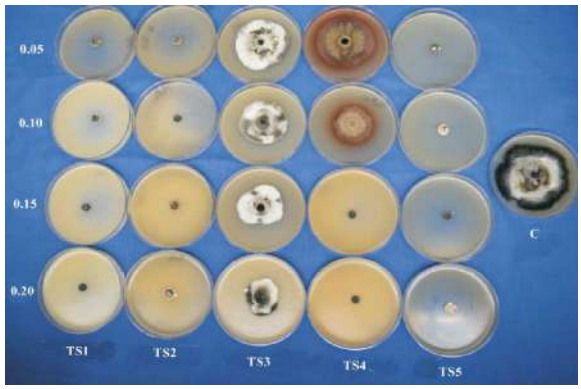




***In vitro* inhibition of *Colletotrichum gloeosporioides* with different contact fungicides**

TC1: Captan 50% WP; **TC2:** Copper Oxy Chloride (COC) 50% WP; **TC3:** Propineb 70 %WP; **TC4:** Copper hydroxide 77% WP;**TC5:** Chlorothalonil 75% WP; **TC6:** Mancozeb 75% WP; **C:** Control

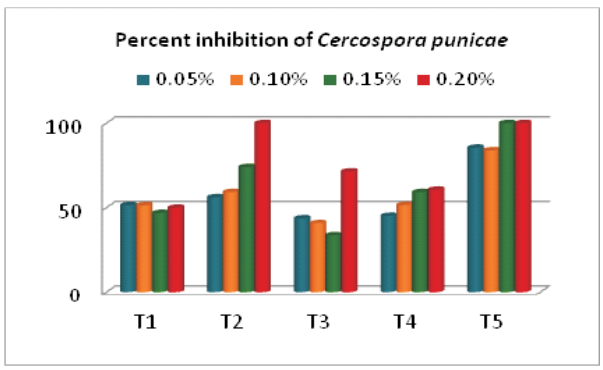




Inhibition of *C. gloeosporioides* at different doses of formulations

T1: Carbendazim 12% + Mancozeb 63% WP; **T2:** Zineb 68% + Hexaconazole 4% WP; **T3:** Metalaxyl-M 3.3% + Chlorothalonil 33.1% SC; **T4:** Tricyclazole 18 % + Mancozeb 62 % WP; **T5:**Propiconazole 25% EC

C. punicae is a slow growing fungus and the fungal growth was completely (100%) inhibited by propiconazole at 0.15% and hexaconazole 4%+zineb 68% WP at 0.2%. In all other treatments inhibition ranged from 43.79-71.03%.



Treatment details	
T1	Carbendazim 12% + Mancozeb 63% WP
T2	Zineb 68% + Hexaconazole 4% WP
T3	Metalaxyl - M 3.3% + Chlorothalonil 33.1% SC
T4	Tricyclazole 18 % + Mancozeb 62 % WP
T5	Propiconazole 25% EC

Efficacy of different fungicides in inhibiting *in vitro* growth of *C. punicae*

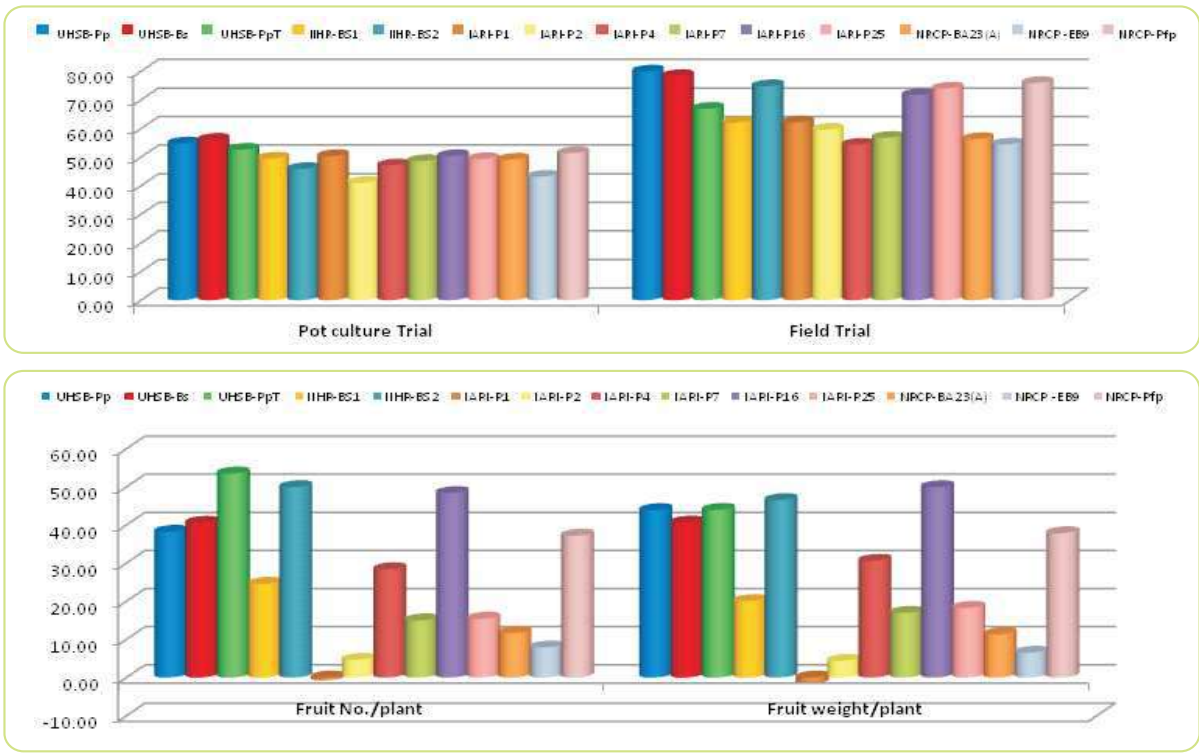
6. INTEGRATED APPROACH TO ERADICATE BACTERIAL BLIGHT

Project Title : Flagship project on integrated approach to eradicate bacterial blight
PI : Dr. Jyotsana Sharma
Co-PI : Dr. Ashis Maity, Dr. N. V. Singh, Dr. Shilpa Parashuram, Dr. K. Dhinesh Babu, ICAR-NRCP
Dr. Aundy Kumar, Dr. K.K. Mondal, ICAR-IARI, New Delhi
Dr. B.N.S. Murthy, Dr. C.Goplakrishnan, ICAR-IIHR, Bengaluru
Dr. Manjunath, Dr. R.K. Mestha, UHS, Bagalkot
Dr. Satish K. Sharma, YSPUHF, Solan

Experiment 6.1.Evaluating novel chemical and biological agents against bacterial blight

Experiment 6.1.1. Evaluation of SAR agents

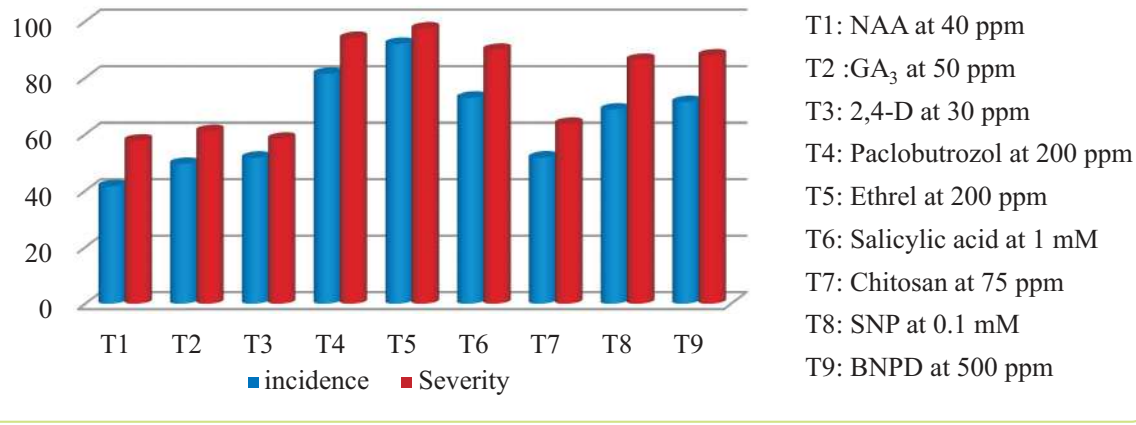
Four SAR chemicals (K_2HPO_4, Salicylic acid, Clove oil, Jasmonic acid/methyl jasmonate) were tested at 100, 200 and 300 ppm doses at NRCP, UHSB, YSPUHF in pot culture trials during 2016-17. All SAR chemicals effectively reduced bacterial blight by 46.36 to 72.41% in comparison to control with average 49.0% severity. Dose of 300 ppm were more effective. In field trials at YSPUHF blight reduction on fruits in different treatments ranged from 72.42% to 88.50%, increase in fruit number from 115.73-260.08% and fruit yield from 131.07-298.84%. Clove oil 0.25% tested in pot trials at NRCP and UHS Bagalkot gave highest disease reduction of 89.94%, hence may be tested further. All four chemicals being effective can be incorporated in schedule after field trial at all locations.



Effect of Bioagents on bacterial blight reduction (upper)) in pot culture trials and field trials & on fruit yield (lower): *Pseudomonas putida* (UHSB-Pp), *Bacillus subtilis* (UHSB-Bs), *P. putida*+ *Trichoderm* metaboloite (UHSB-PpT), *B. subtilis* BS-1 (IIHR-BS1), *B. subtilis* BS-2 (IIHR-BS2), *Pseudomonas stutzeri* (IARI-P1), *Bacillus amyloliquefaciens* (IARI-P2), *Rhizobium pusense* (IARI-P4) and *Agrobacterium fabrum* (IARI-P7), *Brevundimonas terrae* (IARI-P16), *Bacillus safensis* (IARI-P25), NRCP-BA23(A), *Bacillus subtilis* (NRCP-EB9), *Pseudomonas fluorescence* Pf- Parbhani (NRCP-Pfp).

Experiment 6.1.2. Effect of growth regulators and signal molecules on bacterial blight management:

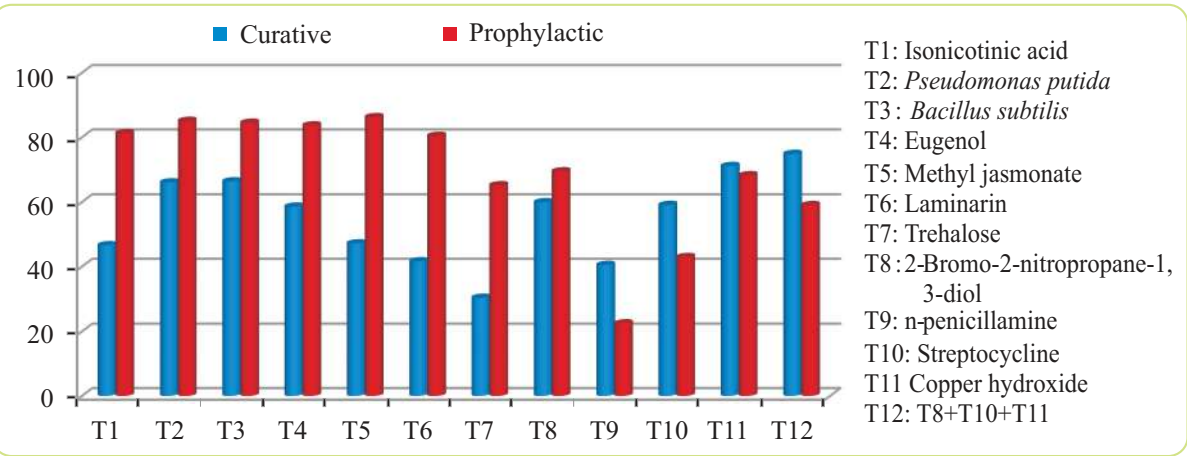
Nine growth regulators and signal molecules were tested in field for two years at UHSB. All the tested molecules significantly helped in checking blight, however, ethylene, salicylic acid, naphthalene acetic acid, and paclobutrazol were most effective due to their resistance inducing properties apart from their role in developmental activities like flowering and fruit development.



Percent reduction in bacterial blight incidence and severity with growth regulators and signal molecules under field conditions

Experiment 6.1.3. Evaluation of resistance inducer agents for blight management:

Efficacy of 8 selected resistance inducers was studied under greenhouse conditions and compared with standard spray chemicals in schedule at UHSB. As curative, the most effective treatment was the recommended combination of synthetic chemicals *viz.* streptomycin sulphate 90% + tetracycline hydrochloride 10% + copper hydroxide + 2-bromo-2-nitropropane-1,3-diol which reduced blight by 74.9%. The study also shows that most bioagents and elicitors are effective as prophylactic sprays and chemicals work better as therapeutic treatments.



Prophylactic and therapeutic potential of bioagents and chemicals in reducing bacterial blight incidence and severity in pot culture

Experiment 6.1.4. Isolation, characterization and evaluation of leaf associated epiphytic microflora:

Single bush leaf samples, with varying degree of bacterial blight infection such as young water soaked lesion, leaves with initial necrotic and late necrotic lesion were collected from farmer's field in Solapur region in central India and studies conducted at IARI, New Delhi. The leaf samples were subjected to polyphasic microbial analysis based on culture dependent methods by classical microbiological procedure and culture independent methods by metagenomics based next generation sequencing tools at IARI. The 16S rDNA amplicon sequencing of total bacterial community using the Illumina 2x300 bp chemistry revealed rich bacterial diversity on healthy leaves of pomegranate. With blight lesion expansion, the native bacterial communities were found replaced with *Xanthomonas axonopodis* pv. *punicae*.

Metagenomic analysis revealed that total Operational Taxonomic Units in healthy leaf was 1026, mild symptom leaf was 249 and in severe symptom leaf it was 270. The healthy leaves harboured diverse microbes as compared to symptomatic leaves as indicated in Shannon (alpha) diversity index of healthy leaves which is five to ten times more than the symptomatic leaves. In all 106 Operational Taxonomic Units were identified up to the species level in healthy as well as symptomatic leaves.

Diversity of phyllosphere microbiome

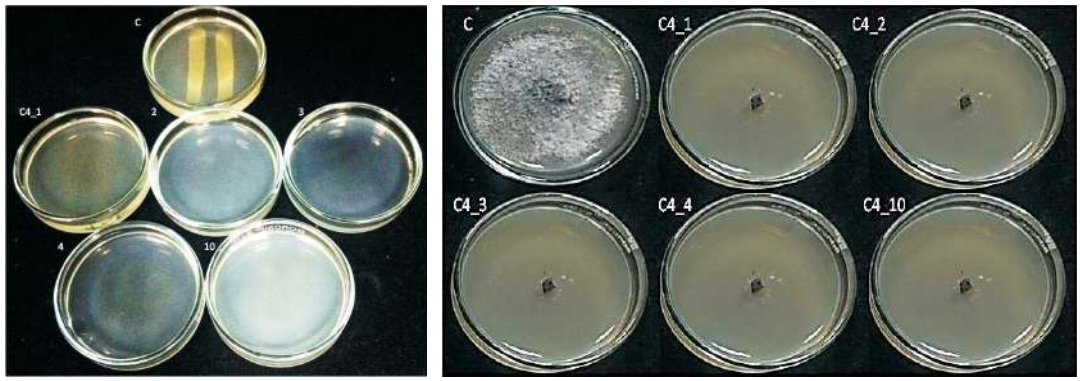
Sample Name	Observed OTUs	Shannon alpha diversity	Total number of rRNA sequences identifying OTUs
Healthy leaf	1026	5.46313816771	282377
Mild symptom	249	0.582068206601	186349
Severe symptom	270	0.990035634827	109243

The cultural bacterial diversity was assessed using polyphasic approaches. The bacterial flora on phyllosphere was dominated by *Bacillus species such as Bacillus subtilis, Bacillus megaterium, Bacillus cereus* followed by *Pantoea species* such as *Pantoea agglomerans, Pantoea anthophilia, Pantoea septica.* Other bacteria found on the phyllosphere included *Phyllobacterium sp, Massilia varians, Sphingomonas yunnanensis, Aureimonas phyllosphaerae, Pseudomonas psychrotolerans* and *Pseudomonas oryzihabitans.*

Bacterial species were evaluated as antagonist of *Xanthomonas axonopodis* pv. *punicae* and *Ceratocystis fimbriata*. Twenty two of them were found to exhibit bactericidal activity against bacterial blight pathogen. Another nineteen of them exhibited fungicidal activity while eight of them had fungistatic activity.

The volatiles released from the two highly antagonistic bacteria *Bacillus subtilis* and *Massilia varians* in broth culture were assessed by Solid phase micro extraction method. A total 50 VOCs were detected in GC-MS analysis of *Bacillus subtilis* and 22 VOCs were detected in *Massilia varians*. Compounds such as Benzene, 1, 2, 3-trimethyl; Oleic Acid; Pyrazine, 2, 5-dimethyl; Pyrazine, 3-ethyl-2, 5-dimethyl were common in both the bacteria.

Potential of these phyllospheric microbial communities for disease management in organic system of pomegranate cultivation has immense significance.



Effect of leaf associated bacterial volatile organic compounds on *Xanthomonas axonopodis* pv. *punicae* (left) and wilt fungus *Ceratocystis fimbriata* (right)

Experiment 6.2. Studies on host pathogen interaction using multiprong approaches

Experiment 6.2.1. XopN T3SS effector of Xap regulates O_2^- activation on pomegranate leaves to favour blight development.

XopN, one of the core effectors of Xap, is involved in suppressing the O_2 accumulation on pomegranate leaves during infection. The O_2 accumulation on pomegranate leaves was assayed using NBT staining method. The Xap ΔxopN produced significantly higher O_2 accumulation compared to the wild type. Earlier studies show that XopN also suppress H_2O_2 production during infection. In this context, observation on another ROS molecule corroborates the fact that XopN plays key role in the suppression of ROS associated immune responses of pomegranate. The study was done at IARI.

Experiment 6.2.2. Changes in defense enzymes in pomegranate plants treated with phytohormones and signal molecules

In the study carried out at UHSB, activity of polyphenol oxidase (PPO) was highest at 12 hours post inoculation (hpi) with salicylic acid (SA) recording 2.42 folds upregulation, ethephon/ Ethrel (ETH) with 1.98 folds, 2,4-D with 2.03 folds compared to control. Paclobutrazol (PZ) treatment, upregulated POP by 1.27 folds at 24 hpi. The other treatments did not show significant increase in PPO activity.

The Phenylalanine ammonia-lyase (PAL) activity was highest at 0 hpi with chitosan treatment showing 3.66 fold upregulation followed by ethrel with 2.08 fold increase compared to control The other treatments did not show significant increase in PAL activity.

Both ethrel and paclobutrazol treatments showed maximum Peroxidase (POD) activity of 1.29 and 1.00 folds at 72 hpi respectively. Foliar application of 2,4-D at 30 ppm induced POD activity by 0.91 folds at 48 hpi compared to control.

Chitinase enzyme was maximum upregulated by chitosan treatment soon after the pathogen inoculation as evidenced by 11.32 fold upregulation at 0 hpi. However, the extent of upregulation was not observed in the later stages. In comparison, ethephon treatment upregulated chitinase at all stages with significant upregulation at 0, 3, 6 and 96 hpi by 7.62, 3.06 and 1.45 folds followed by 2,4-D treatment at 0, 3, 24 and 48 hpi by 3.65, 1.18,1.83 and 2.18 folds respectively. Interestingly, both salicylic acid and nitric oxide treatment showed unregulated activity only at 48 hpi.

