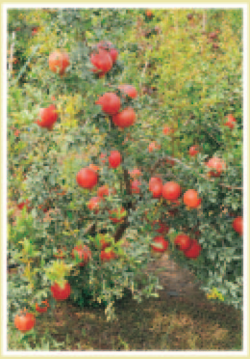

भाकृ अनुप
ICAR

वार्षिक रिपोर्ट
Annual Report
2013-14

(ISO - 9001:2008 Certified Institute)

राष्ट्रीय अनार अनुसंधान केन्द्र
National Research Centre on Pomegranate
(भारतीय कृषि अनुसंधान परिषद)
(Indian Council of Agricultural Research)
सोलापुर – 413 255
Solapur - 413 255

Printed: June 2014

Supervision and Guidance
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Scientist (Agril. Structures & Process Engineering)

Summary in Hindi
N.V. Singh
Scientist (Hort.- Fruit Science)

Correct citation: NRCP Annual Report 2013-14, National Research Centre on Pomegranate, Solapur- 413 255, Maharashtra

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CONTENTS

PREFACE

National Research Centre on Pomegranate (NRCP) was established at Solapur, Maharashtra in 2005 by the Indian Council of Agricultural Research (ICAR) to augment the production, productivity and utilization of pomegranate through basic, strategic and applied research. The centre has been functioning at Kegaon, Solapur following the inauguration of the newly built office- cum-lab building on 7th July 2013.

The experimental farms sprawl over 46.26 ha area at Kegaon and Hiraj villages with a pomegranate plantation over 11 ha area. The experimental farms encompass the state-of –the –art automatic fertigation facilities and water harvesting structures. The national repository of pomegranate has more than 300 pomegranate germplasm collection including the wild accessions, indigenous collections from North Eastern states and western Himalayas besides 92 exotic collections from California, Afghanistan and Iran.

The centre strives hard to make upsurge in solving the core challenges pertaining to pomegranate viz., availability of healthy and disease free planting material, developing varieties resistant / tolerant to biotic and abiotic stresses, etc. The incidence of bacterial blight disease has been brought under control through adoption of Integrated Disease and Insect Pest Management (IDIPM) schedule. New research leads were provided by the institute in the areas of crop improvement, crop protection, post harvest technology and value addition of pomegranate with the establishment of nine state of the art laboratories. Development of technologies for maximizing nutrient and water use efficiency with respect to dry land horticulture is in progress. The NRCP has successfully standardized the technology for biohardening of tissue culture plants of pomegranate. The technology for extraction of seed oil from pomegranate seeds is in progress and technology for clarified wine preparation from pomegranate juice has been refined. The weather report, farmers' alert and day-to-day events are regularly updated in the website of the institute (www.nrcpomegranate.org).

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

June 15, 2014
Solapur

(R.K. Pal)
Director

NRCP : AN INTRODUCTION

India is one of the leading countries in pomegranate acreage and production worldwide. The area under cultivation of Pomegranate in India has grown by 10.73 per cent during last seven years. Pomegranate is an important fruit crop of arid and semiarid regions of the world. India is one of the leading producers of pomegranate in the world. In India, it is cultivated over 1.13 lakh ha with an annual production of 7.44 lakh tones and average productivity of 6.6 tonnes/ha. Maharashtra experienced a very rapid growth in Pomegranate area during the last 20 years from 4.6 thousand ha to 82.0 thousand ha and accounts for 76.40 per cent of the total cultivated area under pomegranate in the country. Maharashtra is the leading producer of pomegranate in India followed by Karnataka, Andhra Pradesh and Gujarat. In recent past, pomegranate cultivation has been gaining momentum in Rajasthan, Orissa, Chhattisgarh,Uttarakhand, Madhya Pradesh and Tamil Nadu.

National Research Centre on Pomegranate was established at Solapur, Maharashtra in 2005 by the ICAR to augment the production, productivity and utilization of pomegranate through basic, strategic and applied research. For a stop gap arrangement the centre was temporarily housed at the premises of Centre for Rabi Sorghum, Shelgi, Solapur. It was established by Indian Council of Agricultural Research (ICAR) to augment the production, productivity and utilization of pomegranate through basic, strategic and applied research. The centre has been functioning at Kegaon, Solapur following the inauguration of the newly built office- cum-laboratory building on 7th July 2013. The building was inaugurated by former Union Minister of Agriculture, Shri Sharad Pawar in presence of former Union Home Minister, Shri. Sushilkumar Shinde and more than one thousand invitees / farmers were present.

The experimental farms sprawl over 46.26 ha area at Kegaon and Hiraj villages with a pomegranate plantation area of 11 ha. Hi-tech polyhouses erected in the farm facilitate the R&D work on mass multiplication of elite, disease free planting material produced through tissue culture and screening of germplasm for bacterial blight tolerance. The experimental farms encompass the state-of –the –art automatic fertigation facilities and water harvesting structures. The national repository of pomegranate has more than 300 pomegranate germplasm collection including the wild accessions, indigenous collections from North Eastern states and western Himalayas besides 92 exotic collections from California, Afghanistan and Iran.

The major thrust areas of pomegranate research at NRCP are crop improvement, crop production, crop protection and post harvest technology. The mandates of the centre are :

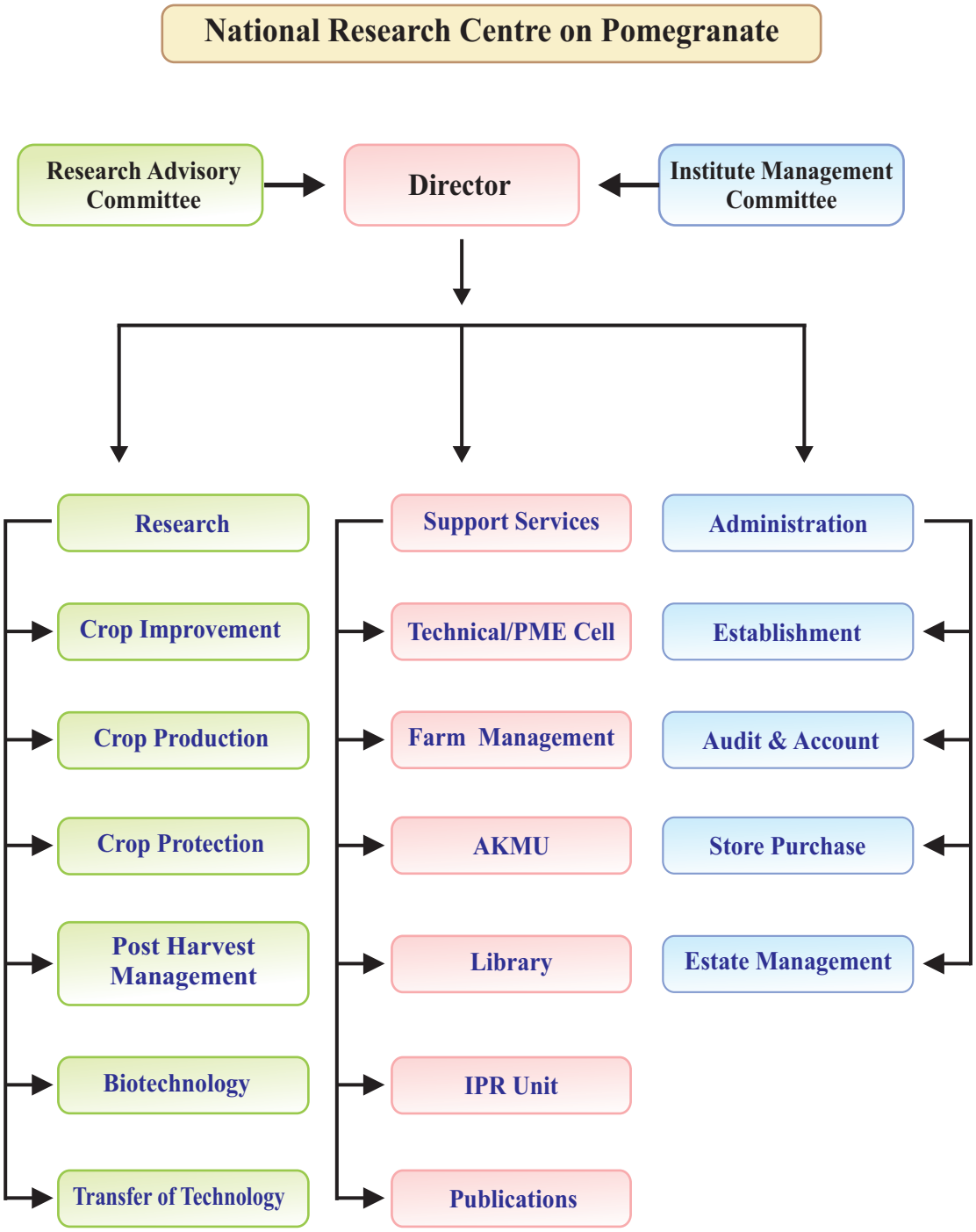
- To develop suitable varieties with high yield potential and quality fruits having resistance to biotic and abiotic stresses.
- To undertake basic, strategic and applied research for developing sustainable technologies for quality fruit production and post harvest value addition.
- To transfer technologies to pomegranate growers and other stakeholders.

NRC on Pomegranate has made special attainments in identification of causal organism for bacterial blight and wilt with development of Integrated Disease and Insect Pest Management (IDIPM) schedule for management of insect pests and diseases affecting pomegranate. Bacterial blight in pomegranate is the major impediment in pomegranate production in India. In view of non availability of resistant sources for this dreaded disease, scientifically sound management system and community approach are the important steps for mitigation of this challenge. In this context a video film has been developed by NRCP for creating mass awareness on management of bacterial blight. The low cost technology for production of disease free

planting material through hardwood cuttings with 85% success has been standardized. Package of practices for establishment of orchard through tissue culture plants is being developed. Protocol has been standardized for *in vitro* propagation of pomegranate and biohardening of tissue culture plantlets. The development of protocol for extraction of seed oil from pomegranate seeds is in progress. The technology for production of clarified pomegranate wine from pomegranate juice has been refined. Similarly, several extension folders viz. establishment of new pomegranate orchard, management of fruit sucking moth, pomegranate wilt and its management, drip irrigation in pomegranate, production of quality plating materials, micronutrient management and water management written in lucid and crisp forms have been prepared and used by several pomegranate growers of India.

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

NRCP is closely associated with All India Pomegranate Growers' and Research Association besides Maharashtra Pomegranate Growers' and Research Association. Further, the centre has close collaboration with State Department of Horticulture, State Agricultural Universities, KVKs and other stakeholders associated with pomegranate cultivation. The centre witnesses a large number of farmers visiting it on various aspects of pomegranate cultivation. The website of NRCP has been designed as per the uniformity guidelines of ICAR which offers the regular update of weather, farmers' alert and day-to-day events etc besides free downloadable publications for farmers and researchers.



Organizational Structure

कार्यकारी सारांश

राष्ट्रीय अनार अनुसंधान केन्द्र, सोलापूर में आठ अनुसंधान प्रयोगशालाऐं और दो शोध प्रक्षेत्रों (केगाँव तथा हिरज) के साथ-साथ आठ वैज्ञनिक, पाँच प्रशासनिक एवं दो सहायक कर्मचारी हैं। केन्द्र कि विभिन्न अनुसंधान, प्रसार तथा अन्य गतिविधियों का सारांश नीचे दिया गया है।

केन्द्र के प्रक्षेत्र जीन कोष मे 225 देशी एवं विदेशी जननद्रव्यों का संग्रह है। बीस आई. सी. संख्याओं की प्राप्ति अनार के जननद्रव्यों के लिए हुई हैं। इसके अलावा पंन्द्रह अन्य जननद्रव्यों के आई.सी. संख्या प्राप्ति के लिए आवेदन दिया गया है, जिसमे ग्यारह जम्मू- कश्मीर के संग्रह हैं तथा दो अनारदाना की आग्रिम लाइन्स हैं।

इक्कीस किस्मों / जननद्रव्यों का प्रसंस्करण हेतु मूल्यांकन किया गया है। छिलका, पोमेश, रस, कुल घुलनशील ठोस एवं अम्लता विभिन्न जननद्रव्यों में क्रमश: 26.67 -41.31%, 19.11- 17.43%, 37.20 - 50.18%, 14.44 - 17.63^0 ब्रिक्स तथा 0.31 - 5.14 के बीच पयी गई। तेबीस्ता, ज्योति, चाईना, सहारनपुर, काबूली येलो, पी - 13, पी - 16, जी - 137, केआरएस, कांन्धारी, आई.सी - 318762, आई.सी -318734 एवं गणेश में सबसे ज्यादा रस प्रतिशत (44.09 - 50.19%) पाया गया। आई.सी - 318705 एवं 318706 में क्रमश: सबसे ज्यादा कुलघुलनशील ठोस (17.6^0 ब्रिक्स) एवं अम्लता (5.15%) पायी गई। अरक्ता, भगवा, गणेश और मृदुला में से गणेश के पुष्पों में टैनिन की मात्रा सबसे अधिक पायी गई (22%) तथा इसके बाद यह भगवा में (20%) पायी गई। इसी प्रकार छिलके में टैनिन की मात्रा सबसे अधिक सहारनपुर (35%) तथा उसके बाद गणेश (31%), कल्पितिया (27.5%), आई.सी - 318708 (27.5) एवं पी -13 में (27.5%) रही।

छयान्वे (96) जंगली, व्यवसायिक किस्मों तथा विदेशी जननद्रव्यों का विविधता विश्लेषण 21 बहुरुपी एस एस आर मार्करों की सहायता से किया गया, विभिन्न जननद्रव्यों के बीच सार्थक भिन्नता पायी गई। भौतिक रसायनिक मापदण्डो के लिए [भगवा X 3/3 {(गणेश X नाना) X दारु}] संकरों कि तुलना भगवा से कि गई। कुल घुलनशील ठोस, संकर 14 (17.79^0 ब्रिक्स) एवं संकर 6 (17.55^0 ब्रिक्स) में भगवा की तुलना में ज्यादा पाया गया, जबकि संकर 5 एवं संकर 6 में यह भगवा के बराबर था। सबसे अधिक अम्लता संकर 5 (5.16%) तथा इसके बाद संकर 12 (4.90%) में थी, ये दोनों जननद्रव्य अनारदाना बनाने के लिए उपयुक्त हैं।

हस्त बहार में विकास नियामकों तथा रसायनों का उपयोग पाँच वर्ष के भगवा के पौधों में पुष्प उत्प्रेरण के लिए किया गया, इन छिडकावों का प्रयोग विपर्णन के 2 सप्ताह बाद किया गया जिसके फलस्वरुप पुष्पन छिडकाव के 2-3 सप्ताह के भीतर हो गया, एन.ए.ए.10 पी पी एम के छिडकाव में सबसे अधिक उभयलिंगी फूल (192.6 / पौधा) जबकी सबसे कम कंट्रोल में (87.5 / पौधा) पाये गए। फल सेट 40-65% के बीच पाया गया, सबसे अधिक फल सेट एन.ए.ए.10 पी पी एम (65%) तथा उसके बाद अमोनियम नाईट्रट 0.5% (63.1%) में पाया गया, सबसे कम फल सेट कंट्रोल में (40%) पाया गया।

दृढ काष्ठ के लिए 15 से.मी. लम्बी कर्तनों को बिना कर्तना सफलता घटाए तथा कम से कम लकडी का इस्तेमाल करते हुए सबसे उत्तम पाया गया।

सूक्ष्म प्रवर्धित पौधों का अर्बस्कुलर माइकोराईजल फन्जाय (ए.एम.एफ) के साथ जैवकठोरीकरण यह दर्शाता है कि जड उपनिवेशन ए .एम. एफ निवेशित तथा ए.एम.एफ + अस्परजिलस नायजर निवेशित पौधों मे क्रमश: 71.21 तथा 65.00% था।

रायजोस्फियर में अस्परजिलस नायजर की संख्या 6 X 10^4 सी एफ यु/ग्रा. मृदा पायी गई जो कंट्रोल में सिर्फ 2 X 10^4 सी एफ यु/ ग्रा. मृदा थी। जैवदृढीकरण किये गए सूक्ष्म प्रवर्धित पौधों का विकास, पादप क्रियाएं एवं जैवरसायनिक क्रियाऐं, कंट्रोल तथा सिर्फ अस्परजिलस नायजर निवेशित पौधों से अच्छी पायी गई।

जड फैलाव अध्ययन यह दर्शाते हैं कि गहरी एवं भारी मृदा की तुलना में हल्की एवं उथली मृदा में अनार के पौधों के जडों का विकास बेहतर होता है। गहरी चिकनी

मिट्टी में पोषक तत्व एवं पानी सोखने वाली सक्रिय एवं पतले जडों का विकास कम होता है । हल्की उथली मृदा में सक्रिय जड मुख्यत: 0-45 से.मी. गहराई तक तथा 0-60 से.मी. क्षैतिज दिशाओं में पाया जाता है।

कैल्केरीयस तथा गैर कैल्केरीयस मृदाओं में गंधक के प्रयोग से जस्ता का पौधों द्वारा अपटेक बढा हुआ पाया गया । पच्चीस (25) ग्रा जस्ता / कि.ग्रा मृदा के उपयोग से दोनों प्रकार की मृदाओं में जस्ता का अपटेक ज्यादा पाया गया । 5.0 ग्रा गंधक/कि.ग्रा गैर कैल्केरीयस मृदा तथा 10 ग्रा गंधक/कि.ग्रा कैल्केरियस मृदा के प्रयोग से लोह एवं मैंग्रीज का अपटेक पौधों द्वारा ज्यादा पाया गया ।

विभिन्न सिंचाई पध्दतियों का उप सतहीय बूँद सिंचन पध्दति से तुलना करने पर यह पता चला पौधों ऊँचाई, पुष्पों की संख्या, शाखे, नमी स्थिति तथा टहनी व्यास, 30X 30 से. मी. की दूरी पर डाले गऐ दो लेटरल वाले उपसतहीय बूँद सिंचन में सबसे बेहतर थी तथा उसके बाद 30 X 40 से.मी.पर डाले गए लेटरलों वाले उपसतहीय बूँद सिंचन में थी । दो लेटरलों वाले उपसतहीय बूँद सिंचन में पानी की बचत बूँद सिंचन की तुलना में 40-50% अधिक पायी गई ।

विभिन्न जैविक तथा अजैविक मल्चों के शोध परिक्षण से यह ज्ञात हुआ कि सबसे अधिक फल गन्ने तथा परवियस मल्च में 0.40 ई टिआर पाये गए तथा इसके बाद गेहूँ के भूसे, कुसुम के भूसे तथा काले मल्च एवं सफेद काले मल्च पर पाये गए । सबसे अधिक मृदा नमी काले मल्च वाले संप्रयोग में पायी गई ।

एरिल ब्राउनिंग के अध्ययन पर यह पता चला कि विभिन्न व्यवसायिक किस्मों में यह विकार 10% तक पाया गया तथा यह किस्मों के बीच सार्थक रुप से भिन्न था । प्रभावित दानों में स्वस्थ दानों की तुलना कैल्शियम, लोह एवं कॉपर ज्यादा पाया गया जब कि जस्ता कम पाया गया । यह अध्ययन सात व्यवसायिक किस्मों गणेश, जालोर सीडलेस, जी-137, रुबी, अरक्ता, मृदुला और भगवा के साथ किया गया । प्रारम्भिक अध्ययन लौह तथा कॉपर के अधिक अपटेक को एरिल ब्राउनिंग का मुख्य कारक दर्शाते हैं ।

बैक्टीरीयल ब्लाइट के प्रबन्धन के लिए किसान के अनार के चार बागों (डोणगाँव, सोलापुर) में 28 संप्रयोगों को लेकर एक प्रक्षेत्र परीक्षण किया गया। दो संप्रयोग जिनमें ट्राइक्लोसान या स्ट्रेप्टोसाक्लीन + 2 - ब्रोमो - 2 - नाइट्रोप्रोपेन - 1,3 - डाइआल के साथ - साथ जस्ता, मैंग्रीज या कॉपर था, बीमारी को 75% तक कम करने में उपयोगी रहे। कापर या जस्ता के कोई भी नैनो फार्मुलेशन्स प्रभावशाली नहीं पाए गए। पालीहाऊस परिक्षण में 21 संप्रयोगों में से, जिनमें 8 नए फार्मुलेशन्स तथा अन्य रसायन थे, 15 संप्रयोग पाँच छिडकाव के बाद बीमारी को 23-53% तक कम करने में सफल रहे । एक संप्रयोग में छिडकाव के 15 और 36 दिनों के बाद पौधे की सतह वॉश और निचोड में उच्च जीवाणूनाशी तथा जैवरसायन प्रतिरोधी क्रियाऐं पायी गई ।

इन विट्रो स्क्रिनींग के माध्यम से दो प्रभावशाली बायोएजेंट्स की पहचान अनार के पत्तों से की गई । जैन्थोमोनास एक्जोनोपोडिस पीवी. प्युनकी को नियंत्रित करने वाले बैक्टीरीयोफॉज को अनार की पत्तीयों, बगीचे की मृदा, नाले तथा कुऐं के पानी से आइसोलेट किया गया तथा संग्रहीत किया गया । ये सभी जीवाणु क्लोरोफॉर्म संवेदनशील पाये गए। रसायनों तथा गरम पानी से कर्तनों को स्वच्छित करके पालीहाऊस में लगाया गया, सभी कर्तन ब्लाइटसंक्रमित बगीचे से लाए गए थे । प्रारंभिक अध्ययन यह दर्शाता है कि जिवाणूनाशी के साथ कार्बेन्डाजिम के प्रयोग से तथा कुछ गरम पानी के संप्रयोगों में कर्तन पाँच महिने तक नोडल ब्लाईट से मुक्त पाये गए । जबकी औसतन सभी संप्रयोगों में 10% संक्रमित कर्तन पाये गये, फर्टीगेशन के द्वारा 400 ग्राम / पेड तक नत्रजन के प्रयोग से ब्लाईट संक्रमण घटता हुआ पाया गया जबकी इससे अधिक नत्रजन की मात्रा ब्लाइट को बढाती हुई पायी गई ।

गामा विकिरणीत 51 आशाजनक गणेश जननद्रव्यों के स्क्रीनींग में दस जननद्रव्यों में बिमारी 5% से कम पायी गई, स्क्रीनींग के दौरान 26 संकर जननद्रव्यों में से, जिनमें 18 रा.अ.अनु.केन्द्र के संकर भी थे, दो रा.अ.अनु. के संकर ब्लाईट सहिष्णु पाये गए, जिनमें ब्लाईट प्रतिशत 10 % से कम पाया गया ।

मौसमी घटकों जैसे कुल घण्टे जिनमें तापमान 25-35^{0} से. के बीच तथा सापेक्षिक आद्रता 50% से अधिक रही, साप्ताहिक वर्षा, प्रति सप्ताह बारिश वाले दिन, 20^{0} से. तथा

30% से अधिक सापेक्षिक आद्रता वाले घण्टो, को सार्थक रुप से ब्लाईट तीव्रता से सहसम्बान्धित पाया गया, अनार की पत्तीयों की ब्लाईट संवेदनशीलता फलों पर ब्लाईट के संक्रमण से सार्थक रुप से सहसम्बान्धित पायी गई ।

सीरेटोसीस्टीस फिम्ब्रीयाटा अनार में मर रोग का मुख्य कारक पाया गया और 92.8% मर रोग प्रभावित आइसोलेशन्स में यह उपस्थित था, जबकी कुछ नमुनों मे फ्यूजेरीयम, सूत्र कृमी, शॉट होल बोरर भी पाये गए । अध्ययन से पता चला की फफूँद की संख्या मुख्यत: मरसंक्रमित पौधों के पास होती है, फफूँदनाशी ट्रायसाक्लाजोल + मेन्काजेब 0.1%, डायफनकोनाजोल 0.1% और बायोएजेन्ट फार्मुलेशन्स जैसे अस्परजिलस नायजर 1.0% और ट्रायकोर्डमा (टि वी / टि एच) 1.0% के प्रयोग से इस फफूँद को शत प्रतिशत इन विट्रो स्थिति में मारा जा सकता है ।

गणेश किस्म के रस से अनार वाइन बनाने के प्रोटोकाल को इन्जाइम मे उपयोग से और बेहतर किया गया। अमाइलेज 100 मिग्रा/ली के पूर्व उपचार से पारदर्शी वाइन बनाने में मदद मिली ।

अपने खुद की शोध परियोजनाओं के अलावा रा.अ.अनु.केन्द्र ने कई अन्य भा.कृ .अनु.प के संस्थानों जैसे भा.बा.अनु.सं, रा.अ.अनु.सं एवं भा. कृ .अनु.सं के साथ मिलकर भी परियोजनाऐं क्रियान्वित की है । बाह्य वित्त पोषित परियोजनाऐं भी भा.बा.बो, रिलायन्स समुह एवं ईमामी बायोटेक की अर्थिक सहायता से सक्रिय हैं ।

वर्ष 2013-14 के दौरान केगाँव एवं हिरज शोध प्रक्षेत्र के 6 हेक्टेयर क्षेत्र में अनार की रोपाई का काम शोध कार्यों के लिए किया गया जिनमें उपसतहीय बूँद सिंचन के प्रयोग से प्रेसिजन खेती, फर्टीगेशन, पौध छत्रक विकास, किस्मों का मुल्यांकन, सूक्ष्म प्रवर्धित,गुटी एवं दृढ काष्ठ कर्तित पौधों का तुलनात्मक मुल्यांकन, ब्लाइट तथा मर रोग के अध्ययन, प्रक्षेत्र जीन प्रकोष, इत्यादी शामिल हैं ।

इस केन्द्र से वैज्ञानिकों को देश तथा विदेशों मे मानव संसाधन विकास सम्बन्धित क्रियाओं के सुदृढिकरण के लिए प्रशिक्षण पर भेजा गया। वैज्ञानिकों को फुलब्राइट स्कालर, यु एस डी ए, एआरएस, बैल्सविलि मैरीलेण्ड, द्वारा भी पीसीआर सम्बन्धित जाँच का प्रशिक्षण दिया गया । प्रशासनिक अधिकारीयों को भी स.प्र.प्र.सं. नई दिल्ली द्वारा आयोजित प्रशिक्षण कार्यक्रम में भेजा गया ।

वर्ष 2013-14 के दौरान विभिन्न प्रशिक्षण कार्यक्रम एवं कार्यशालाऐं आयोजित की गई बैक्टीरीयल ब्लाइट के प्रबधंन के लिए एक कार्ययोजना बैठक आयोजित की गई जिसमें भा.कृ.अनु.प. के संस्थान, राज्य कृषि विश्वविद्यालय तथा औद्योगिक इकाईयों के प्रतिनिधी एवं अनार उत्पादन संघ के सदस्यों ने भी हिस्सा लिया । 500 से अधिक किसानो को केन्द्र द्वारा, आंध्रप्रदेश, महाराष्ट्र तथा गुजरात के विभिन्न स्थानों पर अनार के आदर्श उत्पादन तकनीकों के बारे में प्रशिक्षण दिया गया

रा.अ.अनु. केन्द्र ने अपने स्थापना दिवस समारोह को अनार के कामयाब किसानो की सफल गाथा किसान की कहानी किसान की जुबानी नामक कार्यक्रम के जरिए मनाया। इस कार्यक्रम में अनार के किसान, वैज्ञानिक, एवं औद्योगिक इकाइयों के प्रतिनिधी उपस्थित थे ।

रा.अ.अनु. केन्द्र का व्हिजन 2050 दस्तावेज केंन्द्र की वेबसाइट पर अपलोड किया है। इस वेबसाइट पर नियमित रुपसे बेमौसम बरसात, ओलावृष्टि से सम्बन्धित नवीनतम जानकारी एवं हानि न्यूनीकरण निति उपलब्ध रहती है इसके अलावा विभिन्न ऋतुओं में पालन किये जाने वाली अनार उत्पादन क्रियाओं की सूची भी इसवेबसाइट पर अपलोड की जाती है ।

EXECUTIVE SUMMARY

National Research Centre on Pomegranate (NRCP), Solapur is having eight scientific, six technical, five administrative and two supporting staff besides eight research laboratories and research farms located at Kegaon and Hiraj villages. The various research, extension and other activities undertaken during the year 2013-14 are summarized below.

About two hundred twenty five pomegranate (*P. granatum* L.) germplasm consisting of indigenous and exotic collection were maintained in the newly established field gene banks. IC number for twenty pomegranate germplasm were obtained. Besides, NRCP has applied for IC number of 15 more accessions including eleven indigenous collection from Jammu and Kashmir, two advance lines for table purpose and two advance lines for *anardana* type.

Twenty one varieties/accessions were evaluated for processing purposes. Rind, pomace, juice, TSS and acidity contents differed significantly among the genotypes and their values ranged from 26.67- 41.30 %, 19.11 - 17.43%, 37.20 - 50.18%, 14.44- 17.63°Brix and 0.32 -5.14 %, respectively. Tabesta, Jyoti, China orange, Saharanpur, Kabuli Yellow and P-13, P-16, G-137, KRS, Kandhari, IC-318762, IC-318734 and Ganesh recorded highest juice content in the range of 44.09-50.19%. Significantly highest TSS (17.63° Brix) and acidity (5.15%) were found in IC-318705 and IC-318706, respectively.

The tannin content of pomegranate flowers of four varieties viz. Arakta, Bhagwa, Ganesh and Mridula revealed highest tannin content (22%) in Ganesh followed by Bhagwa (20%). Similarly, tannin content in rind was highest in Saharanpur (35%) followed by Ganesh (31%), Kalpitiya (27.5%), IC-318707 (27.5%) and P-13 (27.5%).

Diversity analysis of ninety six pomegranate genotypes comprising of wild, cultivated and exotic types was done using 21 polymorphic SSR markers. Significant variability was observed among various genotypes of pomegranate at molecular level using SSR markers.

In comparison to Bhagwa, twenty NRCP hybrids obtained from the parentage [Bhagwa x 3/3{(Ganesh x nana) x Daru}] were assessed for physico-chemical parameters. Based on TSS, Hybrid-14 (17.79°B), Hybrid-6 (17.55°B) were found to be superior to Bhagwa (15.95°B) and are suitable for table purpose whereas Hybrid-5, Hybrid-10 were on par with Bhagwa. The acidity was highest in Hybrid-4 (5.16%) followed by Hybrid-12 (4.90%) and are suitable for *anardana* purpose.

Growth regulators and chemicals were applied to induce flowering in 5 year old pomegranate cv. Bhagwa during hasth bahar. Foliar spray during the month of September at 2 weeks after defoliation when new flush initiation occurs revealed that flowering occurred in pomegranate within 2-3 weeks after the foliar spray. The number of bisexual flowers was highest in NAA 10ppm (192.6/ plant) whereas it was lowest in control (87.5/plant). The fruitset was found to range from 40.0 to 65.0%. The highest fruitset was recorded by NAA10ppm (65.0%) followed by ammonium nitrate 0.5% (63.1%) whereas it was least in untreated control (40.0%).

Trial on suitable length of hard wood cutting to optimize the amount of wood required for propagation of pomegranate without compromising the cutting success revealed that the ideal length of hard wood cutting as 15 cm.

The effect of biohardening agents on performance of tissue culture raised plants showed that colonization of roots of *in vitro* raised pomegranate plants with *Arbuscular Mycorrhizal Fungi* (AMF) was found at par in plants inoculated with AMF (71.12 %) and plants inoculated with AMF + *Aspergillus niger*(65.00%). Population of *Aspergillus niger* (AN 27) in the rhizospheric soil was found significantly higher in soil inoculated with *Aspergillus niger* (6×10^4cfu/g of soil) as compared to the control (2×10^4cfu/g of soil). The performance in terms of growth, physiological and biochemical functioning of AMF inoculated plants either alone or

in combination of *Aspergillus niger* excelled significantly as compared to control and the plants treated with *Aspergillus niger* alone.

Root distribution studies clearly indicated that root growth of pomegranate plants was excellent in shallow light textured soils compared to deep, clayey soils. In deep clayey soils, growth of active roots especially very fine roots which are useful for absorption of water and nutrients was found to be very low. In shallow, light textured soils major portion of the roots or its activity has been concentrated in 0-45 cm vertical distance and 0-60 cm in horizontal distance.

Application of elemental S @ 5.0 g kg^{-1} soil in non-calcareous loamy soil and @ 10.0 g kg^{-1} soil in calcareous clayey soil resulted maximum increase in Fe and Mn uptake by the plant. Soil application of Zn @ 25 mg kg^{-1} soil also significantly increased Zn uptake by the plant in both the soil types.

Comparison of various irrigation methods with sub-surface drip irrigation system for pomegranate production revealed that maximum plant height, flowers, branches and stem diameter was recorded in subsurface drip irrigation (SDI) with double laterals (30*30 cm) followed by SDI with double laterals (30*40 cm). Soil moisture retention was also higher in the SDI with double laterals (30*30 cm). Water saving in SDI with double laterals (30*30 cm) is 40-50% over the drip irrigation system.

Trial on mulching with organic and inorganic mulch revealed that maximum number of fruits was recorded in sugarcane and pervious mulches with 0.40*Etr, followed by wheat, safflower and black and white and black. Soil moisture retention was also higher in the black mulch treated plants.

Study on aril browning revealed that the incidence of aril browning in pomegranate was nearly 10% with a significant variability among the cultivars. The browned aril had significantly higher content of Ca, Fe and Cu than healthy aril but Zn content in browned aril was lower than in healthy arils across the seven cultivars viz. 'Ganesh', 'Jalore seedless', 'G 137', 'Ruby', 'Arakta', 'Mridula' and 'Bhagwa'. The preliminary investigations revealed that the increased uptake of Fe and Cu may be responsible for aril browning.

In 4 field trials involving 28 treatments, conducted in farmer's orchard at Doangaon (Solapur), for management of bacterial blight (BB), 2 schedules involving Trichlosan or combination of streptocycline+2-bromo-2-nitropropane-1,3-diol along with Zn, Mn or Cu chemicals were found significantly superior in reducing BB above 75% when compared to control. None of the nano preparations of Copper or Zn were found effective. In a polyhouse trial with 21 treatments involving 8 new formulations and some other chemicals, 23-53% reduction was observed in 15 treatments after 5 sprays. Surface wash and extracts of plants treated with one of the formulation showed high antimicrobial and biochemical resistance activity after 15 and 36 days of application.

Through *in vitro* screening, two effective bioagents from pomegranate foliage were identified against Xap. Bacteriophages against *Xanthomonas axonopodis* pv. *punicae* (Xap) were isolated from pomegranate leaf, orchard soils, sewage and well water and stored. They were found to be chloroform sensitive. Sanitization of cuttings from BB infected orchard was done using chemicals and hot water treatments and planted in polyhouse. Initial study revealed that bactericidal treatment along with carbendazim and some hot water treatments were free from nodal blight upto5 months after planting, however. In all 10 % of total cuttings are showing nodal blight. Fertigation trial revealed that bacterial blight decreased with application of nitrogen upto 400g/plant and increased thereafter.

Screening of 51 promising accessions from gamma irradiated mutant population of cultivar Ganesh against bacterial blight revealed tht 10 accessions showed $\leq$ 5% disease. Out of 26 hybrids/genotypes including 18 NRCP hybrids screened for BB reaction, 2 NRCP hybrids showed tolerance to BB with less than 10% BB.

Correlation analysis showed that among various weather parameters, duration in hrs. when

temp is between 25-35°C+RH ≥ 50%, weekly rainfall, No. of rainy days/wk., hrs. of temp.>20°C and hrs. RH >30%, significantly contributed to bacterial blight incidence and severity , however, wind speed did not play significant role. Susceptibility of pomegranate leaves was positively correlated to pomegranate fruits.

Ceratocystis fimbriata was observed to be the main cause of pomegranate wilt as 92.8% of the isolations from wilt affected samples revealed association of the pathogen. However, a few samples revealed association of *Fusarium*spp., Root-knot nematode and Shot hole borer. Studies on population dynamics of *C. fimbriata* revealed that the pathogen's population had not achieved ubiquity and was mainly distributed in and around wilt affected plants.Fungicides, tricyclazole+mancozeb @0.1%, difenconazole @ 0.05% and bioagentbased formulations namely *Aspergillusniger* @1.0% and *Trichoderma* TV/TH @1.0% resulted in 100% growth inhibition of the wilt pathogen (*C. fimbriata*) under *in vitro* conditions.

Extraction of Pomegranate Seed Oil using the non-polar solvent benzene through soxhlet method revealed that the seed oil recovery (w/w) was around 28.0% in Ganesh whereas it was 26.43% in Bhagwa. The protocol for preparation of pomegranate wine from the juice of pomegranate cv. Ganesh was refined with enzyme treatment. Pre-treatment of juice with α-amylase @100mg/l paved the way for clarified wine preparation.

Apart from in-house research research activities, NRCP has initiated collaborative research with other ICAR institutes namely IIHR, Bengaluru, NRC Grapes, Pune and IARI, New Delhi. Similarly, NRCP also attracted external funding from National Horticulture Board, Gurgaon. M/s. Reliance Industries Ltd and M/s. Emami Biotech Ltd, Kolkata for various research consultancy and extension projects.

During the year 2013-14, 6ha of research farmland at Kegaon and Hiraj research farms have been brought under pomegranate plantation in order to carry out research activities such as precision farming using subsurface drip irrigation (SDI) system, fertigation system, plant canopy architecture, evaluation of varietal performance, comparative evaluation of tissue culture, airlayer and hardwood cutting planting materials, dedicated plot for studies on bacterial blight and wilt diseases, Field Gene Banks (FGB) etc.

The scientists from the institute have undergone training both in India and abroad to strengthen the human resource development activities and capacity building. Similarly, scientists were also trained by visiting Fulbright scholar from USDA, ARS, Beltsville, Maryland on various PCR based diagnostics. Administrative staff were also sent for undergoing training organized by ISTM, New Delhi.

During the period 2013-14, several training programmes and workshop have been organized by NRCP. An action plan meeting on management of bacterial light in pomegranate was organized involving all the stakeholders viz., ICAR institutes, SAUs, industrial representatives and Pomegranate Growers Association at NRCP, Solapur. More than 500 pomegranate growers were trained both at NRCP, Solapur and at various places namely Andhra Pradesh, Maharashtra and Gujarat on Model Production Technologies on pomegranate.

NRCP also celebrated its foundation day with the theme 'Kisan ki kahani, Kisan ki jubani' in which success stories of progressive farmers were shared among large number of pomegranate growers, scientist and industrial representatives.

The vision 2050 document for NRCP was prepared and uploaded in the institute website. The instate website was also regularly updated with latest information on several mitigation strategies for unseasonal rain, hailstorm damage and regular schedules to be followed for taking pomegranate crop in different seasons.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1. Improvement through hybridization

Several Pomegranate varieties and hybrids were evaluated for various traits during 5th year of planting.

1.1.1. Evaluation of commercial varieties

Seven commercial varieties of pomegranate viz., Ganesh, Bhagwa, Ruby, Jalore Seedless, G-137, Arakta and Mridula were evaluated for their quantitative and qualitative traits under field condition during the fifth year of planting. The cultivars differed significantly from each other for most of the traits. The yield/tree was highest in 'G-137' (24.13 kg) closely followed by 'Ganesh' (22.18 kg). The content of total soluble solids was highest in 'Jalore Seedless' (16.25ºB) followed by G-137 (16.20ºB) and 'Ganesh' (16.10ºB). The arils were bold in 'Bhagwa' with highest 100 aril weight (35.1g).

Ganesh

Bhagwa

Ruby

Jalore Seedless

Commercial varieties of pomegranate

1.1.2. Evaluation of bacterial blight tolerant varieties

Four bacterial blight tolerant varieties of pomegranate were evaluated for their quantitative and qualitative traits. The varieties differed significantly for various traits. The yield/tree was highest in Nayana (13.89 kg) followed by Kalpitiya (12.54 kg). The titrable acidity was highest in Nana (4.72%) followed by Daru (2.19%).

1.1.3. Evaluation of other pomegranate varieties

Eleven varieties of pomegranate such as Amlidana, Bedana Sedana, Dholka, Jodhpur Collection, Jyoti, Kabul Yellow, Kasuri, Kerala Local, KRS, Muskat and Yercard-1 were evaluated for their physico-chemical parameters in comparison with Bhagwa. The varieties differed significantly for physico-chemical parameters. The yield/tree was highest in Muskat (22.88 kg) followed by KRS (20.55 kg) and Bhagwa (20.55 kg). Amlidana (16.50ºB) and Yercaud-1 (16.40ºB) were superior in TSS compared to Bhagwa (15.95ºB). The titrable acidity was highest in Amlidana (2.11%) followed by Bedana Sedana (1.11%).

1.1.4. Evaluation of pomegranate hybrids involving Ruby as pollen parent

Four pomegranate hybrids developed at IIHR, Bangalore using Ruby as pollen parent were evaluated for their physico-chemical parameters at NRCP, Solapur and the results in comparison to Bhagwa are as follows. The yield/tree was superior in Nayana x Ruby (21.64 kg) and Kalpitiya x Ruby (21.39 kg) compared to Bhagwa (20.55 kg). The content of total soluble solids was highest (16.96ºB) in [(GxD)xG]xR followed by Kalpitiya x Ruby (16.48ºB) and [(Gxn)x(GxD)]xR (16.28ºB).

Evaluation of Ruby hybrids of pomegranate

Variety	No. fruits/tree	Fruit weight (g)	Yield/tree (kg)	Rind weight (g)	100 aril weight (g)	No. of arils/fruit	Juice (%)	TSS (ºB)	Titrable acidity (%)
Bhagwa	70.8	290.2	20.55	112.84	35.1	500.2	44.5	15.95	0.50
[(GxD)xG]xR	69.0	238.0	16.42	84.5	33.5	406.0	43.5	16.96	0.45
KxR	74.0	289.0	21.39	91.5	35.5	540.0	50.0	16.48	0.45
NxR	74.5	290.5	21.64	92.5	36.0	536.4	49.0	14.85	0.38
[(Gxn)x(GxD)]xR	68.0	262.5	17.85	76.5	34.0	502.0	46.0	16.28	0.40

G- Ganesh, D- Daru, R- Ruby, n- Nana, N-Nayana

1.1.5. Evaluation of other pomegranate hybrids

Eight pomegranate hybrids were assessed for various physico-chemical parameters in comparison with Bhagwa. Sweet 7/10 and sweet 6/7 were found to be sweet types. The yield/tree was highest in Bhagwa (20.55 kg). The 100 aril weight was highest in Sweet 7/10 (45.5 g) followed by Sweet 6/7 (43.0 g). TSS was highest in Bx3/3 {(Gxn)xD}-MR (16.46 ºB) followed by Sweet 6/7 (16.30 ºB). The titrable acidity was highest in Bx3/3 {(Gxn)xD}-R (4.43%) followed by Bx3/3 {(Gxn)xD}-MR (3.67%), Bx{(Gxn)xD}-HA (3.62%), Sour 6/4 (3.62%) and Sour 6/5 (3.49%). The titrable acidity was minimum in Sweet 7/10 (0.41%) followed by Sweet 6/7 (0.45%).

Evaluation of pomegranate hybrids

Variety	No.fruits /tree	Fruit weight (g)	Yield/ tree (kg)	Rind weight (g)	100 aril weight (g)	No. of arils/fruit	Juice (%)	TSS (ºB)	Titrable acidity (%)
Bhagwa	70.8	290.2	20.55	112.8	35.10	500.2	44.5	15.95	0.50
Bx3/3 {(Gxn)xD}-MR	60.8	237.0	14.41	99.0	39.0	450.0	53.5	16.46	3.67
Bx3/3 {(Gxn)xD}-R	63.0	242.0	15.25	91.5	25.0	520.0	43.0	14.53	4.43
Bx{(Gxn)xD}-HA	45.1	292.3	13.18	104.0	38.0	470.0	44.5	15.3	3.62
{[(Gxn)xD]x (Gxn) x B-HB	60.0	284.0	17.04	107.5	43.0	360.4	36.0	16.23	1.83
Sour 6/4	60.5	212.0	12.83	70.0	36.0	410.0	47.0	14.22	3.62
Sour 6/5	72.0	212.5	15.30	70.5	34.5	405.0	46.5	15.34	3.49
Sweet 6/7	65.4	200.0	13.08	65.5	43.0	300.2	45.5	16.30	0.45
Sweet 7/10	56.0	182.2	10.20	59.0	45.5	260.0	47.5	15.33	0.41

B- Bhagwa, G- Ganesh, D- Daru, n- Nana,

1.1.6. Evaluation of pomegranate hybrids developed at NRCP

In comparison to Bhagwa, twenty NRCP hybrids (NRCP H1 to H20) derived from the parentage ' {Bhagwa x3/3[(Ganesh x nana) x Daru]}' were assessed for physico-chemical parameters during 5th year of planting. Based on TSS, Hybrid-14 (17.79°B), Hybrid-6 (17.55°B) were found to be superior to Bhagwa (15.95°B) and are suitable for table purpose whereas Hybrid-5, Hybrid-10 were on par with Bhagwa. The acidity was highest in Hybrid-4 (5.16%) followed by Hybrid-12 (4.90%) and are suitable for anardana purpose.

Evaluation of NRCP hybrids

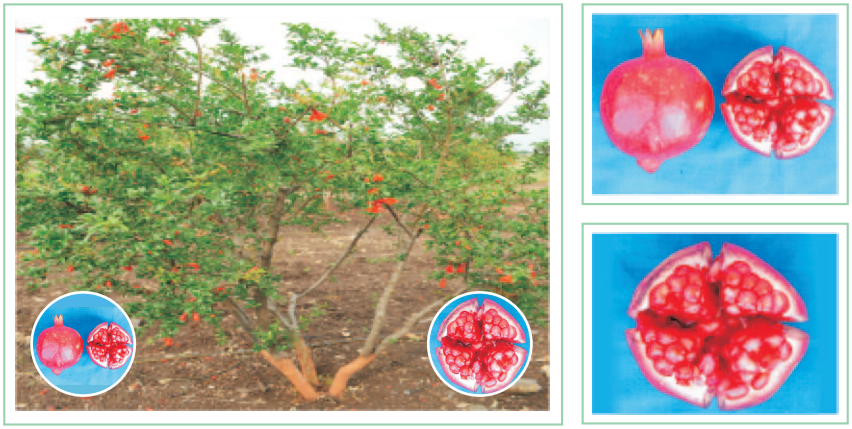
Variety	No. fruits/tree	Fruit weight (g)	Yield/ tree (kg)	Rind thickness (mm)	100 aril weight (g)	TSS (°B)	Titrable acidity (%)
Bhagwa	70.8	290.2	20.55	3.20	35.1	15.95	0.50
NRCP H4	64.0	217.0	13.89	2.77	29.5	15.69	5.16
NRCP H5	78.0	168.2	13.12	2.13	22.6	15.88	0.51
NRCP H6	95.0	216.0	20.52	3.21	38.5	17.55	0.44
NRCP H10	93.0	196.2	18.25	2.14	25.5	16.08	0.51
NRCP H12	96.0	307.7	29.54	2.30	42.4	16.90	4.90
NRCP H14	86.0	263.5	22.66	2.36	44.5	17.79	0.45

1.1.7. Screening of Pomegranate Hybrids / genotypes for bacterial blight resistance

Six month old plants of hybrids and new genotypes were tested for bacterial blight resistance through challenge inoculation. Though none showed resistance, six of them showed tolerance to blight with less than 10% incidence. The six tolerant types also showed delay in blight initiation. Blight initiated 50 days after inoculation in Rosette, 29 days in NRCP H-1 and NRCP H-2, 16 days in Damini, 20 days in Amalidana and 10 days in Sour 6/5.

Bacterial Blight reaction of pomegranate hybrids

Severity Scale	BBD Reaction	No of Hybrids
0	Resistant	0
1 - 10	Tolerant	6
11-20	Susceptible	9
21- 40	Moderately Susceptible	8
41-100	Highly Susceptible	8



NRCP H-6 : Pomegranate hybrid for table purpose

NRCP H-14 : Pomegranate hybrid for table purpose

NRCP H-4 : Pomegranate hybrid for anardana purpose

NRCP H-12 : Pomegranate hybrid for anardana purpose

1.1.8. Preliminary screening for identification of suitable genotypes

After evaluation of F3 open pollinated seedling population of pomegranate, the following hybrids with medium stature were identified as suitable for table purpose. These hybrids would be useful as parents in development of short statured hybrids / varieties.

Hybrid	Parentage	Physico-chemical traits
H2-R-21-1128	F3 open pollinated seedling population	1-1.5m height, yellowish red rind and pink aril, medium to bold aril, juicy aril with soft seed, medium TSS (14.05°Brix), low acidity (0.38%), moderate to high bearing
H2-R-21-1129	F3 open pollinated seedling population	1-1.5m height, yellowish red rind and light pink aril, medium to bold aril, juicy aril with soft seed, medium TSS (13.36°Brix), low acidity (0.32%), moderate to high bearing
H2-R-21-1130	F3 open pollinated seedling population	1-1.5m height, red rind and aril, medium to bold aril, hard seed, medium TSS(14.55°Brix), low acidity (0.44%), moderate to high bearing

1.2. Improvement through selection

1.2.1. Preliminary screening for identification of suitable genotypes

After evaluation of seedling population of pomegranate, the following genotypes were identified for their medium stature and suitability for table purpose. These selections would be useful in development of dwarf statured varieties suitable for high density planting through hybridization.

Particulars	Source	Physico-chemical traits
Sel. 1	Seedling population	Medium plant height, Red aril and rind with very soft seed, medium fruit weight and rind thickness, high TSS (15.85°Brix), low acidity (0.38%)
H2-R-19-1001	Seedling population	Semi tall, dark red rind and aril, medium to large fruit, TSS (15.20°Brix), low acidity (0.36%)

1.3. Improvement through mutation

1.3.1. Preliminary screening for identification of suitable genotypes

After evaluation of gamma irradiated 'Ganesh' and 'Bhagwa' population, the following genotypes were selected for further evaluation and testing.

Particulars	Source	Specific traits
H1- R-2-470-A	Gamma irradiated Ganesh	Semi tall, red rind and aril, medium fruit, soft aril, TSS (13.91°Brix), low acidity (0.40%)
H2-R-8-469	Gamma irradiated Bhagwa	Medium plant height, yellowish red rind and pink aril, medium to bold aril, TSS (14.93°Brix), low acidity (0.38%)

H_1- R-8-469 : Gamma irradiated Bhagwa derivative with medium stature

1.3.2. Screening of mutant population of 'Ganesh' against bacterial blight

In all, 51promising accessions (5 plants of each) from gamma irradiated mutant population of cultivar Ganesh were screened for bacterial blight reaction through challenge inoculation. None was disease free, but 27 accessions showed ≤10 % disease and among these 4 showed less than 5% blight. The 5 highly tolerant types also showed delay in blight initiation.

Reaction of promising irradiated population of 'Ganesh' to bacterial blight in challenge inoculation (First screening)

Plant Reaction	Bacterial Blight Incidence	Number of Accessions
Resistant	0	0
Tolerant	< 5 %	4
Tolerant	5-10%	23
Susceptible	10-25%	19
Moderately susceptible	25-50%	4
Highly Susceptible	50-75%	1
Highly Susceptible	75 -100%	0
	Total	51

1.4. Flowering induction in pomegranate

The occurrence of timely flowering often becomes difficult in pomegranate during *hasth bahar* due to prevailing low temperature. Hence, growth hormones and chemicals were tried to induce flowering in 5 year old pomegranate cv. Bhagwa. Different growth regulators and chemicals were foliar sprayed during the month of September at 2 weeks after defoliation when new flush initiation occurs. There were 14 treatments along with an untreated control. The results revealed that flowering occurred within 2-3 weeks after the foliar spray. The number of bisexual flowers was highest in plants sprayed with NAA 10 mg/l (192.6/ plant) whereas it was lowest in control (87.5/plant). The number of fruits was highest in NAA 10 mg/l (125.3/plant) whereas it was lowest in control (35.0/tree). The fruit set was found to range from 40.0 to 65.0%. The highest fruit set was recorded by NAA 10 mg/l (65.0%) followed by ammonium nitrate 0.5% (63.1%) whereas it was the least in untreated control (40.0%). The fruit yield was found be maximum in plants sprayed with NAA 10 mg/l (23.5 kg/plant) whereas it was minimum in control (9.8 kg/plant).

Induction of flowering in pomegranate

Treatment	No. of bisexual flowers	No. of fruits/tree	Fruitset (%)	Fruit weight (g)	Yield (kg/tree)
NAA 10 mg/l	192.6	125.3	65.0	203.8	23.50
NAA 20 mg/l	180.0	108.0	60.0	205.0	22.14
Ammonium nitrate 0.5%	180.0	113.6	63.1	200.7	22.80
Control	87.5	35.0	40.0	248.1	9.80

Control

Ammonium nitrate@0.5%

NAA@10ppm

Induction of flowering using various growth regulators and chemicals

2. GENETIC RESOURCES

2.1. Pomegranate germplasm maintenance and enhancement

NRCP maintains one hundred and seventy five germplasm of indigenous and exotic nature in its newly established field gene bank and also about fifty breeding materials, advance lines and preliminary collection from the base collections, viz. hybrid, local collection etc. Besides, a new field gene bank with fifty five exotic collections obtained from USDA, California through NBPGR has been established during January, 2014 for further evaluation and utilization. The germplasm are maintained at Kegaon and Hiraj farms. Indigenous collection number (IC) for twenty germplasm was already obtained during 2013 and applied for 15 more accessions consisting of eleven indigenous types collected from Jammu and Kashmir and four advance lines two each of table and *anardana* type.

2.2. Germplasm Evaluation

2.2.1. Morphological and physico-chemical evaluation of germplasm

Sixteen wild types collected from Himachal Pradesh (HP) and nine from Jammu and Kashmir (J&K) were evaluated for morphological and chemical traits. In HP collection, fruit weight (g), calyx length (cm) and rind (%) ranged from 59.33-217, 0.78-2.45 and 28.72-45.73 respectively. These parameters showed higher co-efficient of variation (CV) among the genotypes which ranged from 13.33 - 19.66%. However, in J&K collection, fruit weight (g), calyx length (cm) and acidity (%) showed very high degree of variation (CV) of 25.88%, 43.33% and 44.1%, respectively. Their values ranged between 41.88- 100.11g (fruit weight), 0.46-1.88cm (calyx length) and 0.30-5.14 % (acidity). Interestingly fruit size in HP collections was bigger and in J&K collections it was smaller. Hence, there is wide scope for selection of *anardana* type from HP collections. The J&K materials are more thorny, hardy and preliminary evaluation indicated its tolerance to Bacterial Blight Disease (BBD) and abiotic stresses confirming scope for developing varieties having tolerance to BBD for their usage as a donor parent.

Thirty six genotypes including cultivated and local collections showed significant variation with respect to ten physico-chemical characters studied. CV values were found to be higher for acidity (108.10%) followed by calyx length (34.48%), fruit weight (23.78%) and rind thickness (17.24%). These characters could be considered for crop improvement programme as per the breeding strategy. Patna-5

Variation in physico-chemical parameters of 16 wild pomegranate genotypes of Himachal Pradesh

Characters	Range	Mean	SD	CV (%)
Fruit wt (g)	59.33-217.00	141.40	42.31	16.67
Fruit length (cm)	4.44-7.22	6.25	0.76	8.69
Fruit diameter (cm)	4.32-6.68	5.84	0.79	7.59
Calyx length (cm)	0.78-2.45	1.34	1.44	19.66
Rind (%)	28.72-45.73	35.63	5.84	13.33
Rind thickness (cm)	0.20-0.29	0.26	0.02	9.87
100 aril weight (g)	24.22-32.66	28.39	1.87	3.97
Aril (%)	54.26-71.28	64.36	5.84	7.38
Aril length (cm)	1.03-1.53	1.24	0.20	8.42
Aril width (cm)	0.58-0.77	0.68	0.04	8.48
TSS (°Brix)	12.76-18.86	16.17	7.63	5.09
Acidity (%)	1.41-5.15	3.49	0.94	9.90

recorded significantly higher fruit weight (367.7g) followed by Karnataka Collection 2 (296.17g). Similarly, Alandi, EC-24686, P-26, P-13, Kandhari, Kalpitiya and Jyoti also have a tendency to produce big sized fruits. These genotypes had fruit weight varying between 256.33g and 292.33g. Though, fruit weight of cv. Amlidana was lowest (122.6 g), acidity was higher (4.67%). KA-2 (39.58g), Alandi (41.33 g), EC-24686 (39.64g) and China Orange (37.55g) had bold arils with better 100 aril weight as compared to other genotypes. However, rind thickness found to be higher in KA-2 (0.45 cm), Alandi (0.42 cm) and Bassein Seedless (0.42 cm). Similarly, TSS content was highest in P-23 (15.39°Brix) followed by Bhagwa (15.37°Brix) and Jodhpur Local (15.34 °Brix).

Variation in physicochemical parameters of wild genotypes of Jammu and Kashmir

Characters	Range	Mean	SD	CV (%)
Fruit weight (g)	41.88-100.11	75.31	19.34	25.68
Calyx length (cm)	0.46-1.68	0.90	0.39	43.33
Fruit length (cm)	4.40-6.01	5.38	0.61	11.33
Fruit diameter (cm)	4.21-6.70	5.43	0.76	13.99
Aril length (cm)	0.75-1.03	0.94	0.08	8.51
Aril width (cm)	0.53-0.65	0.58	0.03	5.17
100 aril weight (g)	20.00-31.17	24.76	3.49	14.09
Rind thickness (cm)	0.26-0.41	0.33	0.04	12.12
TSS (◦Brix)	16.10-19.63	17.23	1.12	6.50
Acidity (%)	0.30-5.14	3.65	1.61	44.10

2.2.2. Flowering behaviour and variation in floral characters

Hermaphrodite flowers produced in first succession develop into bigger fruits. Therefore,, flowering behavior of 41 varieties/ accessions with respect to hermaphrodite flowers in first succession was studied during July, 2013. Hermaphrodite flowers significantly differed in different genotypes. The range of hermaphrodite flower production in different genotypes was 14.92-33.56% and CV was 17.33%. Significantly higher hermaphrodite flower production was recorded in IC-444206 (33.56%), Kabul Yellow (31.85%) IC-444204 (30.39%). Twenty four genotypes/ accessions were studied for flower length, calyx length, width and petal size (length and width). All these characters differed significantly among the genotypes. Petal and calyx width and calyx length had higher variation (CV). The CV values for these characters ranged between 8.80 and 13.41%. Flower length, calyx length, calyx width, petal length and width ranged between 41.91-57.8mm, 29.49-45.16mm, 10.50-16.95mm, 20.55-25.15mm and 15.26-24.77mm respectively. Bassein Seedless, Dholka, Bhagwa, Jallore Seedless, KRS, Kandhari and Bedana Suri had long flower and their values ranged between 53.01 and 57.8mm. Bedana Suri recorded maximum flower length, calyx length and petal size (length and width).

2.2.3. Evaluation for processing purpose

Twenty one varieties/accessions were evaluated for processing purpos. Rind, pomace, juice, TSS and acidity contents differed significantly among the genotypes and their values ranged between 26.67 and 41.30 %, 19.11 and 17.43 %, 37.20 and 50.18%, 14.44 and 17.63°Brix and 0.32 and 5.14 % respectively. The CV% found to be higher with respect to acidity content followed by rind and

pomace per content. Kerala collection, KA2, Kalpitiya (37.15%) and EC-24686 (41.30%) recorded higher rind recovery. Similarly, KRS, P-16, Yercaud and Kabuli Yellow had higher pomace content (seed and waste pulp) which ranged between 23.15 and 25.57 %. Tabesta, Jyoti, China orange, Saharanpur, Kabuli Yellow and P-13, P-16, G-137, KRS, Kandhari, IC-318762, IC-318734 and Ganesh recorded highest juice content in the range of 44.09-50.19%. Significantly highest TSS (17.63° Brix) and acidity (5.15%) were found in IC-318705 and IC-318706 respectively. Thus, these two wild collections (IC collections) could be exploited for preparation of *Anardana.* Interestingly acidity contents of local collections and extant varieties were lower (below 0.89%) with moderate sweetness has scope for juice extraction.

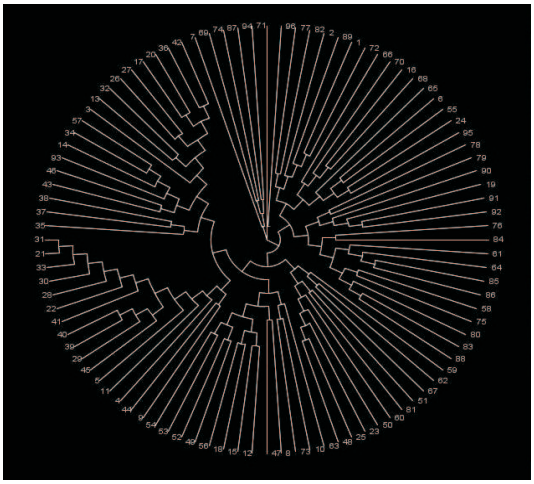
2.2.4. Tannin extraction from flower and rind

In order to utilize flower and rind of pomegranate in textile industry, a collaborative programme was initiated between NRCP, Solapur and CIRCOT, Mumbai. The tannin content of four varieties of pomegranate viz. Arakta, Bhagwa, Ganesh and Mridula determined at CIRCOT, Mumbai revealed highest content (22%) in Ganesh followed by Bhagwa (20%). Similarly rind samples of 8 varieties/ accessions viz. Ganesh, Jodhpur Red, Saharanpur, Kalpitiya, NRCP-34, IC-318707, P-13 and P-26 were also analysed for tannin which ranged between 24 and 35%. However, higher tannin content was recorded in Saharanpur (35%), Ganesh (31%), Kalpitiya (27.5%), IC-318707 (27.5%) and P-13 (27.5%). However, lower tannin content was noted in NRCP-34 (24%), P-26(25%) and Jodhpur Red (24%). The results of cotton fabric samples indicated good scope of utilization of flower and rind tannins in textile industry for dyeing purposes.