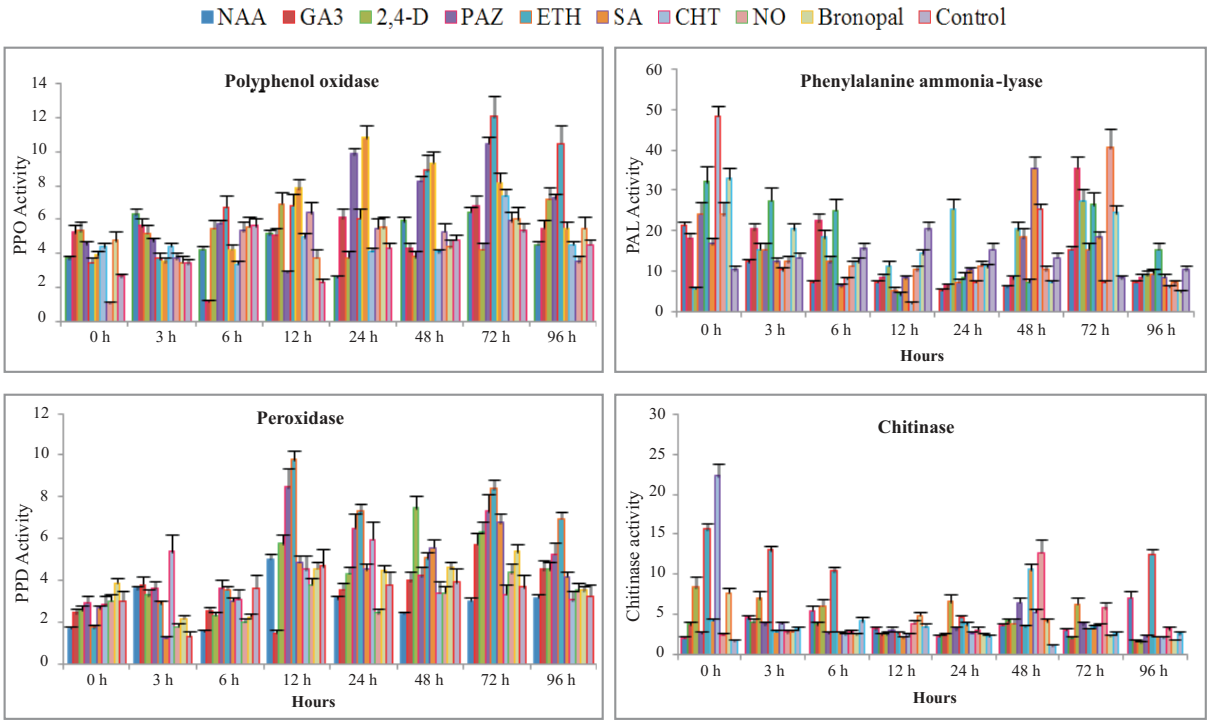
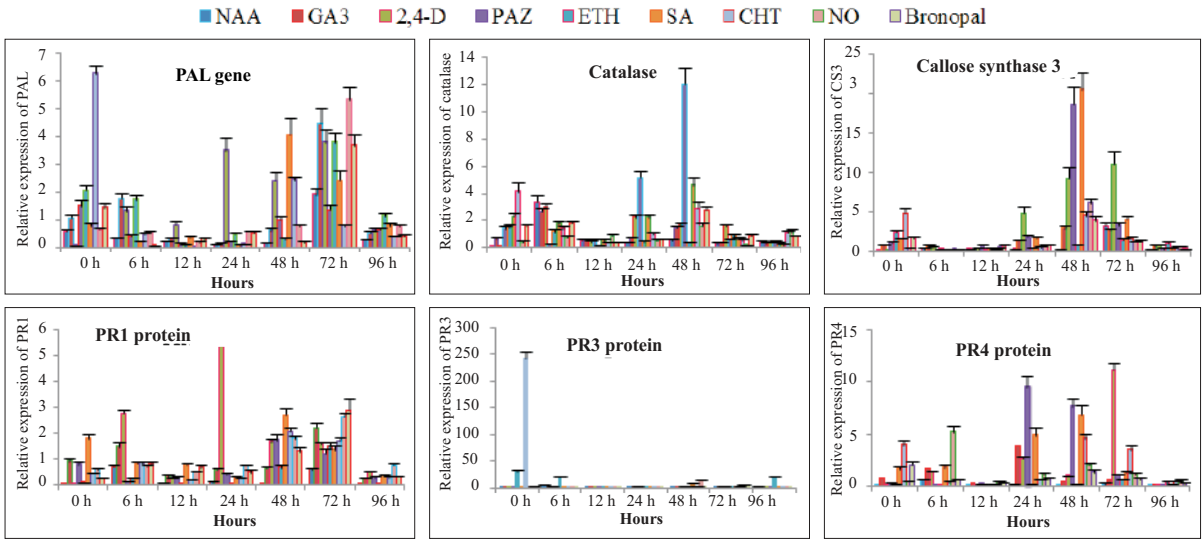


Fig. Effect of plant growth regulators and signal molecules on biochemical enzyme activity at different time intervals upon challenge inoculation with *Xanthomonas axonopodis* pv. *punicae*

Experiment 6.2.3. Defense and pathogenesis related gene expression in various phytohormones and signal molecules treated pomegranate plants

The study was carried out at UHSB. Chitosan (CHT) treatment showed 6.31 fold upregulation of Phenylalanine ammonia-lyase (PAL) gene expression at 0 hours post inoculation (hpi) and later showed gradual decrease in its expression at 6, 12 and 24 hpi. Ethephone -Ethrel (ETH) treatment also upregulated PAL gene by 2.07, 1.76 and 1.15 folds at 0, 6 and 72 hpi followed by salicylic acid (SA) by 4.09 and 2.42 folds at 48 and 72 hpi compared to control. Paclobutrazol (PAZ) treatment upregulated catalase gene by 12.04 and 5.14 folds respectively at 48 and 24 hpi followed by salicylic acid treatment at 48 hpi by 4.60 folds respectively compared to control. The other treatments did not show much increase in expression of catalase gene compared to control. Similarly, foliar application of salicylic acid and paclobutrazol treatment showed maximum upregulation of callose synthase -3 (CS-3) gene at 48 hpi by 20.63 and 18.63 folds followed by 2,4-D treatment with 11.03 folds at 72 hpi compared to control. Pathogenesis related protein, PR-1 showed maximum upregulation upon 2, 4-D treatment by 5.39 folds at 24 hpi compared to control. The other treatments did not show significant increase in PR-1 gene compared to control treatment. PR-3 gene was prominently upregulated by a striking 241.72 folds upon chitosan treatment soon after the pathogen inoculation. However, the upregulation was not consistent upon later stages. Ethephon treatment also upregulated PR-3 gene significantly by 32.19 and 22.54 folds at 0 and 6 hpi followed by an intermittent down regulation at intermediate stages and a significant upregulation at the last stage by 21.97 folds. Maximum upregulation of PR-4 gene was noticed in 2,4-D treatment at 72 hpi by 11.17 folds followed by paclobutrazol and salicylic acid treatment at both 24 and 48 hpi by inducing 9.55, 4.91 and 7.65 and 6.84 folds respectively. In contrast, ethrel treatment down regulated the PR-4 gene expression at different time intervals compared to control.



Relative expression of defense related genes (PAL, catalase and callose synthase 3) and pathogenesis related proteins (PR1, PR3, and PR4) as determined by qRT-PCR in various phytohormones and signal molecules treated pomegranate plants

In all 7 defense genes in host pathogen interactions were characterized and used for assessing the level of resistance induction by different elicitors.

Pomegranate gene sequences submitted to NCBI-GenBank

Gene	Accession No.
Punica granatum pathogenesis-related protein 1 (PR-1)	KU977458
Punica granatum pathogenesis-related protein 3 (PR-3)	KU977459
Punica granatum Pathogenesis-related protein 4 (PR-4)	KU977460
Punica granatum phenyalalanine ammonia-lyase (PAL)	KX450397
Punica granatum Catalase (CAT)	KX450396
Punica granatum Callose synthase 3 (CS-3)	KY933658
Punica granatum Elongation factor 1 Alpha	KU977461

Experiment 6.3. Standardization of techniques for mass production of disease (BB) free planting material of commercial varieties

Among 10 sanitization protocols tested at NRCP including hot water and chemical treatments, 1% fabric bleach (Sodium hypochlorite-4% + Sodium hydroxide-1% + Amine oxide-1%) was most promising with 98 % survival of cuttings in comparison to 86% in control, however effect on latent nodal blight development could not be evaluated as none of the treatments (control included) recorded nodal blight after 10 months in survived cuttings.

Experiment 6.4. Phenotyping and Genome wide analysis of Xap strains originating from diverse geographical locations

Four districts covering 22 villages of Himachal Pradesh were surveyed by YSPUHF, for

bacterial blight status and collection of pathogen isolates for strain variability studies. The disease severity on leaves varied from 2.34 to 79.33 %, whereas on fruits the disease incidence ranged from 0-52.50%. All the locations of Kinnaur district were free from blight. Pomegranate germplasm from this district should be added to germplasm block for screening through challenge inoculation. In all 10 Xap isolates were collected and verified using phenotypic and molecular techniques.

Status of bacterial blight in pomegranate areas of Himachal Pradesh

District	Village	Variety	Bacterial blight	
			Severity (%) on leaves	Incidence (%) on fruits
Sirmour	Sarahan, Dano Devria, Jamta, Kalaghat, Nainatikkar, Narag, Bagthan	Kandhari Kabuli, Wild pomegranate, Bhagwa, Kandhari Kabuli	234 – 33.32	0.00-15.66
Solan	Kandaghat, Massaria, Nauni	Mridula, Kandhari Kabuli, G-137	8.80-79.33	6.31-80.00
Kinnaur	Chotakamba, Nichar, Sharbo, Tapri	Wild pomegranate	0.00	0.00
Shimla	Dhanda, hami, Halog, Waknaghat, Ghannati, Baag, Basantpur, Simlo	Shirin Mohd Ali, Wild pomegranate, Kandhari Kabuli,	7.15-65.55	2.18-52.50

Experiment 6.5. Developing cultivar/s resistant to pomegranate bacterial blight

Experiment 6.5.1. Gene expression upon blight infection in moderately resistant and susceptible pomegranate genotypes

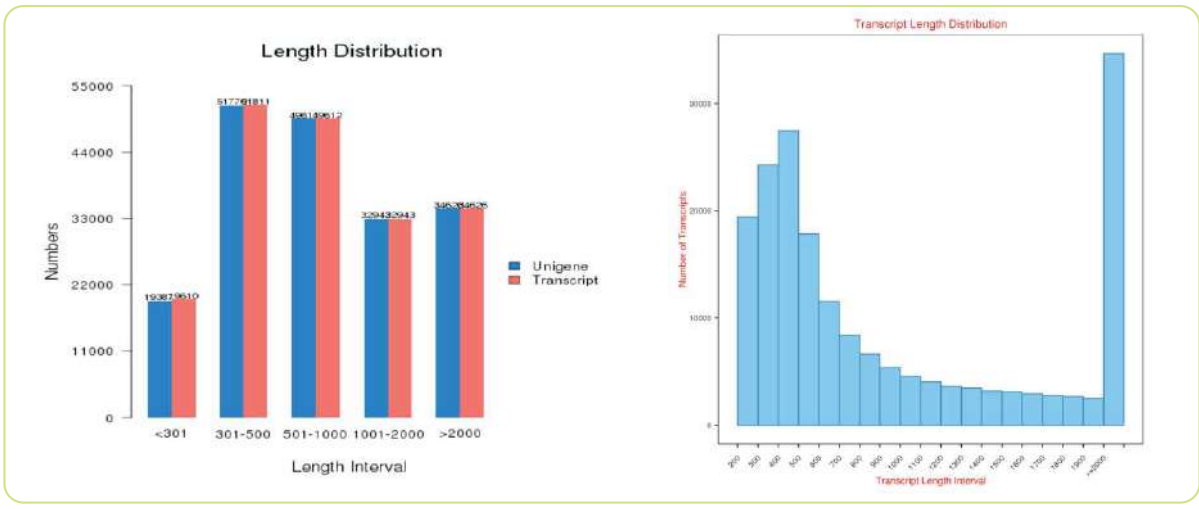
With the aim of finding out differentially expressed genes/unigenes/transcripts upon blight infection in moderately resistant and susceptible pomegranate genotypes and uninoculated control, sufficiently large transcriptome data were generated in pomegranate by NRCP. Twelve samples consisting of leaves and fruits of susceptible and moderately resistant geneotypes at different stages of blight infection were taken for total RNA isolation and cDNA library preparation. The total raw data generated from these samples using Illumina SBS V4 chemistry is 89.58 GB and the data filtered from raw data i.e., clean data is 87.64 GB with more than 92 % Q30 score for all the samples and more than 94 % for most of the samples.

Summary of sequencing data information

Sample Name	Raw Reads	Clean Reads	Clean Base (GB)	Error Rate (%)	Q20 (%)	Q30 (%)	GC Content (%)
LS_1	58279956	56911978	8.54	0.01	98.21	95.57	50.07
LS_2	64644180	63438302	9.52	0.01	98.23	95.59	49.32
LS_3	57946290	56346098	8.45	0.01	97.77	94.31	49.85
FS_1	20630104	19691646	2.95	0.01	97.35	93.47	54.63
FS_2	19578544	18764108	2.81	0.02	97.06	92.70	54.39
FS_3	21913568	21063454	3.16	0.02	97.01	92.57	54.29
LS_C	49579848	48131138	7.22	0.02	96.83	92.01	50.84
FS_C	49733888	47679996	7.15	0.01	97.94	94.85	49.90
LT_1	59916394	58049980	8.71	0.01	97.80	94.69	49.99
FT_1	23247992	22516058	3.38	0.01	97.56	93.84	47.50
LT_C	55469742	53602820	8.04	0.01	97.91	94.53	51.03
FT_C	20155262	19607290	2.94	0.01	97.83	94.21	48.23

LS - Leaves of bacterial blight susceptible genotype
FS - Fruits of bacterial blight susceptible genotype
LT - Leaves of bacterial blight tolerant genotype
FT - Fruits of bacterial blight tolerant genotype
1 - Bacterial blight initial stage with water soaked lesions
2 - Bacterial blight water soaked relations surrounded by necrotic lesions.
3 - Bacterial blight necrotic lesions in advance stage
C - Control with no bacterial blight lesions.

The number of transcripts/ unigenes with size more than 2 kb is 34626 and more than 85 % of the unigene were annotated at least in one of the seven databases *namely*, NR, NT, KO, Swiss Prot, PFAM, GO, KOG and 11 % were annotated in all the seven databases.

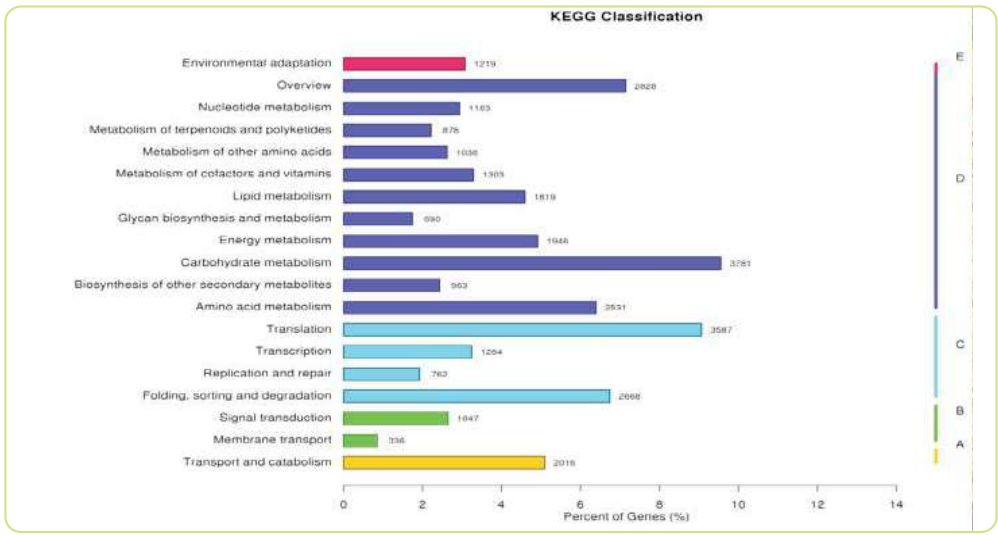


Length distribution of transcripts and unigene

After GO annotation, the successfully annotated genes were grouped into three main GO domains i.e., Biological Process (BP), Cellular Component (CC), Molecular Function (MF). The KEGG metabolic pathways genes depicted 2016 gene involved in cellular processes, 1386 genes in environmental information processing, 4714 genes involved in genetic information processing, 20101 genes involved in metabolism, and 1219 genes in organismal system.

The ratio of successfully annotated genes

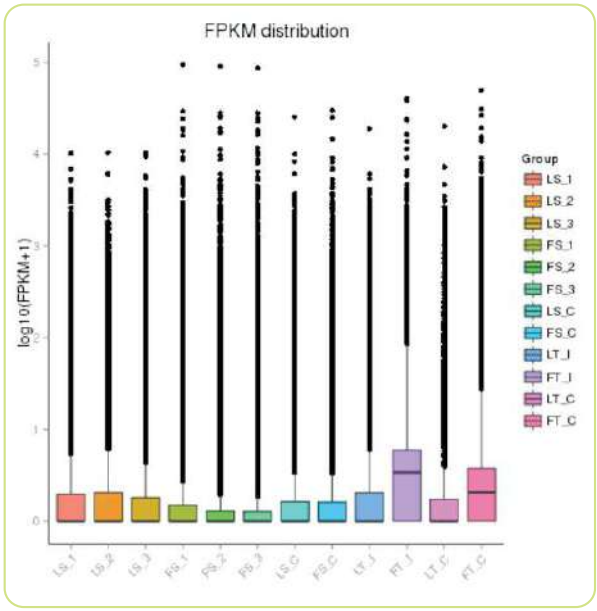
Database for Annotation	Number of Unigenes	Percentage (%)
Annotated in NR	94535	50.19
Annotated in NT	129632	68.82
Annotated in KO	39558	21
Annotated in SwissProt	124999	66.36
Annotated in PFAM	89152	47.33
Annotated in GO	90485	48.04
Annotated in KOG	54102	28.72
Annotated in all Databases	21606	11.47
Annotated in at least one Database	160683	85.31
Total Unigenes	188337	100



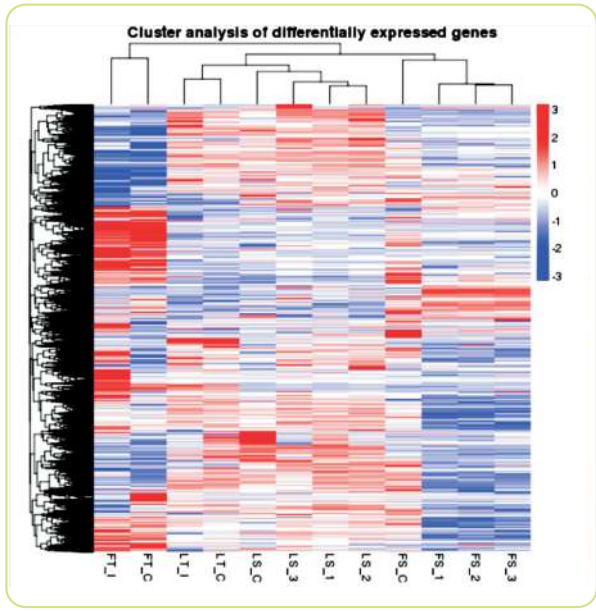
KEGG Classification

Y-axis is the names of KEGG pathways; X-axis is the number of the genes annotated in the pathway and the ratio between the number in this pathway and the total number of annotated genes. The KEGG metabolic pathways gene involved in are divided into 5 branches: A: Cellular Processes, B: Environmental Information Processing, C: Genetic Information Processing, D: Metabolism, E: Organismal Systems.