2.3. Germplasm Diversity

2.3.1. Diversity analysis and population structure studies in pomegranate

Ninety-six pomegranate genotypes comprising of wild, cultivated and exotic types were analyzed using 21 polymorphic SSR markers. Molecular genetic diversity study revealed that there were three major clusters in this collection of pomegranate genotypes. Molecular diversity indices were used to construct Neighbour Joining tree and genetic distance estimates clustered this collection of genotypes into wild types (with large tree stature, highly acidic and small sized fruits), cultivated types and seven genotypes in a separate cluster, with very few misrepresentations. Structure was used to infer K2 to K10 clusters. The k-5 cluster was noted to be the most appropriate as it produced the highest Delta-K distribution coupled with the highest Ln(K). Analysis of Molecular Variance (AMOVA) revealed significantly different variance within and between the groups.



Dendrogram resulting from microsatellites based on genetic distance analysis of 96 pomegranate genotypes

Sr. No.	Name of the germplasm/Collector/ICNo.	Sr. No.	Name of the germplasm/Collector/IC No.	Sr. No.	Name of the germplasm/Collector/IC No.
1.	IC-524026	33.	IC-318734	65.	Surat-Anar
2.	IC-524027	34.	IC-318735	66.	AHPGC-04
3.	IC524028	35.	IC-318740	67.	Poona Collection
4.	IC-524030	36.	IC-318743	68.	Utkal
5.	IC-524031	37.	IC-318744	69.	Double Flower
6.	IC-444197	38.	IC-318749	70.	Shiashirin
7.	IC-444198	39.	IC-318753	71.	Amlidana
8.	IC-444199	40	IC-318754	72.	Buldhana Local
9.	IC-444200	41.	IC-318762	73.	GKVK
10.	IC_444201	42.	IC_318764	74.	Chaupasni Seedless
11.	IC-444202	43.	IC-318766	75.	China Orange
12.	IC-444204	44.	IC-318779	76.	Jodhpur Local
13.	IC-444206	45.	IC-318790	77.	KA-2
14.	IC-444207	46.	IC-318793	78.	Bassein Seedless
15.	IC-444208	47.	ACC 1	79.	Yercaud
16.	IC-540192	48.	ACC 2	80.	Dholka
17.	IC-540195	49.	ACC.3	81.	Kalpitiya
18.	IC-540202	50.	ACC.4	82.	Jodhpur Red
19.	IC-24685	51.	ACC.6	83.	Muscat
20.	IC-318702	52.	ACC 8	84.	KRS
21.	IC-318703	53.	ACC 9	85.	Alandi
22.	IC-318705	54.	ACC 10	86.	JS x Ganesh
23.	IC-318706	55.	ACC.11	87.	Gul-e- Shah Red
24.	IC-318707	56.	ACC.12	88.	Ganesh
25.	IC-318712	57.	Jodhpur Collection	89.	Bhagwa
26.	IC-318716	58.	Allah	90.	G-137
27.	IC-318718	59.	Kandhari	91.	Arakta
28.	IC-318720	60.	Bedana Thinskin	92.	Mridula
29.	IC-318723	61.	Jallore Seedless	93.	Jyoti
30.	IC-318724	62.	Jallore Seedless	94.	EC-24686
31.	IC-318728	63.	Surkh Anar	95.	EC-62812
32.	IC-318733	64.	Kerala Collection	96.	EC-81839

2.4. Germplasm Screening against diseases and insect pests

2.4.1. Screening of pomegranate germplasm against fungal leaf and fruit spots and insect pests

31 Germplasm grown in the Field Gene Bank of the NRCP Hiraj farm were periodically monitored for various important diseases and insect-pests of pomegranate during 2013-14 with an objective to identify disease resistance source. Observations on severity of various diseases and insect-pests were recorded on 31.8.2013, 21.12.2013, 23.1.2014, 24.2.2014 and 21.3.2014. Average severity was derived by averaging the severity recorded during 5 months as mentioned above.

Amongst the various diseases, bacterial blight (*Xanthomonas axonopodis* pv. *punicae*) the most devastating disease of pomegranate, was recorded on only one germplasm (IC-1267) in the month of January and remaining 30 germplasm were observed

Severity of Bacterial blight, Leaf and Fruit spots and Insect-pests on Pomegranate Germplasm at NRCP Hiraj farm during 2013-14

Sl. No.	Germplasm No.	Bacterial blight *Avg.Severity	Fungal leaf and Fruit spots (*Cercospora* spots, *Sphaceloma* scab, *Colletotrichum* rot, *Alternaria* spots) *Avg. Severity (Range)	Insect-pests *Avg. Infestation	
				Thrips (*Scirtothrips dorsalis*)	Fruit Borer (*Deudorix isocrates*)
1.	IC-1253	0.0	5.83 (1.83-9.83)	9.83	0.00
2.	IC-1254	0.0	4.49 (1.83-9.83)	9.83	0.00
3.	IC-1256	0.0	3.66 (1.83-5.5)	5.50	0.00
4.	IC-1257	0.0	4.12 (1.83-3.66)	0.00	0.00
5.	IC-1258	0.0	5.83 (1.83-9.83)	0.00	0.00
6.	IC-1259	0.0	4.58 (5.5-3.66)	1.83	0.00
7.	IC-1260	0.0	3.66 (1.83-5.5)	3.66	0.00
8.	IC-1261	0.0	2.93 (1.83-6.0)	5.50	0.00
9.	IC-1263	0.0	4.4 (1.83-6.0)	9.83	0.00
10.	IC-1265	0.0	4.58 (3.66-5.5)	7.83	0.00
11.	IC-1266	0.0	3.20 (1.83-5.5)	7.83	0.00
12.	IC-1267	1.83	5.83 (1.83-9.83)	0.00	0.00
13.	IC-1269	0.0	7.13 (1.83-22.83)	46.33	0.00
14.	IC-1270	0.0	13.79 (5.5-22.83)	0.00	0.00
15.	IC-1271	0.0	5.66 (3.66-9.83)	7.83	0.00
16.	IC-1272	0.0	3.65 (1.83-5.5)	0.00	0.00
17.	IC-1273	0.0	4.27 (1.83-5.5)	5.50	0.00
18.	IC-1274	0.0	3.66 (1.83-5.5)	5.50	0.00
19.	IC-1275	0.0	2.74 (1.83-5.5)	5.50	0.00
20.	IC-1276	0.0	4.83 (1.83-7.16)	1.83	0.00
21.	IC-1277	0.0	6.49 (1.83-18.0)	3.66	0.00
22.	IC-1278	0.0	2.74 (1.83-5.5)	3.66	0.00
23.	IC-1279	0.0	3.66 (1.83-5.5)	3.66	0.00
24.	IC-1280	0.0	3.66 (2.75-5.5)	1.83	0.00
25.	IC-1281	0.0	8.07 (3.66-15.3)	7.83	0.00
26.	IC-1282	0.0	4.27 (3.66-5.5)	3.91	1.83
27.	IC-1283	0.0	3.19 (1.83-5.5)	1.83	0.00
28.	IC-1284	0.0	11.45 (1.83-24.66)	0.00	0.00
29.	IC-1285	0.0	3.29 (1.83-5.5)	0.00	1.83
30.	IC-1286	0.0	9.16 (3.66-21.0)	24.66	0.00
31.	IC-1187	0.0	4.25 (1.83-7.16)	0.00	0.00

*Average severity of diseases and insect-pests is based on observations recorded 5 times in the months of August, December, 2013, January, February and March 2014. Each germplasm included 3 replications.

free from bacterial blight during the period. Blight symptoms manifested on foliage of one of the plants of IC-1267 with average disease severity of 1.83%. Various leaf and fruit spot pathogens observed during the period included *Cercospora punicae*, *Spahceloma punicae*, Colletotrichum rot (*C. gloeosporioides*) and *Alternaria alternata*. Although, all the 31germplasm were observed susceptible to various spots, fruit scab due to *Sphaceloma punicae* was quite prevalent on most of the germplasm. The average severity of various leaf and fruit spots varied between 2.74-13.79% . Screening of germplasm for various insect-pests revealed infestation mainly due to thrips (*Scirtothrips dorsalis*) and Fruit borer (*Deudorix isocrates*) on some of the germplasm. Although, thrips' infestation was quite prevalent (1.83-46.33%) on most of the germplasm, fruit borer infestation (1.83%) was noticed only on two germplasm (IC-1282 and IC-1285) in the month of December.

It may be concluded that most of the germplasm during the year was found free from bacterial blight, ostensibly due to low disease pressure and also adoption of regular IDIPM schedules. Therefore, more observations and also screening of the germplasm through challenge inoculation may provide actual reaction of the germplasm against bacterial blight. However, other fungal leaf and fruit spots and insect-pests were quite prevalent on the germplasm during the year which needs proper implementation of the spray schedules.

2.4.2. Screening of germplasm for wilt resistance

Thirteen germplasm having 26 potted plants were screened for wilt resistance by artificially inoculating the rhizosphere of the plants with *Ceratocystis fimbriata* on 22nd May, 2013. Observations on wilt reaction of inoculated plants were recorded periodically. Wilt symptoms started appearing after three weeks of inoculations in a few inoculated plants. In August 2013, about three months after the inoculations 15 plants out of 26 revealed wilt infections. Healthy plants were again inoculated with *C. fimbriata* culture on 6th December 2013 for wilt infections. Wilt infections were recorded in all the germplasm barring one plant of accession IC-318728 by the end of March 2014. Also, all the seven germplasm *viz.* IC-1204, Sirin Anar, IC-318759, IC-318753, IC-1182, IC-318705 and Jodhpur selection artificially inoculated (in December 2012) revealed susceptibility to wilt pathogen, *C. fimbriata*, by September 2013.

The Study revealed that all the 20 germplasm screened through artificial inoculations with *C. fimbriata* during 2013-14 for wilt resistance were found susceptible to the wilt pathogen.

Screening of germplasm through artificial inoculation with *C. fimbriata* for wilt reaction

Sl.No	Germplasm	Total Plants	No. of wilt infections			Healthy plants
			August, 2013	October, 2013	March, 2014	March, 2014
1.	IC-1182	6	4	5	6	0
2.	Kandhari	1	1	1	1	0
3.	Gulesha Red	1	1	1	1	0
4.	Bhagwa	1	1	1	1	0
5.	IC-1196	1	1	1	1	0
6.	IC-318718	2	2	2	2	0
7.	IC-318754	1	1	1	1	0
8.	IC-318703	2	2	2	2	0
9.	IC-318728	4	1	3	3	1
10.	Jodhpur Red	2	0	2	2	0
11.	IC-318720	2	0	2	2	0
12.	Arakta	1	1	1	1	0
13.	Sirin Anar	2	0	2	2	0
	Total	26	15	24	25	1

3. CROP PRODUCTION

3.1. Plant Propagation

3.1.1. Propagation of pomegranate through cutting

3.1.1.1. Propagation through hard wood cuttings

An experiment was set up to identify the suitable length of hard wood cutting to optimize the amount of wood required for propagation without compromising the cutting success. At 120 days after planting, there was no significant difference in the cutting success of 20 cm (76.33 %) and 15 cm (70.83 %) long cuttings but when cutting size was reduced to 10 cm, the success rate drastically came down to 45.33 per cent indicating the ideal hard wood cutting size as 15 cm.

Hard wood cuttings of different lengths

3.1.1.2. Propagation through semihard wood cuttings

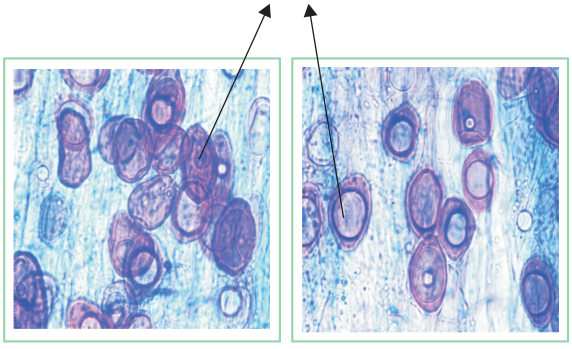
Possibility of utilizing semi hard wood cuttings (4-5 mm diameter) for propagation of pomegranate has been tried on four different planting media. Cutting were pretreated with Carbendazim (0.1%) + Bactronol (0.05%) for 10 minutes followed by one washing with tap water and dipping the lower half of the cuttings for 5 min. in 2000 ppm IBA. Cuttings were maintained at more than 85 % relative humidity. A meager cutting success of 32 per cent was recorded by cuttings raised on cocopeat at 90 days after planting of cuttings.

3.1.2. Propagation through tissue culture

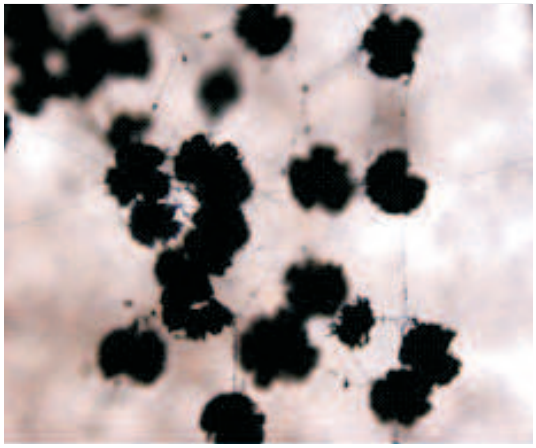
3.1.2.1. Effect of biohardening agents on performance of tissue culture raised plants

An experiment on biohardening of *in vitro* raised plants of pomegranate cv. 'Bhagwa' was laid out during 2013-2014. Two bio inoculants namely, *Arbuscular Mycorrhizal Fungi* (mixture of different types of AMF, predominantly *G. intraradices*) and *Aspergillus niger* (AN 27) were utilized as biohardening agents. Root colonization, population of microbes in rhizospheric soil, growth, physiological and biochemical parameters of biohardened plants as influenced by these beneficial microbes were recorded at 180 days after inoculation. Root colonization of *in vitro* raised pomegranate plants with *Arbuscular Mycorrhizal Fungi* (AMF) was found at par in plants inoculated with AMF (71.12 %) and plants inoculated with AMF + *Aspergillus niger* (65.00%). Population of *Aspergillus niger* (AN 27) in the rhizospheric soil was found significantly higher in soil inoculated with *Aspergillus niger* (6 x10^4 cfu/g of soil) as compared to non-inoculated control (2 x 10^4 cfu/g of soil).

Vesicles of AMF in root cortex of pomegranate



Vesicles of AMF in the cortical cells of pomegranate roots



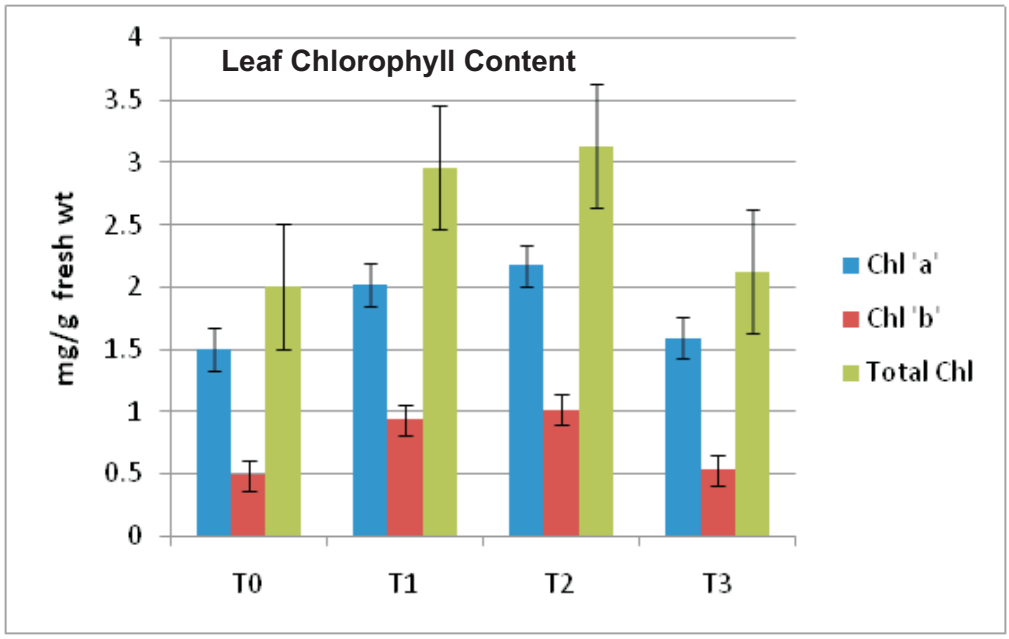
***Aspergillus niger* strain 27 from rhizospheric soil of pomegranate**

Plant height, shoot fresh and dry weight and root fresh and dry weight were recorded for establishing the superiority of biohardened tissue culture raised plants over non biohardened plants. Except for shoot dry weight, which was found non significant among various treatments, all other growth parameters were significantly influenced by biohardening agents. Physiological functioning was also significantly improved by biohardening and to establish this fact two important plant physiological activities namely, Leaf Relative Water Content and Photosynthesis were measured. However, performance of AMF inoculated plants either alone or in combination with *Aspergillus niger* excelled significantly as compared to control and only *Aspergillus niger* treated plants. The increased root biomass and better soil exploration capacity of AMF infected roots might have led to the better water and nutrient balance in the plants which resulted into better growth and physiological functioning of the plants.

Effect of biohardening on growth and physiological attributes of tissue culture raised pomegranate plants

Treatment	Plant Height (cm)	Shoot Fresh wt. (g)	Shoot dry wt. (g)	Root Fresh wt. (g)	Root dry wt. (g)	Leaf Relative Water Content (%)	Photosynthesis (µmol $CO_2m^{-2}s^{-1}$)
Control	110.685	157.085	61.125	49.835	14.625	87.76 (69.54)	9.07
AMF	140.625	196.025	74.250	61.435	16.915	92.34 (73.96)	12.69
AMF + *A. niger* (AN 27)	134.625	184.225	74.935	58.435	16.300	91.74 (73.31)	12.78
Aspergillus niger (AN 27)	130.375	183.225	73.135	60.400	16.035	89.99 (71.60)	9.70

High photosynthetic activity of AMF inoculated and AMF + *Aspergillus niger* treated plants may be due to higher leaf chlorophyll content of plants under the influence of these two treatments as compared to remaining two treatments. The increased root biomass of AMF inoculated plants might have resulted into more exploration of soil volume and higher absorption of phosphorous and other nutrients like magnesium which play critical role in chlorophyll synthesis.



Effect of microbial inoculation on Leaf Chlorophyll of tissue culture raised pomegranate plants

3.1.2.2. Field performance of *in vitro* raised plants

A field experiment has been laid out using tissue culture raised plants, air layered and hard wood cutting raised plants to evaluate the relative performance of plants raised through different propagation methods. Preliminary results have confirmed the faster vegetative growth of tissue culture raised plants in terms of plant height and spread as compared to hard wood cutting raised and air layered plants.

Field evaluation of plants propagated through tissue culture, air-layering and hard wood cuttings

3.2. Soil Management

3.2.1. Identification of suitable soils for sustained productivity of pomegranate

3.2.1.1. Performance of pomegranate orchards on different mixtures used for pit filling

The different soil mixtures used for pit filling include light gravelly soil, 30cm depth; light gravely soil, 60 cm depth; sandy loam soil, 60cm depth; loamy soil, 60cm depth; black clayey soil, 30cm depth; black clayey soil, 60cm depth; black clayey soil, 90cm depth; black clayey soil 120 cm depth; black clayey soil 50% + sand 50%; black clayey soil 75% + sand 25% and weathered murrum.

3.2.1.1.1. Flowering intensity and yield of pomegranate fruit

Fruits of 'Bhagwa' variety grown under different treatments were harvested during the month of April 2013 and observation on yield parameters revealed significant variation amongst the treatments. Highest number of hermaphrodite flowers was found in loamy textured soil followed by heavy textured black soil having depth of 30 cm. In general, it was observed that flowering intensity was more in light textured soil compared to heavy textured black soil.

Fruit yield varied significantly from 22.2 to 36.3 fruits per plant and was highest in the plants grown on black clayey soils having depth of 60 cm followed by loamy soil 30 cm depth. In general, fruit yield of Bhagwa variety was better in black clayey soil having depth only up to 90 cm and beyond 90 cm, it recorded drastic reduction in yield due to poor drainage.

3.2.1.1.2. Quality of pomegranate fruit

Fruits of pomegranate cv. 'Bhagwa' in *'hasth bahar'* were harvested during the month of April 2013 and analysed for quality parameters. Juice percent in the fruit was highest (49.3%) in loamy soil followed by murrum (47.9%) while it was lowest (43.5%) in black soils filled up to 60 cm soil depth. Total soluble solids percentage was highest (15.3^0Brix) in the juice of the fruits produced on loamy soils followed by black clayey soils (15.03^0Brix) having depth of 30cm. Similarly TSS / acidity ratio was also highest in loamy soils (35.8) followed by black clayey soil mixed with 50 % sand (34.8). In general it was observed that better quality fruits were produced in light textured soils treatments.

3.2.1.1.3. Disease incidence and severity on pomegranate

Incidence of bacterial blight disease (BBD) occurred during June - July month of the year 2013.The incidence and severity of both wilt and bacterial blight disease was low in variety Ganesh as compared to Bhagwa.

In 'Bhagwa', wilt incidence was highest (50.0%) in the plants grown on the pits filled with black clayey soil up to 120 cm depth, while it was low in case of loam textured soil (16.7%) and black clayey soils having shallow depth (16.7%) .

Incidence of Bacterial Blight Disease was higher on fruits followed by leaves and twigs of the plants. In 'Bhagwa' incidence on fruits was observed on the plants grown under all the treatments while in Ganesh variety incidence on fruits was not observed in the plants grown on murrum, gravelly soil and loamy soils.

In 'Bhagwa', incidence of this disease occurred on leaves and stem of the plant grown on most of the soils except the plants grown under gravelly, light textured soils and black soils mixed with 50 percent sand. While in case of Ganesh variety, incidence occurred on leaves and stem of the plants grown on black clayey soils of all depth and black clayey soil mixed with sand. Black clayey soils having very high water holding capacity might have high humidity in the microclimate of the plants resulted in to more spread of the disease.

3.2.2. Root distribution studies in pomegranate grown under different soil types

Root distribution pattern of pomegranate cv. Bhagwa planted in pits of 1x1x1m (lbd) were studied under very shallow, medium deep and deep soil conditions.

Very shallow soil : 10 to 12 cm deep underlain by weathered rock, gravelly loam texture.

Medium deep soil : 35 to 40 cm deep underlain by weathered rock, clayey texture soil.

Deep soil : 60 to 80 cm deep, clayey textured soil.

Based on diameter, roots were categorized as very fine (<0.5 mm), fine (0.5-2 mm), small (2-5 mm), medium (5-10 mm), large (10-20 mm) and very large (>20 mm).

Root distribution pattern under these soil type showed that roots under medium, large and very large categories were concentrated near the stem portion only up to 30 cm in horizontal and vertical directions. These roots are mostly merged with stem of the plants and their main function seems to give support to the plant.

Comparison of percent distribution of various types of roots on cumulative root length basis grown under different soil types revealed that,

- Under shallow, light textured soil, percentage of very fine roots was highest (66.06%) followed by medium deep, clayey soil (60.58%) and was lowest in deep, clayey soil (44.22%).
- Share of fine size roots in total root distribution was highest in deep, clayey soils (48.01%) followed by medium deep clayey (33.1%) and was lowest (28.66%) in shallow light texture soil.
- Similarly share of small roots follows same trend.
- Root distribution in vertical direction also revealed that 83.55 and 85.43 percent root length has been restricted to 45 cm depth while in case of deep clayey soil it extends further up to 75 cm.
- Root distribution in horizontal direction revealed that in shallow and medium deep soil majority of the root length (67.58 & 66.74 % respectively)

Root distribution pattern of pomegranate plants grown under different soil types on percent root length basis

Vertical spread (cm)	Horizontal spread (cm)						
	0 - 30	30 - 45	45 - 60	60 - 75	75 - 90	90-105	Total
	Percent total roots						
Shallow, light textured soil							
0 - 15	14.62	10.41	7.76	6.01	4.04	2.37	45.21
15 - 30	9.83	4.15	4.91	3.14	2.06	2.09	26.18
30 - 45	2.32	1.92	2.29	2.11	1.72	1.79	12.16
45 - 60	1.66	1.08	1.50	1.74	1.51	0.00	7.48
60 - 75	1.36	0.83	0.83	0.91	1.36	0.00	5.28
75 - 90	0.97	0.66	0.48	0.68	0.90	0.00	3.68
Medium deep, clayey soil							
0 - 15	18.03	9.48	5.49	3.65	2.78	1.76	41.20
15 - 30	5.68	3.66	4.51	4.49	3.62	3.74	25.70
30 - 45	3.52	3.14	2.45	1.91	2.65	4.85	18.53
45 - 60	2.48	1.98	0.92	0.73	1.09	0.33	7.53
60 - 75	2.08	1.00	0.54	0.47	0.60	0.00	4.70
75 - 90	0.77	0.64	0.35	0.31	0.28	0.00	2.34
Deep clayey soil							
0 - 15	8.03	6.48	5.07	3.82	1.35	4.14	28.89
15 - 30	3.89	2.98	4.76	3.18	1.71	2.91	19.43
30 - 45	3.47	4.23	2.97	2.96	3.30	2.98	19.90
45 - 60	2.13	2.15	1.59	2.22	1.94	3.04	13.07
60 - 75	1.81	1.96	1.61	1.42	1.10	2.47	10.37
75 - 90	2.37	1.61	2.21	1.29	0.45	0.40	8.33

were concentrated in 0 – 60 cm distance while in case of deep clayey soil it extend further up to 90 cm or more.

Based on the study, the following recommendations are made :

- Root distribution studies clearly indicated that root growth of pomegranate plants was excellent in shallow light textured soils compared to deep, clayey soils. In deep clayey soils growth of active roots especially very fine roots which are useful for absorption of water and nutrients was found to be very low. Rather it hampered the growth of very fine roots in the soil profile.
- In shallow, light textured soils major portion of the roots has been concentrated in 0-45 cm vertical distance, and hence it is necessary to maintain well drained and / good aeration in upper 45 cm soil layer. In such soils it is not required to dig very deep pits for pomegranate cultivation. Even water and nutrient application should also be done in upper 30 cm soil layer so as to improve nutrient and water use efficiency.
- In shallow, light textured soils major portion of the roots has been concentrated in 0-60 cm horizontal distance. Hence for pomegranate plantation in such soils pits should be wider (1.25 x 1.25 m) in surface layer. Similarly water and nutrient application should also be done at 45 cm away from the stem of the plant.

In case of deep, clayey soils all types of roots were found to be well distributed in horizontal as well as vertical direction; hence nutrient and water can be applied as per the convenience. But in such soils special care has to be taken to increase the root growth especially very fine roots by adopting improved management practices or using chemicals to promote root growth.

3.3. Nutrient management in pomegranate

3.3.1. Response of various organic sources of nutrients on growth, yield and quality of pomegranate

To find out actual effect of organics, inorganic fertilizers have been applied as a check along with control. Inorganic fertilizers were applied as per the recommended dose while organics were applied on nitrogen equivalent basis.

The leaf nutrient content of majority of the nutrients were better in the plants supplied with organic manuring consistently for four years. Analysis of leaf samples revealed that highest N content (2.52%) in the leaves was observed with the application of farmyard manure treatment, while P, K, Ca and Mg content was high with the application of poultry manure. Highest Fe content (174.5 ppm) was with the application of *Glyricidia* green manuring while 'Mn' was high (34.3 ppm) in treatment having green manuring with Karanj. Considerable increase in leaf nutrient content was recorded with the application of organic manures to the plants.

Nutrient content in the leaves of pomegranate plants as affected by different treatments of organic manuring

Treatments	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
	(%)					(ppm)			
Farmyard manure	2.52	0.162	0.96	1.97	0.45	141.6	27.6	57.3	22.1
Vermicomopost	2.38	0.149	0.81	1.89	0.57	138.6	25.6	41.1	25.6
Poultry manure	2.10	0.195	1.01	2.03	0.63	147.9	29.2	47.0	33.8
Sunhemp green manuring insitu	2.33	0.138	0.97	1.82	0.48	151.9	25.4	35.1	32.1
Glyridicia green manuring ex situ	2.33	0.134	0.84	1.91	0.52	174.5	23.1	72.3	28.1
Karanj green manuring ex situ	2.05	0.132	0.88	1.79	0.43	131.0	34.3	69.7	30.3
Neem leaves green manuring ex situ	2.18	0.138	0.87	1.97	0.45	154.3	21.5	39.7	27.5
Inorganic fertilizers	2.40	0.159	0.94	2.00	0.57	117.1	23.5	56.1	29.3
Control	1.83	0.158	0.76	2.03	0.46	112.1	22.9	50.7	30.7

3.3.2. Response of application of farmyard manure in liquid form (slurry) on pomegranate performance

The experiment comprises of soil application (in circular ring of 10-15 cm wide & 15 cm deep) of well decomposed farmyard manure as a sole application and in combination with micronutrients ($FeSO_4$, $MnSO_4$ and $ZnSO_4$, 75 g each / plant/ year) and various microbial inoculants as mentioned. In the same manner fresh and well decomposed farmyard manure was applied in the form of slurry at the interval of 6 months. Different microbial inoculants used were as mentioned below.

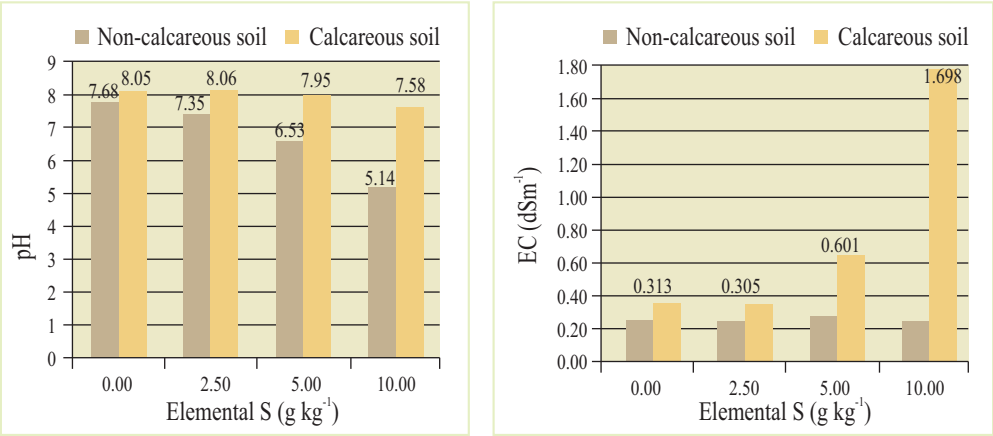
1. Symbion-AMF (Arbuscular Mycorrhizal Fungi) (Glomus fasciculatum) – 40 multispores / g, 1300 I.P. / g @ 2 kg / acre or 9 g / plant.
2. Kalisena® {*Aspergillus niger* (AN - 27)} - 10 x 10^{-5} cfu / g @ 1 kg (5 g / plant) mixed with 1 ton of organic manure, incubate for 10 days with intermittent mixing after 3 days interval and the prepared mixture applied @ 5 kg per plant.
3. *Trichoderma viridi* - 1 % WP, 2 x 10^{-6} cfu / g @ 150 g for 11 plants.
4. *Azotobacter crocoum* - 1 x 10^{-8} cfu / ml @ 250 ml in 100 kg FYM for 1 acre or 11.25 ml / plants.
5. PSB - 1 x 10^{-8} cfu / ml @ 11.25 ml / plants.
6. *Pseudomonas species* - 1 x 10^{-8} cfu / ml @ 11.25 ml / plants.
7. Potash Mobilizing Bacteria - 1 x 10^{-8} cfu / ml @ 11.25 ml / plants.

Fruit yield

Number of hermaphrodite flowers were more in the treatment involving application of fresh cowdung manure in the form of slurry. Number of fruit per plant revealed large variation from 15.1 to 39.0 fruits per plant and was highest in the plants having combined application of well decomposed organic manure in the form of slurry along with micronutrients and microbial inoculants.

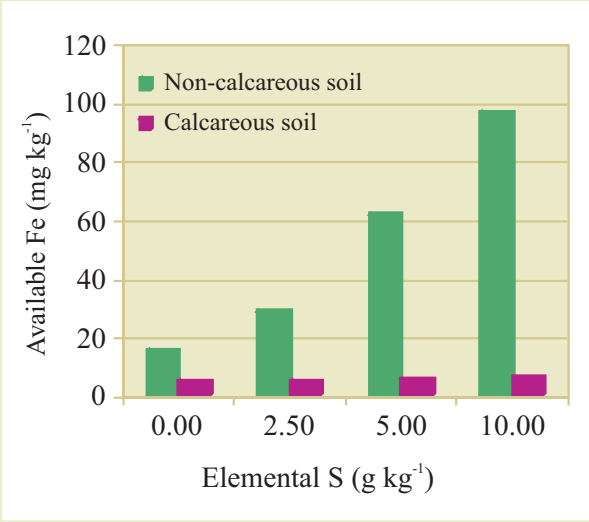
3.3.3. Study on the effect of elemental S and Zn on availability of micronutrients and their uptake by the plant

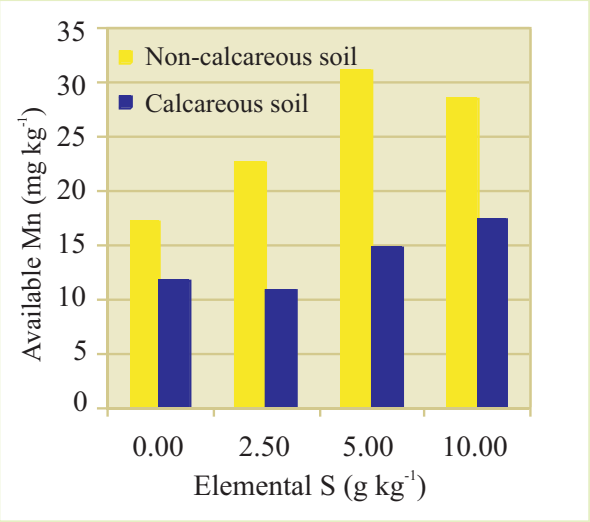
Soils of pomegranate growing areas are moderate to strongly alkaline in reaction which limits the availability of micronutrients particularly, Fe, Mn, Zn and Cu to the plant. Use of elemental S produces soil acidity through biological oxidation mediated by microorganisms. That is why, an effort was made to study the effect of elemental S and Zn on micronutrient (Fe, Mn, Zn & Cu) availability and consequently their uptake by the plant in two types of soil viz. non-calcareous loamy soil and calcareous clayey soil. The study indicated that application of elemental S significantly reduced pH from 7.68 to 5.14 in non-calcareous loamy soil and from 8.05 to 7.58 in calcareous clayey soil. The degree of reduction of soil pH was higher in non-calcareous loamy soil. Conversely, significant increase in electrical conductivity was observed in calcareous clayey soil owing to its poor drainage characteristics.



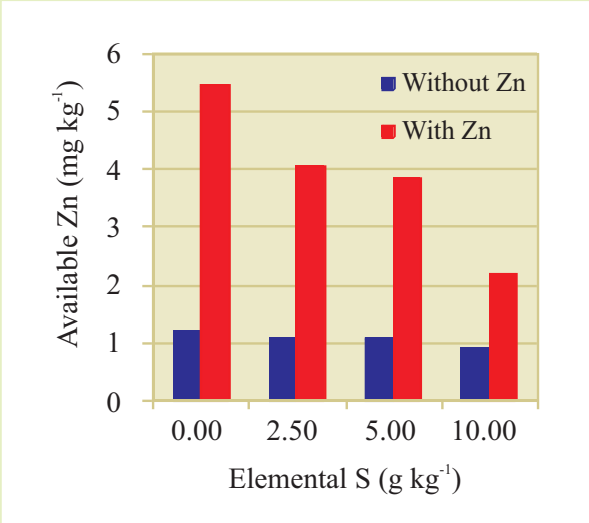
Effect of elemental S on soil pH and electrical conductivity

Lowering of soil pH upon application of elemental S significantly increased available Fe and Mn status in both the soil, however the extent of increase in availability of Fe and Mn was higher in non-calcareous loamy soil than calcareous clayey soil. Application of elemental S also enhanced available Zn status of calcareous clayey soil. Although, application of Zn @ 25 mg kg^{-1} soil significantly increased available Zn status in both the soils but significant negative interaction between elemental S and Zn was observed in both the soil.

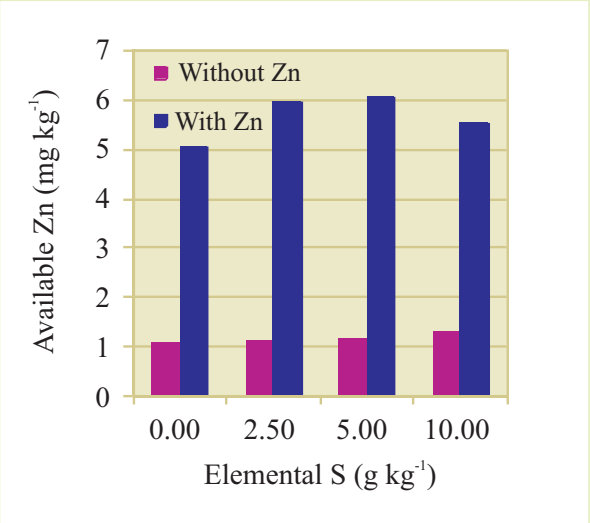




Effect of elemental S on available Fe and Mn content of soil



(a)

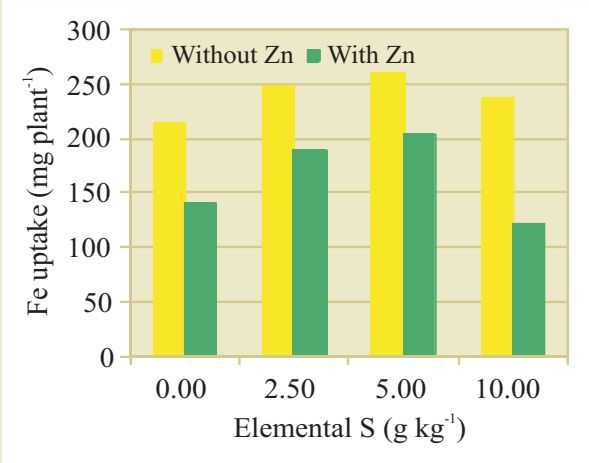


(b)

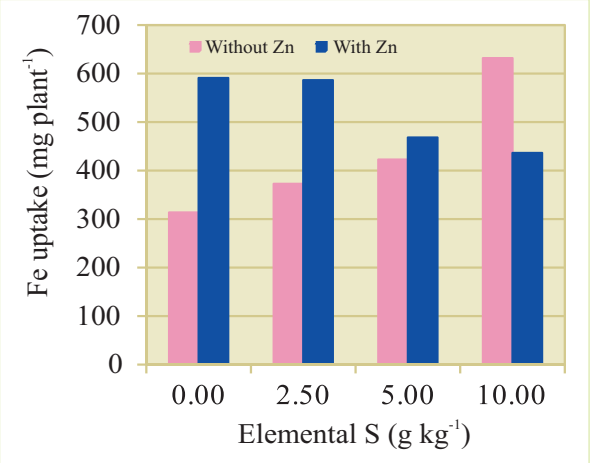
Effect of elemental S and Zn on available Zn content of (a) non-calcareous loamy soil and (b) calcareous clayey soil.

There was significant increase in Fe and Mn uptake by the plant with the application of elemental S in non-calcareous loamy soil and the maximum increase was observed when elemental S was applied @ 5.0 g kg^{-1} soil. In calcareous clayey soil application of elemental S also increased Fe and Mn uptake by the plant however, maximum uptake was observed with elemental S when applied @ 10.0 g kg^{-1} soil. Further, application of Zn @ 25 mg kg^{-1} soil in non calcareous loamy soil significantly increased Fe and Mn uptake by the plant but this extent of increase reduced with the increasing rate of elemental S application. Here, negative interaction was noticed.

Application of elemental S significantly increased Zn uptake by the plant in both calcareous and non-calcareous soils. However, maximum increase in Zn uptake was observed with 2.5 g S kg^{-1} soil in non-calcareous loamy soil whereas in calcareous clayey soil it was with 10.0 g S kg^{-1} soil. Further, application of Zn @ 25 mg kg^{-1} soil significantly increased Zn uptake by the plant in both the soils however, positive interaction was observed in non-calcareous loamy soil and negative interaction was observed in calcareous clayey soil.

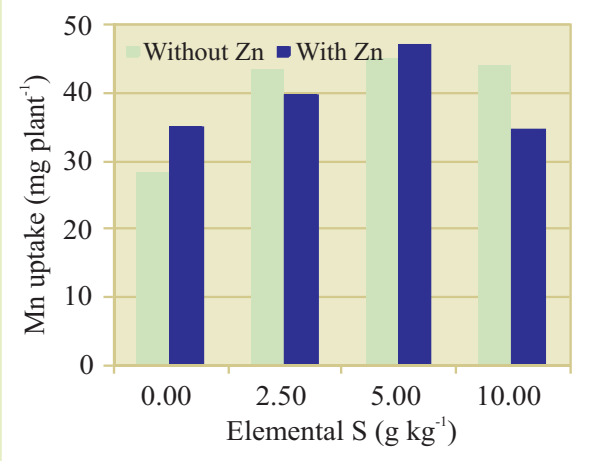


Non-calcareous loamy soil

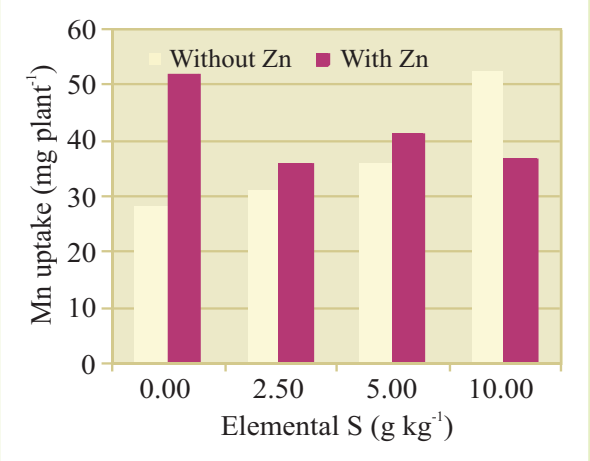


Calcareous clayey soil

Effect of elemental S and Zn on uptake of Fe by plant

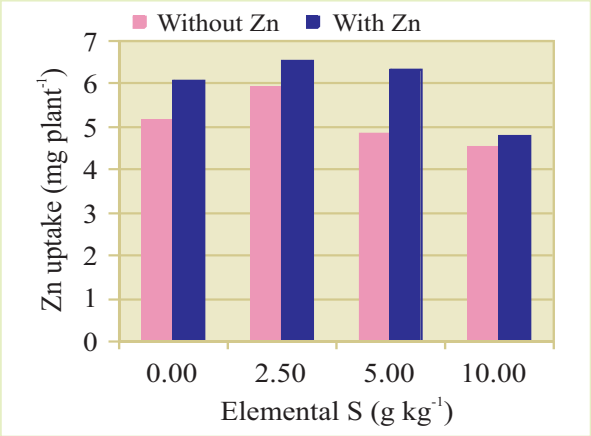


Non-calcareous loamy soil

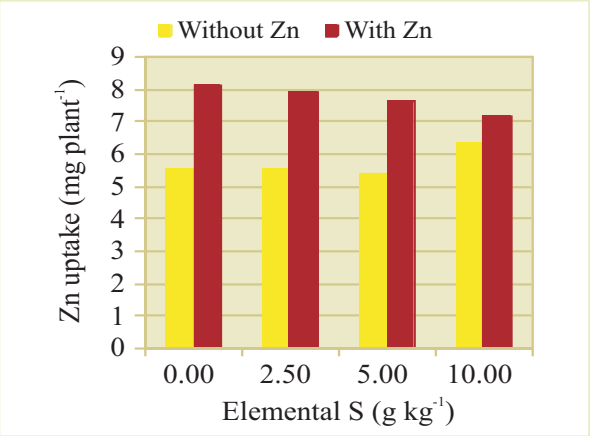


Calcareous clayey soil

Effect of elemental S and Zn on uptake of Mn by plant

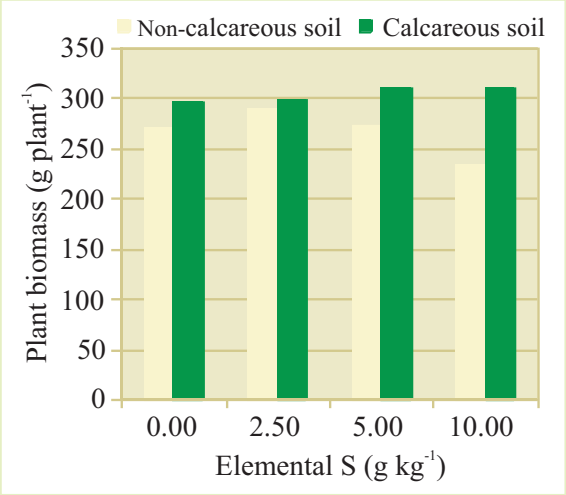


Non-calcareous loamy soil



Calcareous clayey soil

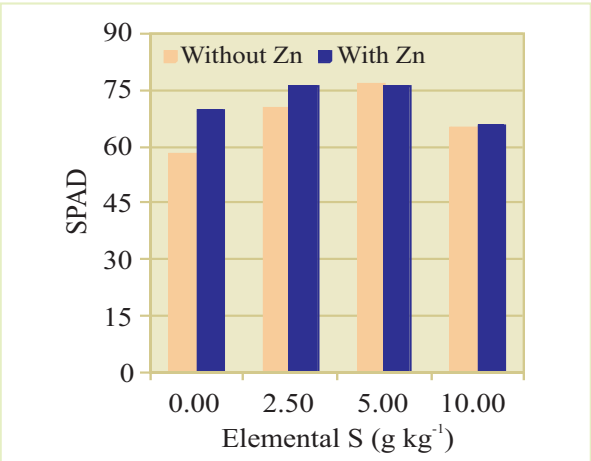
Effect of elemental S and Zn on uptake of Zn by plant

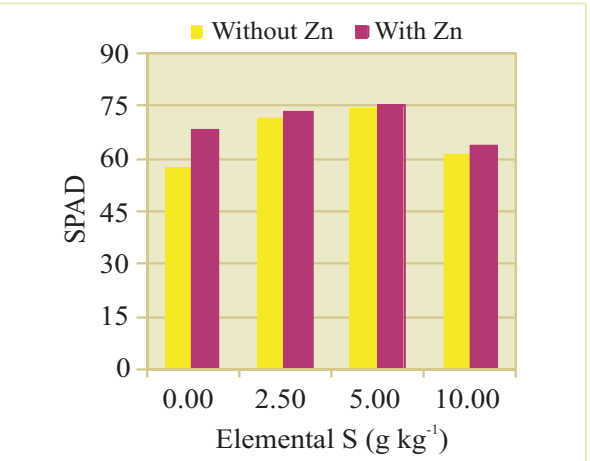


Effect of elemental S on plant biomass production

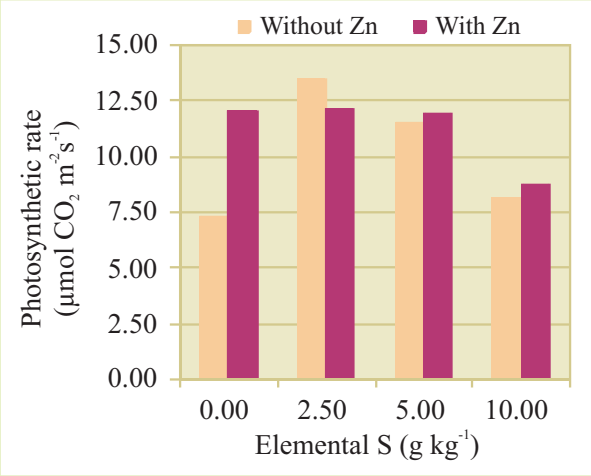
Higher nutrient uptake particularly Fe and Mn with the application of elemental S resulted in significantly higher biomass production in both the soils. Maximum plant biomass was produced with application of 2.5 g S kg^{-1} soil in non-calcareous loamy soil while in calcareous clayey soil, maximum plant biomass was produced with application of 5.0 g S kg^{-1} soil.

Use of elemental S significantly increased SPAD value (measure of chlorophyll content of leaves) in both the soil and maximum SPAD value was noted with the application of 5.0 g S kg^{-1} soil. This increase in SPAD value in-turn resulted significant increase in photosynthetic rate in non-calcareous loamy soil and maximum photosynthetic rate was noted with 2.5 g S kg^{-1} soil.





Effect of elemental S and Zn on chlorophyll content as measured by SPAD value of plant on (a) non-calcareous loamy soil and (b) calcareous clayey soil

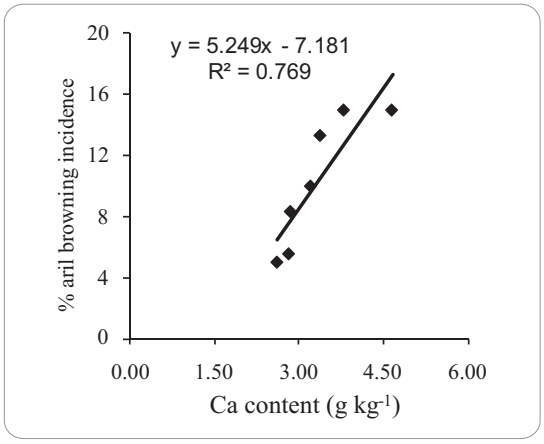


Effect of elemental S and Zn on photosynthetic rate of plant on non-calcareous loamy soil.

Application of elemental S @ 5.0 g kg^{-1} soil in non-calcareous loamy soil and @ 10.0 g kg^{-1} soil in calcareous clayey soil resulted maximum increase in Fe and Mn uptake by the plant. Soil application of Zn @ 25 mg kg^{-1} soil also significantly increased Zn uptake by the plant in both the soil types, however negative interaction with elemental S was observed. As a result of higher nutrient uptake by the plant there was significant increase in plant growth as indicated by biomass production, chlorophyll content of leaves as indicated by SPAD value and photosynthetic rate of plant.

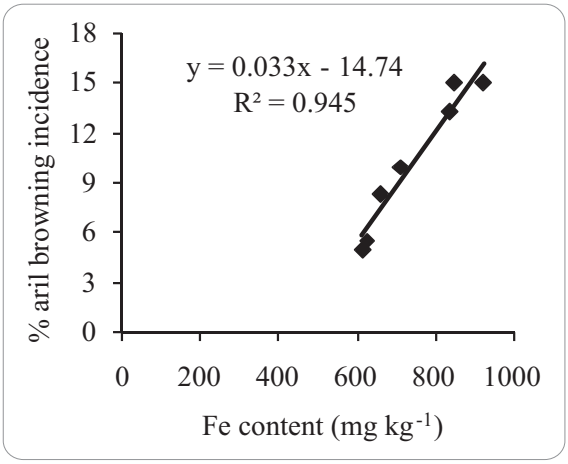
3.3.4. Identification of underlying mechanism of aril browning in pomegranate

Aril browning in pomegranate (*Punica granatum* L.) is a physiological disorder critically affecting fruit quality. As the fruit affected by the disorder remain free from any external symptoms, they can not be separated out before being packed, thus posing serious problems in export trade. Thus an effort was made to identify the underlying mechanism of aril browning in pomegranate. The study indicated that the magnitude of aril browning incidence in commercial cultivars ranged from 5% to 15% with a mean of 10.34% showing significant variability among the cultivars. Among the cultivars, 'Ganesh' and 'Jalore Seedless' had maximum incidence of aril browning (15%) and 'Bhagwa' the minimum (5%). Although, the means for N, P, K and Mg concentration of the browned arils were higher than the healthy arils but they were not significantly different. Thus no definite relationship could be established between N, P, K, and Mg concentration and per cent aril browning incidence, because no significant differences were found between browned arils and healthy arils. Notice that Ca concentration was significantly higher (3.78 g kg^{-1}) in browned arils than healthy arils (2.71 g kg^{-1}). As to Ca concentration, significant difference between browned arils and healthy arils were found and a linear relationship was established (% aril browning incidence = 5.25Ca – 7.18; R^2= 77%, $p<0.05$).

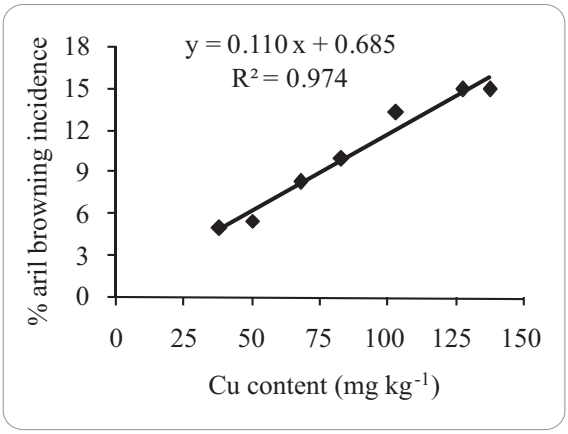


Relationship between Ca content in fruit and aril browning incidence

The concentration of Fe and Cu of the browned arils were higher than healthy arils, thus regression equation were established for Fe and Cu concentration in fruit (% aril browning incidence = 0.03Fe – 14.74; R^2 = 95%, p<0.05; % aril browning incidence = 0.11Cu + 0.69, R^2 = 97%, p< 0.05).

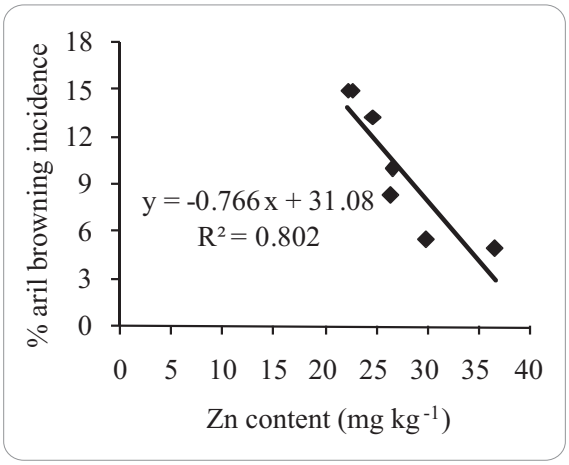


Relationship between Fe content in fruit and aril browning incidence



Relationship between Cu content in fruit and aril browning incidence

On the contrary concentration of Zn was lower in browned arils than healthy arils and thus a definite relationship was established between per cent aril browning incidence and concentration of Zn in fruit (% aril browning incidence = -0.77Zn + 31.08, R^2 = 80%, p< 0.05).



Relationship between Zn content in fruit and aril browning incidence

The study indicated that the incidence of aril browning in pomegranate was nearly 10% with a significant variability among the cultivars. The browned aril had significantly higher content of Ca, Fe and Cu than healthy aril but Zn content in browned aril was lower than in healthy arils across the seven cultivars viz. 'Ganesh', 'Jalore seedless', 'G 137', 'Ruby', 'Arakta', 'Mridula' and 'Bhagwa' used in the study.

3.4. Water management

3.4.1. Comparison of various irrigation methods with sub-surface drip irrigation system for pomegranate (*Punica granatum* L.) production

The experiment was conducted on comparative performance evaluation of micro-irrigation methods to find out the effect on growth performance of 1st year pomegranate orchard. Six treatments were replicated four times in RBD during 2013-14. 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 (30x30 cm) followed SDI with double laterals (30x40

cm), SDI with double laterals (30x50 cm), DI with double laterals (4D), SDI with single laterals (30 cm) and DI with single lateral (2D). Soil moisture retention was also higher in the SDI with double laterals (30x30 cm).

In lateral geometry experiment, 3 main treatments and 6 sub-treatments in split plot design were conducted to find out the effect on 1st year old age pomegranate orchard during 2013-14. The pomegranate evapotranspiration (liter/day/tree) of 0.20*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 0.20*ETr. Monthly shaded area (m^2), wetted area (%), Total leaf area (m^2) and leaf area index at solar noon hours is mentioned.


SDI at 30cm spacing system


DI with 4 drippers

Growth performance and water use in various micro-irrigation methods during July, 2013 to March, 2014

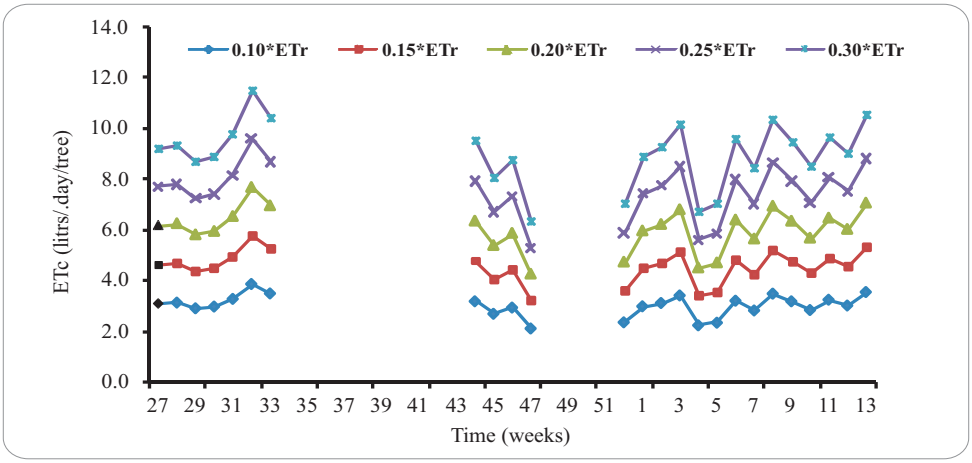
Treatments	Water use (Litrs.)	Plant height (cm)	Plant spread (cm)		Stem diameter (cm)	Stem girth (cm)	Thorn length (cm)	Flowers (Nos.)
			EW	NS				
SDI with single lateral (30 cm)	1428	121	105	103	2.0	2.3	2.0	68
SDI with double laterals (30x30 cm)	2856	127	118	121	2.2	2.4	2.5	60
SDI with double laterals (30x40 cm)	2380	128	130	125	3.2	2.8	3.1	65
SDI with double laterals (30x50 cm)	2142	122	114	114	2.5	2.0	3.3	66
DI with single lateral (2D)	1904	116	104	104	2.0	1.8	2.1	70
DI with double laterals (4D)	3808	127	120	117	2.1	2.0	1.8	78

(Spacing-4.5 x 2 m)

Growth performance and water use in lateral geometry experiment (July, 2013 to March, 2014)

Treatments (0.10 to 0.35 * Etr)	Plant height (cm)	Plant spread (cm)		Steam diameter (cm)	Steam girth (cm)	Thorn length (cm)	Flowers (Nos.)
		EW	SE				
double laterals (4D	120	110	102	2.1	2.2	2.1	50
double laterals (4D	123	126	120	3.0	2.4	3.2	59
Ring type (6Di)	119	118	98	2.2	2.1	2.4	60

(Spacing-4.5 x 2 m)



Pomegranate evapotranspiration, Etp (lit./day/tree)

Monthly shaded area, wetted area and leaf area index

Months	APP (m^2) *	SA (m^2)	WA (%)	TA (m^2)	LAI_{SN}
July, 2013	9.0	0.50	5.5	1.77	3.54
August	9.0	0.75	8.33	2.44	3.25
September	9.0	0.81	9.00	2.94	3.62
October	9.0	0.95	10.50	3.51	3.69
November	9.0	1.00	11.11	3.55	3.55
December	9.0	1.10	12.22	3.80	3.45
January, 2014	9.0	1.20	13.33	4.30	3.58
February	9.0	1.30	14.44	4.24	3.26
March	9.0	1.35	15.00	4.54	3.36

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

Screening of pomegranate for diseases and insect pests under different methods of irrigation

Prevalence of important diseases and insect-pests was monitored on pomegranate under various micro-irrigation methods and compared with subsurface drip irrigation system during 2013-14 at NRCP farm. Monitoring carried out on 5 months old pomegranate crop of cv. Bhagwa during November 2013, December, January, February, March and April 2014 revealed the prevalence of diseases like bacterial blight, fungal leaf spots and sap sucking insects mainly aphids.

Bacterial blight: In November 2013, bacterial blight severity was up to 18.0% in surface drip irrigation system while no blight was observed in subsurface irrigation system. During the month of December 2013, no bacterial blight was observed under the treatment of subsurface drip irrigation (SDI), where as blight was prevalent in other micro-irrigation systems in varied proportions. Blight incidence was maximum (14.0%) under double lateral method followed by single lateral (7.2%) and ring system (4.0%). However, disease severity was almost same (5.5%) under all the surface drip irrigation systems. There was a slight decline in the incidence of bacterial blight in the month of January and no blight was observed further during the months of February, March and April 2014 in any of the treatments.

Fungal Leaf spots: Microscopic examination of leaf spots prevalent on pomegranate under various

irrigation treatments in December 2013 revealed the association of *Cercospora punicae*, *Sphaceloma punicae* and *Alternaria altenata*. It is evident from the results that incidence of various leaf spots was quite high under different surface drip irrigation methods (30.0-40.0%) as compared to subsurface drip irrigation system where incidence was only 16.25%. However, there was not much difference in the severity of the spots. Unlike bacterial blight which was not observed after January month, leaf spots were prevalent during all the months of observations from November 2013 to March 2014.

Insect-pests : Among the insect-pests, aphid (*Aphis punicae)* infestation was prevalent in all the methods of irrigation in mild to moderate proportion. Incidence of aphid infestation was maximum under single lateral system (38.0%) followed by subsurface drip irrigation (26.5%) , Ring system (20.0%) and double lateral system (15.0%). However, subsurface drip irrigation system revealed lowest severity of aphid infestation (8.71%) as compared to lateral system (10.16-10.71 %). No aphid infestation was observed during the months of February and March 2014 under any of the drip irrigation systems. In December, one plant under the treatment double lateral system also revealed infestation due to brown hairy caterpillar eating the foliage of the plant.