In toto 1300 genes expressed differentially in sample LS1 (susceptible genotype with blight infection stage I on leaf) and LS control (susceptible genotype non-inoculated leaf) and 2088 genes expressed differentially in LS 1 (susceptible genotype with blight infection stage I on leaf) and LT1 (moderately resistant genotype with blight infection stage I on leaf).



Gene expression levels under different experimental conditions box plot of fpkm



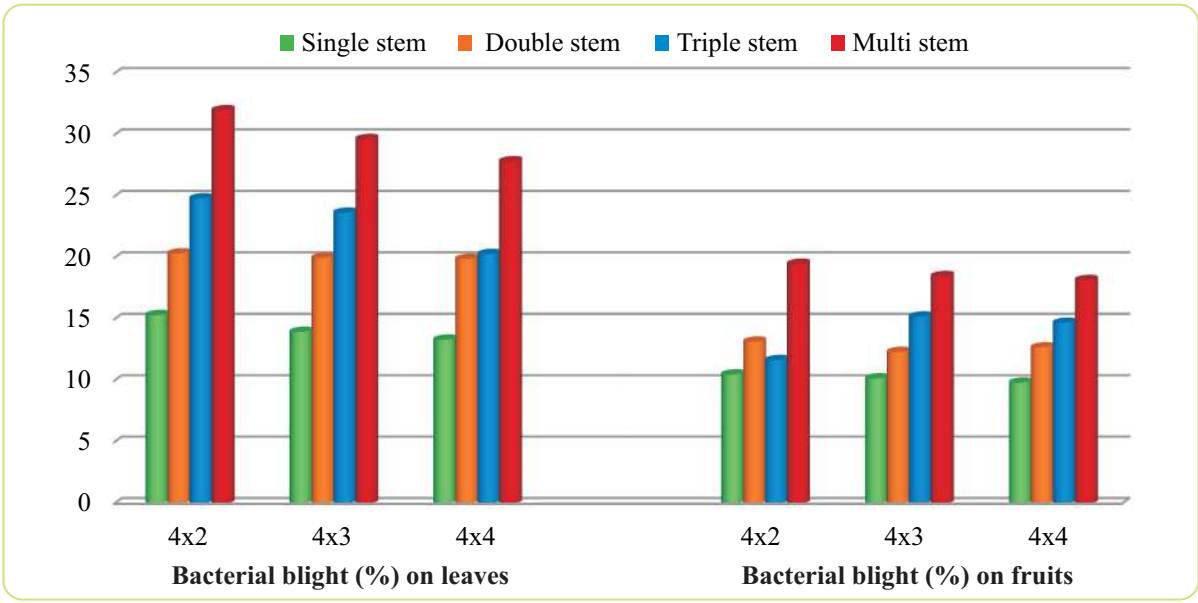
FPKM cluster analysis, clustered using the log10 (FPKM+1) value.

(Red denotes genes with high expression levels, and blue denotes genes with low expression levels)

Experiment 6.6. Development of IDM

Experiment 6.6.1. Effect of plant architecture and geometry on the extent of disease

In a farm trial at YSPUHF, Solan with variety Kandhari Kabuli, plant architecture (single, double, triple and multiple stem) and spacing 4x2, 4x3, 4x4m significantly influenced bacterial blight. Maximum blight was recorded in multiple stem plants at a spacing of 4x2 m and minimum disease in single stem plants at 4x4m spacing.



Effect of plant architecture and geometry on bacterial blight

Experiment 6.6.2. Modified IDM Schedule

The modified IDM schedule at NRCP, using bioformulations having *Aspergillus niger* AN 27 and VAM fungi *Rhizophagus irregularis* along with FYM twice a year from planting, adding Sulphur and humic acid for optimum soil pH and sprays for insect and fungal disease control as and when required, was found to reduce BB by 95.75% in first year of fruiting and 100 % in second year along with improved plant growth and productivity by 29.5%. No bactericides have been sprayed in the plot for last 18 months and still there is no blight. The use of these bioformulations was also found to check wilt in 3 year old plantation completely. In the treated plot no wilt incidence was recorded during last 2 years after initial wilt of 4 plants due to *Ceratocystis fimbriata* within 6 months of planting.

Produce from modified IDM plot at NRCP Hiraj block in 2015 and 2016 (Top three rows) and flowering in March 2017 (Bottom row)

7. POST-HARVEST MANAGEMENT AND VALUE ADDITION

Project Title	:	Post harvest management value addition and improving knowledge of stakeholders for increasing production and marketing of pomegranate
PI	:	Dr. Nilesh N. Gaikwad
Co-PI	:	Dr. R. K. Pal, Dr. K. Dhinesh Babu

Experiment 7.1.Effect microwave pretreatment on pomegranate seed oil recovery and quality

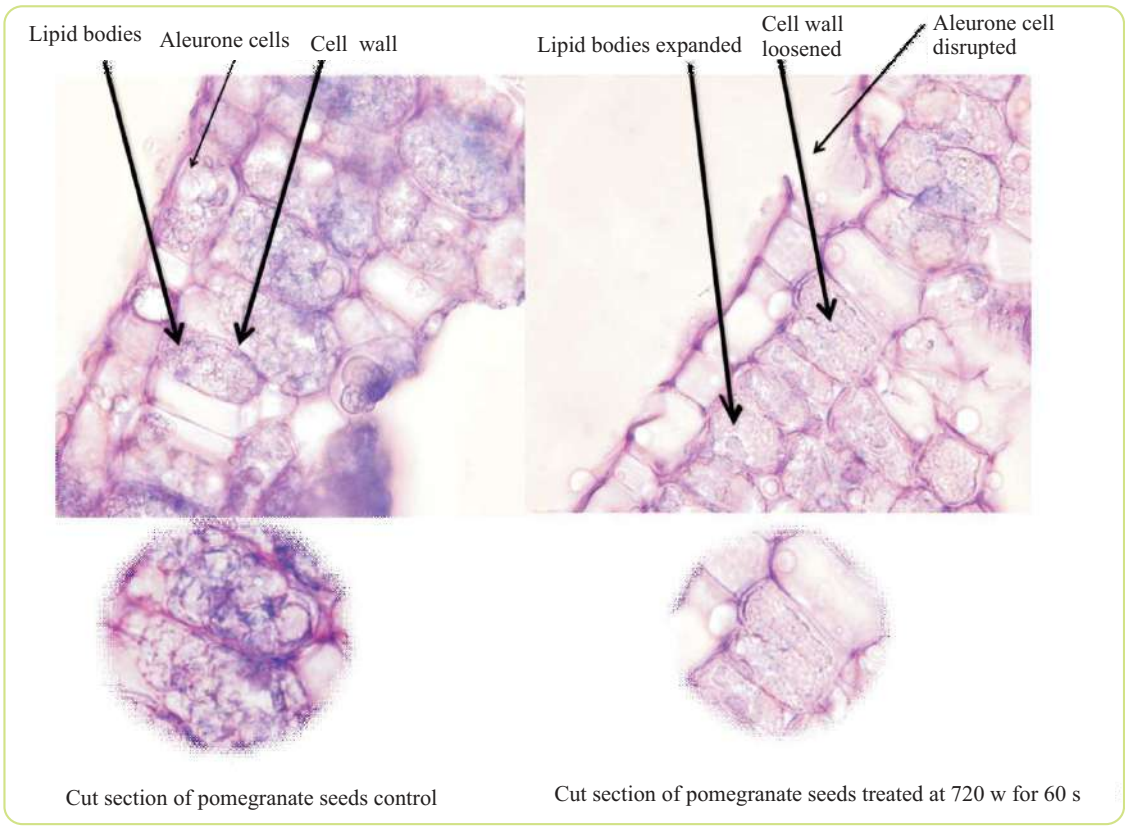
To study effect of microwave pretreatment on pomegranate seed oil recovery and quality experiments were conducted. The seed samples were pretreated in microwave oven at microwave power levels of 360, 540, 720 and 900 watt for pretreatment time of 30, 60, 90, and 120 seconds. Oil was extracted with three levels of extraction time (3, 4 and 5 h). The extraction yield increased with increase in wattage and pretreatment time. The microwave pretreatment also reduced the extraction time. The data on oil yield at different MW level, pretreatment time and extraction time has been tabulated . The microwave pretreatment did not affect the oil quality parameters such as per cent free fatty acid, acid value, saponification value, ester value, per cent glycerin and antioxidant capacity. The thin cut section of pomegranate seed kernel was studied under microscope. The thin cut section of seed kernel was cut with razor blade. The cut section was placed on clean and dry glass slide. The ethanol, histoclear, single distilled water and toluidine blue (as stain) were added at 1 minute intervals each. The slides were flooded with water, and as soon as the water douches the first section, DePex was put on a coverslip, placed over sections and allowed to dry overnight. A Nikkon (Eclipse 90 i, Kawasaki, Japan) light microscope equipped with Nikkon (DS- Ri 1 model, Kawasaki, Japan) photographic camera was used to view and record representative images. Microwave pretreatment on pomegranate seeds shows that aleurone cell gets disrupted, cell walls containing lipid body gets loosened and the lipid bodies released. The optimum conditions for microwave pretreatment were 720 watt, pretreatment time of 60 s and extraction time of 4 h.

Effect of microwave level, pretreatment time and extraction time on seed oil recovery

MW Level (w)	Pretreatment Time (s)	Pomegranate seed oil recovery V/W (%)		
		Extraction Time (h)		
		3	4	5
control		18.00	19.98	20.72
360W	30	18.47	20.13	20.80
	60	19.37	22.13	22.23
	90	19.63	22.40	22.43
	120	19.90	22.60	22.77
540W	30	21.50	22.00	22.53
	60	24.00	24.90	24.77
	90	24.23	25.20	25.07
	120	24.50	25.37	25.33

MW Level (w)	Pretreatment Time (s)	Pomegranate seed oil recovery V/W (%)		
		Extraction Time (h)		
		3	4	5
720W	30	21.87	23.00	23.53
	60	26.77	28.30	28.20
	90	26.63	28.33	28.33
	120	26.87	28.50	28.43
900W	30	22.20	24.47	24.93
	60	26.90	27.63	27.93
	90	26.67	27.9	27.83
	120	26.87	27.83	28.00

F1 CD=0.218, F2 CD=0.723, and F3 CD=0.189
All three factors were found to be significant on % oil recovery at p ≤ 0.05 %



Pomegranate cut section under micrscope at 1000X magnification

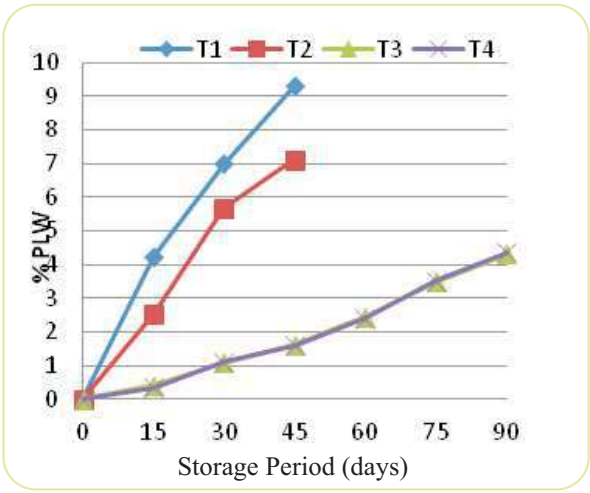
Experiment 7.2. Effect of wax coating and packaging on storability of pomegranate fruits:

The present investigation has been planned to study post-harvest quality of pomegranate fruits cv. Bhagwa during and post cold storage. Improvement in storability will be beneficial for long distance transport through sea for export to Europe and USA. The cold storage studies are useful to avoid distress sale during glut situation. The information on post

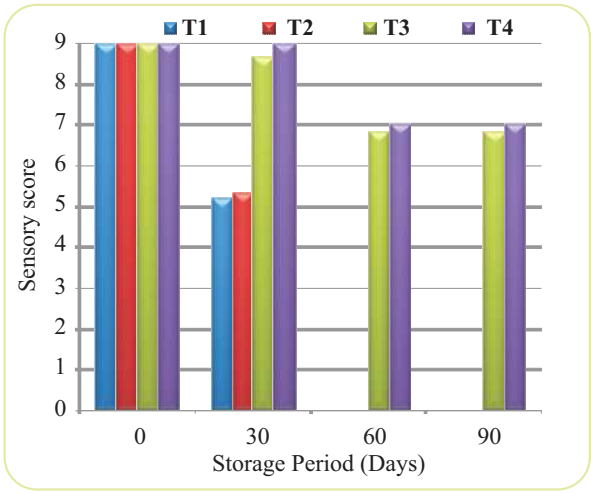
cold storage shelf-life will be important for retail marketing. The four treatments studied were Control (T1), wax pretreatment (T2), packaging in liner bag (T3), wax pretreatment and packaging in liner bag (T4). Fruits with different treatments were stored at 5 ℃ at 90% RH. The experiment was laid down with factorial design. The fruits were wax pretreated with shellac (18 %) in commercial waxing line followed by packaging in Flexfresh™ liner bags wherein 3.5 kg fruits were accommodated. The packaged fruits were placed in open top cartons box at 5±0.5 ℃ at 90± 1% RH. The quality parameters of stored fruits such as per cent physiological loss in weight, texture, color, sensory attributes and the biochemical parameters such as total soluble solids (°Brix), acidity (%), antioxidant (mg/100ml of ascorbic acid), total phenol content (mg GAE /L), anthocyanin (mg/100ml) and ascorbic acid (mg/100ml) were determined.

The data on quality parameters was analyzed at 15 days interval for storage period of 90 days. It has been observed that the control fruits which have neither been wax treated nor packaged in liner bags were acceptable only up to 30 days, on the basis of sensory score. The PLW on 30th day for control fruits was 7.00%. The wax pretreated fruits were acceptable on the basis of sensory score up to 45 days with PLW of 7.10 %. The fruits packaged in liner bag either pretreated or non-treated with wax were found to be acceptable up to 90th day of storage with low PLW of 4.30 and 4.36% respectively. The wax treatment improved storability of fruits by 15 days over control fruits. The fruits treated with wax and packaged in liner bag improved storability significantly by 60 days over control.

The experiment was carried out for post cold storage shelf life of fruits. The fruits were removed at every 15 days from cold store and evaluated for PLW on each day of post cold storage. The fruits were waxed, packaged and were stored at room temperature, mall condition (20 °C). The post cold storage shelf life of fruits stored in cold store (5±0.5℃ at 90± 1% RH) and removed on 90th day was found to be 3 and 4 days for storage at room temperature and mall condition respectively. The post cold storage wax treated fruits on 0th day, at room temperature, on 4th day and at mall conditions on 5th day were depicted.



PLW (%)



Sensory score

PLW (%) and sensory score of pomegranate fruits stored upto 90 days

Control fruits on 0th Day

Shellac wax treated on 0th Day

Control fruits on 30th day of cold storage

Shellac wax treated and packaged in liner bag on 90th day of cold storage

The fruits appearance before and after cold storage

Wax treated fruits on 90+ 1st day

Wax treated fruits at room temperature on 90+4th day

Wax treated fruits at 20 °C on 90+5th day

Post cold storage (90 days in liner bag packaging) pomegranate fruits at different storage conditions

Experiment 7.3. Grading

Seven commercial cultivars were examined with respect to fruit grading. The fruits harvested from the trees were sorted into different grades and were counted. The percentage of different grades are as follows. King size grade was highest in G-137 (2.47%) followed by Jalore Seedless (2.00%). Queen size grade was highest in G-137 (14.84%) followed by Ganesh (14.72%). Prince size grade was highest in Jalore Seedless (38.74%) followed by G-137 (37.43%).

Among the different grades, largest proportion of fruits belonged to prince size (35.56 %) followed by 200-300g grade (28.75%) in Bhagwa.

Grading (%) of fruits of commercial varieties

Variety	King size >500g	Queen size >400-500g	Prince size >300-400g	>200-300g	>100-200g	<100g
Bhagwa	1.47	12.50	35.56	28.75	14.77	6.82
Ganesh	2.21	14.72	36.87	28.01	12.84	4.76
Ruby	0.71	9.88	34.04	32.14	15.83	6.66
Jalore Seedless	2.00	14.11	38.74	25.82	14.11	5.24
G-137	2.47	14.84	37.43	25.76	13.07	4.94
Arakta	0.80	8.90	32.00	34.50	16.20	8.50
Mridula	0.80	8.70	33.20	30.58	16.30	8.70

Experiment 7.4. Juice recovery

Commercial cultivars of pomegranate were evaluated for their juice recovery percentage by two different methods. ie. Extraction from cut fruits (halved fruits) by using hand press and extraction of juice from extracted arils. The juice recovery was found to be comparatively higher from the arils compared to halved fruits. Arakta recorded the highest juice recovery from halved fruits (46.43%) and from arils (49.22%).

Variety	Juice recovery (%)	
	Extraction from halved fruits	Extraction from arils
Bhagwa	41.99	43.71
Ganesh	45.70	48.50
Ruby	43.00	45.00
Jalore Seedless	44.83	47.52
G-137	45.36	48.20
Arakta	46.43	49.22
Mridula	45.88	48.81

8. EXTERNALLY FUNDED PROJECTS

8.1. Establishment of DUS centre at ICAR-NRC on Pomegranate, Solapur

Project Title : Establishment of DUS centre at ICAR–NRC on Pomegranate, Solapur
PI : Director, ICAR-NRCP
Co-PI : Dr. Shilpa Parashuram

During 2016-17, twenty pomegranate germplasm were characterized for fruit, morphological, physico- chemical properties as per the DUS descriptors, PPV &FRA, New Delhi. In total, 28 observations were recorded. All accessions recorded higher plant height (cm) except Patna-5 and G-137, All germplasm were spreading type except IC-524027, IC-444200 and IC-444201. Leaf blade length of all the accessions were long except IC-444201, IC-444204, IC-444206, IC-444207, IC-444208 having medium length, leaf blade width(mm) were all medium except in Patna-5, which has having elliptic lanceolate. Leaf blade shape of 20 genotypes were lanceolate. Leaf blade apex shape of 19 were obtuse whereas G-137 has acute type.

Petiole length (mm) of all were short except G-137, KRS, Patna -5, IC-524027, IC-524030, IC-444200, IC-444206, IC-318707, IC-318716 having medium petiole length. Petiole anthocyanin colouration (% part covered) in IC-524031, IC-0599597, having high coloration while Surat Anar, IC-524027, IC-444200, IC-444206, IC-444207, IC-444208, IC-0599595, IC-318766 with medium coloration and rest are with low anthocyanin coloration. Calyx length (mm) of all were mediumh except Bedana Sri and Surat Anar. Calyx width (mm) of Surat Anar with broad calyx while IC-524027, IC-524030, IC-524031, IC-444200, IC-444201, IC-444208, IC-0599595, IC-318716, IC-318766 having narrow width and others with medium calyx width. Calyx color and Corolla color of all accessions were orange. Corolla type of all genotypes was single. Petal length (mm) of all genotypes were medium except in IC-524030, IC-524031, IC-444201, IC-318716, having short petals. Petal width (mm) was medium except IC-524030, IC-524031, IC-444201, IC-318716, having narrow width. Fruit length (cm) of Bedana Sri, G-137, KRS, Patna-5, were long, while BedanaThinskin, Surat Anar, IC-444206, IC-444207, IC-444208, IC-0599597 and IC-318707 have medium length and others with short fruit length.