Incidence and Severity of bacterial blight, fungal leaf spots and insect-pests on pomegranate under different methods of micro-irrigation during December, 2013

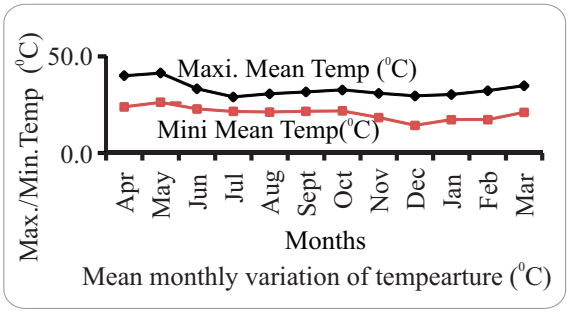
Methods of irrigations	Bacterial blight % infection		Fungal Leaf spots % infection		Insect-pests (Aphids) % infestation	
	Incidence	Severity	Incidence	Severity	Incidence	Severity
Single lateral with two drippers	7.2	5.5	32.0	5.5	38.0	10.71
Double lateral with 4 drippers	14.0	5.5	30.0	5.5	15.0	10.16
Ring system with 6 drippers	4.0	5.5	40.0	5.5	20.0	9.66
Subsurface drip irrigation with 2-4 drippers.	0.0	5.5	16.25	5.5	26.5	8.71

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

3.4.2.1. Climatic Parameters at Experimental site:

Various weather parameters required for the estimation of ET_r, viz., air temperature, soil temperature, relative humidity, wind speed, evaporation, rainfall, bright sunshine hrs. etc. were recorded daily at 7.30 and 14.30 hrs from April- 2013 to March-2014 and the details were given below.

Air Temperature : The mean monthly maximum temperature varied from 29 to 41.4 ^{0}C. May was the hottest month and temperature was highest (43.4^{0}C) on 23rd May and lowest (10.6^{0}C) on 10th Dec. The temperature gradually increased from April to May and then started declining till Jan then again it increased**.** Mean monthly minimum temperature varied from 14.2 ^{0}C in Dec. to 26.2 ^{0}C in May.

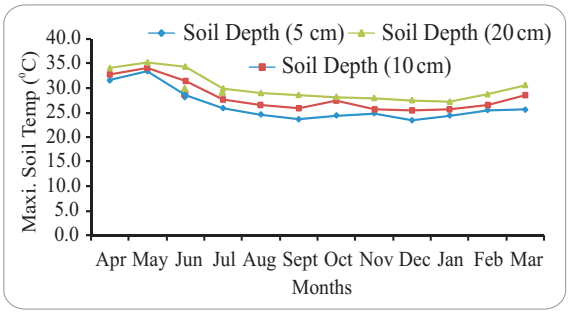


Mean monthly variation of tempearture (°C)

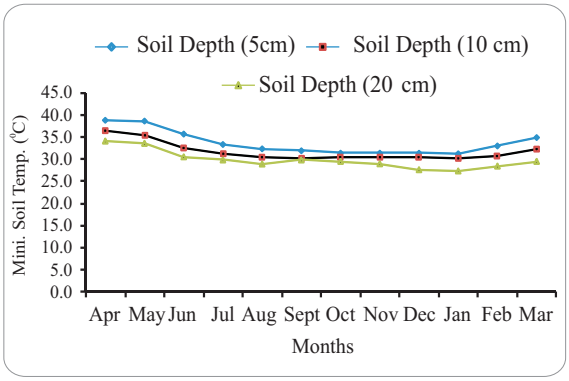
Soil Temperature:

Soil temperature in the morning increased with increase in soil depth from 5 to 20 cm whereas, it decreased with increase in soil depth in the evening hrs. During morning hours, mean monthly temperature of surface soil was highest in the month of May (34.1 °C) and in lowest in Dec (23.3 °C). Soil temperature was always less than the air temperature.

During evening hours, mean monthly temperature of surface soil was highest in May (38.8 °C) and lowest in January (27.4 °C).



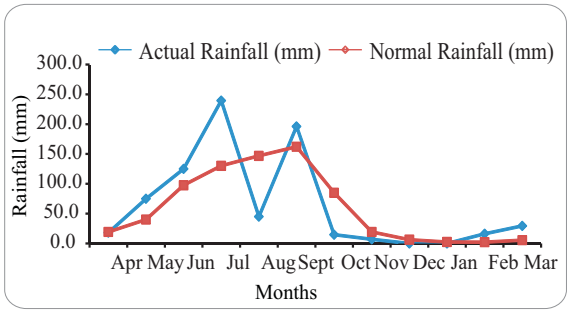
Soil Temperature variation in the morning hours



Soil Temperature variation in the evening hours

Rainfall and Rainy days:

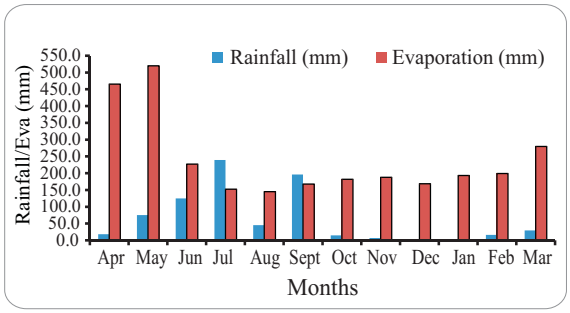
Total rainfall received during Apr, 2013 to Mar, 2014 at NRCP, Solapur was 782.05 mm which was distributed over. Annual rainfall was about 271.8 mm higher than last year (510.7mm). More than 80 % of rainfall was received during June to October. There were about 292 days without any rain. Highest amount of rainfall for a single day was recorded on 6th June (52.00 mm).



Deviation of monthly rainfall-2013 from Normal rainfall

Evaporation :

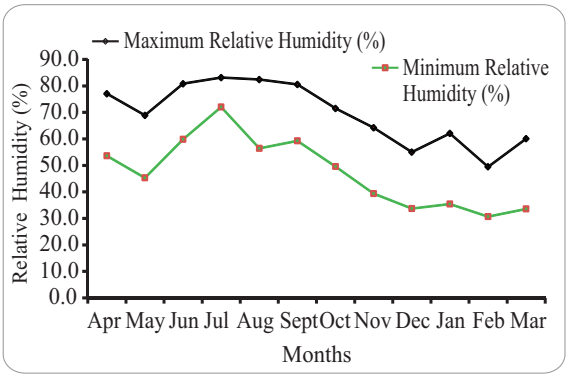
Total monthly evaporation was highest in May (520 mm) and lowest (144 mm) in Aug. Evaporation recorded in a single day was highest (20.0 mm) on 11th May and lowest (0.2 mm) on 20thJan. From Apr. to May evaporation was higher than the rainfall but from July and September rainfall was higher than the evaporation.This indicates the water stress in the soil existed from Apr-2013 to June-2013 and from Oct-2013 to Feb-2014. The total evaporation for this year was 2888.02 mm.



Distribution of total rainfall and evaporation

Relative Humidity

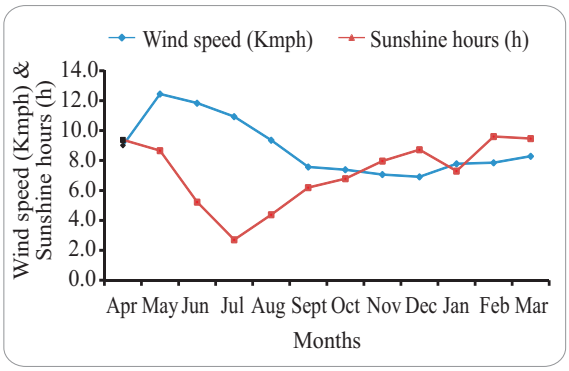
The mean monthly maximum relative humidity at NRCP was highest in Jul. (83.10 %) and the lowest in Feb (49.5 %). Relative humidity remained low during Dec. to Mar. Minimum relative humidity varied from 30.6 % to 72 % .



Variation of humidity during morning and evening hours

Sunshine Hours and Wind Speed

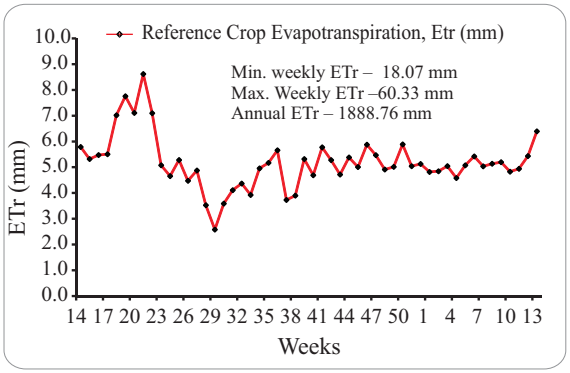
The sunshine hour at NRCP, Solapur ranged from 2.7 h day in July to 9.6 h/day in Feb. From June to October. Sunshine hour ranged from 2.6 to 6.8 h/day. But from Nov. onwards, sunshine was available for more than 7.3 h /day. Mean monthly wind speed ranged from 6.9 km/h in Dec. to 12.4 km/h in May. Wind speed was highest (20.5 km/h) on 26th May and lowest (2.9 Km/h) on 12th September .



Mean monthly variation of wind speed and sunshine hours

3.4.2.2. Estimation of Reference Crop Evapotranspiration (ET_r, mm)

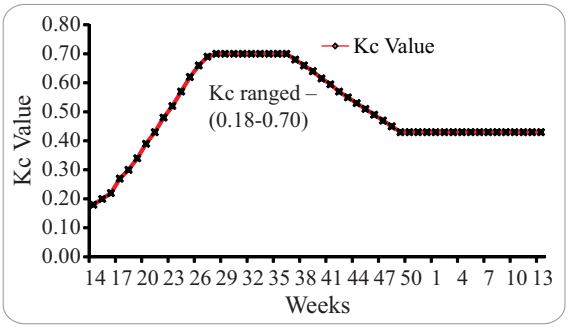
The daily climatic data for the period of April, 2013 to March, 2014 were used to determine daily and weekly reference crop evapotranspiration (ET_r) by using Penman-Monteith Method**.** The trend of variation of average ET_r values over the year is shown below. The yearly reference crop evapotranspiration (ET_r) obtained was 1888.76 mm. The ET_r was maximum in May (19-21 SMW) and minimum in December (49-52 SMW). The weekly minimum and maximum ET_r ranged from 18.07 to 60.33mm.



Weekly Etr (mm) values from April, 2013 to March, 2014 at Experimental site

3.4.2.3. Development of crop coefficient (Kc) values

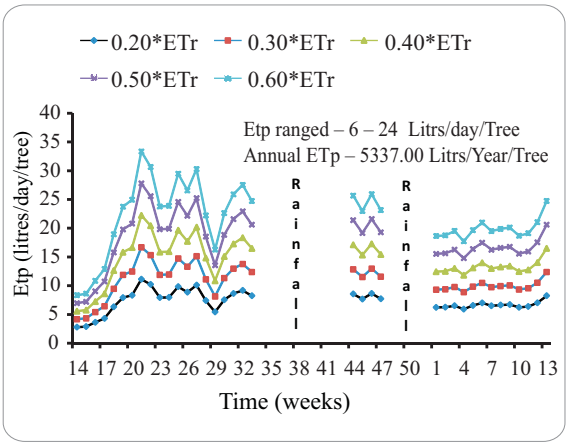
The weekly crop coefficient value was computed by using equation (Kc=0.014x+0.08). The crop coefficient curve for pomegranate tree in the 3rd year was estimated**.** The values of crop coefficient increases from 0.18 to 0.70 due to the development, maturation of the leaf surface, increased number of leaves, water sprout, flowers and fruits of the tree during 3rd year. The Kc values increased linearly from 14th to 35th weeks due to increases in number of leaves, water sprout, flowers, fruits and shaded area as observed from the representative trees and decreased from 36th to 50th weeks due to removal of water sprout, leaf drop and harvesting of fruits. The crop coefficient (0.45-0.55) increases in the 51th to 13th weeks due to increase in water sprout, foliage and management practices.



Crop coefficient curve for 3rd year pomegranate tree

3.4.2.4. Estimation of Pomegranate Evapotranspiration (Etp, litres/day/tree)

The daily water to be applied through drip irrigation system at 90 % efficiency from April, 2013 to March, 2014 ranged from 6–24 liters/day/tree for 3 years old pomegranate tree. The application of water at 0.40 Etr was found to be the best for better growth and development. Lower Kcvalues represent slower plant growth and less plant canopy cover, indicating lower Etp. The amount of water to be applied to pomegranate during the season is 5337 liters/ year/tree.



Daily pomegranate evapotranspiration (liters/day/tree) of 3 year old tree

3.4.2.5. Pomegranate Evapotranspiration for Inorganic and Organic Mulches (Etp, litres/ day/ tree)

An experiment on different organic (i.e. Wheat, Safflower and Sugarcane straw) and inorganic mulches (i.e. Black and White, Black and Pervious) was conducted to find out the effect of mulches on soil properties and growth of Pomegranate. Eight treatments including control were replicated four times in split plot design. Various-mulching treatments improved plant growth, reduced moisture loss through 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 0.40*Etr, followed by wheat, safflower and black and white mulch and black mulch.

Growth parameters

Pomegranate cv.Bhagwa was evaluated for their growth performance under organic and inorganic mulches. Plant height, plant spread (EW & NS), stem diameter, stem girth, thorn length, flowers, and number of fruits ranged from 110 to 155 cm, 115 to 162 cm, 110 to 150 cm, 3.0 to 4.6 cm, 2.1 to 3.8 cm , 2.2 to 4.6 cm, 90 to 152 and 32 to 55 respectively.

Organic mulch

Inorganic mulch

Growth performance of pomegranate under organic and inorganic mulch

Type of mulch	Plant height (cm)	Plant spread (cm)		Stem diameter (cm)	Stem girth (cm)	Thorn length (cm)	Flowers	Fruits
		EW	SE					
Organic (0.20 to 0.60*ETr)								
Wheat	110	115	110	3.0	2.2	2.3	100	45
Saf flower	132	125	132	3.4	2.5	2.8	120	55
Sugarcane Begasse	141	138	128	4.2	2.3	3.2	140	50
Control	129	119	120	3.9	2.1	3.5	90	32
Inorganic (0.20 to 0.60*ETr)								
Black and white	120	143	125	3.2	2.3	2.4	150	35
Black	137	152	135	3.2	2.6	2.7	145	40
Pervious	145	162	135	3.9	2.1	3.1	152	52
Control	127	138	124	3.5	2.4	3.4	100	35

3.4.3. Water management in pomegranate orchards under different soil types

3.4.3.1. Irrigation in pomegranate orchards using varied number of drippers

For 'Bhagwa', the quantity of irrigation water to be applied was calculated on the basis of daily pan evaporation data of the experimental farm. Irrigation based on 0.80 E-pan was provided through various treatments of drip irrigation systems viz. irrigation through 2 drippers**;** 3 drippers; 4 drippers; 6 drippers fixed on 2 laterals; lateral having 8 inline drippers placed in the form of ring encircling the plant

3.4.3.1.1. Water applied during the period

Equal quantity of irrigation water was applied to all the treatments during the experimental period. Highest quantity of water was applied during the month of May while it was lowest in December month.

Quantity of water applied through varied number of drippers treatments during different months

Months	Water applied under all the treatments (liters / plant)	
	Per month	Per day
Dec. 2012	159.6	5.15
Jan. 2013	181.1	5.84
Feb. 2013	193.9	6.93
Mar. 2013	266.0	8.58
Apr. 2013	360.4	12.01
May 2013	411.9	13.29
Jun. 2013	181.8	6.06
Total	1754.7	

3.4.3.1.2. Flowering intensity and fruit yield of pomegranate plants grown in light texture soil

Fruit yield in terms of number of fruits per plant varied significantly from 22.4 to 36.1 fruits per plant amongst the treatments and was highest in the plants supplied with irrigation through two laterals placed on both side of the plant followed by irrigation through inline lateral encircling the plant.

Effect of irrigation method on flowering intensity and fruit yield of pomegranate plants grown on light texture soil

Treatments	Hermaphrodite Flowers / plant	No. of fruits / plant	No. of cracked fruits/plant	Percent cracked fruits/plant	Wt. of fruits / plant (kg)	Average wt of each fruit (g)
2 drippers	141.6	22.4	3.0	11.1	4.434	200.8
3 drippers	131.3	25.0	1.5	5.0	4.596	186.0
4 drippers	122.1	28.6	0.4	1.1	5.397	194.0
6 drippers fixed on 2 laterals	130.0	36.1	0.3	0.6	6.889	192.4
Lateral with 8 inline drippers placed as ring around the plant	111.6	32.4	0.9	2.3	5.698	178.2

3.4.3.1.3. Quality of the fruits of pomegranate plants grown in light texture soil

Pomegranate cv. 'Bhagwa' fruits of *'Hasta'* bahar grown under different treatments were harvested and analysed for different quality parameters. Highest juice recovery from the fruits was observed in plants receiving irrigation through 4 drippers placed on four side of the plant. While highest TSS of fruit juice was found in plants receiving irrigation through two laterals placed on both side of the plant.

3.4.3.1.4. Flowering intensity and fruit yield of pomegranate plants grown in heavy texture soil

'Hasta bahar' fruits of pomegranate plants grown under different treatments were harvested during the month of Mar - Apr 2013 at maturity. Fruit yield varied significantly from 25.1 to 35.1 fruits per plant and was highest in the plants supplied with irrigation through two laterals placed on both side of the plant followed by irrigation through 4 drippers.

Effect of irrigation method on flowering intensity and fruit yield of pomegranate plants grown on heavy texture soil

Treatments	Hermaphrodite flowers/plant	No. of fruits / plant	No of cracked fruits/plant	Percent cracked fruits/plant	Wt. of fruits / plant (kg)	Average wt of each fruit (g)
2 drippers	133.3	25.1	1.79	6.5	5.224	212.0
3 drippers	124.8	28.0	1.00	3.1	5.553	201.5
4 drippers	120.4	33.0	0.38	1.0	6.833	208.2
6 drippers fixed on 2 laterals	128.4	35.1	0.13	0.3	7.808	224.8
Lateral with 8 inline drippers placed as ring around the plant	112.3	29.9	1.75	5.4	6.398	216.3

3.4.3.1.5. Quality of the fruits of pomegranate plants grown in heavy texture soil

Fruits of pomegranate cv. 'Bhagwa' in *'Hasta bahar*, were harvested and analysed for different quality parameters. Highest TSS values were recorded in the fruit juice of the fruits of the plants receiving irrigation through two laterals placed on both sides of the plant. Application of irrigation water through 6 (2lph) online drippers fixed on two laterals placed along the row on both side of the plant was found to be the best method of irrigation due to good moisture distribution in horizontal as well as vertical direction, good aeration, better root growth and nutrient absorption from more area increasing nutrient uptake by the plant.

3.4.3.1.6. Moisture content in the root zone of the plant

Observations on gravimetric moisture content in the root zone of the plant at 0-15, 15-30 and 30-45 cm vertical depth was taken during March, April and May month. In light texture soil, during most of the times, variations in moisture content were significant amongst the treatments. Application of irrigation water through inline lateral placed in the form of circular ring recorded higher moisture content in all the depth during all the periods. Moisture content was lowest where water was applied through two laterals.

Effect of irrigation method on moisture content in the root zone of pomegranate plant under light textured soil (sampling before irrigation)

Treatments	March 2013			April 2013			May 2013		
				Soil Depth (cm)					
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
2 drippers	19.0	20.2	19.3	20.1	20.9	19.0	19.2	20.2	18.8
3 dripper	19.2	19.8	21.4	20.0	21.2	22.2	18.8	19.8	21.0
4 drippers	18.8	19.5	20.3	19.5	20.9	21.4	18.0	19.5	19.6
6 drippers fixed on 2 laterals	17.5	18.8	20.1	17.5	17.8	20.5	16.6	18.3	19.6
Lateral with 8 inline drippers placed as ring around the plant	20.0	21.3	23.0	20.7	22.5	23.9	19.2	22.7	20.9

Effect of irrigation method on moisture content in the root zone of pomegranate plant under heavy textured soil (sampling before irrigation)

Treatments	March 2013			April 2013			May 2013		
				Soil Depth (cm)					
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
2 drippers	21.9	24.6	24.0	22.1	24.3	23.2	21.5	22.3	20.6
3 drippers	22.3	25.2	24.2	21.8	25.3	23.4	22.0	24.8	25.0
4 drippers	22.0	22.3	25.2	21.7	22.0	25.6	20.9	22.3	24.8
6 drippers fixed on 2 laterals	20.1	23.5	23.7	19.2	24.0	23.4	18.6	23.5	23.0
Lateral with 8 inline drippers placed as ring around the plant	22.5	24.3	25.2	22.9	25.0	25.6	21.0	23.8	24.0

3.4.3.2. Frequency of irrigation in pomegranate orchards grown on different soil types

An experiment was conducted during December 2012 to June 2013 on pomegranate cv. Bhagwa plants grown under heavy (clayey) and light textured soils separately at research farm of NRC on Pomegranate, Solapur. Quantity of irrigation water to be applied was calculated on the basis of daily pan evaporation data of the experimental farm. Irrigation based on 0.80 E-pan was provided as daily and cumulative quantity of water after one, two, three, four and five days interval through drip system of irrigation. Plant performance in the form of vegetative growth, yield and quality of the fruits was monitored.

3.4.3.2.1. Water applied during the period

Equal quantity of irrigation water (1639.6 liters) was applied to the plants grown under each treatment. In all the treatments, quantity of irrigation water was highest during the month of May followed by April and was lowest in the month of June.

3.4.3.2.2. Fruit yield of pomegranate plants grown in light texture soil

Highest number of hermaphrodite were recorded in the plants receiving irrigation after 3 days interval due to optimum water stress which is beneficial for induction of flowering. Fruit yield varied significantly from 20.0 to 33.0 fruits per plant and was highest in the plants supplied with irrigation on every alternate day. Reduction in fruit yield was recorded in the plants receiving irrigation after 4 and 5 days.

3.4.3.2.3. Quality of the fruits of pomegranate plants grown on light texture soil

Pomegranate cv. 'Bhagwa' grown during *'Hasth' bahar* under different treatments were harvested and analysed for different quality parameters. Juice percent and TSS / acidity ratio of the fruit juice was highest in plants receiving irrigation on every alternate day. Similarly juice acidity was lowest in this treatment.

3.4.3.2.4. Fruit yield of pomegranate plants grown on heavy texture soil

Pomegranate cv. Bhagwa grown during *'Hasth bahar'* under different treatments revealed that the highest number of hermaphrodite flowers were produced on the plants receiving irrigation after 2 days interval. Fruit yield in terms of number of fruits per plant varied significantly from 22.0 to 38.0 fruits per plant and was highest in the plants supplied with irrigation at 2 days interval followed by 3 days interval.

3.4.3.2.5. Quality of the fruits of pomegranate plants grown on heavy texture soil

Pomegranate cv. 'Bhagwa' fruits grown during *'Hasth' bahar* under different treatments were harvested and analysed for different quality parameters. Juice percent in the fruit was highest in the plants receiving irrigation at the interval of 2 days followed by daily irrigation while it was lowest in the fruits of the plants receiving irrigation at 4 and 5 days interval.

Plants growing on light texture soil, cumulative irrigation should be provided on every alternate day as these soils have low water holding capacity.

In case of pomegranate plants growing on heavy texture soil, cumulative irrigation should be provided after 2 days interval. These soils have very high water holding capacity as such much adverse effect was not observed due higher irrigation interval. Still during fruit development stage irrigation interval should not exceed 3 days, which may induce fruit cracking leading to lower fruit yield.

In case of plants growing on light texture soil, quality of the fruits was better in the plants receiving irrigation at 1 to 3 days interval. With the increase in irrigation interval beyond 3 days reduction in fruit quality took place which might be due to moisture stress, shrinkage and cracking of fruits. While in case of plants growing on heavy texture soil much variation in quality of fruits was not observed.

3.4.3.2.6. Moisture content in the root zone of the plant

Observations of gravimetric moisture content in the root zone of the plant at 0-15, 15-30 and 30-45 cm vertical depth was taken before scheduled irrigation during March, April and May months. Variations in moisture content amongst the treatments was higher in light textured soil than heavy texture soil it was non-significant on many occasions. In both soil types higher moisture content was recorded at lower irrigation interval of 1 to 3 days while it drastically reduced in case of 4 and 5 days irrigation interval.

Effect of irrigation interval on moisture content in the root zone of pomegranate plant under light textured soil

Treatments	March 2013			April 2013			May 2013		
	Soil depth (cm)								
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
Daily	18.93	20.23	17.83	19.20	17.03	17.20	18.20	17.20	15.80
After 1 day	19.23	19.80	21.43	19.43	20.20	20.93	18.50	19.00	21.00
After 2 days	18.78	19.50	20.33	19.00	19.53	21.33	18.23	19.20	19.80
After 3 days	17.53	18.83	20.10	16.83	17.60	20.00	15.50	17.20	20.30
After 4 days	17.03	18.00	18.83	17.00	16.53	19.43	16.00	17.93	18.40
After 5 days	16.93	17.53	19.60	16.50	17.50	20.73	15.80	18.00	18.93

Effect of irrigation interval on moisture content in the root zone of pomegranate plant under heavy textured soil

Treatments	March 2013			April 2013			May 2013		
	Soil depth (cm)								
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
Daily	21.93	22.30	20.63	22.23	21.88	19.90	21.50	22.30	20.63
After 1 day	22.33	21.28	24.18	21.90	20.93	23.43	22.03	21.33	23.58
After 2 days	22.00	22.30	25.20	21.80	22.83	25.63	21.80	22.30	24.78
After 3 days	20.10	23.50	24.00	20.30	24.00	23.38	20.60	23.50	23.03
After 4 days	18.33	20.20	21.33	17.83	19.20	22.38	17.03	20.23	20.78
After 5 days	17.80	20.63	20.00	17.50	21.00	19.70	16.88	20.63	21.23

3.4.3.3. Irrigation requirement of pomegranate orchards under different soil types.

The experiment was conducted in pomegranate cv. Bhagwa plants at research farm of NRC on Pomegranate, Solapur. During the year 2012-13, various treatments were imposed from December 1, 2012 to June 10, 2013. Quantity of irrigation water to be applied was calculated on the basis of daily pan evaporation data of the experimental farm. Irrigation water equivalent to 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, and 0.90 E.Tc was applied.

3.4.3.3.1. Total quantity of irrigation water applied during the period

Quantity of irrigation water applied under different treatments was as low as 614.7 liters at 0.30 ETc to as high as 1844.1 liters / plant at 0.90 ETc treatments during the experimental period. In all the treatments, quantity of applied irrigation water was highest during the month of May while it was lowest in December month.

Quantity of irrigation water applied to the experimental plants during the year 2012-13 on monthly basis

Month Year 2012-13	Water applied liters / plant / month equivalent to						
	0.30 E Tc	0.40 E Tc	0.50 E Tc	0.60 E Tc	0.70 E Tc	0.80 E Tc	0.90 E Tc
December - 2012	59.9	79.9	99.8	119.8	139.7	159.7	179.7
January - 2013	67.9	90.5	113.2	135.8	158.4	181.1	203.7
February - 2013	72.7	96.9	121.1	145.4	169.6	193.8	218.1
March - 2013	99.7	133.0	166.2	199.4	232.7	265.9	299.1
April - 2013	135.1	180.1	225.2	270.2	315.2	360.2	405.3
May -2013	154.4	205.9	257.4	308.8	360.3	411.8	463.3
11 June 2013	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Total	614.7	819.6	1024.5	1229.4	1434.3	1639.2	1844.1
Average quantity of water applied liters / plant / day							
December - 2012	1.93	2.58	3.22	3.86	4.51	5.15	5.80
January - 2013	2.19	2.92	3.65	4.38	5.11	5.84	6.57
February - 2013	2.60	3.46	4.33	5.19	6.06	6.92	7.79
March - 2013	3.22	4.29	5.36	6.43	7.51	8.58	9.65
April - 2013	4.50	6.00	7.51	9.01	10.51	12.01	13.51
May -2013	4.98	6.64	8.30	9.96	11.62	13.28	14.94
11 June 2013	2.27	3.03	3.79	4.55	5.30	6.06	6.82

3.4.3.3.2. Fruit yield of pomegranate plants grown on light texture soil

Highest number of hermaphrodite flowers were found in the plants receiving water equivalent to 0.30 ETc followed by 0.50 ETc. Fruit yield in terms of number of fruits per plant varied significantly from 9.0 to 35.1 fruits per plant amongst the treatments and was highest in the plants supplied with water equivalent to 0.70 ETc followed by 0.80 ETc. Drastic. reduction in fruit yield was recorded in the plants supplied with 0.30 to 0.50 ETc water mainly due to very high percent of fruit cracking (58.8 to 37.7 %) under these treatments. In general, it is observed that during fruit development period irrigation water equivalent to 0.70 ETc must be supplied to the plant below which drastic reduction in fruit yield was observed with highest percentage of fruit cracking

Flowering intensity and fruit yield of pomegranate plants grown on light texture soil supplied with varied quantity of irrigation water

Irrigation equivalent	Hermaphrodite flowers /plant	No. of fruits/plant	No of cracked fruits/plant	Percent cracked fruits/plant	Wt. of fruits/ plant (kg)	Average fruit wt (g)
0.3 ETc	140.3	9.0	13.0	58.8	1.637	182.0
0.4 ETc	128.0	12.0	10.0	45.3	2.291	192.5
0.5 ETc	135.1	15.0	9.0	37.7	2.912	196.2
0.6 ETc	117.8	28.0	3.0	9.7	5.274	190.4
0.7 ETc	125.2	35.1	0.3	0.8	6.786	194.6
0.8 ETc	110.0	33.0	0.0	0.0	6.533	199.5
0.9 ETc	112.3	31.0	0.0	0.0	6.480	210.7

3.4.3.3.3. Quality of the fruits of pomegranate plants grown in light texture soil

Fruit length and fruit diameter was highest in the fruits produced on the plants supplied with irrigation equivalent to 0.80 ETc followed by 0.60 ETc. Juice percent in the fruit was highest at irrigation equivalent 0.90 ETc followed by 0.70 ETc. Higher Juice acidity and lower values of TSS and TSS/ acidity ratio were observed in plants applied with irrigation equivalent less than 0.5 ETc. In general it was observed that quality of the fruits was drastically reduced in the treatments receiving less quantity of irrigation water equivalent of 0.30 to 0.40 ETc. The fruits produced on the plants under these treatments got shrunk and some fruits got cracked leading to deterioration of fruit quality.