Fruit diameter (cm) of IC-524027, IC-318716, IC-318766 were small whereas Bedana Sri, Bedana Thinskin, G-137, KRS, Patna -5, Surat Anar, have larger diameter and rest had medium diameter. Fruit color of IC-444200, IC-444201 and IC-444207 was yellow coloured fruits and rest were with other coloured fruits. Rind thickness (mm) of Patna-5 have thick rind, while Bedana Sri, G-137, KRS, Surat Anar, IC-524031, IC-444206, IC-444207, IC-0599597, IC-318766 have medium thick rind and others with thin rind. The nipple or fin was absent in all except Bedana Sri, G-137. Crown length (mm) was medium length in Bedana Sri, KRS, Patna -5, Surat Anar, IC-0599595, IC-0599597, IC-318707 and others having short crown length, Crown neck Present in all genotypes.

Aril colour of IC-444201 was with light yellow arils, while Bedana Thinskin, G-137, Surat Anar, IC-524031, IC-444207, IC-444208, IC-0599595, IC-0599597, have pink arils and rest with light pink arils. Aril length (mm) of Bedana Sri, G-137, KRS, Patna -5, Surat Anar, IC-318707, have medium length and others with short length arils. Aril width (mm) of all genotypes have medium aril width. Regarding Seed hardiness, all were hard seeded except G-137, KRS, Patna -5, having medium hard s

eeds. TSS (° brix) of Bedana Sri, Patna -5, Surat Anar, IC-0599595, IC-0599597 was medium TSS(^{0}Brix), and others were with high TSS (°B). Acidity (%) of Bedana Sri, BedanaThinskin, Patna -5 were medium acidity, while G-137, KRS, were low in acidity and others were with high acidity.

8.2. Consortium Research Platform on Agro biodiversity

Project Title : Consortium Research Platform on Agro biodiversity
PI : Dr. R.K. Pal
Co-PI : Dr. Shilpa Parashuram

During 2016-17, 25 genotypes of pomegranate were characterized for 20 were recorded for fruit, Physico- chemical properties as per the DUS descriptor, PPV &FRA, New Delhi, the 20 genotypes are as follows, IC- 1201, IC – 1203, IC – 1205, IC- 1181, IC – 1182, IC-1184, IC-1185, IC-1196, IC-1197, IC- 1198, IC – 318723, IC-318728, IC-318703, IC-318718, IC- 318720, IC- 318762, IC-318724, IC- 318734, IC-318743, IC -318706, IC-318735, IC-318744, IC-318766, Acc. – 2 and Acc. -5 . Fruit shape of all accessions were round, Fruit skin colour of all accessions were yellow with pink tinge except in IC -1182 having yellow skin colour, fruit length (mm) was ranged between 4.81 (IC-318766) to 6.61 (IC-318703), Fruit width (mm) ranged between 4.94 to6.69 mm in IC-318766 and IC-318762 respectively, Fruit weight(g) of selected accessions were ranged from 80.25 (IC-1197) to 207.10(IC - 318706) g. Number of arils / fruit were recorded lowest(130.71) in IC-318766 and highest number of arils/ fruit in IC – 1205 (322.93). Dry weight of 100 arils (g) are recorded highest of 9.53 (IC -318706) and lowest of 5(IC - 1197).

Aril colour of fruits varied from yellow to pink, IC - 318723 was yellow, IC- 1198 was with light yellow arils, whereas, IC- 1201, IC – 1203, IC- 1181, IC – 1182, IC-1184, IC-1197, IC-318728, IC- 318720,IC-318724, IC- 318734 were light pink and rest of all genotypes were with pink arils, TSS (^{0}Brix) ranged between 15.86 (IC – 1182) to 18.98 (IC – 318706). Acidity (%) of fruits were 1.51 to 3.42% in IC -1196 and IC-318718 respectively. Juice content (%) were 26.01 to 52.02 % in IC-318766 and IC – 318703 respectively. Seed hardness of all accessions were found to be hard. Rind thickness (mm) of fruits were IC – 1203, IC-1185, IC-318744, IC-318766 and Acc -5 were medium and rest of the genotypes were with thin rind. Aril length (mm) was medium, IC – 318723, IC-318728, IC-318703, IC- 318720, IC- 318762, IC-318724, IC- 318734, IC-318743, IC -318706 and rest of the genotypes were found short types.

Aril width (mm) of all the accessions was found to be medium except in IC – 318706 which was broad. The seed length (mm) of all accessions were medium except in IC – 318728, IC – 1205, IC – 1182 and IC- 1184. Seed width (mm) was found narrow in IC – 318728, IC -1 203, IC – 1205, IC – 1184 and rest all were with medium seed width.

8.3. Demonstration of model pomegranate production practices for effective management of bacterial blight disease

Project Title	:	Demonstration of model pomegranate production practices for effective management of bacterial blight disease
PI	:	Dr. R.K.Pal, Director, ICAR-NRCP (Project Leader)
Co-PI	:	Dr. Ashis Maity (Coordinator)

The model pomegranate production practices for management of bacterial blight disease were demonstrated in six pomegranate orchards in Shej-Babhalgaon and Ankoli villages of Mohol Taluka, Solapur. However, one orchard was discontinued due to non-cooperation of selected beneficiary. The results showed that bacterial blight disease in demonstrated plots got drastically reduced to 2.49-8.93% compared to 30.02-46.85% as recorded in plots managed by the farmers.

There was 80.94-93.01% reduction of bacterial blight disease in demonstration plots as a consequence of adoption of model pomegranate production practices. Fruit yield in demonstrated plots ranged from 13.53 to 30.00 t ha^{-1}, while with farmers' own practice, it ranged from 8.40 to 22.99 tha^{-1}. A clear cut increase of fruit yield by 30.49-63.21% was recorded in the demonstrated plots as compared to farmers' owned managed plots. Before adoption of pomegranate orchards for demonstration, the yield gap was quite high, ranging from 12.00 to 22.00 t ha^{-1}. With the adoption of model pomegranate production practices, these yield gaps got narrowed down, ranging from 0-16.47 t ha^{-1}. The cost of cultivation in demonstration plots ranged from Rs. 1,02,575/- to Rs. 1,15,000/-, while income obtained from selling of produce ranged from Rs. 6,00,950/- to Rs. 15,00,000/-. The net profits in the demonstrated plots were appreciably high ranging from Rs. 4,98,375/- to Rs. 13,85,000/- with cost-benefit ratio ranging from 1:4.86 to 1:12.04 The results of demonstration of model pomegranate production practices clearly shows that if these practices are followed thoroughly, it is sure to bring down significantly the level of bacterial blight disease infection in pomegranate orchard and enhance productivity to appreciably high level. The training programmes conducted in the state of Maharashtra, Andhra Pradesh and Gujarat under this project was very fruitful in creating awareness on the management of bacterial blight disease with model production practices.

The impact of training programme could be visualized from the rising trend of area, production and productivity of pomegranate at national level. During 2012-13 the area, production and productivity of pomegranate were 113.20 thousand ha, 745 thousand MT and 6.6 MT/ha respectively which rose to 180.64 thousand ha, 1789.31 thousand MT and 9.90 MT/ha respectively in 2014-15. Because of wide spread awareness made under this project, farmers who were once thinking to uproot pomegranate orchards now planning for establishing new orchard.

8.4. Micronutrient management in horticultural crops for enhancing yield and quality
(Network Project)

Project Title : Micronutrient management in horticultural crops for enhancing yield and quality
PI : Dr. Ashis Maity

Attempts were made to determine the critical levels of Zn, Mn and B in pomegranate leaves using the data generated from the field experiment. Cate and Nelson (1965) graphical method was used using the concept of Relative yield. Critical value is defined as the lowest amount of element in plants accompanying the maximum yield. Relative % yield was calculated using the formula:

$$\text{Relative yield (\%)} = \frac{\text{Yield of check/treatment}}{\text{Maximum yield}} \times 100$$

The scattered diagram of Relative % yield (Y-axis) versus nutrient values in the leaves (X-axis) was plotted using Microsoft-Excel. A pair of intersecting lines perpendicular to the axes as overlay was drawn using computer's "Drawing" menu bar of MS-word in such a way that the diagram was divided into four sectors (two positive and two negative) of roughly equal size. Upper right and lower left quadrants are positive while others are negative. 4. The intersecting overlay lines were moved about horizontally and vertically on the diagram in such a way to accomplish maximizing the number of points in the positive quadrants and minimizing in the negative sectors. The point where the vertical line crosses the X-axis was defined as the "critical level".

The critical level for Mn, Zn and B were worked out to be 40, 29.5 and 28 mg kg^{-1} respectively. These can be used as guide for diagnosing Mn, Zn and B deficiency in pomegranate and management practices for alleviation the deficiency of micro-elements.

Effect of Mn application on the fruit yield, quality and response to bacterial blight disease

The results from the field experiment indicated that Manganese application significantly increased fruit yield, average fruit weight, total soluble solids (TSS), anthocyanin concentration and average rind thickness. Maximum increase in fruit yield and average fruit weight was obtained when inorganic salt of Mn i.e. $MnSO_4$ used @ 0.6% through foliar application and soil application (mixed and incubated with well decomposed FYM before application) @ 80 g $plant^{-1}$. However, foliar application resulted maximum increase in fruit juice TSS and anthocyanin concentration of arils. An interesting observation was noticed that Mn application caused significant reduction in sugar content (both reducing and non-reducing) of fruit and maximum reduction was noticed with the foliar application $MnSO_4$ @ 0.6%. Further, Mn application significantly reduced bacterial blight disease incidence. However, it had no significant effect of the disease severity. Here also maximum reduction in bacterial blight disease was achieved with foliar application of $MnSO_4$ @ 0.6% and soil application of $MnSO_4$ @ 80 g $plant^{-1}$.

Effect of foliar application of Zn and B on pomegranate fruit yield and quality

Foliar application of $ZnSO_4$ @ 0.3% and boric acid @ 0.25% significantly increased pomegranate fruit yield and aril per cent of fruit with concomitant reduction in rind percent when used separately. The highest increase in fruit yield was obtained with the foliar application boric acid @ 0.25% at full bloom followed by another two application at one month interval. Among the varieties, Ganesh was found to be most responsive to

the application of Zn and B. However, foliar application of $ZnSO_4$ @ 0.3% at full bloom followed by two more application at one month interval significantly improved quality attributes of fruits like phenol, anthocyanin and ascorbic acid concentration of fruit. On the contrary, foliar application of $ZnSO_4$ and boric acid caused significant reduction in sugar content (both reducing and non-reducing) of fruit.

8.5. Evaluation of chitosan derivatives and chitosan based formulation XANSIL to control bacterial blight of pomegranate. (Funded by Swasti Agro & Bioproducts Pvt. Ltd., Pune)

Project Title	:	Evaluation of chitosan derivatives and chitosan based formulation XANSIL to control bacterial blight of pomegranate.
PI	:	Dr. Jyotsana Sharma
Co-PI	:	Dr. R.K. Pal, Mr. Mallikarjun, Dr. K. Dhinesh Babu, Mr. Yuvraj Shinde

Xansil formulation by itself was not effective in reducing bacterial blight in field conditions, however, five sprays of Xansil in combination with the NRCP-IDIPM schedule reducedbacterial blight at par with NRCP-IDIPM but with significantly highest marketable yield and improved fruit quality in comparison to IDIPM schedule alone. The project has been concluded and final report ready.

8.6. Performance evaluation of Fosetyle –Al 80WP (Aliette) and other protection range chemicals of Bayer Crop Science Limited on pomegranate health and productivity. (Funded by Bayer Crop Science Limited, Mumbai)

Project Title	:	Performance evaluation of Fosetyle –Al 80WP (Aliette) and other protection range chemicals of Bayer Crop Science Limited on pomegranate health and productivity.
PI	:	Dr. Jyotsana Sharma
Co-PI	:	Dr. R.K. Pal, Mr. Mallikarjun, Dr. K. Dhinesh Babu, Mr. Vijay Lokhande

In 2 field trials conducted at NRCP during ambe and mrig bahar during 2016-17, Bayer protection range chemicals and Alliete protocols were found ineffective in checking bacterial blight and thrip infestation, however were promising and at par with IDIPM in checking some fungal fruit spots and rots and fruit borer infestation.

Four farmers plots adopted in taluka Malshiras (Solapur) jointly by BCSL and ICAR-NRCP for demonstrations of BCSL protection range chemicas schedule vs farmers schedule. For late hastH baher 2 plots (Velapur and Khandali) and 2 (Tandulwadi and Malewadi) in *ambebahar* season were adopted. The Bayer protocol plot and farmers plot recorded no significant differences in disease and insect pest management and in yield.

8.7. Horticulture crop pest surveillance and advisory project for Mango, Pomegranate, Banana, Citrus and Sapota. (Funded by State Hort. Department, Commensurate of Agri., Pune)

PI : Dr. Jyotsana Sharma
Co-PI : Mr. Mallikarjun

Surveys were conducted in 87.75 Acres of pomegranate area covering 4 talukas (Jamner, Chopda, Jalgaon and Pachora)of Jalgaon District. Blight was observed in only 2 orchards of Pachora taluka with max 4.5% BB incidence. Thrips infestation was the major problem. Fungal fruit spots were commonly observed with incidence ranging from 0-11.5%.

Surveys were conducted in 45 orchards covering 150 acres of pomegranate plantation in 8 talukas of Solapur District. Blight was observed in 6 orchards with max incidence of 3.8% ; wilt in 4 orchards with max 9% incidence, fungal spots (scab) in 21 orchards with max 4.5% incidence other disorders and diseases were in traces.

Another survey was conducted in Gujarat covering 563.5 acres of pomegranate area in 6 talukas (Anjar, Bachchau, Mundra, Mandvi, Kutch and Bhuj)of Kutch District. No bacterial blight incidence was recorded. Wilt due to *Ceratocystis fimbriata* was a major problem in Anjar, Mundra and Bhuj talukas. Recording around 5% wilt. Nematode and Thrips infestation was also one of the major problems in these areas.

Survey was conducted in seven different talukas of Solapur district to record the incidence and infestation by various borer and sucking pests on pomegranate. The infestation of thrips varied from to 50-75%, aphids 22-37%, whiteflies and mealy bugs 0.5- 4 %, fruit borer incidence varied from 7-17 % and shot hole borer and stem borer incidence varied from 5-9%.

8.8. Standardization and demonstration of propagation and production technologies for protected cultivation of pomegranate (*Punica granatum* L.) (Funded by National Horticultural Board, Gurugram)

Coordinator : Dr. R.K. Pal
PI : Dr. N.V. Singh

Initiated investigation on protected cultivation of pomegranate using 50 % shade net house with cv. Bhagwa planted at 2 m x 2m distance, fabrication of one 50 % shade net house and another 35 % shade net house of 800 m^2 each was carried out.

8.9. Mechanization in pomegranate cultivation and its demonstration (Funded by National Horticultural Board, Gurugram)

Coordinator : Dr. R.K. Pal
PI : Dr. N.V. Singh

Procured modern farm equipments and machineries including orchard sprayer machine, bag and pot filling machine, battery operated pruner, electric soil sterilizer and in-row weeder.

8.10. Development of fruit based carbonated drink from pomegranate and grapes
(Funded by Extramural research project, ICAR)

Project Title : Development of fruit based carbonated drink from pomegranate and grapes
PI : Dr. Nilesh N. Gaikwad
Co-PI : Dr. R. K. Pal

Although the health benefits are very high for pomegranate and grape juice they are not much popular as compared to commercial carbonated drinks. The reason behind this is the taste of the carbonated drink is much liked by the consumers due to their fizzy taste. Chemically, adding CO_2 to water creates carbonic acid, which is tasted by sour-sensing taste cells. However they lack in nutritional content. The research has been undertaken to standardize level of carbonation and brix acid ratio (BAR) for pomegranate and grapes based carbonated drinks and to standardize their blending.Experiment was carried out in two steps.

Initially, the process is standardized by optimizing level of carbonation and BAR of pomegranate and grape based carbonated drink. Total nine treatment combinations with three BAR (30, 35 and 40) and three levels of carbonation ie. per cent carbonated water (50,60 and 70%) were used for optimization through sensory evaluation. The carbonation level in terms of carbonic gas pressure was measured with piercing type pressure gauge. In second step the carbonated drinks of pomegranate and grape (P:G) were blended in different proportion (100:0,0:100.50:50, 60:40 and 40:60). Sensory evaluation was also carried out for these blends. Further the biochemical analysis for different blends was carried out. Carbonation found to improve the overall acceptability of fruit drink. Pomegranate and grapes juice based carbonated drinks prepared at 35 BAR and 70 % carbonation water level were best among all treatments. Blend of 60:40% of pomegranate and grape juice based carbonated drink had best sensory score as well as nutritional qualities.

Sensory evaluation scores for blends of pomegranate and grape carbonated drink

Treatment	Colour	Flavour	Taste	Overall Acceptability
Pomegranate : Grape (100:0)	8.45	7.30	8.00	7.92
Pomegranate : Grape (0:100)	7.50	6.90	6.90	7.10
Pomegranate : Grape (50:50)	8.25	7.65	8.20	8.03
Pomegranate : Grape (60:40)	8.70	8.90	8.70	8.77
Pomegranate : Grape (40:60)	7.85	7.65	7.95	7.82

Standardization of blends of pomegranate and grape carbonated drink

Treatment	Anthocyanin (mg/100ml)	Antioxidant activity (mg/100ml of Ascorbic acid	Total phenol (mg GAE /L)	Ascorbic acid (mg/100ml)
Pomegranate : Grape (100:0)	4.275	7.98	990.40	1.63
Pomegranate : Grape (0:100)	0.184	3.12	479.00	2.08
Pomegranate : Grape (50:50)	2.538	6.98	407.60	1.80
Pomegranate : Grape (60:40)	2.822	7.067	585.40	1.75
Pomegranate : Grape (40:60)	2.121	5.74	439.60	2.10
C.D.	0.074	0.237	48.752	0.122
SE(m)	0.025	0.08	16.411	0.041
C.V.	2.329	2.868	6.322	4.907

Blended pomegranate and grape fruit juice based carbonated drinks at 35 BAR and 70% carbonated water.

Piercing type pressure gauge

8.11. Trait-specific characterization of indigenous and exotic pomegranate accessions to arrive at core collection for genetic improvement programme (Funded by Extramural research project, ICAR)

Project Title	:	Trait-specific characterization of indigenous and exotic pomegranate accessions to arrive at core collection for genetic improvement programme.
PI	:	Dr. BNS Murthy, ICAR-IIHR, Bangalore
Co-PI	:	Dr. K. Dhinesh Babu, Dr. Shilpa Parashuram

Evaluation of 13 indigenous collections of wild pomegranate 'Daru' planted during 2009 at the experimental block of ICAR-NRCP, Solapur revealed that the number of fruits/plant ranged from 34 to 102 with highest in Daru-13 (102 fruits/plant). The fruit weight ranged from 30.5 to 112.5g with highest weight in Daru-1 (112.5g). The fruit yield ranged from 1.76 to 9.69 kg/plant with highest yield in Daru-13 (9.69kg/plant). Daru-4 recorded the highest value for 100 aril weight (40.5g/100 arils) followed by Daru-14 (33.0g/100arils). Total soluble solids content ranged from 14.0 to 16.7°B with highest TSS in Daru-7 (16.9°B) followed by Daru-6 (16.8°B). The titrable acidity ranged from 1.92 to 6.65%. The acidity was highest in Daru-11 (6.65%) followed by Daru-6 (5.44%) and Daru-5 (5.12%). The germplasm with titrable acidity content of above 5% viz., Daru-11, Daru-6 and Daru-5 have prospects for anardana preparation.

8.12. SNP marker based mapping of bacterial blight genes in pomegranate (Punica granatum L.) (Funded by Extramural research project, ICAR)

PI	:	Dr. Shilpa Parashuram, Scientist, ICAR – NRCP, Solapur
Co-PI	:	Dr. NV Singh, Scientist, ICAR–NRCP, Solapur
		Dr. B.N.S. Murthy, Pr. Scientist, ICAR- IIHR, Bengaluru

Screening of 192 germplasm lines including exotic, indigenous accessions and varieties was carried out against *Xanthomonas axonopodis* pv. *punicae,* 16 were found free from bacterial blight and 21 tolerant to bacterial blight at ICAR- NRCP, Solapur. Mined SNP markers using 192 genotypes through genotyping by sequencing (GBS). Identified differentially expressed unigenes in leaf and fruit tissues of susceptible and moderately resistant pomegranate genotypes.

9. ACTIVITIES UNDER TRIBAL SUB-PLAN

Introduction of pomegranate cultivation in Bankura and Purulia districts of West Bengal for livelihood security of tribal population

The western part of West Bengal (Paschimanchal) i.e. Bankura and Purulia districts experience quite similar type of climatic condition. The major crops of these two districts are rice, wheat, oilseeds and vegetables. Because of small holding size, the return on investment per unit area is quite low making agriculture less attractive and compelling tribal population to move toward city for seeking non-farm job opportunities. Under such a situation, Dr. Ram Krishna Pal, Director, ICAR-National Research Centre on Pomegranate took an initiative in convergence with MGNREGS of Bankura to introduce pomegranate for improving the livelihood security of tribal population of Bankura district under Tribal Sub-plan (TSP) scheme, Govt. of India. Initially about 3500 tissue-cultured pomegranate saplings were supplied and planted in four blocks viz. Simlapal, Bankura I, Ranibandh and Onda, each of 1 ha area during 2015-16. Realizing the scarcity of water, drip irrigation systems have been installed in all the plantations under the TSP scheme. Being new crop for the area, the demand for this crop is rising day by day. Another additional 15000 tissue-cultured pomegranate saplings have been planted during 2016-17 in different blocks of Bankura viz. Onda, Sonamukhi, Indpur, Chhatna and Purulia viz. Puncha, Kashipur and Balarampur. The establishment and growth of plants in both the districts are very much encouraging.

A view of pomegranate orchard in West Bengal

Pomegranate plant established in West Bengal

In-depth practical training on all aspects of pomegranate cultivation viz. production of planting materials, establishment of orchards, canopy management, nutrient management, plant protection measures and value addition of produce was imparted at ICAR-NRCP Solapur, Maharashtra to about 18 State Govt. employees from W.B. involved in MGNREGS and looking after these pomegranate plantations. The trainees were taken to the pomegranate growers' field in Maharashtra to provide them hands on training and exposure to the commercial pomegranate orchards.


Exposure visit of farmers from West Bengal to commercial pomegranate orchards in Maharashtra

On experimental basis, crop will be taken in pomegranate orchard at Bamunpathri, Simlapal block this year and accordingly the practices so standardized will be implemented in all other plantation made in Bankura and Purulia districts under TSP.

Introduction of pomegranate cultivation to tribal farmers of Gadchiroli district

Ten farmers were selected for demonstration of pomegranate cultivation in light texture soil at Sironcha taluka of Gadchiroli district of Maharashtra (i.e. Villages- Bamani, Ranggapalli, Gumalkonda, Poc hanpalli and Venkatpura). Each of the ten farmers was given 325 plants of pomegranate variety 'Bhagwa' along with other inputs. Technical knowhow was provided on cultivation of pomegranate. The performance of pomegranate plantation in light soil was found to be very good.


Technical inputs provided to tribal farmers at Sironcha taluka

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

The potential areas for pomegranate cultivation have been identified with respect to different categories viz., highly suitable, moderately suitable, marginally suitable and not suitable based on soil, temperature and rainfall distribution pattern. A research paper was presented at International Conference at NBSS&LUP, Nagpur on "Identification of suitable land for pomegranate (*Punica granatum* L.) cultivation in Gujarat, India by using Remote Sensing and Geographical Information System".

10. OUTREACH ACTIVITIES

10.1. Trainings/workshops

Several trainings, workshops and interactive meets were organized by different organizations in collaboration with NRCP during the, where several scientists of NRCP participated as resource persons to disseminate the technologies developed to different stake holders. These outreach activities are summarized below

S.No.	Name of the training programme	Venue	Date	Participants
1.	Training programme on GAP, POP, GHP in pomegranate organized jointly by Dept. of Agri., Govt. of Maharashtra, APEDA and confederation of Indian Industries	Hotel Surya Executive, Solapur, MS	14.05.16	50 Farmers, Exporters and other stake holders
2.	Workshop on pomegranate production, protection and value addition organized by State Department of Agriculture, Maharashtra	Sangola, Solapur, MS	18.07.16	50 growers, Sangola
3.	Outreach programme on the pomegranate processing value addition opportunities organized by APEDA	Hotel Tunga Regency, Vashi, Navi Mumbai	19.07.16	60 growers and entrepreneurs
4.	Training programme for pomegranate cultivation organized by KVK Solapur	Yedrav, Mangalweda, Solapur, MS	21.07.16	50 farmers from Mangalweda
5.	Workshop on Market Development for Pomegranate organized by APEDA and MSAMB	INI farms, Vasunde, Baramati	27.08.16	50 clients
6.	Farmer Training Programme for Planning for Hasta Bahar organized by Pomegranate Growers' Association, Pune	Sadashivnagar, Malshiras, Solapur, MS	24.09.16	500 farmers from Solapur
7.	Interactive meet with Farmers organized by NRCP and Madha Welfare Foundation	Nimgaon, Madha, Solapur, MS	28.10.16	30 farmers, Nimgaon
8.	Pomegranate Growers Workshop organized by MSAMB, ICAR-NRCP and APEDA	Shivdare Sabhagruh, Market Yard Solapur, MS	28.11.16	100 Pomegranate growers from Solapur
9.	Training to the members of tribal self -help of MGNREGS of Purulia and Bankura districts, West Bengal organized by ICAR -NRCP, Solapur	Bankura and Purulia Dist. West Bengal	13.12.16 17.12.16	50 tribal farmers
10.	Training programme for Farmers, Agricultural Officers, Scout & Pest Monitors under HORTSAP organized under RKVY, State Agri. Dept., Baramati, Pune, MS	State Agri. Dept., Baramati, Pune, MS	28.12.16	25 farmers, Baramati
11.	Agri Industry meet organized by KVK Neemuch, ICAR-ATARI zone VII Jabalpur	KVK, Neemuch, Jabalpur	11.01.17	95 growers, exporters, KVK PD from M.P.

12.	Training on Pomegranate production and value addition in changing climate scenario organized by ICAR-Zonal project Directorate, Jabalpur, MP	College of Agriculture, Indore, Rajmata Vijayaraje Scindhia Krishi Vishwavidyalaya, Gwalior, MP	13.01.17	50 Officials from 25 KVKs
13.	Training programme for Farmers on all aspects pomegranate cultivation organized by NRCP	Phondsiras, Malshiras and Natepute Solapur, MS	25.02.17	50 farmers, Malshiras
14.	Interactive meet on Export promotion in Pomegranate organized by NRCP Solapur	ICAR- NRCP, Solapur, MS	07.03.17	APEDA, MSAMB, State Horticulture department, Growers Association, Exporters and Scientists
15.	Training on Nutrient management in pomegranate organized by Akhil Maharashtra Dalimb Utpadak Sanshodhan Sangh, Pune, MS	Pune, Maharashtra	19.03.17	700 farmers
16.	Farmers- Scientist interaction meet organized by Department of Agriculture, Solapur	Rotary club hall Temburni, Madha, Solapur, MS	24.03.17	300 Farmers

10.2. Consultancy agreement signed by ICAR-NRCP

10.2.1. Establishment of minimal processing and packaging unit for pomegranate at Nashik

ICAR-NRCP signed MOU with M/s. MOSCOS Food processing Pvt. Ltd. for "Technical consultancy for establishment of minimal processing and packaging unit for pomegranates" at Nashik for export of minimally processed arils with an outlay of approximately 6.00 Crores. The consultancy fees is Rs. 6.90 lakh for providing consultancy for establishment this business start-up. The consultants for the project include Dr. Nilesh Gaikwad and Dr. R K Pal.

ICAR-NRCP and M/s. MOSCOS Food Processing Pvt. Ltd. signed MOU

10.2.2. Implementation of total orchard management practices for pomegranate plantation at Bhognipur, Kanpur Dehat (UP)

ICAR-NRCP provided consultancy for total orchard management practices for 10 ha of pomegranate plantation to M/S. Sanjeevni Fertilizers and Chemicals (P) Ltd. (Raghuvansh Agro Farms, at Bhognipur, Kanpur Dehat, Kanpur (UP). The orchard was affected with bacterial blight, fungal spots and wilt and in a bad shape at adoption. Today after 1 year of adoption it is in good health and bearing. Dr. NV Singh and Dr. Jyotsana Sharma were the advisors and Mr. Yuvraj Shinde gave technical support.

Before adoption

After adoption

Pomegranate plantation at Bhognipur, Kanpur Dehat, Kanpur (UP)

10.3. Mera Gaon Mera Gaurav

Under Mera Gaon Mera Gaurav programme interactive meets and field visits were conducted in 6 adopted vilages *viz.* Waghdari (Akkalkot), Karkambh (Pandharpur) Nimgaon (Madha) and Nandgaon, Nalduraga (Osmanabad) in Maharashtra and Jambga B Ambalaga in Kalburgi, Karnataka. In all, 193 beneficiaries were covered through Farmers –Scientist interface and demonstration organized in every month in different adopted villages. Local KVKs of Solapur and Kalburg Many farmers were motivated for cultivation of pomegranate for their livelihood. Several farmers became aware of various schemes of National Horticulture Board, GOI for establishment of new orchards and enlightened about importance of cleanliness and Swachha Bharat mission of GOI. Famers were apprised of the demerits of burning crop stubble (wheat stubble) through this training programme and became aware of conservation practices for improvement of soil health. All specific and general questions and queries of farmers related to the agriculture were answered by the scientists.

Technical know-how on pomegranate provided to farmers at Nandgaon, Tuljapur

Interaction with farmers at Ambalaga and Jambaga B village of Kalburgi, Karnataka

Farmers at Nimgaon, Madha taking Swachata Oath and Interacting with NRCP and KVK, Solapur Scientists

One day Pomegranate growers- Scientist Interaction meet was organized under MGMG programme at Todal village of Basavakalayan taluka (Bidar District) in collaboration with KVK and Dept. of Horticulture Bidar.

10.4. Scientific agro advisories

Scientific agro-advisories were sent to 1853 pomegranate growers through the m-Kisan portal and every day scientists send advisories to the queries of the farmers on email and phone/mobile.

11. TRANSFER OF TECHNOLOGY & ENTREPRENEURSHIP DEVELOPMENT

11.1. Trainings

ICAR-NRCP, Solapur **o**rganized 5 in house trainings for farmers and field staff to promote pomegranate cultivation and livelihood in different states of India. These are tabulated below.

S.No.	Name of the training programme	Venue	Participants	Date
1.	Training programme on "Precision Cultivation in Pomegranate" for RAMETI field staffs of Amravati district, Maharashtra during 20-23rd July, 2016	ICAR-NRCP, Solapur	47 RAMETI field staffs of Amravati district, Maharashtra	20.07.16-23.07.16
2.	Training programme on "Quality Production of Pomegranate" for Pomegranate farmers of Mehsana, Banaskatha and Sabarkatha districts, Gujarat during 24-26th October, 2016.	ICAR-NRCP, Solapur	49 farmer of Mehsana, Banaskatha and Sabarkatha districts, Gujarat	24.10.16-26.10.16
3.	Four days training programme on "Skill Development on Water Management in Pomegranate" for Tribal Farmers of Dhule and Nadaurbar District, Maharashtra during 26-29th Dec, 2016.	ICAR-NRCP, Solapur	20 Tribal Farmers of Dhule and Nadaurbar District, Maharashtra	26.12.16-29.12.16
4.	Four days training programme on "Various Aspect of Pomegranate" for pomegranate farmers of Madhya Pradesh during 26-29th Jan, 2017.	ICAR-NRCP, Solapur	30 farmers of Madhya Pradesh	26.01.17 - 29.01.17
5.	Training programme on "Model pomegranate production practices and value addition of produce"	ICAR-NRCP, Solapur	18 employees of Bankura and Puruliadt., Govt of W.B.	27.02.17 – 02.03.17

11.2. Technology transfer agreements

ICAR-NRCP technologies were transferred to 3 entrepreneurs through MoU

S.No.	Technology Transferred	Beneficiary	Revenue received (Rs)
1.	*In vitro* propagation of pomegranate cultivar Bhagwa including biohardening"	M/s. Hybrid Agri Biotech P. Ltd., Vardhaman Chamber, Plot No. 84, Navi Mumbai-400705	3,45,000.00
2.	Development of pomegranate juice and RTS beverage	Mr. Girish Uttam Ware, Sr. no. 223/4B, Muktai, Parijat colony, Hadapsar, Pune- 411028	88,875.00
3.	Process for production of juice and RTS beverage from pomegranate	TVK Beverage Pvt. Ltd. 176/A, Sindhu Vihar, JuleSolapur, Vijapur Road, Solapur 413008	85, 875.00

Mr. Girish Uttam Ware, Solapur

TVK Beverage Pvt. Ltd., Solapur

Technology Transfer Agreement

11.3. Exhibitions

S.No.	Name of the Exhibition	Venue	Participants (No.)	Date
1	Science center exhibition	Science Centre, Solapur	2500	03.08.16
2	Agrowon Pomegranate Grape exhibition	Home Maidan, Solapur	1500	05.08.16
3	Technology innovation day cum Kisan Mela	CAZRI, Jodhpur	1100	21.09.16
4	Krishi Unnati Mela	IARI, New Delhi	14000	15.03.17-17.03.17
5	State level Agri. Exhibition	Aurangabad	17000	24.12.17-27.12.17

11.4. Pomegranate growers/ visitors to ICAR-NRCP, Solapur

11.4.1. Individual visitors

Individuals/group of farmers, students, officials, entrepreneurs visited ICAR-NRCP for guidance. The visitors are listed below

Individual visitors

S. No.	Date	Locality of farmers	No. of visitors
1.	28.05.16	Mohol	01
2.	07.06.16	Sangola	04
3.	22.06.16	Pune	01
4.	30.06.16	Nashik	01
5.	03.07.16	Solapur	03
6.	08.07.16	Chincholi	01
7.	11.07.16	Mohol, Pune	04
8.	12.07.16	Ahmadnagar	04
9.	13.07.16	Pandharpur	01

S. No.	Date	Locality of farmers	No. of visitors
10.	14.07.16	Tuljapur	04
11.	21.07.16	Gulbarga	02
12.	22.07.16	Nashik	01
13.	25.07.16	Solapur	04
14.	06.10.16	Pandharpur	01
15.	25.10.16	Bellary	02
16.	23.11.16	Shahapur	01
17.	24.11.16	Majrewadi	01
18.	30.11.16	Malshiras	01
19.	08.02.17	Osmanabad	02
20.	09.02.17	Vagholi	01
21.	13.02.17	Mangalvedha	01
22.	16.02.17	Aurangabad	18
23.	01.04.16-31.03.17	Maharashtra and adjoining states	164

11.4.2. Group visitors

During the year, 35 groups involving 1628 beneficiaries visited this Centre and the details are given below.

S.No.	Date	Visitors Organization	Beneficiaries	
			Category	No
1.	22.04.16	Department of Agriculture, Govt. of Karnataka, Gadag	Farmers	49
2.	29.04.16	Bagalkot, Karnataka	Farmers	104
3.	29.04.16	Department of Agriculture, Govt. of Karnataka, Davanagere	Farmers	95
4.	02.05.16	Chamannagar, Karnataka	Farmers	46
5.	05.05.16	Department of Agriculture, Govt. of Karnataka, Raichur	Farmers	48
6.	03.06.16	Department of Horticulture, Govt. of Karnataka, Hirekerur	Farmers	22
7.	03.06.16	Department of Horticulture, Govt. of Karnataka, Hirekerur	Farmers	22
8.	08.07.16	Bidar, Karnataka	Farmers	22
9.	11.07.16	Arabahvi, Karnataka	PG students	13
10.	12.07.16	Dharwad , Karnataka	Farmers	44
11.	01.08.16	Raichur, Karnataka	Farmers	25
12.	08.08.16	Poddar Internationl School, Solapur	Students	70
13.	19.08.16	Ankoli, Solapur	Students	40
14.	22.08.16	Department of Agriculture, Govt. of Karnataka, Bellary	Farmers	49
15.	24.08.16	Arabhavi, Karnataka	Farmers	46
16.	25.08.16	Chikballapur, Karnataka	Farmers	46
17.	27.08.16	Lokmangal ABM College Wadala, Solapur	UG students	54
18.	23.09.16	ATMA Scheme, Karnataka, Davanagere	Farmers	95
19.	23.09.16	Department of Agriculture, Government of Karnataka, Belagavi	Farmers	49
20.	28.09.16	Nilanga, Latur, Maharashtra	Farmers	44

S.No.	Date	Visitors Organization	Beneficiaries	
			Category	No
21.	04.10.16	Vijaypur, Karnataka	Farmers	44
22.	22.10.16	Kisan Kalyan Tatha Krushi Vikas Dist. Badavani (MP)	Farmers	18
23.	16.12.16	Shree Kamal Public school Dhulakhed, Indi,Vijapur Karnataka	Students	70
24.	07.01.17	New English School, Kurul, Mohol, Solapur	Students	45
25.	07.02.17	V G Shivdare, Bieotech. college,Solapur	UG students	33
26.	20.02.17	College of Horticulture Jaudan, Mahesana, Gujaratha	UG students	35
27.	20.02.17	Bagalkot Karnataka	Farmers	44
28.	20.02.17	College of Horticulture AAU, Gujaratha	UG students	41
29.	21.02.17	Walchand College Solapur	PG students	60
30.	22.02.17	Walchand College Solapur	UG students	72
31.	23.02.17	Lokmangal College Wadala, Solapur	UG students	33
32.	21.03.17	Agriculture College, Latur, Maharashtra	UG students	35
33.	22.03.17	UAHS Shivamogga, Karnataka	Farmers	45
34.	24.03.17	Lokmangal College of Biotechnology Wadala, Solapur	UG students	33
35.	24.03.17	Department of Agriculture, Govt. of Karnataka, Jamkhandi	Farmers	37

12. INSTITUTIONAL ACTIVITIES

The following events concerned with R&D activities of ICAR-NRCP were conducted during the year 2016-17.