Quality of the fruits of pomegranate plants grown on light texture soil supplied with varied quantity of irrigation water

Irrigation equivalent	Fruit length (mm)	Fruit diameter (mm)	Rind thickness (mm)	Fruit Rind (%)	Fruit Arils (%)	Fruit Juice (%)	Juice acidity (%)	TSS (^{O}B)	TSS/ acid ratio
0.3 ETc	58.0	61.5	2.53	39.7	60.3	40.4	0.53	14.8	28.0
0.4 ETc	56.1	59.9	2.38	40.8	59.3	42.8	0.54	14.6	27.3
0.5 ETc	63.1	66.1	2.69	38.2	61.8	44.4	0.51	15.0	29.8
0.6 ETc	70.2	73.2	2.95	37.1	62.9	46.3	0.48	15.7	32.9
0.7 ETc	68.3	71.5	2.82	37.4	62.6	47.1	0.46	15.6	34.1
0.8 ETc	71.9	74.6	3.19	36.2	63.9	46.6	0.45	15.4	34.5
0.9 ETc	69.8	72.8	3.09	37.0	63.0	47.7	0.45	15.5	34.3

3.4.3.3.4. Fruit yield of pomegranate plants grown in heavy texture soil

Highest number of hermaphrodite flowers were found on the plants receiving water equivalent to 0.30 ETc followed by 0.50 Etc, this was due to water stress. Fruit yield varied significantly from 15.0 to 38.0 fruits per plant was highest in the plants supplied with water equivalent to 0.60 ETc followed by 0.70 ETc. Drastic reduction in fruit yield was recorded in the plants supplied with water equivalent to 0.30 and 0.40 ETc mainly due to very high percent of fruit cracking (44.3 & 33.4 %) due to water stress under these treatments.

In general it observed that for the plants grown on heavy texture soil, irrigation water equivalent to 0.60 ETc must be supplied during fruit development period.

Flowering intensity and fruit yield of pomegranate plants grown on heavy texture soil supplied with varied quantity of irrigation water

Treatments	Hermaphrodite flowers /plant	No. of fruits /plant	No of cracked fruits /plant	Percent cracked fruits/plant	Wt. of fruits / plant (kg)	Average wt. of fruit (g)
0.3 ETc	147.1	15.0	12.0	44.3	2.275	151.5
0.4 ETc	134.0	20.0	10.0	33.4	3.201	161.1
0.5 ETc	137.8	26.0	6.0	18.6	4.925	190.3
0.6 ETc	122.7	38.0	0.6	1.5	7.855	206.8
0.7 ETc	130.0	36.0	0.0	0.0	7.776	216.3
0.8 ETc	114.8	35.1	0.0	0.0	7.657	218.7
0.9 ETc	115.6	31.9	0.1	0.4	7.438	236.0

3.4.3.3.5. Quality of fruits of pomegranate plants grown on heavy texture soil

Fruit length and fruit diameter was highest in plants supplied with irrigation equivalent to 0.80 ETc followed by 0.60 ETc. Highest percentage of fruit rind was found in 0.40 ETc followed by 0.30 ETc. Higher percent of fruit aril was found in 0.70 and 0.90 ETc treatments. Juice percent in the fruit was highest in 0.90 ETc followed by 0.70 ETc treatment. Lower values of fruit juice acidity and higher values of TSS and TSS / acid ratio was found in plants supplied with irrigation water equivalent to 0.60 and 0.70 ETc.

Quality of fruits of pomegranate plants grown on heavy texture soil supplied with varied quantity of irrigation water

Treat.	Fruit length (mm)	Fruit diameter (mm)	Rind thickness (mm)	Fruit Rind (%)	Fruit Arils (%)	Fruit Juice (%)	Juice acidity (%)	TSS (^{O}Brix)	TSS / acid ratio
0.3 ETc	60.0	63.2	2.66	40.1	59.9	41.4	0.51	14.9	29.2
0.4 ETc	61.1	64.4	2.72	40.4	59.6	43.3	0.52	14.8	28.3
0.5 ETc	65.0	67.7	3.04	39.3	60.7	44.9	0.46	15.2	33.6
0.6 ETc	74.0	77.0	2.92	36.6	63.4	48.4	0.44	16.0	36.2
0.7 ETc	70.1	73.2	3.17	38.4	61.6	49.2	0.45	16.2	36.2
0.8 ETc	74.8	77.6	3.15	37.0	63.0	47.5	0.46	15.9	34.7
0.9 ETc	72.5	75.7	2.97	36.6	63.4	48.6	0.46	16.0	35.1

Leaf temperature of pomegranate plants supplied with varied quantity of irrigation water

Treatments	Leaf temperature (^{0}F)					
	Plants grown on light texture soil			Plants grown on heavy texture soil		
	March 14, 2013	April 1, 2013	May 2, 2013	March 14, 2013	April 1, 2013	May 2, 2013
Ambient (^{0}F) temp•	104.00	109.00	114.50	104.00	109.00	114.50
0.3 ETc	96.15	99.81	106.35	92.90	98.27	105.40
0.4 ETc	96.00	99.13	105.81	91.94	98.81	104.94
0.5 ETc	94.19	97.00	106.00	92.19	98.06	104.06
0.6 ETc	94.83	96.83	105.15	91.25	96.40	103.54
0.7 ETc	93.92	96.98	104.46	90.13	96.02	104.00
0.8 ETc	91.75	97.31	102.13	89.75	95.25	102.31
0.9 ETc	92.02	96.15	102.56	90.19	95.38	102.00

3.4.3.3.6. Moisture content in the root zone of the plant

Observations of gravimetric moisture content in the root zone of the plant at 0-15, 15-30 and 30-45 cm vertical depth was taken during March, April and May months. Variations in moisture content amongst the treatments were higher in light textured soil compared to heavy texture soil. In light texture moisture content showed significant variation 15-30 cm and 30-45 cm depth during all the 3 months. In both soil types moisture content found to increase with the increasing quantity of irrigation water to pomegranate plant.

Moisture content in the root zone of pomegranate plant as affected by quantity of irrigation water

Treatments	March 2013			April 2013			May 2013		
	Soil depth (cm)								
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
Light textured soil									
0.3 ETc	16.9	17.5	15.6	17.0	17.5	14.9	16.5	16.5	14.3
0.4 ETc	17.0	18.0	16.2	16.8	16.5	15.0	17.0	16.0	14.6
0.5 ETc	17.5	18.8	18.0	17.3	17.0	17.2	16.5	17.2	15.8
0.6 ETc	18.2	18.4	18.8	18.6	18.9	19.0	17.6	18.4	19.5
0.7 ETc	18.8	19.5	20.3	19.0	19.5	20.3	18.2	19.2	19.8
0.8 ETc	19.2	19.8	21.4	18.9	19.8	20.9	18.5	19.0	21.0
0.9 ETc	20.4	21.4	22.7	21.0	22.0	23.0	20.4	22.1	22.5
Heavy textured soil									
0.3 ETc	20.1	20.0	17.3	19.8	19.6	18.0	19.0	20.2	17.2
0.4 ETc	20.0	19.8	17.9	19.6	19.0	17.8	20.0	21.2	17.0
0.5 ETc	21.2	22.3	19.4	20.0	22.0	18.8	20.6	20.5	19.4
0.6 ETc	22.6	23.5	19.2	21.6	23.8	22.0	21.4	23.5	24.2
0.7 ETc	22.3	23.6	22.9	22.5	24.0	25.2	23.0	22.4	25.0
0.8 ETc	23.1	24.0	25.3	23.0	23.8	25.1	22.6	23.8	24.3
0.9 ETc	23.2	25.4	25.0	23.8	24.2	24.0	23.0	24.8	26.0

Quantity of irrigation water applied to the experimental plants

Month	Irrigation water applied liters / plant / month			
Year 2012-13	Drip Irrigation through 4 drippers	Microjet - 180^{O}	Microjet - 360^{O}	Double ring surface irrigation
December -2012	159.6	366.0	349.0	265.6
January -2013	181.1	444.0	415.0	239.4
February – 2013	193.9	483.0	450.0	301.7
March- 2013	266.0	462.0	431.5	341.3
April- 2013	360.3	567.0	520.0	395.5
May- 2013	411.9	603.0	562.5	415.8
11 June- 2013	66.7	129.0	130.0	121.8
Total	1639.5	3054.0	2858.0	2081.1
Average quantity of water applied liters / plant / day				
December -2012	5.15	11.81	11.26	8.57
January -2013	5.84	14.32	13.39	7.72
February – 2013	6.92	17.25	16.07	10.78
March- 2013	8.58	14.90	13.92	11.01
April- 2013	12.01	18.90	17.33	13.18
May- 2013	13.29	19.45	18.15	13.41
11 June- 2013	6.06	11.73	11.82	11.07

3.4.3.4. Performance of different micro-sprinklers in pomegranate

An experiment was conducted on pomegranate cv. Bhagwa at research farm of NRC on Pomegranate, Solapur. During the year various treatments were imposed from December 12 to June 11, 2013. Quantity of irrigation water was calculated on the basis of daily pan evaporation data of the experimental farm. Irrigation water was applied by adopting different methods of irrigation as 1) Drip irrigation through 4 drippers (2 online, 2 attached to 1 m long micro-tube) placed on four sides of the plant, 2) Micro-sprinklers as Microjet-180^{O}, 2 numbers fixed on both side of the plant along the row, 3) Micro -sprinklers Microjet -360^{O}, 2 numbers fixed on both side of the plant along the row and, 4) Double ring method of surface irrigation water applied directly in ring by pipe. Plant performance in terms of plant growth, fruit yield and quality was monitored during the period.

3.4.3.4.1. Total quantity of water applied during the period

Quantity of irrigation water applied under different treatments was as low as 1639.5 liters in drip irrigation using 4 drippers to as high as 3054.0 liters / plant in Microjet 360^{O} during the experimental period. In all the treatments, quantity of applied irrigation water was highest during the month of May while it was lowest in December month.

3.4.3.4.2. Vegetative Growth of the plants

Initial vegetative growth of the plants in terms of plant height, plant spread in east - west and north - south direction was were noted during December 2012. Irrigation water was applied as per the treatment up to 11 June 2013. Observations on vegetative growth were taken during July 2013 and percent increase in growth of the plant over initial was calculated.

Vegetative growth of the plants in terms of all the growth parameters showed significant variation amongst the treatments in light as well as heavy texture soil. Highest increase in vegetative growth was observed in the plants supplied with irrigation using double ring method of surface irrigation followed by drip irrigation through 4 drippers. Application of irrigation water using micro-sprinklers was not much effective in increasing vegetative growth of the plant. More over water use under this system was higher than the other systems of irrigation used in this experiment.

3.4.3.4.3. Fruit yield of pomegranate plants grown in light texture soil

'Hasth bahar' fruits of pomegranate plants grown under different treatments were harvested three times during the month of March - April 2013. Flowering intensity was measured during "*Hasth bahar*" which prolonged for more than one month. Actual count of male flowers dropped on the ground below the canopy of the plant was taken while hermaphrodite flowers dropped on ground and set on plants were counted.

The data indicated that almost all the parameters related to flowering and fruiting revealed significant variation amongst the treatments except number of hermaphrodite flowers of the plant grown on light texture soil.

Significantly higher number of male, hermaphrodite and total flowers were recorded in the plants receiving irrigation using Microjet-360 and Microjet-180 system of irrigation. The plants grown under these treatments continuously remains under stress leading to induction of flowering on the plants.

Fruit yield in terms of number of fruits per plant varied significantly amongst the treatments from 10.1 to 40.0 and 14.0 to 45.0 fruits per plant respectively in light and heavy texture soil. Such a large variation in fruit yield was mainly due to very high fruit cracking under Microjet system of irrigation (42.6 to 58.6 %). The cracking was high in light texture soil than heavy texture soil. Fruit yield in terms of weight of total fruits and average weight of individual fruit per plant also follows similar pattern. The quantity of water applied to the plant through microjet was very high compared to other irrigation method, but plants grown under these treatments

remains under moisture stress leading to very high fruit cracking and yield of the fruits. In this system, water loss takes place in the form of small size water droplets along with blowing wind. The irrigation water spreads on very large area on soil surface and lost due to evaporation.

Flowering intensity and fruit yield of pomegranate plants grown on light and heavy textured soil supplied through various micro-sprinkler system of irrigation

Treatments/ Irrigation method	Male flowers / plant	Hermaphrodite flowers / plant	Total no of flowers	No. of fruits / plant	No. of cracked fruits / plant	Percent cracked fruits / plant	Wt. of fruits / plant (kg)	Average wt. of each fruit (g)
Light texture soil								
4 drippers (2 online, 2 on micro-tube) placed at four sides	203.7	124.7	328.4	31.9	0.0	0.0	6.248	196.5
Micro-sprinklers Microjet - 180^{O} 2 No's fixed on both side	250.1	138.6	388.7	10.1	14.1	58.2	1.703	167.8
Microsprinklers Microjet - 360^{O} 2 No's fixed on both side	259.6	144.2	403.8	13.0	12.0	47.6	1.966	151.7
Double ring method of surface irrigation	186.7	138.0	324.7	40.0	0.0	0.0	8.747	219.5
Heavy texture soil								
4 drippers (2 online, 2 on micro-tube) placed at four sides	205.5	132.7	338.2	35.8	0.0	0.0	7.617	214.4
Micro-sprinklers Microjet - 180^{O} 2 No's fixed on both side	230.3	150.7	381.0	14.0	12.0	46.3	2.222	158.9
Microsprinklers Microjet - 360^{O} 2 No's fixed on both side	221.0	160.9	381.9	17.5	12.9	42.6	2.866	165.6
Double ring method of surface irrigation	195.8	140.8	336.6	45.0	0.0	0.0	10.392	230.8

3.4.3.4.4. Quality of the fruits of pomegranate plants grown on light texture soil

Almost all quality parameters as fruit length, fruit diameter, percent fruit rind, percent fruit aril, percent fruit juice, acidity of fruit juice, Total Soluble Solids (TSS) and TSS/ acid ratio showed significant variation amongst the treatments except rind thickness of the fruit in case of heavy texture soil.

In light texture soil, fruit length and fruit diameter was highest in the fruits produced on the plants supplied with drip system of irrigation while in heavy texture soil it was with double ring method of surface irrigation. All other quality parameters were significantly better in the plants supplied with double ring method of surface irrigation.

Quality of the fruits of pomegranate plants grown on light and heavy textured soil supplied with varied micro-sprinkler system of irrigation

Treatments	Fruit length (mm)	Fruit dia. (mm)	Rind thick (mm)	Fruit Rind (%)	Fruit Arils (%)	Fruit Juice (%)	Juice acidity (%)	TSS (^{O}Brix)	TSS/acid ratio
Light texture soil									
4 drippers (2 online, 2 on micro-tube) placed at four sides	69.7	73.5	3.09	36.7	63.4	48.1	0.46	15.6	33.9
Micro-sprinklers Microjet - 180^{O}, 2 No's fixed on both side	59.7	63.4	2.43	40.0	60.1	43.0	0.54	15.0	28.2
Microsprinklers Microjet - 360^{O}, 2 No's fixed on both side	61.8	65.5	2.59	39.7	60.3	43.7	0.52	14.9	28.8
Double ring method of surface irrigation	69.0	71.7	2.86	35.4	64.6	50.0	0.44	15.8	36.0
Heavy texture soil									
4 drippers (2 online, 2 on micro-tube) placed at four sides	69.9	73.3	2.84	37.5	62.5	46.9	0.46	15.4	33.7
Micro-sprinklers Microjet - 180^{O}, 2 No's fixed on both side	63.0	70.8	2.67	41.7	58.3	40.8	0.54	14.6	27.3
Microsprinklers Microjet - 360^{O}, 2 No's fixed on both side	64.9	69.2	2.74	42.8	57.2	42.8	0.52	14.8	28.9
Double ring method of surface irrigation	71.9	75.2	3.02	35.2	64.8	48.6	0.48	16.0	33.7

3.4.3.4.5. Root distribution

The data showed that the total quantity of roots in terms of weight was highest in drip system of irrigation followed by double ring surface irrigation and was lowest in case of Microjet irrigation systems. In terms of root length or root activity it was much higher than other irrigation systems. In drip irrigation system amount of very fine roots or its contribution towards root activity was much higher as compared to other systems.

Root distribution in terms of root weight revealed that contribution of fine roots was very low followed by fine and small roots. When we compare contribution of root length then totally reverse trend was found where contribution of very fine roots was very high followed by fine roots and it was very meager in case of small roots.

Effect of micro-sprinkler system of irrigation on root distribution pattern of pomegranate plants grown in light texture soil

	4 Dripper	Micro sprinkler mircorjet 180^0	Micro sprinkler mircorjet 360^0	Double ring
	Percentage of roots on weight basis distributed in 0 - 60 cm horizontal layer			
Total very fine roots	11.95	6.93	9.70	11.03
Total fine roots	38.44	41.12	30.83	40.90
Total small roots	49.62	51.95	59.47	48.07
Total Roots in 0-15 cm	47.77	39.51	45.43	43.50
Total roots in 15-30 cm	39.63	40.42	35.45	37.51
Total roots in 30-45 cm	12.61	20.07	19.12	18.99
Actual weight of total roots (g)	163.8	117.1	104.3	130.7
	Percentage of roots on length basis distributed in 0 - 60 cm horizontal layer			
Total very fine roots	70.0	46.1	58.6	58.8
Total fine roots	25.1	46.4	33.7	35.3
Total small roots	4.9	7.5	7.7	5.9
Total Roots in 0-15 cm	62.6	50.0	53.1	48.7
Total Roots in 15-30 cm	25.1	28.3	29.5	28.5
Total Roots in 30-45 cm	12.3	21.7	17.4	22.8
Actual length of total roots (meter)	423.4	196.7	188.4	249.7

Very Fine (< 0.5 mm), fine (0.5 - 2 mm), Small (2 - 5 mm)

3.4.3.4.6. Moisture content in the root zone of the plant

Observations of gravimetric moisture content in the root zone of the plant at 0-15, 15-30 and 30-45 cm vertical depth was taken during March, April and May months. In light texture soil, variation in moisture content at different depths was quite high compared to heavy texture soil. Highest moisture content at all the soil depth was recorded in double ring system of surface irrigation while it was very low in Microjet system specially at lower depth.

4. CROP PROTECTION

4.1 Bacterial blight

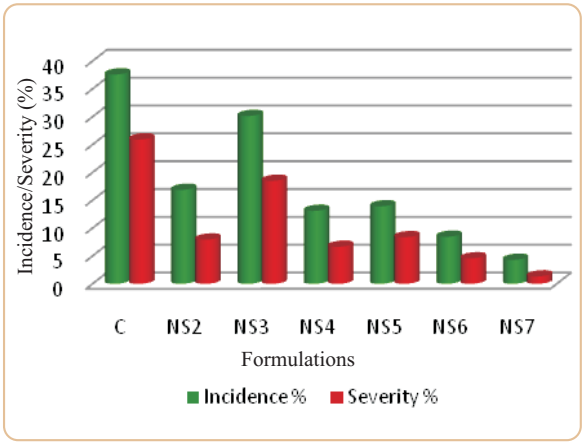
4.1.1. Management of bacterial blight

Four field trials were conducted in a severely bacterial blight affected farmer's orchard at Doangaon, Solapur during rainy season to evaluate spray schedules and new chemicals and products for management of bacterial blight disease.

4.1.1. New spray schedules for management of bacterial blight on fruits :

Six spray schedules using chemicals effective against bacterial blight of pomegranate variety Bhagwa were used. Sprays were taken at 10 days interval. Data was recorded at each spray. Owing to severe attack by fruit sucking moths during September month, very small numbers of fruits were left for maturity, hence experiment was terminated after 6 sprays only and data analysed.

All spray schedules except schedule comprising of Bronopol alone significantly reduced bacterial blight disease on fruits. Two schedules viz. NS7 comprising of bactericides Trichlosan 0.5% altered with Bronopol 500ppm + Ziram 80WP (0.2%/ Mancozeb75WP(0.2%)/Fosetyl Aluminium 80 % (0.2%) and NS6 (Streptocycline 500ppm +Bronopol 500 ppm +one fungicide) sprayed at 10 days interval were found to be most effective in reducing bacterial blight incidence and severity on fruit by 88.56% and 94.9% (in NS7) and 77% and 82.35% (in NS6) respectively.



Effect of new spray schedules on bacterial blight on fruits

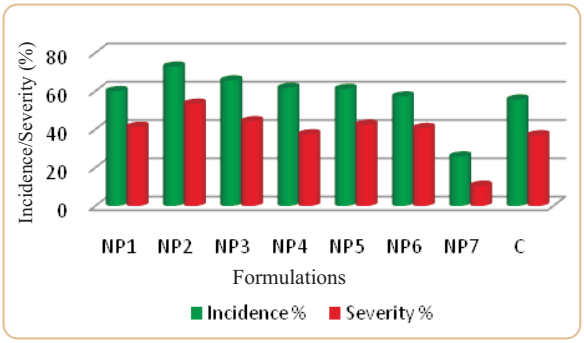
	Treatment Details
C	Control
NS2	streptomycin sulphate 90%+oxytetracycline 10% (sulphatecycline) 500ppm
NS3	Bronopol 500 ppm
NS4	Streptocycline 500 ppm altered with Bronopol 500ppm
NS5	Ziram 80WP (0.2%), Mancozeb 75WP(0.2%), Captan 50WP(0.25%) and FosetylAluminium 80 % (0.2%) in alteration
NS6	Streptocycline 500ppm +Bronopol 500 ppm mixed
NS7	Trichlosan 0.5% altered with Bronopol 500 ppm+fungicide

4.1.2. Nano and micro products :

Two nano products were tested in various combinations. None of the products could restrict the spread of bacterial blight disease in the orchard and the disease incidence and severity were at par with unsprayed control. The OHM schedule in use resulted lowest disease incidence of 25.83% and severity 10.52% in comparison to 55% and 36% respectively in control.

4.1.3. Effect of new formulations:

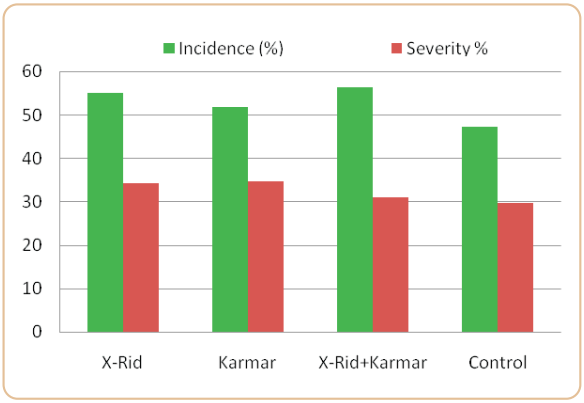
The effect of two new formulations X-rid (0.2%) and Karmar (0.25%) were used alone and in combination. As the fruit setting was erratic the data recorded on leaves after 4 sprays were analyzed. None of the treatments could reduce blight incidence or severity on leaves and were found non- significant in rainy season crop.



Effect of nano and micro formulationson Bacterial Blight

OHM : Streptocycline @500ppm or Bronopol @500ppm along with copper hydroxide 72% @0.2% or copper oxy chloride 50% @ 0.25% and Bordeaux mixture 0.5% M: Micro Chemicals (India), Mandsaur (MP) C: CIRCOT Mumbai

	Treatment
NP1	Nano Copper - M
NP2	Micron Special Super M
NP3	Nano Copper-M followed by Micron Special Super M after 1 week
NP4	Nano ZnO - C
NP5	Nano copper - C
NP6	Nano Copper - C followed by ZnO - C after 1 week
NP7	OHM
C	Control

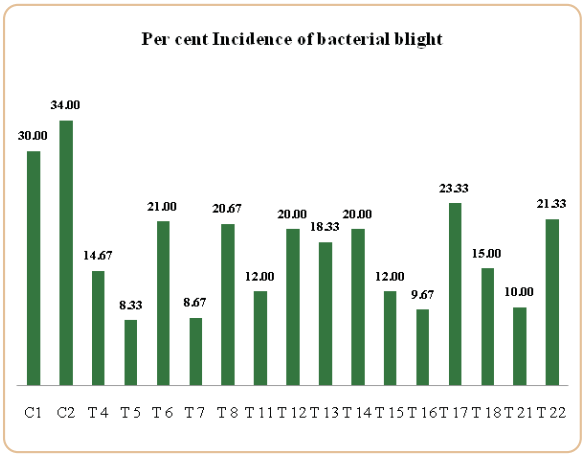


Effect of new formulations on Bacterial Blight in rainy season

Effect of various new formulations in pot culture were studied. The effect of various new formulations claimed to control bacterial blight of pomegranate by various agencies were tested in pot culture trials with challenge inoculation of *Xanthomonas axonopods* pv. *punicae* causing bacterial blight. The sprays were started after the symptoms of blight were observed on the plants and continued for 2 months. In all there were 22 treatments including 2 controls and chemicals in vogue and out of which 15 treatments (Fig 3b) significantly reduced blight over control, however, 3 treatments (T5, T7 and T16) reduced blight incidence by 70% or even more and were found better or at par with streptocycline (T21).

4.1.4. Biocontrol agents for control of *X. axonopodis* pv. *punicae*

Microflora isolated from blight free foliage in blight affected orchard was evaluated *in vitro*. Among 20 isolates tested 2 isolates viz. BA 23(A) and F6(2A) were found effective against ***X. axonopodis*** pv. *punicae*. The bacterial bioagent BA 23(A) checked growth of *X. axonopodis* pv. *punicae* by growing over them, while the fungal bioagent F6 (2A) appeared to hyper parasitize the pathogen, thereby killed them. In a separate experiment attempts were made to test various foliage, soil and water samples for presence of effective bacteriophages. In all 11 samples were tested. Phage zones were observed in two samples and was confirmed by electron microscopy observation at Advance Centre of Plant Virology, IARI. The stored samples were found sensitive to chloroform.

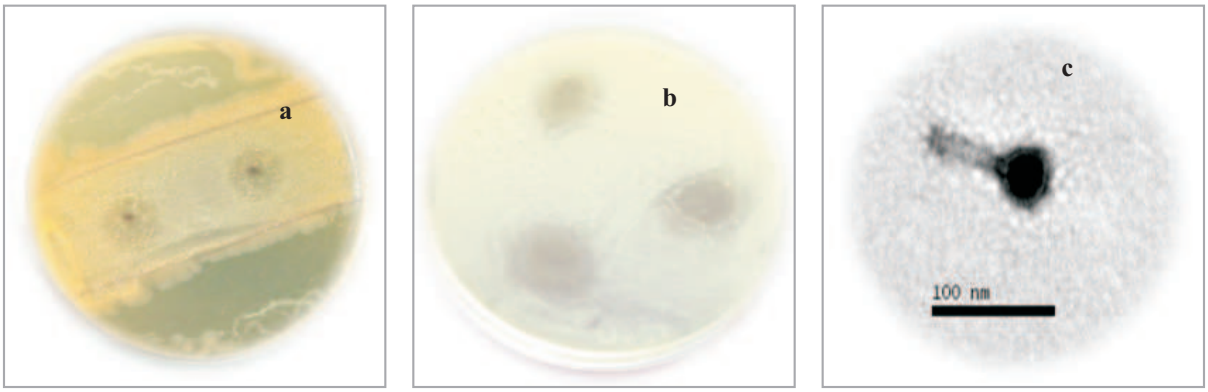


Effect of various new formulations claimed to control bacterial blight of pomegranate (Pot culture)

Treatment details	
C1	Control (untreated)
C2	Control (Water sprayed)
T4	TelbaSuper (0.05%)
T5	Sil-Sila (0.1%)
T6	Telba Super/Sil-Sila
T7	Salicylic acid (0.03%)
T8	X- Rid (0.2%)
T11	Copper Hydroxide(0.2%)/COC (0.25%) altered
T12	Kirtaphal(0.1%)
T13	Xanthos(0.2%)
T14	Agri–oil (0.5%)
T15	Cash+ (0.1%)
T16	Kiltel(0.1%)
T17	Fosetyl Al80%WP (0.25%)
T18	Mancozeb (0.25%)
T21	Streptocycline(0.05%)
T22	Bactronol 100 (0.05%)

Control (Xap 90) BA 23 (A) F6 (2A)

Bioagents effective against *X. axonopodis* pv. *punicae (Xap) in vitro*



Phage plaques observed against *X. axonopodis* pv.*punicae* in (a) leaf and (b) soil samples and (c) Phage x 200000, observed in EM

4.1.5. Sanitization of Planting material

Transmission of bacterial blight latent infectionsthrough planting material prepared from infected orchards was observed up to 10% in cuttings collected during May 2014. While the transmission of latent infection was found even upto 40% in cuttings collected after rains in Oct. 2013.

Hence, trials were conducted under protected conditions to sanitize planting material from infected orchards using various chemicals and water treatments. Bactericidal treatment along with carbendazim and some hot water treatments resulted production of planting material which were found to be free from nodal blight after 5 months of planting.

Latent BB infection developed in planting material after 5-6 months

Trials on sanitization of planting material

Correlation analysis of various environmental conditions with bacterial blight incidence and severity

Parameters		Correlation Coefficient (R) with	
		Incidence	Severity
v1	Incidence	1	0.717*
v2	Severity	0.717*	1
v3	Hrs. when Temp. = 25-35°C + RH ≥ 50%	0.501*	0.504*
v4	weekly rainfall	0.294*	0.137
v5	No. of rainy days/wk	0.450*	0.178*
v6	wind speed	0.028	0.112
v7	Hrs.Temp.>20°C	0.498*	0.492*
v8	Hrs. RH >30%	0.498*	0.492*
* Signifcant at 5%			

Regression models

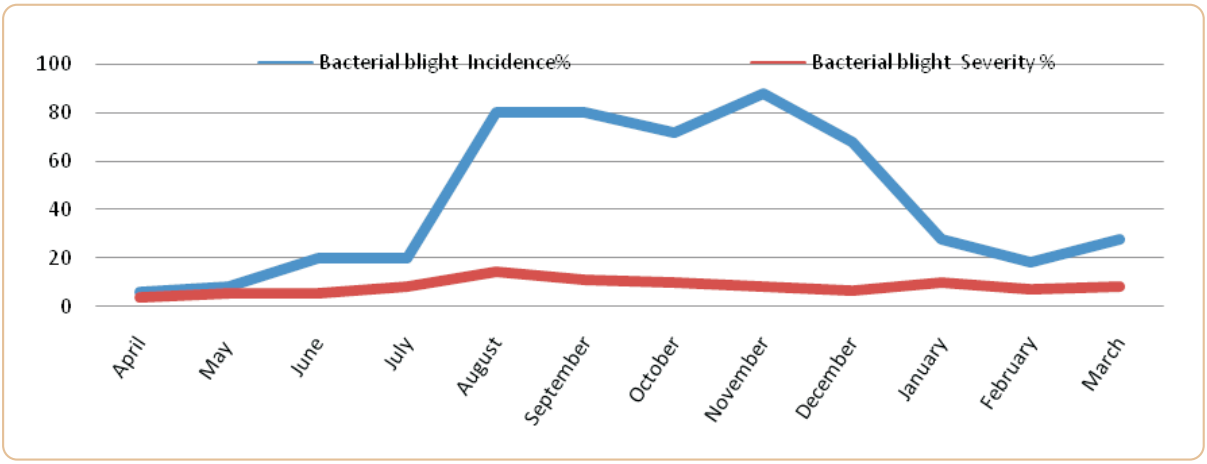
Bacterial blight incidence: v1 = 0.814 +(5.660) x v3+ (0.051) x v4+ (-0.055) x v5+ (2.807) x v7+ (-0.324) x v8+ 6.530; with R^2=0.633 and R=0.796

Bacterial blight severity: v2 = 6.663 +(1.000) x v3+ (-1.663) x v5+ (3.464) x v7+ (3.887) x v8+ 1.850; with R^2=1.00 and R=1.00

4.1.6. Effect of environmental condition on bacterial blight

Correlation of environmental conditions with bacterial blight : Correlation analysis of 170 weeks data on various environmental conditions shows that among various weather parameters, hours when temperature lies between 25-35°C with relative humidity (RH) ≥ 50% (v3), weekly rainfall (v4), No. of rainy days/week (v5), hours when temperature remain >20°C (v7) and hours when RH >30% (v8), significantly contributed to bacterial blight incidence (v1) and severity (v2), however, wind speed did not play significant role. Temperature and humidity were most important for disease development. The regression models have been developed.