12.1. RAC meeting

The meeting of the tenth Research Advisory Committee (RAC) of ICAR- National Research Centre on Pomegranate was held on December 20, 2016, at NRCP, Kegaon, Solapur under the chairmanship of Dr. R.B. Deshmukh, former Vice Chancellor, MPKV, Rahuri.

The committee visited the farm, polyhouses, shade net and laboratory facilities at the Centre. The RAC members interacted with the concerned scientists and gave suggestions to improve the experimental output. The committee appreciated the infrastructure developments and research efforts made by the Centre. he RAC members were briefed on the past developments of the NRCP through a recently developed video 'NRCP Profile'. This was followed by review of 'Action Taken Report' on the recommendations of previous RAC and research progress under various projects. After detailed deliberations on the progress made by the Centre on research and developmental fronts. The chairman and committee members appreciated the progress made during the past years and complimented the Director for the significant developments under pomegranate processing. The committee gave 4 recommendations:

Research Advisory Committee		
1	Dr. RB Deshmukh Former Vice Chancellor (MPKV, Rahuri)	Chairman
2	Dr. Vitthal Benagi Director of Extension, UAS Dharwad	Member
3	Dr DP Waskar Director of Research, VNMKV, Parbhani (MS)	Member
4.	Dr. KS Mohan* Plant Biotechnologist (Retd.) Monsanto Research Centre, Bengaluru	Member
5	Dr. WS Dhillon ADG- HS-I, ICAR, New Delhi	Ex Officio Member
6	Dr. RK Pal Director, ICAR-NRCP on Pomegranate, Solapur	Ex Officio Member
7	*Shri. Baburao Ramchandra Gaikwad Progressive grower, Sangola, Solapur	Member
8	Dr. Jyotsana Sharma Pr. Scientist, ICAR-NRCP on Pomegranate, Solapur	Member Secretary
* Meeting not attended		

RAC Recommendations

1. The NRCP varieties sent for registration should be included in AICRP for arid zone fruits trials.
2. Major problems in pomegranate should be discussed and suitable breeding program planned in IRC.
3. Work on fruit cracking, flowering problems and emerging diseases and pests should be given top priority.

Flagship Project on 'Integrated Approach to Eradicate Pomegranate Bacterial Blight' should be extended for another 3 years.


Research Advisory Committee interacts with scientists

12.2. IRC meeting

The meeting of the eleventh Institute Research Council (IRC) of ICAR- NRCP, Solapur was held at the institute on December 22, 2016 under the chairmanship of Dr. R.K. Pal, Chairman, IRC and Director, NRCP and attended by all the Scientists. In all 7 institute projects were discussed and recommendations given and 2 new research proposals presented were approved.

12.3. QRT Meeting

The second Quinquennial Review Team (QRT II) constituted vide ICAR order F. No. HS/1(1)/2015-IA.V dated, November 3, 2015, reviewed the R&D work of ICAR-NRCP for the period April 1, 2011- March 3, 2016.

S. No.	Name and Contact Details	Designation
1.	Dr. YS Nerkar Former Vice Chancellor (MPKV, Rahuri, Maharashtra)	Chairman
2.	Dr. SK Singh Professor & Head, Div. Fruits and Horticultural Technology ICAR-IARI, New Delhi	Member
3.	Dr. KK Kumar Former Director (NRC on Litchi, Muzaffarpur, Bihar)	Member
4.	Dr. R Palaniappan Former Principal Scientist (ICAR-IIHR, Bengaluru)	Member
5.	Dr. SH Jalikop Former Principal Scientist (ICAR-IIHR, Bengaluru)	Member
6.	Dr. Jyotsana Sharma Principal Scientist, ICAR-NRC on Pomegranate, Solapur (Maharashtra)	Member Secretary

Itinerary of QRT meetings

S.No.	Date	Meeting Theme	Venue	Participants
1.	22.06.16	Preliminary meeting	ICAR, New Delhi	Dr. NK Krishna Kumar, QRT chairman and members and Dr. RK Pal, Director NRCP
2.	28.07.16-29.07.16	Review meeting	NRCP, Solapur	QRT chairman and members, Director, Scientists, Technical and Administrative staff of NRCP
3	23.08.16	Pomegranate research workers meet	CoH (MPKV), Pune	QRT chairman and members, Dr. KP Vishwanatha, VC MPKV Rahuri. Dr. WS Dhillon, ADG (Fr. & Pl. Crops), ICAR, Dr. SD Masalkar , Principal COH (MPKV), Pune, Scientists from Karnataka, Gujarat, Rajasthan, AP & Telangana, Uttar Pradesh, Delhi and Maharashtra
4	24.08.16	Visit to Pomegranate orchards and interaction with farmers	Pavai Mal, PO Pandare, Baramati, Pune	QRT chairman and members, Dr. RK Pal, delegates + KVK Baramati officials + Farmers
5.	20.09.16-23.09.16	Visit to orchards in Papri and Penur in Solapur district, Interaction with IMC and finalization of QRT Report	NRCP, Solapur	QRT Chairman and members

The QRT after review commented in its overall assessment, 'The National Centre on Pomegranate during the last five years has made commendable impact not only at state level but also at national level. Based on the contributions made by the ICAR-NRCP, Solapur in the R&D activities pertaining to the pomegranate leading to creating a brighter scope for its cultivation in the country, the QRT-II assesses the performance of the Centre as Very Good'.

Quinquennial review team reviews R&D activities at ICAR-NRCP


Quinquennial review team interacts with farmers

12.4. IMC meeting

The XIII[th] Institute Management Committee (IMC) meeting of ICAR-NRCP, Solapur was held on Sep 22, 2016. The members of the IMC team interacted with the QRT team regarding the institute management aspects.

12.5. Hindi Pakhwada

ICAR-NRCP celebrated 'Hindi Pakhwada' from 14.09.16 to 28.09.16 by conducting various competitions *viz.*, elocution, essay writing, translation, quiz, etc. for staff members. Prize distribution ceremony was organized. Dr. Toshnival attended the ceremony as Chief Guest and delivered his address on the concluding ceremony, Sep 29, 2016. Dr. Toshnival, Chief Guest and Dr. R.K. Pal, Director, ICAR-NRCP distributed the certificates to the active participants. The importance of Hindi language in bringing social integrity was highlighted. Dr. D.T. Meshram, Hindi Officer facilitated the successful conduct of the event.

Address by Director, ICAR-NRCP in Hindi Pakhwada concluding ceremony

Certificate distribution during concluding ceremony of Hindi Pakhwada

12.6. Constitution day

The constitution day was observed at the ICAR-NRC on Pomegranate, Solapur on 26.11.2016. On this occasion, the scientific, technical and administrative staff of institute took the pledge of the constitution day.

Staff taking pledge on the constitution day

12.7. Swachh Bharat Abhiyan

Swachh Bharat Abhiyan (Clean India Mission) was observed at the institute from 16.10.16 to 31.10.16. As part of the programme, cleaning of the premises and various laboratories was done. Hon'ble DG (ICAR), Dr. T. Mohapatra who visited the institute on 23.10.16 participated in the cleaning event at the premises of the institute. Dr. N.P. Singh, Director, NIASM, Baramati also graced the occasion with his presence.

The National Research Centre on Pomegranate, Solapur, observed the '*Swachta Pakhwada'* from Oct.16-31, 2016. Dr. RK Pal, Director NRCP, Solapur administered the '*Swachata Shapath*' to the staff on October 16, 2016, followed by the cleaning of the premises, orchards, connecting roads, laboratories and administration rooms from Oct. 16-22, 2016. Cleaning of garbage thrown by residents of Police Training Centre, on the approach road to Hiraj block of NRCP was done on Oct. 23. Dr. T. Mohapatra, Hon'ble DG, ICAR and Secretary DARE who visited the institute on 23.10.16 also participated in the cleaning event at the premises of the institute. Dr. N.P. Singh, Director, NIASM, Baramati also graced the occasion with his presence. Planting of different horticultural crops was done in crop cafeteria of NRCP on Oct. 22-24, 2016. Sorting of recyclable plastic and glass, paper wastes, biodegradable waste and cleaning of dumping spot in NRCP was done on Oct. 26-27, 2016. Farmers of Nimgaon Madha taluka (Solapur) were administered the '*Swachata Shapath*' on October 28, 2016 by jointly by NRCP and KVK Solapur. The neglected areas in the campus were cleaned on October 29, 2016.

On Oct 31, 2016 Director interacted with NRCP staff and emphsized on developing awareness among the masses and willingness of individuals for cleaniness in the place of work, residence and other places. The decision was taken to write a letter to (i) the competent authority in the neighbouring 'Police Training Centre' for making suitable arrangement for waste disposal by the residents and (ii) Muncipal corporation of Solapur for arranging picking of the recylable and toxic wastes from NRCP at periodic intervals. The staff was shown 3 videos on Swach Bharat Abhiyan, Segregation and Management of Wastes and Swach Bachpan Swach Zindagi, and chairperson Swachta Committee presented report of NRCP activities during Swachta Phakwada.

All the staff members and contractual staff in NRCP participated in various activities.

Inauguration of Crop Cafeteria by
Dr. T. Mohapatra, Hon'ble DG, ICAR

Cleaning of garbage dumping site by
NRCP staff

Activities during Swachata Pakhwada

12.8. Vigilance Awareness Week

The National Research Centre on Pomegranate, Solapur, observed the 'Vigilance Awareness Week′ from Oct. 31 – Nov 5, 2016. Dr. RK Pal, Director NRCP, Solapur administered the pledge to uproot corruption, to the staff on October 31, 2016, followed by 'Rashtriya Ekta Shapat'. Banners were put at the entrance with the messages related to fight corruption at individual and organization level.

During the 'Vigilance Week' various lectures were organised for the NRCP staff. Dr. RK Pal, Director NRCP also briefed the audience what comes under fraud and what is negligence in day to day official working. Mr. AR Devakar, Deputy. Superintendent Police, and Mr. Vishwanath Sid, Police Inspector, Anti-Corruption Bureau, Solapur were invited for guest lectures on anticorruption, theyenlightened the house, on what activities of the organization come under corruption and how public can help police in reaching the culprit. This was followed by an interactive session in which the audience shared their experiences faced in getting passports, driving licenses and other work done from government offices with public dealings. The speakers advised ways in which one can avoid such difficult situations and also how we can report to them. They also gave their contacts for any difficulty in future.

Mr. RB Rai, AAO, NRCP, Solapur in his speech informed the audience about, 'Important Administrative and Purchase Rules'; Mr. VA Shinde, AF&AO, talked on, and 'Rules for different advances and CVC guidelines for Tenders'.M /s Roopa Sowjanya, Scientist, NRCP, gave a very informative speech on, 'ATM Frauds' and how we can avoid being trapped in such frauds. All the staff members and contractual staff in NRCP participated in various activities.

Mr. AR Devakar, Deputy Superintendent of Police, Anti-Corruption Bureau, Solapur addressing NRCP staff

12.9. National Science Day

The ICAR-NRC on Pomegranate observed National Science Day 2017 with the theme "Science and Technology for specially abled persons" by visiting Rotary North Radhakishan Fomra deaf and dumb dchool at Damani Nagar, Solapur. The team comprising Dr. Nilesh Gaikwad, Scientist and Mr. D T Chaudhari, Sr. Technical Asst. led by Dr. R. K. Pal, Director, ICAR-NRCP visited school and interacted with students about science and need of scientific temperament in life. The inspirational speech by Dr. R K Pal was translated through sign language by the school teacher.

Science Day Programme 2017 at Rotary North Radhakishan Fomra Deaf and Dumb School

12.10. Distinguished visitors

Dr. S.D. Shikhamany, Former Vice-Chancellor, APHU & Former Chairperson, RAC, ICAR-NRCP, Solapur visited the institute on 08.12.16. He visited the fields and laboratories and interacted with the scientists on various ongoing research activities. He congratulated the Director & staff for the various developmental activities of the institute.

13. INFRASTRUCTURE CREATED

13.1. Lift Irrigation

Lift irrigation system for supply of irrigation water was established at ICAR-NRCP, Solapur. The pump house was established at Pakni which is located 9.9 km from the institute. The capacity of the lift irrigation system is 1 lakh liters of water/ day.

Pump house at Pakni

Percolation well for lift irrigation system

Lift irrigation system

13.2. Trainees' Hostel

A well furnished trainee's hostel has been constructed for the benefit of trainees / farmers undergoing training at ICAR-NRCP, Solapur. This double floor building has a capacity of 43 beds with 2 VIP rooms, a conference hall and with other essential facilities. It was built within a record time of 15 months and well within the allocated AA&ES.

A view of newly built trainees hostel

VVIP room in the trainees hostel

Newly constructed trainees hostel

13.3. New Plantation and crop cafeteria

About 6 ha area of experimental farm was planted with pomegranate by planting the cuttings *in situ*. The new plantation established would be utilized for experimental purpose. Besides, 1 ha plot of crop cafeteria was also established with different fruit crops viz. mango, sweet orange, guava, sapota, aonla, custard apple, jamun etc.

New Pomegranate Plantation

Crop Cafteria

13.4. Pilot Plant

Pilot plant for processing of pomegranate was established at ICAR-NRCP, Solapur. This was inaugurated by Hon'ble DG, ICAR Dr. Trilochan Mohapatra on October 23, 2017. The juice production capacity of the plant is 100 litres/ hour.

Pilot plant for pomegranate juice processing

13.5. Modified atmospheric packaging system

Modified atmospheric packaging (MAP) machine with digital gas mixer and cylinder for packaging of minimally processed pomegranate arils was established at ICAR-NRCP, Solapur

Modified atmospheric packaging system

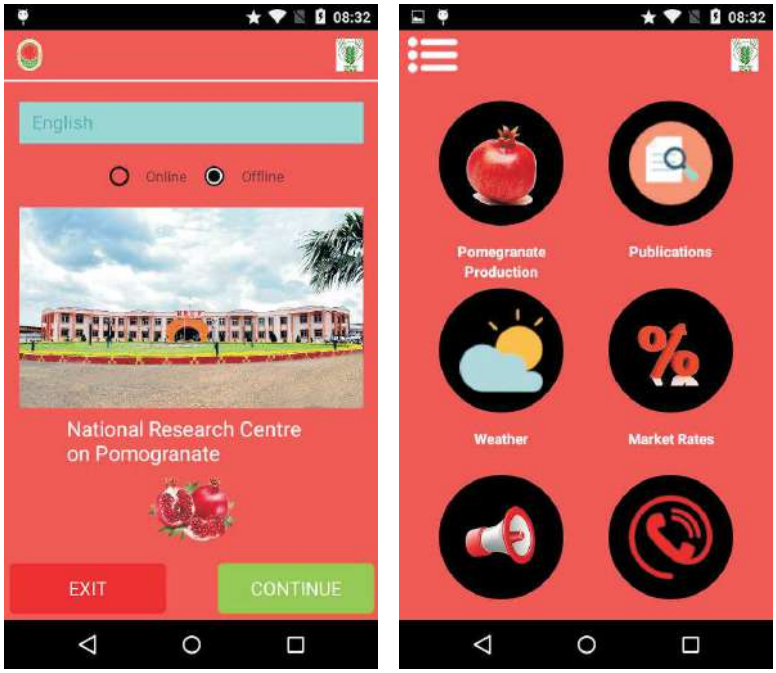
13.6. LED Boards

Twenty four nos. of bilingual LED boards on technologies developed by ICAR-NRCP and different aspects of pomegranate *viz.,* tissue culture techniques, processing and value addition, new varieties, water management, insect and disease management etc. were placed in corridors of the institute.

LED Boards displaying ICAR-NRCP technologies

13.7. Mobile app

ICAR-NRCP has launched second version of its mobile app Solapur Anar in six different languages including Hindi, English, Marathi, Kannada, Gujarati and Telugu. The app has all information related to pomegranate farming and post harvest management an value addition. The app was launched by Hon'ble DG ICAR, Dr. Trilochan Mohapatra on April 30, 2017.



Mobile app Solapur Anar

13.8. ICAR-NRCP website

ICAR-NRCP has developed new user friendly website (nrcpomegranate.icar.gov.in) and hosted it at secured government server. The website is designed to provide information on events, activities, research and technology highlights, publications and facilities at ICAR-NRCP.

The specially designed farmer's corner provides information on frequently asked question on pomegranate in three languages, success stories in pomegranate cultivation, list of pomegranate exporters, and feedbacks. The website has become very popular with 182000 hits in short span of time.

14. TRAINING AND CAPACITY BUILDING

14.1. Human resource development

During the year under report, 6 scientists, 3 technical, 4 administrative & finance and 2 supporting staff have undergone need based training as a part of capacity building. Details of trainings undergone by different categories of staff are given below:

S.No.	Training Programme	Date	Venue	Participants
	a. Scientific staff			
1.	One month Orientation Training	10.04.16-10.05.16	ICAR-NRCP, Solapur	Roopa Sowjanya P.
2.	Professional Attachment Training of ARS Scientist	11.05.16-12.08.16	ICAR-IIHR, Bangalore	Roopa Sowjanya P.
3.	Packaging Technologies and Innovations	26.05.16 - 28.05.16	Indian Institute of Packaging, Bengaluru	Nilesh Gaikwad
4.	Analysis of experimental data	18.08.16-23.08.16	ICAR-NAARM, Hyderabad.	Nilesh Gaikwad
5.	Strategy of RNA sequencing and reference based *de novo* transcriptome analysis of plant samples including pomegranate'	03.10.16-07.10.16	Nucleome Informatics Pvt. Ltd., Hyderabad	N. V. Singh Shilpa Parashuram
6.	Advances in Experimental Data Analysis	06.10.16-26.10.16	ICAR-IASRI, Pusa, New Delhi	Ashis Maity
7.	Competency enhancement programme for effective implementation of training functions by HRD Nodal officers of ICAR	16.02.17-18.02.17	NAARM, Hyderabad.	Mallikarjun
	b. Technical staff			
7.	Typing in Microsoft word & acquaintance with routine computer operation	01.04.16 - 30.04.16	ICAR-NRCP, Solapur	Govind Salunke
8.	Microbial Culture handling and maintenance	02.08.16 – 11.08.16	NDIAM, Mau Nath Bhanjan	Vijay U. Lokhande
9.	Training cum awareness programme on J-Gate@CeRA	08.10.16	Agriculture College, Navsari	D. T. Chaudhari
	c. Administrative and Finance staff			
10.	Training programme for Nodal Officers of Public Authority releated to RTI Online Portal of DoP&T	25.10.16	NAARM, Hyderabad	V.A.Shinde
11.	Training Programme on FMS-MIS	19.01.17-24.01.17	NIASM Baramati	V.A.Shinde, K.B. Khatmode, A.S. Babar, Vipin Dagar
12.	Training on Module of Public Financial Management Systems	08.02.17 - 09.02.17	Institute of Government Accounts & Finance, New Delhi	V.A.Shinde
	d. Supporting staff (SSS)			
13.	Typing in Microsoft word & acquaintance with routine computer operation	01.04.16 - 30.04.16	ICAR-NRCP, Solapur	Shailesh Bayas, Vishal Gangane

14.2. Conferences, Workshops and Meetings

The scientists of the Centre \ participated in 18 conferences/workshops and 10 meetings conducted by different organizations in India apart from meetings mentioned in the chapter on institutional activities.