Blight progress during 2013-14 : During the year under report bacterial blight started increasing in last week of April due to rains in March and increase in humidity. It showed increasing trend till August, decreased slightly in September, again increased to reach maximum in November (88.0%).Thereafter, disease started declining again until February (18.0%). However, blight severity was maximum (14.6%) in August.



Progress of Bacterial Blight during 2013-14

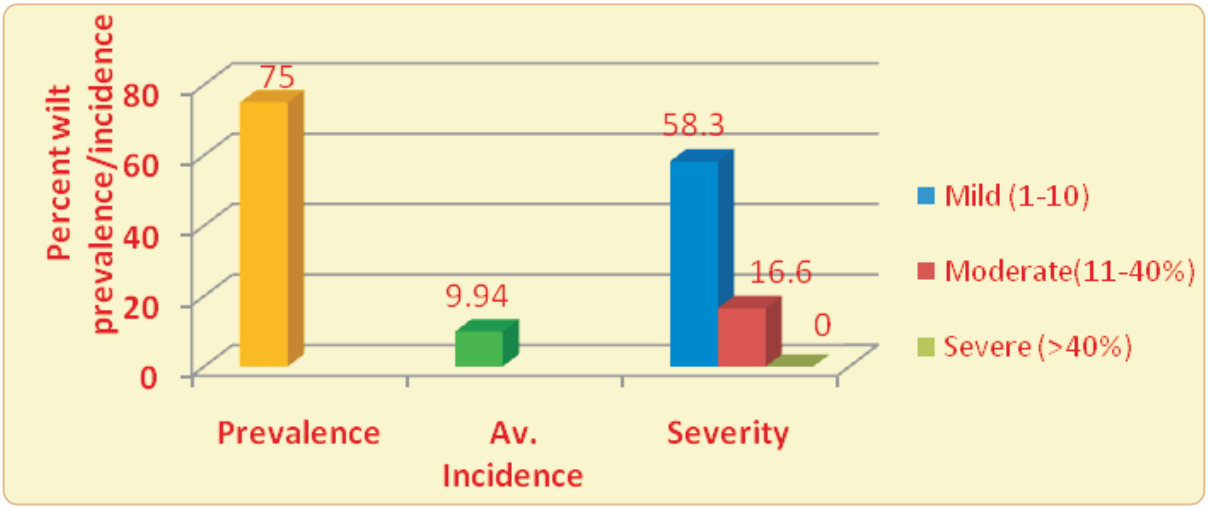
Effect of temperature on growth of *Xanthomonas axonopodis* pv. *punicae* : Bacterial blight pathogen when grown in culture under different temperatures showed colony growth after 4 days of incubation at 20° and 30°C whereas, no growth was evident at 10° and 40°C even after one week of incubation. At 40°C, no growth of *X.axonopodis* pv. *punicae* was observed even after one month of incubation.

Blight severity at farmers' orchards : Surveys conducted of 13 farmers' orchards in Mohol, South Solapur and Akkalkot areas in January 2014 revealed blight prevalence of 23.07 % and disease severity ranged between 5.5 to 38.0% with average severity of 16.33%. Other diseases and pests were in traces.

4.2. Wilt

Wilt prevalence and incidence in Surveyed Orchards: Surveys were carried out in the month of January 2014 in Mohol, Wadgi and Akkalkot areas of Solapur district and it was observed that wilt disease was prevalent in 9 out of 12 orchards (75.0%)

and its incidence ranged from 0.1- 40.0% with average incidence of 9.94%. Wilt was prevalent in mild form (<10% incidence) in 55.3% of the orchards and in moderate form (10-40% incidence) in only 16.6% orchards.



Prevalence and severity of wilt during 2013-14

4.2.1. Etiology of wilt

About 28 wilt infected samples were examined for association of wilt pathogens. Isolations obtained from soil and plant roots collected from wilt infected orchards through carrot bait method and onto PDA medium revealed association of *Ceratocystis fimbriata* in 26 samples (92.8%). One sample revealed association of *C.fimbriata* with Root-knot nematode, two samples revealed the only presence of *Fusarium* spp. and one sample showed complex association of *C. fimbriata*, root knot nematode and shot hole borer.

Apart from this, one sample brought from wilt infected orchard of Amravati district in June 2013 revealed severe infestation of root-knot nematode (*Meloidogyne incognita*) and *Rhizoctonia bataticola*.

4.2.2. Population dynamics of *C. fimbriata*.

To study the ecology and distribution of wilt pathogen, particularly, *C. fimbriata,* soil samples were collected from different locations (within the plant vicinity and 3 feet away from the plant) and at different depths (Surface, 20cm and 30 cm) of the farmer's orchard and NRCP farm in May 2013. Most of the soil samples from different locations and depths revealed presence of *Penicillium* spp., *Aspergillus* spp., *Fusarium* spp., and some bacterial colonies. However, isolations from soil surface also revealed prevalence of *Rhizopus* spp. which were not frequent in isolations from different depths. The study revealed that existence of *C. fimbriata* was not ubiquitus and was mainly distributed in and around the wilt infected plants. However, intensive studies are required on ecology of *C. fimbriata* to know its exact distribution at different locations owing to anisotropic nature of soil and of rapid changing microclimate/ environment.

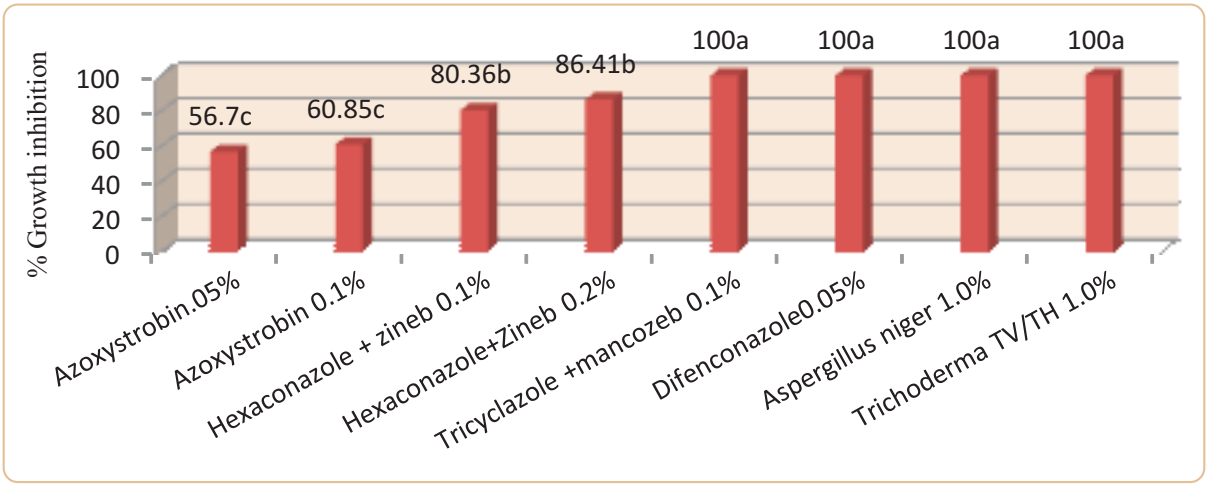
4.2.3. Screening of germplasm for wilt resistance

During the year, 13 potted germplasm (26 plants) were screened for wilt reaction through artificial inoculation with *C. fimbriata* in May 2013. Initiation of wilt symptoms was noticed after three weeks of inoculations in few plants and after 3 months all the germplasm (14 plants out of 26) revealed

partial or complete wilt symptoms. By the end of March, 2014 (10 months after inoculations) 25 out of 26 plants of all the 13 germplasm (IC-1182, Kandhari, Gulesha Red, Bhagawa, IC-1196, IC-318718, IC-318754, IC-318703, IC-318728, Jodhpur Red, IC-318720, Arakta and Sirin Anar) died completely owing to wilt infection. Other seven germplasm *viz.* IC-1204, SirinAnar, IC-318759,IC-318753,IC-1182,IC-318705 and Jodhpur selection artificially inoculated (in December 2012) revealed susceptibility to wilt pathogen, *C. fimbriata*, by September 2013.

4.2.4. Studies on control of *C. fimbriata*

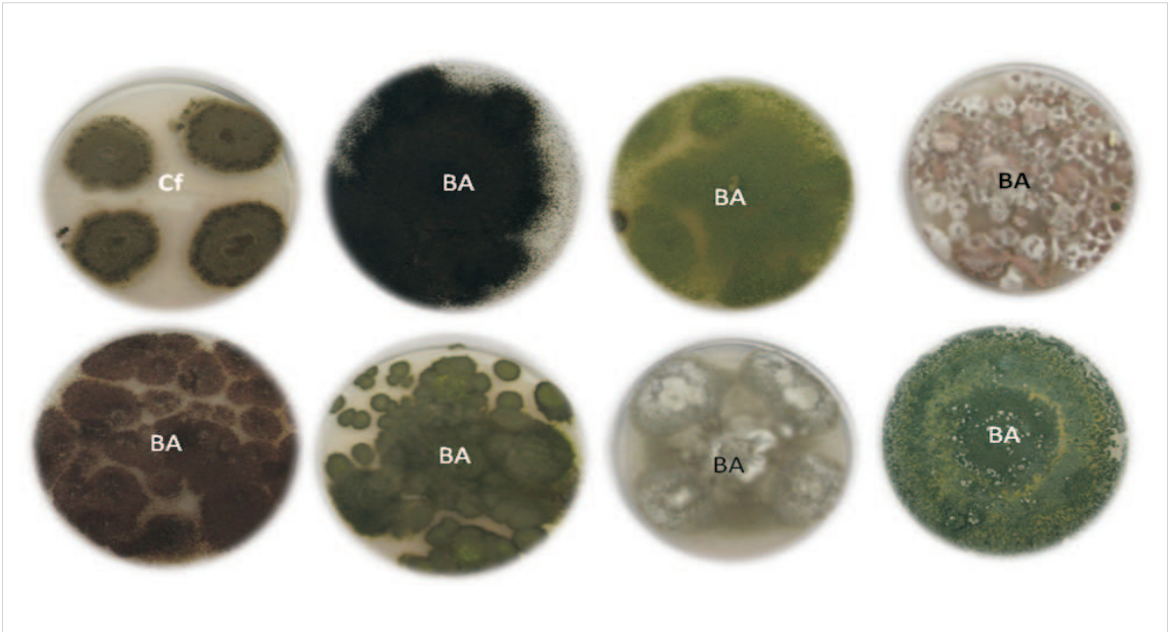
Different fungicides and bioagents were evaluated *in vitro* against the wilt pathogen, *Ceratocystis fimbriata* through poisoned food technique incubated at 26°C. On the basis of fungal growth, colony diameter recorded after 7 days of incubation, fungicides namely tricyclazole + mancozeb (Merger 0.1%) and difenconazole (score, @0.05%) and bioagents, *Aspergillus niger* (Kalisena SA @1.0%) and *Trichoderma* TV/TH (@1.0%) exhibited 100% growth inhibition of *C. fimbriata* over control and were significantly superior to other treatments.



In vitro* efficacy of Fungicides and Bioagents against *C. fimbriata
(Values with same alphabet do not differ significantly)

Rhizosphere microflora and cuttings from a single vigorously growing healthy plant in a completely wilted orchard at Supali, Pandharpur (Solapur) were tested for antagonistic activity against *Ceratocystis fimbriata* and plant resistance respectively. Seven fungal isolates effectively checked the growth of wilt causing fungi, *Ceratocystis fimbriata* (Cf) under *in vitro* Six month old plants raised from cuttings of single healthy plant of Supali orchard were inoculated with *Ceratocystis fimbriata* to see resistance if any against wilt causing pathogen. The plant did not show any resistance to *C. fimbriata* however, started showing wilting symptoms 3 weeks later than check Bhagwa.

Planting material from healthy plant at wilt affected orchard at Supali tested against *C. fimbriata*



Bioagents from rhizosphere soil of single healthy plant in a wilt affected orchard tested against *C. fimbriata*

5. POST HARVEST TECHNOLOGY

5.1. Pomegranate seed oil

5.1.1. Soxhlet Extraction of Pomegranate Seed Oil

The commercial cultivars of pomegranate such as Bhagwa and Ganesh were studied for its seed oil content. The soxhlet method of oil extraction was used with petroleum benzene, a non-polar solvent. The pomegranate seeds were dried at 35-37 ˚C up till constant weight is reached. The 10 gram of crushed seeds is placed in a thimble and 310 ml of petroleum benzene is used as solvent for soxhlet extraction. The ˚C. The oil solvent mixture is collected in bottom flask. The remaining solvent was evaporated and oil remained is collected and measured. The average per cent oil in Bhagwa cultivar was found to be 28% (w/w) and that in Ganesh cultivar was 26.43 % (w/w). The average specific gravity of pomegranate seed oil was found to be 0.90 and 0.92 for Bhagwa and Ganesh cultivars respectively 60°C. Pretreatment of pomegranate juice was done with enzyme, α-amylase @100mg/l. Fermentation of juice was carried out using yeast (*Saccharomyces cerevisiae*) in incubator shaker at 20°C for about10-12 days. Wine was then clarified by centrifugation (5000 rpm for 5 minutes). The bentonite@ 100ppm was added to wine. The wine was siphoned, bottled and stored.

Pomegranate Seeds

Pomegranate Seed Oil

The wine prepared by the above method was compared for the clarity / transparency with the wine obtained without pre-treatment of α-amylase enzyme. The wine obtained with enzyme pre-treatment was found to be superior in clarity / transparency compared to the control.

5.2. Pomegranate wine

5.2.1. Refinement of protocol for preparation of pomegranate wine

The protocol for preparation of pomegranate wine was refined with the inclusion of enzyme pre-treatment. Pomegranate wine was prepared from pomegranate juice using the shake flask culture method by adopting the following steps. The juice was extracted by cutting the fruits of pomegranate cv. Ganesh fruits in to two halves and pressing in a hand press. The 500ml capacity flask was filled to 2/3 of its capacity. The content of total soluble solids (TSS) was measured with refractometer and then adjusted to 22°B by adding sugar. The juice was pasteurized at extraction was carried out for 6 h at temperature at 50

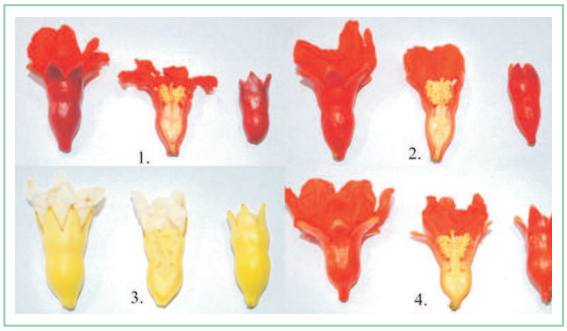
Enzyme treated wine of cv. Ganesh

Control

6. EXTERNALLY FUNDED PROJECTS/TRIALS

Project : Establishment of DUS Center at National Research Center on Pomegranate (Project funded by PPVFRA, New Delhi)

A new field gene bank with fifty five exotic collections obtained from USDA, California through NBPGR has been established during January, 2014 which will be used as reference collection for DUS testing. Received IC number for 15 accessions including eleven indigenous types collected from Jammu and Kashmir and four advance lines two each of table and *Anardana* types. Prepared photo library of pomegranate germplasm. Some distinct characteristics of flower traits and arilcolour were recorded.

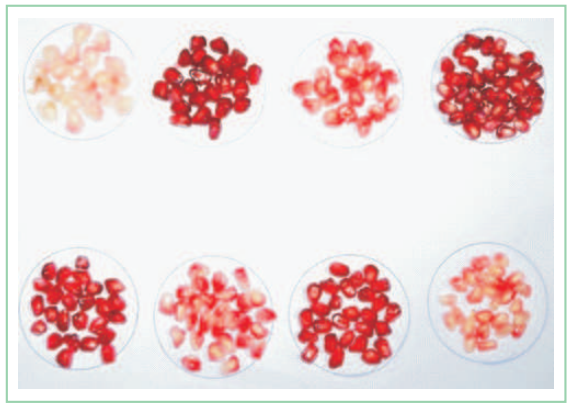


Variation in calyx and petal colour of 1. Arakta 2. Bhagwa 3. Kabuli Yellow 4. Ganesh

	Variety	Petal colour	Petal length (mm)	Petal width (mm)	Calyx colour	Calyx length (mm)	Calyx width (mm)
1.	Arakta	Orange	23.6	19.3	Dark Red	36.4	12.9
2.	Bhagwa	Orange	24.0	19.3	Red	41.2	13.6
3.	Kabuli Yellow	Yellow	23.3	18.9	Yellow	39.8	14.2
4.	Ganesh	Orange	23.6	19.6	Orange	37.6	14.4

Project: Crop pest surveillance and advisory project for Mango, Pomegranate & Banana (Externally funded project under RKVY, Maharashtra State Hort. Dept.)

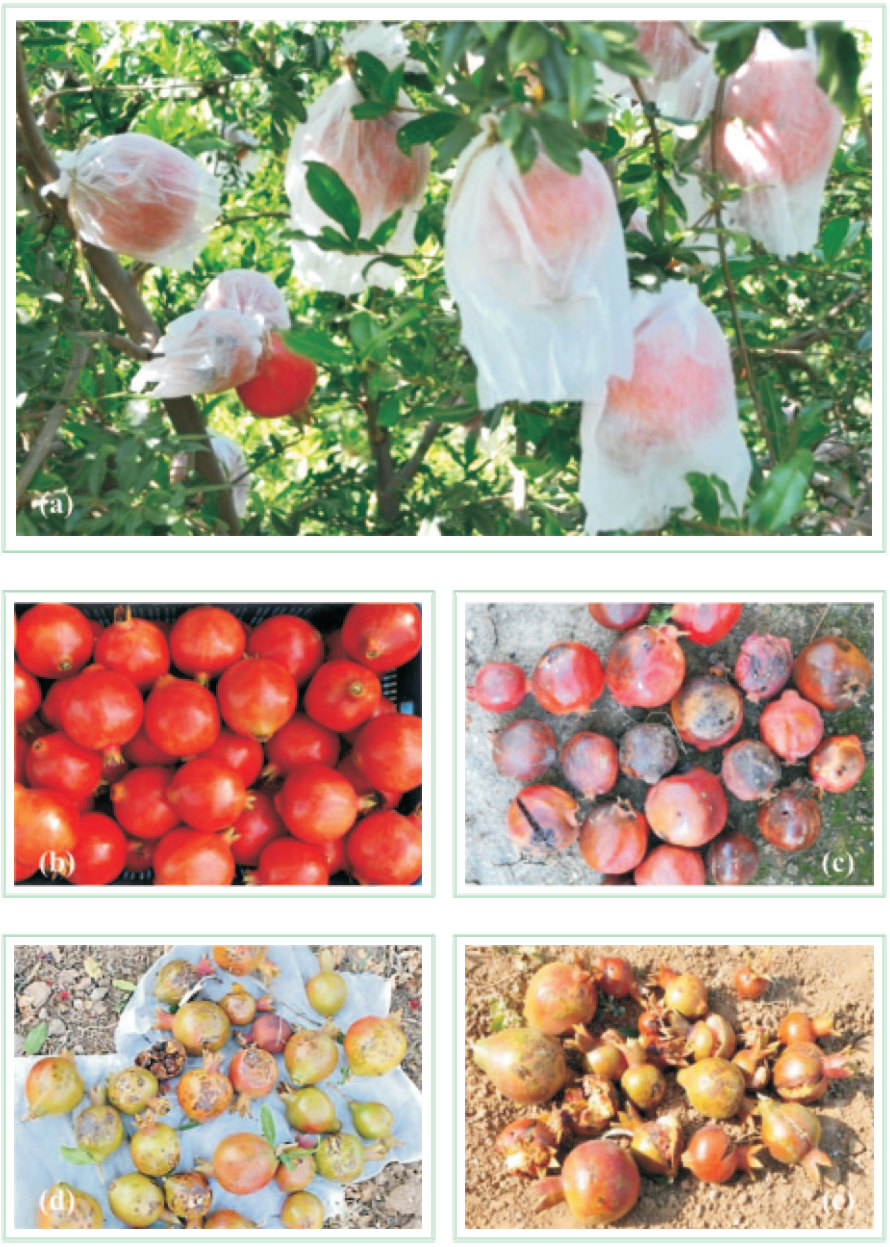
Trainings were imparted in Sangli and Pandharpur to SAOs, scout and pest monitors and farmers. Surveys were conducted in March 2014, in Maharashtra covering 222 ha including 169 orchards, 110 villages, 16 talukas for hail damage and diseases and pests. In all 15% orchards covering 33 ha of surveyed area in Nashik, Solapur, Satara, and Sangli lost 50-100% produce due to hailstorm, losses due to blight and other diseases and insect pests was below 5%. The losses in pomegranate due to hail storm and unseasonal rain in general were of temporary nature (except where plants were uprooted) and can be regulated for new *bahar* after pruning, rest and recommended spray schedule. The losses were high in some orchards which were ready for harvest. Advisory for Hail mitigation was prepared and sent to local news papers, ICAR, DAC, Ministry of Agri., GOI and Maharashtra Government.



Variation in aril colour of different varieties/genotypes

Project: Evaluating performance of poly propylene non-woven bags with respect to diseases, insect pests, physiological disorders and quality of pomegranate fruits (Contract research trial, Reliance Industries Pvt. Ltd.)

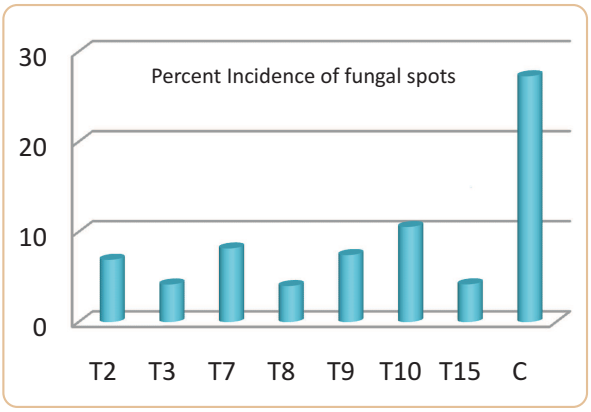
Four different type of bags, both closed and open types were evaluated for effect on diseases, insect pests and fruit quality in rainy season crop. The polypropylene (PP) bags both closed and open type of were effective in giving 100% protection from fruit sucking moth but bacterial blight was more severe in PP bags.



(a) Fruits covered with bags (b) Covered fruits free from fruit sucking moth damage (c) uncovered fruits damaged with fruit sucking moth followed by rotting and dropping (d) Bagged fruits affected with BB (e) unbagged fruits affected with BB

Project : Evaluating bioefficacy of formulations Avtar and Merger in the management of fungal leaf/fruit spots and rots of pomegranate (Contract research trial, Indofil Chemicals Limited)

Sixteen different treatments were evaluated for fungal spots and rots in a farmer's field including Merger (Tricyclazole 18%+Mancozeb 62% WP) and Avtar (Hexaconazole 4%+Zineb 68% WP).Fungal spots particularly scab caused by *Spaceloma* sp. were significantly reduced with Merger (2.5-3.0g/l), mancozeb (2.5g/l), Avtar (2-2.5g/l) and OHM schedule where fungicides in vogue were alternated, and were at par among themselves. Incidence was reduced between 69-85% and severity between 42-72%.



	Treatment Details
T2	Merger @0.25%
T3	Merger @0.3%
T7	Mancozeb 75 % WP @0.25%
T8	Avtar@ 0.2%
T9	Avtar@.025%
T10	Avtar@3%
T15	Altering Bordeaux Mix. @0.5% /Kocide@0.2%/COC @2.5 /Carbendazim@1.0 /ThiophanateMethyl@1.5
C	Control – Water spray

Effect of Avtar and Merger on fungal spots

Project: Model Pomegranate Production Practices (Funded by National Horticulture Board, New Delhi)

Training Programmes

Field visits and two training programmes were conducted in district Anantapur(Telangana) on March 25-26, 2014. The farmers were distributed folders on various aspects of pomegranate cultivation and wilt control. The schedules for managing bacterial blight were given to the state officers for translation in vernacular and distribution. The overall response of farmers was overwhelming

Field visit to tissue culture orchards at Aulanna, Tk. Beluguppa; Kanekalla in Anantapur on March 25, 2014

Training programmme at RDT, Kanekal, Anantapur (AP) on March 25, 201

Training programme at RHTI, Anantapur (AP) on March 26, 2014

Project : Technical Consultancy for the establishment of pomegranate orchard

(Consultancy Research Project**)**

Client : M/s. Emami Biotech Limited, 687, anandapur, EM Bypass, Kolkata 700107

Investigators : Dr. K. Dhinesh Babu (PI) & Dr. R.K.Pal

Associates : Mr. D.T. Chaudhari, Mr. M.S. Gogaon

Location of the project : Kilkudi, Virudhunagar Dt, Tamil Nadu

Duration : 1 year

Period : August 2013- July 2014

Consultancy Fees : Rs. 2.5 lakhs per annum

Advisory consultancy was provided regarding varieties, spacing, population, planting time, planting method, pit size, pit filling, layout of drip irrigation to establish the plantation of pomegranate cv. Bhagwa. The demonstration on pit filling and planting was arranged. The planting with Bhagwa air-layers was done over 10 acres area during February -March 2014 in Kilkudi, Virudhunagar, Tamil Nadu.

Field visits and trainings organized at Anantapur

Date	Details	Organized by	Venue	Participants/ No of farmers attended	Remarks
Mar 25, 2014	Field visits	National Research Centre on Pomegranate, Solapur in Collaboration with Dep. of Hort. and Hortl. Res. Stat. Anantapur	Orchards at Aulanna, Tk. Beluguppa; Kanekalla and Aluru in Anantapur.	Jyotsana Sharma Pr. Scientist, Dr. K Dhinesh Babu, Sr. Scientist, and Mr. Mahadev Gogaon, Senior Technician, NRCP, Solapur, Dr. K. Subramanyam, Principal Scientist, Hortl. Res. Stat., Anantapur, Mr. Chandra Shekar, Hort. Officer, Dep. of Hort., Anantapur/ 7 orchards and 25 farmers	Growers had opted for both Bhagwa and Ganesh varieties. Some growers also planted tissue culture crops. Wilt and stem borer was the major problem, bacterial blight was observed but not in serious proportions, as farmers practiced the IDIPM schedule. Farmers had also developed their innovations in training system.

Date	Details	Organized by	Venue	Participants/ No of farmers attended	Remarks
	Model Pomegranate Production Practices, funded by NHB, New Delhi	National Research Centre on Pomegranate, Solapur in Collaboration with Dep. of Hort. and Hortl. Res. Stat. Anantapur	Rural Development Trust (RDT), Kanekal, Anantapur (AP)	Jyotsana Sharma Pr. Scientist, Dr. K Dhinesh Babu, Sr. Scientist, and Mr. Mahadev Gogaon, Senior Technician, NRCP, Solapur, Dr. K. Subramanyam, Principal Scientist, Hortl. Res. Stat., Anantapur, Mr. Chandra Shekar, Hort. Officer, Dep. of Hort., Anantapur/107 farmers attended	Farmers asked about processing prospects in pomegranate, flowering and best season for taking disease free produce.
Mar 26, 2014	Model Pomegranate Production Practices, funded by NHB, New Delhi	National Research Centre on Pomegranate, Solapur in Collaboration with Dep. of Hort. and Hortl. Res. Stat. Anantapur	Regional Horticultural Research Institute (RHTI), Anantapur	Jyotsana Sharma Pr. Scientist, Dr. K Dhinesh Babu, Sr. Scientist, and Mr. Mahadev Gogaon, Senior Technician, NRCP, Solapur, Dr. K. Subramanyam, Principal Scientist, Hortl. Res. Stat., Anantapur, Mr. Chandra Shekar, Hort. Officer, Dep. of Hort., Anantapur, Mr, Chandrashekar Goel, Principal Regional Horticultural Research Institute (RHTI). and Jt. Director Dep. of Hort., Anantapur/ 105 farmers	Farmers asked the problems of diseases and pests, processing of unmarketable produce, planting material- tissue culture and air layers, bahar regulation etc. One farmer Mr. Krishna Reddy, from Mahaboonagar requested for a raining in his district and also wanted information on processing, as National Bank for Agriculture and Rural Development (NABARD) was ready for funding for processing plant. The state department requested for more interactive session for the benefit of growers as new area has tremendously increased in Andhra Pradesh.