S.No.	Title	Date	Venue	Participants
Conferences and Workshops				
1.	National Conference on 'Challenges and opportunities in quality production of pomegranate', organized by Maharashtra Pomegranate Growers Research Association, Pune and Jain Irrigation Systems Ltd., Jalgaon (MS)	16.04.16 - 18.04.16	Jain Irrigation Systems Ltd. Jalgaon (MS)	Jyotsana Sharma, Nilesh Gaikwad
2.	Krishi Divas Mela organized by District Agricultural Department	01.07.16-07.07.16	Yeshwantrao Chavan Sabhagruh, Solapur	U. R. Sangle, D.T. Chaudhari
3.	International Conference on "Agricultural sciences and food technologies for sustainable productivity and food security"	25.08.16-27.08.16	UAS, Bengaluru, Karnataka	D. T. Meshram
4.	Madhu Sandesh day at KVK, Baramati, Pune Maharashtra	03.11.16	KVK, Baramati, Pune	Mallikarjun
5.	National Expo and National Conference of "8th Agro-Vision organized by "Agrovision Foundation"	11.11.16-14.11.16	Reshim Bag Ground, Nagpur,	D. T. Meshram
6.	International Conference on "Integrated Land Use Planning for Smart Agriculture" organized by NBSS & LUP, Nagpur.	10.11.16-13.11.16	NBSS & LUP, Nagpur	D. T. Meshram
7.	7th Indian Horticulture Congress – An International meet : Doubling farmers income through horticulture,	15.11.16-18.11.16	IARI, New Delhi	K. Dhinesh Babu, Ashis Maity, U.R. Sangle
8.	38th Annual Conference & National Symposium on "Challenges towards plants health under changing climate scenario for sustainable agriculture"	24.11.16-26.11.16	Department of Plant Pathology, Krishi Viswavidyalaya, Nadia, WB	U. R. Sangle
9.	14th International Workshop on Trichoderma and Gliocladium (TG2016) "Principles to Practice"	27.11.16-30.11_16	Nagpur	U. R. Sangle
10.	Farmers Workshop and International Soil Day organized by KVK Solapur at Chapalgaon, Solapur district dated 5th December, 2016.	05.12.16	Chapalgaon, Solapur	Ashis Maity
11.	National Workshop on Advances in disease management technologies in horticultural crops	07.12.16-08.12-16	YSPUHF, Solan	Jyotsana Sharma
12.	National Workshop on 'Technological changes and innovations in pomegranate production and utilization for enhancing farmers' income'	10.12.16	Agri. University, Jodhpur	Jyotsana Sharma

S.No.	Title	Date	Venue	Participants
13.	National Symposium on 'Behavioural ecology and management of agriculturally important insects and other animals'	27.12.16-28.12.16	UAHS, Shivamogga	Mallikarjun
14.	National Seminar on 'Enhancing productivity of fruit crops - mitigating major challenges'	08.01.17	ICAR-IIHR, Bangalore, 08.01.17	K. Dhinesh Babu
15.	"National level Expert Consultation meeting" for drawing roadmap for future research in management of abiotic stress in Agriculture and Horticulture	30.01.17-31.01.17	ICAR-NIASM, Baramati	Ashis Maity K. D. Babu
16.	51st Annual Convention of Indian Society of Agricultural Engineers (ISAE) and National Symposium on Agricultural Engineering for sustainable and climate smart agriculture	16.02.17-18.02.17	CCSHAU, Hissar	N. Gaikwad
17.	Kaushal Vikas Se Krishi Vikas Regional Workshop on Skill Development in Agriculture	20.02.17	ICAR-NAARM, Hyderabad	Mallikarjun
18.	National Seminar on Pomegranate organized by All India Pomegranate Association, Pune	18.03.17-19.03.17	Pune	Jyotsana. Sharma, U. R. Sangle, Ashis Maity
Meetings				
1.	Fullbright - Nehru and other fellowship opportunities in the USA	12.03.16	ICAR-NRCP Solapur	All staff
2.	Safety handling approaches, Borosil glassware	24.05.16	ICAR-NRCP Solapur	All Scientists and Technical staff
3.	Second surveillance ISO Certification Audit Meet and Annual General Body Meeting SARP	30.05.16	ICAR-NRCP Solapur	All Scientists and SARP members
4.	Institute management committee meeting of DFR, Pune	04.06.16	ICAR-DFR Pune	Jyotsana Sharma
5.	Brain Storming Session on Pomegranate, organized by MPKV Rahuri and ICAR-NRCP Solapur	16.06.16	COH, Pune	RK Pal, Jyotsana Sharma, Yuvraj shinde
6.	Weather based insurance scheme meeting of Horticulture crops (*Ambe bahar*)	20.08.16	Shivajinagar Pune	Mallikarjun
7.	Meeting on Export of Pomegranate	26.09.16	MSAMB, Market yard Gultekadi, Pune	Mallikarjun
8.	Interactive Meeting with DG, ICAR	23.10.16	ICAR-NRCP, Solapur	All staff
9.	Stakeholders meet/workshop with APEDA	28.11.16	ICAR-NRCP, Solapur	Mallikarjun
10.	21st Research workers group meeting of the AICRP on Arid Zone Fruits	05.03.17-07.07.17	ICAR-CIAH, Beechwal, Bikaner	K. D. Babu

15. PUBLICATIONS

15.1 Papers in research journals

1. Maity A., Sharma, J., Sarkar, A., More A. K. and Pal, R.K. 2016. Nutrient imbalance indices are closely related with susceptibility of pomegranate to bacterial blight disease. *Scientia Horticulture*, 211, 79-86.
2. Maity, A., Babu, K.D., Sarkar, A. and Pal, R.K. 2016. Seasonality of nutrients vis –a-vis fruit quality of pomegranate cv. Bhagwa on Vertisol. *Journal of Plant Nutrition.* 40(9): 1351-1363.
3. Meshram DT, Chandra, R., Singh, N.V. and Pal, R.K. 2017. Thermal requirement of pomegranate (*Punica granatum* L.) varieties growing in Maharashtra, India. *Indian Journal of Horticulture* 86(2):192-196.
4. Meshram, D.T., Singh, N.V. and Pal, R.K. 2016. Improvement of water use efficiency in pomegranate (*Punica granatum* L.) cv. Bhagwa under micro-irrigation system. *Indian Journal of Agricultural Sciences* 86(2):192-196.
5. Suroshe, S., Sharma, J., Singh, N.V. and Pal, R.K. 2016. New report of insect pests and their natural enemies in pomegranate. *Indian Journal of Horticulture* 73 (3):445-448.
6. Pal, R.K., Singh, N.V. and Maity, A. 2017. Pomegranate fruit cracking in dryland farming. *Current Science*112 (5):896-897.
7. Marathe, R.A., Sharma, J., Murkute, A.A. and Babu, K.D. 2017. Response of nutritional supplementation through organics on growth, yield and quality of pomegranate. *Scientia Horticulturae* 214 :114-121.
8. Marathe, R.A., Murkute, A.A. and Babu, K.D.. 2016. Mineral nutrient deficiencies and nutrient interactions in pomegranate. *National Academic Science Letters*. DOI: 10.1007/s40009-016-0487-4.
9. Marathe, R.A., Babu, K.D. and D.T. Chaudhari. 2016. Effect of irrigation frequencies on nutrient uptake, growth and yield of pomegranate (*Punica granatum*) grown on heavy textured soils of semiarid region. . *Indian Journal of Agricultural Sciences*. 86 (12) :1559-65.
10. Marathe, R.A., Babu, K.D., Murkute, A.A. and D.T. Chaudhari. 2016. Root distribution pattern of pomegranate in different soil types. *Indian J. Hort.* 73 (4): 288-591.
11. Sharma Jyotsana, Sharma, K.K., Kumar, A., Mondal, K.K., Thalor, S., Maity, A., Gharate, R., Chinchure, S. and Jadhav, V.T. 2017. Pomegranate bacterial blight: symptomatology and rapid inoculation technique for *Xanthomonas axonopodis*pv. *punicae. Journal of Plant Pathology* 99 (1) : 109-119.
12. Marathe R.A., Sharma, J.,Shinde, Y.R. and Chaudhari, D.T.2016. Standardization of organic manure application in pomegranate (*Punica granatum*) orchards grown in semi-arid regions. *Indian Journal of Agricultural Sciences* 86 (10): 1265–70.
13. Marathe R.A., Sharma, J., Babu, K.D. and Murkute, A.A. 2017. Bedding System: A unique plantation method of pomegranate in arid and semi-arid region. *National Academy Science Letters*. (Accepted)
14. Suroshe, S., Sharma, J., Singh, N.V. and Pal, R.K. 2016. New report of insect pests and their natural enemies in pomegranate. *Indian J. Hort. 73(3): 445-448.*
15. Babu, K.D., Singh,N.V., Gaikwad, N., Maity, A., Suryavanshi, S.K. and Pal. R.K. 2017. Determination of maturity indices for harvesting of pomegranate (*Punica granatum* L.) *Indian Journal of Agricultural Sciences*. (Accepted).

16. Maity,A., Gaikwad,N.N., Babu, K.D., More, A.K., Sarkar, A. and Pal,R.K.2017. Nutritional physiology for flowering, fruit yield and quality of pomegranate grown in semi-arid region of India. *Journal of Plant Nutrition.* (Accepted).

15.2 Book chapters

1. Babu, K.D., Singh, N.V. Shilpa, H.B., Maity, A., Gaikwad, N. N., Pal, R.K. and Sankaran, M. 2017. Pomegranate. In: Genesis and evolution of horticultural crops. Vol.1 (Ed. K.V.Peter), Kruger Brentt Publishers, UK Ltd, Middlesex, UK, 297-311.
2. Sharma Jyotsana. 2016. Advances in integrated pest management in pomegranate. In : "*About Diseases of Horticultural Crops*" (Eds. Sharma, I.M. and Gautam, H.R.), Neoti Book Agency Pvt. Ltd., New Delhi, pp 145-155.

15.3 Popular articles

1. Gaikwad, N.N., Pal, R.K., Yadle Vaidanath, Suryavanshi, S.K. and Maity, A. 2017. Dalimba mulyavardhit prakriya utpadan ani uddojkata vikas sandhi. *Dalimbwrut,* Jan.-Mar., 17-21. (*Marathi*)
2. Meshram, D.T., Pal, R.K. and Khopde, R.T. 2016. Dalimbache rajniya shetr, Uthpadan Uthpadaktha. *Dalimbwrut*. Jan-Mar., 51-52 (*Marathi*)
3. Meshram, D.T, Pal, R.K and Bhake, N.P. 2016. Dalimbachya bagela Jaivik ani ajaivik achadanache mahatav. *Krshiking*, May 20-22 (*Marathi*)
4. Meshram D.T, R.K. Pal and Bhake N.P. 2016. Dalimbachya bagela Sushma sinchan padhatiche mahatav. *Dalimbwrut*, July-Sep 20-22 (*Marathi*)
7. Sharma Jyotsana, Mallikarjun, Gaikwad, N.N. 2016. Piknihay Tadnya salla. *Krishiking,* October 2016 (*Marathi*)
8. Sharma Jyotsana. 2017. Dalimb Pikawaril Rog wa Niyantran. *Krishijal* 1: 22-26 (*Marathi*)
9. Sharma Jyotsana, Mallikarjun, Nilesh Gaikwad and Yuvraj Shinde. 2017. Rog, Vikar, Kid ani Vyavasthapan. *Dalimbwrut:* Smarnika: 30-54 (*Marathi*)
10. Mallikarjun, M. H. Joshi, S and Pal, R.K. 2016. Invasive scale insect (*Lopholeucaspis japonica* Cockerell) on pomegranate- A first report from India. *Indian Horticulture,* 61(5) : 27-28.
11. Jyotsana Sharma, Mallikarjun and Nilesh Gaikwad. 2016. Fruit sucking moths of pomegranate and their management, *Krishiking*, (*Marathi*).
12. Pal, R.K. and Gaikwad, N.N. 2016. Exploiting full pomegranate potential for double benefit. *Indian Horticulture*. 61 (6): 15-17.
13. Gaikwad, N.,Yedle Vaijenath, Suryavanshi, S.K. and Pal, R.K. 2016. Dalimb: Kadhani Pashchyat Vyavasthapan, *Krishiking*, 7 : 22-25 (*Marathi*)
14. Pal, R.K., Gaikwad, N.,Yedle Vaijenath and Suryavanshi, S.K. 2017. Dalimb Prakriya Udyog ani Rojgaranchya sandhi, *Shetkari, Krishi Ayukatalay, Krishi Vibhag*, Maharashtra Shasan, 8: 7-9 *(Marathi).*
15. Sangle, U, R., and Meshram, D.T. 2016. Ek Anar Sou Bimar, *Akshay Kheti Krishi Patrika,* ICAR-RCER, Patna (*Hindi*).
16. Meshram, D.T., Lad, A.S. and Sangle, U.R. 2016. Anar Ropan aur bahar ka prabandh, *Akshay Kheti Krishi Patrika*, ICAR-RCER, Patna (*Hindi*).

15.4 Presentation in Conferences / Symposia / Seminars/ Workshop / Other fora

1. Maity, A., Sharma, J., Gharate, R.D., Sarkar, A., More, A.K., and Pal, R.K. 2016. Nitrogen nutrition and salicylic acid induced defense responses against bacterial blight disease in pomegranate. Proceedings of 7th Indian Horticulture Congress - An International Meet for doubling farmers income through horticulture, ICAR-IARI, New Delhi, 15-18, November, 2016, p 398. (Abstract).
2. Meshram, D.T. 2016. Efficient irrigation management of pomegranate (*Punica granatum* L.). National Conference on challenges and opportunities in Quality Production of pomegranate held at Jain Irrigation Systems Ltd. Jalgaon during 16-18th April, 2016.
3. Meshram, D.T. 2016. Effects of micro-irrigation systems on WUE of pomegranate (*Punica granatum* L.) in semi-arid conditions of Maharashtra, India. International Conference on Agricultural Sciences and Food Technologies for sustainable productivity and Food Security, UAS, Bengaluru, Karnataka, India during 25th–27th August, 2016.
4. Meshram, D.T. 2016. Efficient water management for maximization of pomegranate (*Punica granatum* L.) production. International Conference on Agricultural Sciences and Food Technologies for sustainable productivity and Food Security, UAS, Bengaluru, Karnataka, India, 25th–27th August, 2016.
5. Meshram, D.T. 2016. Improving water use efficiency in pomegranate (*Punica granatum* L.) through organic and inorganic mulches. International Conference on Integrated Land Use Planning for Smart Agriculture, November, 10-13, 2016, Nagpur, India.
6. Meshram, D.T. 2016. Identification of suitable land for pomegranate (*Punica granatum* L.) cultivation in Gujarat, India by using Remote Sensing and Geographical Information System. International Conference on Integrated Land Use Planning for SmartAgriculture, November, 10-13, 2016, Nagpur, India.
7. Pal, R.K. Gaikwad, N.N. and Singh, N.V. 2016. Pomegranate for entrepreneurship development through production of bioactive compounds as ingredients for food, pharmaceuticals and cosmetic industry. Souvenir of International Conference in Recent Advances in Food Processing and Biotechnology. Institute of Agricultural Sciences, BHU, Varanasi, April 02-05, 2016, pp. 24-30 (IJCN:ISSN-0971-9210).
8. Babu, K.D., Singh, N.V., Shilpa, P., Sharma, J., Pal, R.K., Jalikop, S.H. and Murthy, B.N.S. 2016. Development and evaluation of new pomegranate hybrid for table purpose. Souvenir cum Invited Paper Abstracts. 7th Indian Horticulture Congress – An International Meet: Doubling farmers income through horticulture, B.P. Pal Auditorium, IARI, New Delhi, Nov 15-18, 2016, p.285 (Invited Oral Paper).
9. Sharma Jyotsana. 2016. Advances in Integrated Pest Management in Pomegranate. National Workshop on Advances in disease management technologies in horticultural crops, organized jointly by Himalayan Phytopathological Society and Department of Plant Pathology, at Dr YS Parmar University of Hort. & Forestry Nauni (Solan) at Nauni from 7th-8th Dec, 2016.
10. Sharma Jyotsana. 2016. Pomegranate diseases and insect pest management. National Workshop on Technological Changes and Innovations in Pomegranate Production and Utilization for Enhancing Farmers' Income organized jointly by AU, Jodhpur, Confederation of Horticulture Association of India in collaboration with ASM Foundation, New Delhi and Jain Irrigation Systems Ltd., Jalgaon at Agriculture University, Jodhpur on Dec 10, 2016.
11. Kumar, P, Aravind, L.B., Manjunatha, G., Lokesh, V. and Sharma Jyotsana. 2016. Genetic variability assessment of *Ceratocystis fimbriata* using ITS and RAPD marker systems. National symposium on recent advances in plant health management for sustainable productivity, 15-16 December, 2016, UAS Dharwad, India.

12. Mallikarjun, M.H., Ballal, C.R. and Pal, R.K . 2016. Standardization Laboratory Rearing Protocol for Pomegranate Fruit Borer on Semisynthetic Diet. Souvenir National symposium on Behavioural ecology and management of agriculturally important insects and other animals, UAHS, Shivamogga, December 27-28, 2016 pp 47.

13. Gaikwad, N.N., Pal, R.K., Sharma J., Babu, K.D., Yedle, V.H. and Suryawanshi, S.K. 2017. Effect of microwaves pretreatment on extraction of pomegranate seed (cv. Bhagwa) oil. In Technical compendium of 51st Annual Convention of Indian Society of Agricultural Engineers (ISAE) and National Symposium on Agricultural Engineering for Sustainable and Climate Smart Agriculture, February 16-18, 2017 ISAE-2017/PDF/FDE-11, pp. 80.

14. Gaikwad, N.N., Suryavanshi, S.K. and Pal, R.K. 2016. Entrepreneurial opportunities' in pomegranate processing. Three days national conference on challenges and opportunities in quality production of pomegranate, Jain Hills, Jalgaon, 26-28 March 2016.

15. Gaikwad, N.N., Pal, R.K. and Suryavanshi, S.K. 2017. Total utilization of pomegranate through value addition and commercialization of technologies: ICAR-NRCP model, Technical compendium of 51st Annual Convention of Indian Society of Agricultural Engineers (ISAE) and National Symposium on Agricultural Engineering for Sustainable and Climate Smart Agriculture February 16-18, 2017 ISAE-2017/PDF/HCP-44, PP 117.

15.5 Technical/ Extension Bulletins & folders

1. Gaikwad, N.N. and Meshram, D.T. 2016. *Dalimb Uthpadan, Vipanan ani Upyukatata,* ICAR-NRCP Technical Bulletins, 2017/1, 1-93 (Marathi).

2. Sharma Jyotsana, Suroshe, S., Shinde, Y.R. and Chaudhari, D.T. 2017. *Dalimbawaril Rog Avum Kid: Nidanaani Vyawasthapan*. ICAR-NRCP Tech. Bull. 2017/2. 76 (Marathi).

15.6 Annual Reports

1. Pal, R.K., Babu, K.D., Maity, A., Singh, N.V., Gaikwad, N.N., Meshram, D.T. 2016. ICAR-NRCP Annual Report 2015-16. ICAR-NRCP, Solapur, p.116.

2. Pal, R.K., Singh, N.V., Meshram, D.T., Gaikwad, N.N., Sangle, U.R., Babu, K.D. and Maity, A. 2016. ICAR-NRCP Annual Report 2015-16. ICAR-NRCP, Solapur (Hindi version), p.124

15.7 Manual/ Compendium

1. Maity, A., Gaikwad, N.N., Pal, R.K., Sharma Jyotsana, Babu, K.D., Meshram, D.T.. Singh, N.V. and Mallikarjun. 2017. Model pomegranate production practices and value addition of produce. ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra 58p.

2. Meshram, D.T. 2016. Course compendium of training programme for RAMETI field staffs of Amravati district on "Precision farming for pomegranate" during 20-23rd July, 2016.

3. Meshram, D.T. 2016. Course compendium of training programme for Mehsana, Banaskatha and Sabarkatha pomegranate farmers on "Quality Production of pomegranate" during 24-26th October, 2016.

4. Meshram, D.T. 2016. Course compendium of training programme for Tribal Farmers of Dhule and Nadaurbar Districts, Maharashtra on "Skill Development on Water Management in Pomegranate" during 26-29th Dec, 2016.
5. Meshram, D.T. 2017. Course compendium of training programme for Madhya Pradesh, pomegranate farmers on "Various Aspect of Pomegranate Cultivation" during 26-29th January, 2017.

15.8 Patent

Gaikwad. N.N. and Pal, R.K. 2017. "A process of extraction of virgin pomegranate seed oil with retention of bioactive compounds" Patent Filed Application No. 201611011366 E-2/528/2017/DEL.

15.9 Gene sequences deposited to gene bank of NCBI.

1. Sharma Jyotsana, Manjunath, G., Kumar, P., Balagannur, A.L., Lokesh, V., Gowda, A.A. 2016. Submitted partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, to GenBank of four Wilt strains of *Ceratocystis fimbriata* isolates NRCP-CF19, NRCP-CF22, NRCP-CF24, NRCP-CF26 having Genbank Accession Nos. KU877209, KU877210, KU877211 and KU877212 respectively.
2. Kumar , A., Munjal, V., Kumar, S., Sharma, J., Singh, N.V. 2017. Submitted 16S rDNA sequences of 9 endophytic bacteria on pomegranate in Gene bank of NCBI. These endophytic isolates submitted with accession numbers in parenthesis are TC6: *Bacillus subtilis* (KY575578); TC7:*Burkholderia stabilis* (KY575579); TC15: *Shingomonas paucimobilis* (KY575580); TC 130:*Bacillus licheniformis,* (KY575581); TC 310: *Bacillus tequilensis* (KY575582); BW: *Bacillus aryabhattai* (KY575583); EB4: *Bacillus tequilensis*(KY575584); EB6 *Lysinibacillus macrolides,* (KY575585) and EB9: *Bacillus subtilis* (KY575586)
3. Kumar, A., Munjal, V., Kumar, S. Sharma Jyotsana. 2017. Submitted 16S rDNA sequences of 9 phyllospheric bacteria on pomegranate in Gene bank of NCBI. These endophytic isolates submitted with accession numbers in parenthesis are Pg_1: *Bacillus subtilis* (KY575587); Pg_3: *Acinetobacter wooffii*(KY575588); Pg_4: *Bacillus megaterium*(KY575589); Pg_6: *Microbacterium arborescens* (KY575590); Pg_8: *Sphingomonas yunnanensis* (KY575591); Pg_9: *Aureimonas phyllosphaerae* (KY575592); Pg_10: *Massilia varians* (KY575593); Pg_11: *Bacillus cereus* (KY575594) and Pg_12: *Staphylococcus hominis* (KY575595)
4. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N.N., Sangolgi D. and Mundevadikar, D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, Bacillus aryabhattai Accession no. KY575583.
5. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad, N., Sangolgi D. and Mundevadikar, D.M.. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Bacillus subtilis* Accession no. KY575578.
6. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad, N., Sangolgi D. and Mundevadikar, D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Burkholderia stabilis* Accession no. KY575579.
7. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar. D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Shingomonas paucimobilis* Accession no. KY575580.

8. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar. D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Bacillus licheniformis* Accession no. KY575581.
9. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar. D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Bacillus tequilensis* Accession no. KY575582.
10. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar, D.M. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Bacillus tequilensis* Accession no. KY575584.
11. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar, D.M.. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Lysinibacillus macroides* Accession no. KY575585.
12. Kumar A., Munjal V., Thalor S., Sharma J., Singh N.V., Gharate R., Dinkar M., Gaikwad N., Sangolgi D. and Mundevadikar, D.M.. 2017. Molecular and functional characterization of endophytic bacteria associated with pomegranate, *Bacillus subtilis* Accession no. KY575586.
13. Kumar, A., Munjal, V., Kumar, S., Sharma, J., Singh, N.V., Gharate, R., Dinkar, M., Gaikwad, N., Sangolgi, D., Mundewadikar, D.M. 2017. Molecular and Functional Characterization of endophytic bacterial associated with pomegranate. Sequence of the below mentioned endophytes submitted to NCBI database: *Bacillus subtilis, Burkholderia stabilis, Shingomonas paucimobilis, Bacillus licheniformis Bacillus tequilensis, Bacillus aryabhattai, Lysinibacillus macroides.*
14. NV Singh, S Parashuram, J Sharma, KD Babu, Roopa SP, DM Mundewadikar, VR Sangnure and RK Pal. 2017. Transcriptome analysis of moderately bacterial blight resistant and susceptible genotypes of *Punica granatum.* Submitted pomegranate transcriptome data to NCBI (Accession/ Bio Project ID: PRJNA361285).

15.10 Other reports

1. "Report of Second Quinquennial Review Team for the period April 1, 2011 to March 31, 2016", pertaining to ICAR-NRCP, Solapur was compiled by Dr. (Mrs.) Jyotsana Sharma, M.S. QRT and submitted to ICAR, New Delhi. pp97.
2. Maity, A. and Pal, R.K. 2017. Project Report (January, 2014-March, 2017) Demonstration of model pomegranate production practices for effective management of bacterial blight disease. ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra.
3. Frequently asked questions (FAQ) on pomegranate (120 Nos.) were compiled by Dr.(Mrs.) Jyotsana Sharma.

15.11 E-publications

1. Pal, R.K., Gaikwad, N.N., Maity, A., Singh, N.V., Meshram, D.T., Sharma Jyotsana and Babu, K.D. 2017. Innovation, Capacity building and success stories in pomegranate. ICAR-NRCP e-Publication 2017/1, 21p.
2. Pal, R.K., Singh, N.V., Sharma, J., Maity, Babu, K.D. and Gaikwad, N.N. 2017. Yield gap analysis of adopted and non-adopted pomegranate orchards of Maharashtra, Karnataka and Andhra Pradesh. ICAR-NRCP e-Publication 2017/2, 12 p.
3. Pal, R.K., Maity, A., Marathe, R.A., Meshram, D.T., Singh, N.V., Sharma Jyotsana and Gaikwad, N.N. 2017. Region specific technology inventory for pomegranate cultivation in Maharashtra. ICAR-NRCP e-Publication 2017/3, 47p.

16. BUDGET ESTIMATE

Financial Outlay 2016-17

(Rs. in lakhs)

Head of Account	Rupees in Lakhs			
	2016-17			
	Plan		Non-Plan	
	RE	Expenditure	RE	Expenditure
A) Recurring				
Estt. Charges	0.00	0.00	240.83	205.67
T.A.	3.25	3.25	5.00	4.98
Other Charges	199.75	199.71	269.47	266.69
Total A	**203.00**	**202.96**	**515.30**	**477.34**
B) Non-Recurring				
Equipment	1.50	1.49	6.00	5.60
Major Work	199.50	199.50	0.00	0.00
Library	0.00	0.00	2.00	2.00
Furniture	0.00	0.00	4.00	3.84
Total B	**201.00**	**200.99**	**12.00**	**11.44**
C) Loan & Adv.	0.00	0.00	2.98	1.84
D) Pension	0.00	0.00	10.53	9.32
E) Vehicles & Vessels	0.00	0.00	0.00	0.00
Grand Total (A+B+C+D)	**404.00**	**403.95**	**540.81**	**499.84**

Revenue Receipts 2016-17

Sl. No.	Items	Amount (Rs.)
1.	Income from farm produce	832870.77
2.	Income from Royalty and Publication	183080.00
3.	Income from other sources	355729.00
4.	Interest on loans and advances	155643.00
5.	Interest earned on short term deposits	236230.00
6.	Recovery of loans and advances	430000.00
7.	Training programmer	7600.00
8.	Analytical testing fee	3400.00
9.	License fee	22290.00
	Total Revenue Receipts	**2226842.77**

17. STAFF POSITION

Category	Sanctioned during XIIth plan	Staff position	Vacant
RMP	01	01	00
Scientific	10	10	00
Technical	06	06	00
Administrative	11	05	06
Supporting	02	02	00
Total	**30**	**24**	**06**

18. AWARDS / RECOGNITION / JOINING / PROMOTION / RELIEVING

Awards

- Dr. R.K. Pal, Director was conferred "NAAS Fellowship-2017" by the National Academy of Agricultural Sciences, New Delhi.
- Dr. R.K. Pal, Director was conferred "Fellow of SARP-2017" by the Society for Advancement of Research on Pomegranate, Solapur
- Dr. K. Dhinesh Babu, Principal Scientist (Hort.- Fruit Sc.) was conferred "Fellow of Horticultural Society of India-2016" by the HSI, New Delhi.
- Dr. (Mrs.) Jyotsana Sharma was conferred "Dalimb Ratna Award-2016" by Akhil Maharashtra Dalimb Utapadak Sanshodhan Sangh, Pune for developing the model for management of bacterial blight disease (Telya) plant health management systems in pomegranate crop.
- Dr. Ashis Maity was conferred "Dalimb Ratna Award-2017" by Akhil Maharashtra Dalimb Utapadak Sanshodhan Sangh, Pune for exploring microbial wealth for plant nutrition and triggering plant defense mechanism with elicitor molecules and nutrients in pomegranate.
- Dr. N.V. Singh was awarded Krushi Kranti Award-2016 by RK Foundation, Ahmednagar for the outstanding contribution in the field of pomegranate production.
- Dr. N.V. Singh, Dr. Ashis Maity and Dr. N. Gaikwad were awarded the Young Scientist Award-2017 by the Society for Advancement of Research on Pomegranate, Solapur.
- Dr. D.T. Meshram and Dr. K. Dhinesh Babu were awarded the 'SARP Associate Award-2017' by the Society for Advancement of Research on Pomegranate, Solapur.
- Dr. Ashis Maity was conferred 'Best Poster award' in 7th Indian Horticulture Congress held at New Delhi on 15-1^{8th} November, 2016 organized by The Horticulture Society of India**.**
- Dr. D.T. Meshram was conferred 'Best oral presentation award' in International Conference on "Agricultural Sciences and Food Technologies for sustainable productivity and Food Security" held at UAS, Bengaluru, Karnataka, India during 25th–27th August, 2016.
- Dr. U. R. Sangle was conferred 'Best poster award' in 7th Indian Horticulture Congress held at New Delhi on 15-18 November, 2016 organized by The Horticultural Society of India.
- Dr. (Mrs.) Shilpa Parashuram was conferred "Best PhD thesis award" by SVWS, Lucknow, UP, India

Recognition

- Dr. N.V. Singh, was involved in formulation of certification guidelines for pomegranate tissue culture raised plants by "National certification system for tissue culture raised plants" (NCS-TCP).
- Dr. N.V. Singh was involved as one of the reviewer (Reviewer no. 23) of the United States-Israel Binational Agricultural Research and Development funded project proposal (US $ 0.31 million): "Heart Rot in pomegranate: exploring the host-pathogen interactions for developing environmental friendly means of disease management".

Promotion

- Dr. D.T. Meshram, Sr. Scientist promoted to Sr. Scientist (PB-IV) w. e. f. 18.03.2016.
- Mr. Diwakar V. Sawaji, Technical Assistant promoted to Senior Technical Assistant w.e.f. 15.04.2013.

Dr. R.K.Pal, Director, ICAR-NRCP was conferred NAAS Fellowship-2017 on 5th June 2017 at the Foundation Day and AGM of NAAS, New Delhi.

Dr. (Mrs.) J. Sharma received Dalimb Ratna Award-2016 from Mr. Sharad Pawar on behalf of Akhil Maharashtra Pomegranate Growers Research Association for her valuable contribution in development of model for management of bacteria blight disease of pomegranate

Dr. K. Dhinesh Babu was conferred Fellow of Horticultural Society of India -2016 by 'Padma Shri' Dr. K.L. Chadha, President of HSI, New Delhi on 17.11.2016

Appendix I

Institute Management Committee of ICAR-NRCP

Chairman			
1.	Dr. R. K. Pal Director ICAR-NRCP, Solapur		
	Members		
2.	Dr. (Mrs.) Jyotsana Sharma Pr. Scientist, ICAR-NRCP, Solapur	8.	Dr. Prabhakar Project Coordinator (Millets) GKVK Campus, Bengaluru
3.	Director of Horticulture Govt. of Maharashtra	9.	Sh. Prabhakar Chandane Po. Ekhatpur, Tal. Sangola, Dist. Solapur (MS)
4.	Dr. R. G. Somkuwar, Principal Scientist, ICAR-NRC for Grapes, Post Box No. 3, Manjari Farm, Pune 412 307 (MS)	10.	Dr. W.S. Dhillon The Assistant Director General (HS-I) Indian Council of Agricultural Research Krishi Anusandhan Bhavan, Phase II, Pusa New Delhi 110 012
5.	Director of Horticulture, Govt. of Rajasthan	11.	Sh. Baburao Ramchandra Gaikwad Ramkrishna Niwas, Shivaji Nagar, At. Post. Sangola, Solapur
6.	Dr. S. Sriram Principal Scientist Division of Plant Pathology, ICAR-Indian Institute of Horticultural Research, Bengaluru	12.	The Finance and Accounts Officer Indian Institute of Rice Research,, Rajendranagar, Hyderabad
7.	Dr. D. P. Waskar Director of Research, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani		**Member Secretary**
		13.	Sh. R. B. Rai Assistant Administrative Officer ICAR-NRCP, Solapur

Appendix II

Research Advisory Committee of ICAR-NRCP

(As on 31.03.2017)

Chairman			
1.	Dr. R. B. Deshmukh Former Vice Chancellor MPKV, Rahuri		
Member			
2.	Dr. Vitthal Benagi, Director of Extension, UAS, Dharwad	6.	Dr. R. K. Pal Director, ICAR-NRC on Pomegranate, Solapur
3.	Dr. D. P. Waskar, Director of Research, VNMKV, Parbhani	7.	Shri Baburao Ramchandra Gaikwad, RamkrishnaNiwas, Shivaji Nagar, At. Post. Sangola, Dist. Solapur
4.	Dr. W. S. Dhillon, ADG (HS-I) (Fruits and Plantation Crops) ICAR, KAB-II, Pusa,New Delhi		**Member Secretary**
5.	Dr. K.S. Mohan, Former Biotechnologist, Monsanto Research Centre, Bangalore	8.	Dr. (Mrs.) Jyotsana Sharma Principal Scientist, ICAR-NRC on Pomegranate, Solapur 413255 (MS)

Institute Research Council of ICAR-NRCP

(As on 31.03.2017)

Chairman			
1.	Dr. R. K. Pal Director, ICAR-NRCP		
Member			
2.	Dr. K. Dhinesh Babu Pr. Scientist (Hort.-Fruit Science) ICAR-NRCP, Solapur	7.	Dr. N. N. Gaikwad Scientist (AS & PE) ICAR-NRCP, Solapur
3.	Dr. D. T. Meshram Sr. Scientist (L & WME) ICARNRCP, Solapur	8.	Dr. (Mrs.) Shilpa Parashuram Scientist (Gen. & Pl. breeding) ICAR-NRCP, Solapur
4.	Dr. U. R. Sangle, Sr. Scientist (Plant Pathology) ICAR-NRCP, Solapur	9.	Mr. Mallikarjun Scientist (Entomology) ICAR-NRCP, Solapur
5.	Dr. Ashis Maity Scientist (Soil Science-Pedology) ICAR-NRCP, Solapur	10.	Ms. Roopa Sowjanya, P. Scientist (Gen. & Pl. breeding) ICAR-NRCP, Solapur
6.	Dr. N. V. Singh Scientist (Hort.-Fruit Science) ICAR-NRCP, Solapur		**Member Secretary**
		11.	Dr. (Mrs.) Jyotsana Sharma Pr. Scientist (Plant Pathology) ICAR-NRCP, Solapur

Appendix III

Institute Joint Staff Council of ICAR-NRCP

(As on 31.03.2017)

Chairman			
1.	Dr. R. K. Pal Director, ICAR-NRCP		
	Members (Official Side)		**Members (Staff Side)**
2.	Dr. (Mrs.) J. Sharma, Pr. Scientist, ICAR-NRCP	8.	Sh. R. B. Rai, Member (CJSC) AAO, ICAR-NRCP
3.	Dr. N. V. Singh, Scientist, ICAR-NRCP	9.	Sh. Y. R. Shinde, Secretary (IJSC) Sr. Tech. Asstt., ICAR -NRCP
4.	Dr. D. T. Meshram, Sr. Scientist, ICAR-NRCP	10.	Sh. D. T. Chaudhari, Sr. Tech. Asstt., ICAR-NRCP
5.	Dr. Nilesh Gaikwad, Scientist, ICAR-NRCP	11.	Sh. Kiran Khatmode, LDC, ICAR-NRCP
6.	Officer I/c- Accounts ICAR-NRCP	12.	Sh. S. S. Bayas SSS, ICAR-NRCP, Solapur
7.	Officer I/c – Admn. ICAR-NRCP	13.	Sh. V. S. Gangane SSS, ICAR-NRCP

Appendix IV
Personnel
(As on 31.03.2017)

RMP

Dr. R. K. Pal
Director

Scientific Staff

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

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

Dr. D. T. Meshram
Sr. Scientist
(Land and Water Management Engg.)

Dr. U. R. Sangle
Sr. Scientist
(Plant Pathology)

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.)

Dr. (Mrs.) Shilpa Parashuram
Scientist
(Genetics & Plant Breeding)

Mr. Mallikarjun
Scientist
(Agri. Entomology)

Ms. Roopa Sowajanya P.
Scientist
(Genetics & Plant Breeding)

Technical Staff

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

Sh. Yuvraj Shinde,
Sr. Tech. Asstt.

Sh. Diwakar Sawaji
Sr. Tech. Asstt.

Sh. M. S. Gogaon
Sr. Technician

Sh. Govind Salunke
Sr. Technician

Sh. Vijay Lokhande
Sr. Technician

Administrative Staff

Sh. R. B. Rai
AAO

Sh. Shinde V. A.
AF & AO

Sh. Kiran Khatmode
LDC

Sh. A. S. Babar
LDC

Sh. Vipin Dagar
LDC

Supporting Staff

Sh. Shailesh Bayas
SSS

Sh. Vishal Gangane
SSS

Certificado · Sertifika · प्रमाण पत्र · Zertifikat · شهادة

CERTIFICATE OF REGISTRATION

EQUALITAS

NATIONAL RESEARCH CENTRE ON POMEGRANATE

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

This certificate verifies that the above Organisation has been audited on the above address for scope as under and found to be in accordance with the requirements of Management system.

ISO 9001:2008
Quality Management System

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

Certificate No: **Q-01140603**

Original Issue Date: **03 Jun 2014**

Issue Date: **25 Jul 2016**

1st Surv. Done on: **25 May 2015**

2nd Surv. Done on: **20 Jul 2016**

Valid Till: **02 Jun 2017**

This Certificate is valid as per Rules and Regulations of ECL & also the surveillance audits conducted atleast once a year.
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