Field visit to Orchards at Aulanna, Tk. Beluguppa; Kanekalla and Aluru in Anantapur

7. RESEARCH PROGRAMMES AND PROJECTS

Programmes and Projects	Title	Principal Investigators (PI)	Status
Programme 1: Pomegranate Improvement			
Project 1.1	Evaluation and Cataloguing of pomegranate (*Punica granatum* L.) germplasm	Dr. Ram Chandra	Ongoing
Project 1.2	Development of pomegranate varieties through breeding	Dr. K. Dhinesh Babu	Ongoing
Programme 2: Pomegranate Production			
Project 2.1	Propagation of pomegranate through conventional and non-conventional methods	Dr. N.V. Singh	Ongoing
Project 2.2	Identification of suitable soils for sustained productivity of pomegranate	Dr. R.A. Marathe	Completed
Project 2.3	Nutrient management in pomegranate	Dr. R.A. Marathe	Completed
Project 2.4	Water management in pomegranate orchards under different soil types	Dr. R.A. Marathe	Completed
Project 2.5	Micronutrient management for sustainable growth, yield and quality of pomegranate (*Punica granatum* L.)	Dr. Ashis Maity	Ongoing
Project 2.6	Effect of mulches on yield, quality and WUE of pomegranate (*Punica granatum* L.)	Dr. D.T. Meshram	Ongoing
Project 2.7	Comparison of various micro irrigation methods with sub-surface drip irrigation system for pomegranate production	Dr. D.T. Meshram	Ongoing
Project 2.8	Fertigation scheduling of major nutrients with reference to crop-soil environment in pomegranate	Dr. R.A. Marathe	Ongoing
Programme 3: Pomegranate Protection (Management of diseases of pomegranate)			
Project 3.1	Studies on economically important diseases of pomegranate with special emphasis on bacterial blight and their control	Dr. Jyotsana Sharma	Ongoing
Project 3.2	Integrated management of wilt of pomegranate	Dr. K.K. Sharma	Ongoing
Programme 4: Post-harvest technology			
Project 4.1	Post-harvest management of pomegranate (*Punica granatum* L.)	Dr. Nilesh Gaikwad	Ongoing

Programmes and Projects	Title	Principal Investigators (PI)	Status
Externally funded projects			
1. Project under RKVY	Crop pest surveillance and advisory project for mango, pomegranate and banana	Director, NRCP	Ongoing
2. Intellectual Property Right	Intellectual property management and transfer/commercialization of Agriculture Technology scheme	Director, NRCP	Ongoing
3. Technology development and transfer scheme of NHB	Demonstration of model pomegranate production practices for effective management of bacterial blight disease	Director, NRCP	Ongoing
4. DUS project	DUS centre on pomegranate at	Director. NRCP	Ongoing
5. Contract research service (Paid-up trial)	Evaluating bioefficacy of formulations 'Avtar' and 'Merger' in the management of fungal leaf /fruit spots and rots of pomegranate	Dr. Jyotsana Sharma	Ongoing
6. Contract research service (Paid-up trial)	Evaluating performance of poly propylene non-woven bags with respect to diseases, insect-pest, physiological disorders and quality of pomegranate fruits	Dr. Jyotsana Sharma	Ongoing
7. Consultancy project	Technical consultancy for establishment of pomegranate orchard	Dr. K. Dhinesh Babu	Ongoing

8. TRANSFER OF TECHNOLOGY

Organization of Training Programmes by NRCP, Solapur

Sl.No.	Name of Training programme	Venue	Participants	Date
1.	Training Programme on pomegranate cultivation under Tribal Sub Plan	Raigada, Odisha	180 Farmers of Raigada, Odisha	10-11th Jul. 2013
2.	Training programme on Pomegranate Cultivation for Pomegranate Growers of Gujarat at NRCP	Kachh, Gujarat	Farmers of Kachh, Gujarat	5-8th Aug. 2013
3.	Training Programme on Model Pomegranate production practices Under NHB Funding	KVK Yavatmal, MS	Farmers of Yavatmal, MS	7th Mar. 2014
4.	Training Programme on Model Pomegranate production practices Under NHB Funding	KVK Bhuj, Gujarat	Farmers of Bhuj, Gujarat	18th Mar. 2014
5.	Training Programme on Model Pomegranate production practices Under NHB Funding	KVK Baramati	Farmers of Baramati, Maharashtra	24th Feb. 2014
6.	Training Programme on Model Pomegranate production practices Under NHB Funding	KVK Ananthpur, Andhra Pradesh	Farmers of Kanaikal and Ananthpur, Andhra Pradesh	25 - 26th Mar. 2014

Participation in Workshop/Training programmes

Name of Training programme	Venue	Participants	Date
Workshop on Pomegranate Production organized by Pomegranate Growers Association and State Government of Maharashtra	Achalpur, Amravati, MS	400 Farmers of Amaravati, MS	28th Oct. 2013
Training Programme on Pomegranate production organized by Precision Farming Development Centre, MPKV, Rahuri	Mandave, Solapur, MS	500 Farmers from Malshiras, Solapur, MS	19th Nov. 2013
Training Programme on Pomegranate Cultivation Technology and Management	Jamnagar, Gujarat	450 Farmers from Jamnagar and Rajkot, Gujarat	23rd Dec. 2013
Workshop on "Quality Production of Pomogranate & Processing Opportunities" at Agro vision 2013	Nagpur,MS	1000-1200 Farmers from Vidarbha, MS	27th Dec. 2013
Workshop on Pomegranate Production technology organized Maharashtra Bank	Haji Takali, Pune,MS	750 Farmers from nearby of Haji Takali, MS	5th Jan. 2014
Training programme on insect pest and disease management in Pomegranate	KVK Yavatmal, MS	200 farmers from Yavatmal, MS	7th Mar. 2014
Training Programme on Pomegranate Production technology	Nastalpur, DistNashik,MS	25 farmers, from Nashik, MS	22nd Mar. 2014

Participation in Exhibitions/ KrishiMela

Sl. No.	Exhibition	Venue	Date
1.	Agrowon Agri Exhibition 2013	Pune	22nd November 2013
2.	Agricultural Exhibition	KVK Baramati, Malegaon	18-20th January 2014
3.	KrishiVasant 2014 from	CICR, Nagpur	9-13th February 2014.

Visit of Farmers group at NRCP

Sl.No	Date	Farmers Group	No. of farmers	Sponsored by
1	27.11.2013	Nanded, MS.	06	Self-interested
3	27.11.2013	Pandharpur, Solapur, MS.	05	Self-interested
4	29.11.2013	Nalgonda, AP.	22	SAO, Nalgonda
5	06.11.2013	Women farmers Group, Gujarat.	50	ATMA
6	07.11.2013	Tahsil Aashti, Ahmednagar, MS.	15	SAO Ahmednagar
7	01.01.2014	Tahsil Satana, Nasik, MS.	45	SAO Nasik
8	06.01.2014	Tahsil Shrigonda, Ahmednagar, MS.	45	SAO Nagar
9	08.01.2014	Tahsil Dhule, MS.	50	SAO Dhule
10	08.01.2014	Tahsil Malegaon, Nasik , MS.	50	SAO Nasik
11	09.01.2014	Tahsil Nifad, Nasik, MS.	50	SAO Nifad
12	22.01.2014	Tahsil Nasik, MS.	45	SAO Nasik
13	27.01.2014	Beed Agriculture Mandal officer	50	SAO Beed
14	30.01.2014	Karnataka SAO's & officers Team	20	SAD Karnataka
15	30.01.2014	Karnataka Farmers group	15	SAD Karnataka
16	15.02.2014	Hatknagale, Kolhapur, MS.	45	SAO Kolahapur
17	15.02.2014	Satara, MS.	45	SAO Kolhapur
18	04.03.2014	Beed Agriculture Mandal officer, MS.	45	SAO Beed
19	11.03.2014	Tahsil Washim, MS.	45	SAO Washim

Glimpses of Training Programmes and Exhibitions

Training Programme by NRCP at Raigada, Odisha

Training Programme for Gujarat farmers at NRCP

Workshop programme at Mandave, Solapur

Agro vision workshop at Nagpur

Visit of women Farmers from Gujarat

Visit of SAO of Karnataka

Agrowon Agri Exhibition at Pune

Agro exhibition at KVK Baramati

KrishiVasant, 2014 at Nagpur

9. INSTITUTIONAL ACTIVITIES

The following events concerned with 'Research and Development' activities of the National Research Centre on Pomegranate were held during the year 2013-14.

Research Advisory Committee Meeting

The VII[th] meeting of Research Advisory Committee of NRC on Pomegranate was held on 7[th] June, 2013 at NRCP, Solapur under the chairmanship of Dr. C. D. Mayee, Former Chairman, ASRB, New Delhi. The constitution of the VII[th] RAC of NRCP was as follows:

Sl. No.	Name	Designation/Address
1	Dr. C.D. Mayee- Chairman	Former Chairman, ASRB, New Delhi
2	Dr. B. B. Vashistha - Member	Former Director, NRCSS, Ajmer, Rajasthan
3	Dr. S. K. Malhotra - Member	ADG(Horticulture-I), ICAR, New Delhi
4	Dr. R. K. Jain - Member	Head, Plant Pathology, IARI, New Delhi
5	Dr. R. K. Pal - Member	Director, NRC on Pomegranate, Solapur
6	Dr. R. A. Marathe -Member Secretary	Principal Scientist, NRC on Pomegranate, Solapur

The committee after evaluating the research achievements of the centre presented by the principal investigator of respective research projects suggested following recommendations.

1. The centre should have one scientist in the field of Agril Economics who can conduct the studies on price system, export and import of important horticultural crops viz. Pomegranate, Grapes, Banana, Onion and Potato and submit the report to respective NRC's.
2. It was suggested to prepare an Indian map indicating the most important production zones showing acreages of pomegranate and finding out reasons of pomegranate cultivation in these areas based on rainfall pattern, soil type etc. It will help in exploring the possibility of area expansion of pomegranate in India in nontraditional areas.
3. In contrast to the suggestion of previous RAC it was suggested to keep research on production of pomegranate in MRIG BAHAR as a low key affair in order to avoid the increase inoculum load of bacteral blight pathogen at the NRCP research farm.
4. Signing MoU with institutions working on pomegranate in Iran and other countries may be explored for exchange programs.
5. Work on DNA fingerprinting should be done at NRCP for screening of germlasm for variability studies with respect to desirable characters for use as table purpose or processing, high seed oil content, tolerance against BBD, wilt pathogen and drought. This work may also be initiated for identifying good root stock with desirable characteristics.
6. Research in the area of horticulture should be focused on finding out the economically best planting materials and innovative method of propagation in pomegranate. Experiment also should be planned on use of plant growth regulators.
7. While appreciating the work on production of disease free planting material through hard wood cuttings it was suggested to lay out experiment on semi-hard wood or soft wood cuttings and T-budding. T budding of pomegranate may be tried on *Syzygiumcumini*or other related pants for use as root stock in order to develop wilt resistant plant.

8. Emphasis should be given on horticultural research viz. canopy architecture and pruning techniques so as to initiate flowering on older shoots. Relationship between flowering intensity and age and position of shoots as well as position of flower on shoot and fruit size should be studied.
9. Work should be initiated on 'Precision Horticulture' using all aspects of production and protection technologies as an ideal demonstration plot.
10. Large scale application of elemental Sulphur may be practiced in NRCP farm
11. Water requirement of pomegranate crop under different soil type should be quantified.
12. Survey may be conducted in Vidharba areas of Maharashtra where pomegranate cultivation is increasing on large scale.
13. New methodologies should be tried for quick screening of germplasm against bacterial blight using inoculation studies with detached leaves and fruit. Evaluation of correlation and susceptibility of xap to fruit or leaves need to be done. Cross inoculation studies with *Xanthomonascitri* may be carried out.
14. PCR based diagnostic for bacterial blight disease should be further validated for detection of latent infection. Studies on PCR based diagnosis of wilt may also be initiated
15. A disease forecasting model needs to be developed for early warning. It was suggested to take 100 plants in the field and inoculate them and observe the progress of disease. Reverse regression may be worked out similar to the forecasting model of apple scab.
16. A disease scale needs to be developed for fruit crops, especially for pomegranate taking into consideration impact on fruit quality and yield.
17. Phylloplane microflora from pomegranate orchards may be isolated and tested against *Xanthomonas axonopodis* pv. *punicae* for management of bacterial blight.
18. Basic research on interaction between population dynamics of *Meloidogyne* sp. and wilt should be taken up.
19. In the area of post harvest technology the centre should concentrate to develop commercially viable technologies in the area of production of pomegranate wine, seed oil and utilization of wastes.

Research may also be focused on development of pomegranate varieties exclusively for processing.

Research Advisory Committee Meeting

Institute Management Committee Meeting

The IXthIMC meeting of NRCP was held on May 24, 2013 at NRCP and was attended by following members

Sl.No.	Name	Designation
1	Dr. R.K. Pal- Chairman	Director, NRC on Pomegranate, Solapur
2	Dr. A.K. Mishra -Member	Project Co-ordinator (STF), CISH, Lucknow
3	Dr. D.P. Waskar -Member	Associate Dean and Principal, Collage of Agriculture, Latur
4	Dr. Ram Chandra-Member	Principal Scientist, NRCP, Solapur
5	Shri Ram Avtar Parashar- Member	Finance & Accounts Officer, NIASM, Baramati
6	Shri V. A. Shinde -Special invitee	Assistant Finance & Account Officer, NRCP, Solapur
7	Shri A.A. Goswami- Member Secretary	Administrative Officer, NRCP, Solapur

The following issues pertaining to the development of the centre were discussed and approved: i) lift irrigation system installation, ii) construction of pomegranate processing pilot plant iii) construction of net house and iv) miscellaneous farm development work, v) approval of instruments / equipments/ furnitures essential for purchase before approval of XIIth plan EFC.

Again Xth IMC meeting of NRCP was held on November 15, 2013 at NRCP and was attended by following members

Sl.No.	Name	Designation
1	Dr. R.K. Pal- Chairman	Director, NRC on Pomegranate, Solapur
2	Dr. A.K. Mishra -Member	Project Co-ordinator (STF), CISH, Lucknow
3	Dr. D.P. Waskar -Member	Associate Dean and Principal, Collage of Agriculture, Latur
4	Dr. Ram Chandra-Member	Principal Scientist, NRCP, Solapur
5	Dr. A.K. Shrivastav -Member	Principal Scientist, NRC for Citrus, Nagpur
6	Shri Ram AvtarParashar - Member	Finance & Accounts Officer, NIASM, Baramati
7	Shri V. A. Shinde -Special invitee	Assistant Finance & Account Officer, NRCP, Solapur
8	Shri K.S. Sharma, Special invitee	Assistant Administrative Officer, NRCP, Solapur
7	Shri A.A. Goswami- Member Secretary	Administrative Officer, NRCP, Solapur

The following issues pertaining to the development of the centre were discussed and approved: i) construction of vehicle parking stands at Kegaon and Hiraj and rain out shelter, ii) establishment of structures for mass multiplication facilities of elite disease free planting materials, net house etc. and iii) approval of instruments/ equipments/furniture essential for purchase before approval of XIIth plan EFC.

Members of IMC visiting germplasm block of NRCP

Institute Research Committee Meeting

The VIIIth IRC meeting of NRCP was held on 30th September, 2013 and was attended by following members

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

A brief account of ongoing projects and action taken report on VIIth IRC held on 6th March, 2013 was presented by Dr. Ram Chandra. This was followed by the presentation made by Dr. K.K. Sharma, I/C PME cell on the status report of various projects. The chairman also requested to all the scientists to implement the suggestions made by RAC meeting and meeting with DDG (Horticulture) on priority basis. The research achievements of 18 projects were presented by PIs/Co-PIs of respective projects. Out of 18 projects, 7 projects were completed and respective PIs of those projects were asked to submit RPF-III. Two projects were terminated on account of transfer of Scientist on promotion. The action plan of 9 ongoing projects and progress made during last one year was critically reviewed and suggestions were put forward. One new project was approved.

Other institutional activities organized during the year 2013-14 are mentioned hereunder.

Workshop on "Action Plan for the Management of Bacterial blight of Pomegranate"

One day Workshop on "Action Plan for the Management of Bacterial blight of Pomegranate" was organized by the National Research Centre on Pomegranate Solapur on May 29, 2013 by involving scientists working on pomegranate and other stakeholders of pomegranate industry. The workshop was inaugurated by Dr S.B. Dandin, Chief Guest and Vice-Chancellor, University of Horticultural Sciences, Bagalkot The chief guest, in his address emphasized the importance of Bacterial blight as the disease has assumed status of national importance and needs concerted efforts from all major groups involving scientists, private entrepreneurs, growers etc. He further stressed the need of tissue culture plants for ensuring disease free planting material and need to study the impact of climate change disease spread. The workshop was attended by about 40 delegates from ICAR Institutes, SAUs, Private sectors and pomegranate growers. The workshop comes out with short-term action plan which need to be implemented on short-term basis and long-term action plans.

Workshop on "Action Plan for the Management of Bacterial blight of Pomegranate" Inauguration of Office-cum-Laboratory Building

The office-cum-laboratory building of National Research Centre on Pomegranate, Solapur was inaugurated on 7th July, 2013 in the auspicious presence of Honorable Shri Sharad Pawar, Union Minister of Agriculture and Food Processing Industries, Govt. of India and the function was presided over by Honorable Shri Sushilkumar Shinde, Union Minister of Home Affair, Govt. of India in presence of dignified state ministers, MPs and MLAs. The Chief Guest, Shri Sharad Pawar highly appreciated the development and activities of NRCP and emphasized the need for undertaking farmers' field oriented research programme in order to make India self-sufficient in food production. The inaugural function was attended by more than 1000 dignitaries, media persons and farmers of Maharashtra and Karnataka. The inaugural function successfully ended with the vote-of-thanks delivered by Dr. R.K. Pal,Director, NRCP, Solapur.

Inauguration of Office-cum-Laboratory Building on 7th July, 2012

Celebration of 120th birthday of Late Dr.G.S. Cheema

An interactive meeting was organized on 2nd August, 2013 at NRC on Pomegranate, Solapur to celebrate 120th birthday of Late Dr. G.S. Cheema. The chief guest of the function was Ltd. Gen. N.S. Cheema, son of Late Dr. G.S. Cheema. He made appraisal of his father's lifestyle, hobbies and devotion to work towards Horticultural development in Maharashtra. Scientists from Centre for Rabi Sorghum, Associate Director of Research, MPKV, University of Horticultural Sciences, Bagalkot and all the staff of NRCP attended the function. Dr. R.K. Pal, Director, NRC on Pomegranate briefed the audience the introduction of Late Dr. G.S. Cheema and enlightened about his contribution in the field of Horticulture especially in fruit crops and post-harvest technology. A big portrait of Late Dr. G.S. Cheema was presented to the Director, NRCP by Ltd. Gen. N.S. Cheema as a token of memory of his father Late Dr. G.S. Cheema.

Dr. G.S. Cheema Day Celebration

Independence Day Celebration

NRC on Pomegranate celebrated Independence Day on 15th August, 2013. The national flag was hoisted by the Director, NRCP and several cultural programmes were organized after the flag hoisting ceremony.

Independence Day

Hindi Activities of NRC on Pomegranate, 2013-14

This year NRC on Pomegranate has celebrated Hindi Festival from 2nd to 13th Sept, 2013. Different competitions were organized in Hindi during the period and all the members of this centre participated in these events. At the end of these competitions prize distribution ceremony was organized on 23rd Sept, 2013 and the chief guest of the event was Dr.(Mrs.) Anita Mane, Director, Sinhgad Business School, Solapur and the programme was Chaired by Dr. J.R. Kadam, Associate Director of Research, ZARS, Solapur. In her speech, honourable chief guest highlighted the importance of Hindi in bringing unity in diversity and congratulated the staff of NRCP for organizing very useful and commemorative programme to celebrate Hindi Month. The Chairman emphasized on the easiness and connecting power of Hindi as medium of instruction in India. The Director, National Research Centre on Pomegranate also emphasized upon the importance of Hindi in bringing cultural and linguistic unity in India. The event was managed by Mr. R. B. Rai in cooperation with all the scientific, administrative and supporting staff of National Research Centre on Pomegranate.

A one day workshop on "Use of Hindi for Administrative Work" has also been organized by NRCP on 25.10.13. Besides these, various farmers' training day and scientists-farmers interactions and Independence Day celebration were also organized in Hindi.

Prize distribution ceremony on conclusion of Hindi Fortnight

A one day workshop on "Use of Hindi for Administrative Work"

Republic Day Celebration

NRC on Pomegranate celebrated the 65th Republic day of the Nation on 26th January, 2014. On the occasion, Dr. R.K. Pal, Director, NRCP hoisted the national flag and addressed the staff of this centre highlighting the importance and strength of Indian constitution and its role in building up the nation.

Flag Hoisting by the Director NRCP on the occasion of 65th Republic day of the Nation

Celebration of NRCP's Foundation day

A farmers interaction programme named "kisanki kahani kisanki jubani " was organised on the occasion of ninth foundation day celebration of National Research Centre on Pomegranate on 25th September, 2013. This interactive programme provided a platform for interaction between successful pomegranate growers and other stakeholders of pomegranate industry including farmers. The chief guest on this occasion was Dr. S. A.Patil former Director, IARI. The programme was well attended by the farmers. The eleven numbers of farmers shared their success stories with fellow farmers and scientist. The NRCP felicitated them for their success.

NRCP foundation Day Celebration

Infrastructure facility created

Fertigation unit (Netaject) installed at NRCP during 2013-14 for improving water and nutrient use efficacy

Fertigation units was (i.e. Netaject) installed at NRCP, Solapur during 2013-14 for improving water and nutrient use efficacy of pomegranate. The components of fertigation units include pumping unit, control head, pipe network, drippers, solenoid valves, automatic metering valves, digital meter, ply relay, hydraulic connectors, fertilizer injectors, fertilizer tanks, pressure flow regulators, controllers, filtration units etc.

Fertigation is to feed the plant in appropriate time, quantity and location. It is a timely application of water and nutrients as per phenological stages of plants through drip irrigation. The most important aspect of fertigation is to apply the exact quantity of water and fertilizers through drip irrigation on daily and monthly basis for pomegranate fruit crop.

10. HUMAN RESOURCE DEVELOPMENT

Participation of Scientist/ Staff in Conference/RefresherCourses/Meetings/Symposia/Workshops/Trainings

Title	Date and Venue	Participants
Awareness workshop on "National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA)"	27-28th Sep. 2013. CIFE, Mumbai.	Dr. Nilesh Gaikwad
Workshop on Management Information System including Financial Management System (FMS) in ICAR	23rd Oct. 2013. CIFE, Mumbai.	Sh. A. A. Goswami Sh. V. A. Shinde
National Training on MAS for Molecular Breeding in Fruits.	11-24th Nov.2013at CISH, Lucknow	Dr. N.V. Singh
Training course on "Good Governance"	18-22nd Nov. 2013 at ISTM, New Delhi.	Sh. A. A. Goswami
Workshop on Quality Production of Pomegranate and	27thDec. 2013 at Reshimbag, Nagpur, Maharashtra.	Dr. Nilesh Gaikwad
National Symposium on Plant Diseases: Diagnostics and Integrated disease management for food security held during	27-28th, Dec 2013 at MAU, Parbhani, MS	Dr. Jyotsana Sharma Dr. K. K. Sharma
An international training under HRD program of NAIP on Marker Assisted Selection (Horticulture).	8th Jan.-29thMar. 2014 atWest Virginia State University, USA.	Dr. N V Singh
National Conference on Biodiversity, Bioresources and Biotechnology	30-31 Jan. 2014 at Mysore	Ms. Rigveda Deshmukh
2nd International Conference on Agricultural and Horticulture Science	3-5th Feb., 2014 at Hyderabad, India.	Dr. D T Meshram
Workshop on Texture Analysis of food products organized by Indian Dairy association and SDS instruments	22nd Feb. 2014 at NASC, New Delhi.	Dr. Nilesh Gaikwad
Workshop on IPv6 in DARE/ICAR	27th Feb. 2014 at NASC Complex, New Delhi.	Dr. Nilesh Gaikwad
Knowledge sharing workshop on tropical fruits – Banana, mango and Pomegranate for value chain management and farm profitability enhancement,	1-2 Mar. 2014, Coimbatore, T.N. at Hotel Residency	Dr. Jyotsana Sharma Dr. K. Dhinesh Babu

11. PUBLICATIONS

Research articles:

A. International :

1. Barman, K., Asrey, R., Pal, R.K., Kaur, C. and Jha, S.K.(2014). Influence of putrescine and carnauba wax on functional and sensory quality of pomegranate fruits during storage. *Journal of Food Science and Technology* 51(1):111-117.
2. Maity, A., Pal R.K., Chandra Ram and Singh N.V. (2014). *Penicilliumpinophilum*- a novel microorganism for nutrient in pomegranate (*Punicagranatum* L.) *Scientia Horticulturae*. 169 : 111-117.
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4. Alemwati, P., Sagar, V.R., Pal, R.K., Asrey, R., Sharma, R.R. and Singh, S.K. (2014) Physiological and quality changes during postharvest ripening of purple passion fruit *(Passifloraedulis* Sims). *Fruits*. 69:19-30.
5. Asrey, R., Patel, V.B., Barman, K. and Pal, R.K.(2013).Pruning affects fruit yield and post harvest quality in mango (*Mangiferaindica* L.) cv. Amrapali. *Fruits.* 68:367-380
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8. Meshram, D. T., Gorantiwar, S. D. Kulkarani, A. D. and Hangargekar, P.A. (2013). Forecasting of evaporation for Makani reservoir in Osmanabad district of Maharashtra, India. *International Journal of Advanced Technology in Civil Engineering*. 2(2):19-23.
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1. Sharma, R.R., Pal, R.K., Asrey, R. and Sagar, V. R. (2013). Pre-harvest fruit bagging influences fruit color and quality of apples cv Delicious. *Agricultural Sciences.* 4(9):443-448.
2. Neelavati, R., Pal, R.K., Sen, S. and Kumar, P. (2013). Effect of blanching on the quality of dehydrated cauliflower. *Indian Journal of Horticulture.* 70(2):313-315.
3. Archak, S. Chandra, R. Gaikwad, A., Jamla, M., Gautam, D. and Jadhav, V.T. (2013). Molecular and morphometric analysis of pomegranate *(Punicagranatum)*germplasm. *Indian journal of agriculture sciences*. Accepted.

REVIEW ARTICLE :

1. da Silva, J. A. T., Rana, T.S., Narzary, D., Verma, N., Meshram, D. T. and Ranade, S. A. (2013), "Pomegranate: Biology and Biotechnology- a review paper". *Scientia Horticulture.* 160 : 85-107.

BOOKS :

1. Bhagat Arun, Meshram, D and Pratibha, K. (2013). Optimization of Pomegranate Production: through Rainfall, Evapotranspiration and climate shifting analysis. Lambert Academic Publishing. 185p.

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1. Chandra, R., Jadhav,V.T. and Sharma,J. (2013). Pomegranate In: *Fruit production in India* (Ed:WSDhillon) Narendra Publishing House, New Delhi 559-584.
2. Ahuja, D.B., Sharma, J.,Suroshe,S.S.*et al*., (2013).CROPSAP (Horticulture) team of e' pest surveillance: 2013: *Pests of Fruits (Banana, Mango and Pomegranate) - 'e' Pest Surveillance and Pest Management Advisory*, (Ed. DB Ahuja) Published by National Centre for Integrated Pest Management, New Delhi and Department of Horticulture, Commissionerate of Agriculture (Horticulture), MS, Pune. 67p.
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4. Maity,A. and Jadhav,V.T. (2013) Soil quality: A new challenge for sustainable agriculture. In: Rodriguez, H.G., Ramanjaneyulu, A.V., Sarkar, N.C. and Maity, R. (eds.) Advances in Agro-technology, Puspa publishing house, Kolkata, pp. 147-164.
5. Gaikwad, N., Pal, R.K. and Chaudhari,D.T. (2013) Post harvest management and value addition in Pomegranate. In: Sudhir Dahiwalkar, Narendra Firake and Sunil Gorantiwar eds. Training Booklet on Precision Farming Technology for Pomegranate. MPKV Res Pub. No. 100/2013, MPKV Rahuri, pp 23-27.

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2. Ram Chandra, N.V. Singh and R.K. Pal (2013). Patch budding in pomegranate-an easy in-situ budding technique. ICAR news 19(2):1-2.
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5. Sharma, J. and Pal, R.K. (2013) Dalimbsalla-Telkat daag rogancha jeevankram janunkar aniyantran. *Agrowon.* Nov 22, 2013, pp16
6. Sharma, J. and Marathe, R. (2013) Dadimbavaril telkat daag rogniyantranache upay. A*growon.* Oct 7, 2013, pp11
7. Sharma, J., Suroshe, S.S. and Marathe, R. (2013) *D*alimbbatar paper lava fruit sucking manthlarokha. *Agrowon.* Oct 7, 2013:pp11
8. Sharma, J. and Pal, R.K. 2013 *T*elkat Daag Roogache Nidan Shetat Kasa Kara. *Agrowon.* Nov 8, 2013, pp11
9. Babu, K. D. and Pal, R.K. (2014) Dalimbathil phoolgalichee karne va uphay, *Agrowon,* Jan 19,2014. pp.7 (Daily Newspaper in Marathi)
10. Meshram, D. T. and Pal, R. K., (2013) Water Management in Pomegranate. Dalimb Pikasathi Katekore Sethi Tandradyan. MPKV/RES/PUB/No.100/2013.
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PRESENTATION OF RESEARCH PAPERS/ABSTRACTS IN CONFERENCES/ SYMPOSIA/ SEMINARS/ WORKSHOP/ OTHER FORA :

1. Pal, R.K., Babu, K. D. and Gaikwad, N. (2014). Management strategies in pomegranate Keynote Lecture delivered on Mar, 2, 2014 at Knowledge sharing workshop on tropical fruits – Banana, mango and Pomegranate for value chain management and farm profitability enhancement, 1-2 March 2014, Coimbatore.
2. Sharma, K.K. Chandra, R. and Sharma, J. (2013). Field assessment of pomegranate germplasm for bacterial blight (*Xanthomonas axonopodis* pv. *punicae*) resistance. National Symposium on Plant Diseases: Diagnostics and Integrated disease management for food security held during 27-28 at MAU, Parbhani, MS, pp. 26.
3. Chandra, R.,Pal,R.K.,Deshmukh, R. and Suryavanshi,S. (2013). Genetic diversity of wild pomegranate (*Punica granatum L.*) distributed in Western Himalayas. National Conference on Biodiversity, Bioresources and Biotechnology held during 30-31at Mysore, pp. 14.
4. Sharma, Jyotsana. (2013.) Pomegranate bacterial blight: Present status and management. In:*Souvenir cum Abstracts: National Symposium (West Zone) on Plant Diseases: Diagnostics and Integrated Management for Food Security, o*rganized by Indian Phytopathological Society (IARI) New Delhi And Department of Plant Pathology, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani on Dec 27-28, 2013, at COA, VNMKV, pp. 19-20 (Lead Lecture)
5. Sharma KK, Ram Chandra and Jyotsana Sharma (2013).Field assessment of pomegranate germplasm for bacterial blight (*Xanthomonas axonopodis* pv. *punicate*) resistance. In:*Souvenir cum Abstracts: National Symposium (West Zone) on Plant Diseases: Diagnostics and Integrated Management for Food Security, o*rganized by Indian Phytopathological Society (IARI) New Delhi And Department of Plant Pathology, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani on Dec 27-28, 2013, at COA, VNMKV, pp. 25-26.
6. Jadhav VT and Jyotsana Sharma (2014) Integrated management of pomegranate diseases. In: GyanManthan: Knowledge Sharing Workshop on Tropical Fruits, Banana, Mango and Pomegranate for value chain Management and Farm Profitability Enhancement. Organized by Confederation of Horticulture Association of India (CHAI), ASSOCHAM- The Associated Chambers of Commerce and Industry of India at Tamil Nadu Agriculture University, pp.200-204
7. Meshram, D. T., Gorantiwar, S. D., Singh, N. V. and R. K. Pal. (2013). SARIMA Model for Generating and forecasting of Pomegranate (*Punicca granatum* L.) Evapotranspiration for Solapur distict of Maharashtra, India in 2nd International Conference on Agricultural and Horticulture Science during 03-05th February, 2014 at Hyderabad, India.
8. Singh, N. V. (2013). Oral Presentation on 'Production of disease free planting material through tissue culture' in Workshop on Action Plan for the Management of Bacterial Blight of Pomegranate. May, 29th, 2013 at NRC on Pomegranate, Solapur, India.
9. Nilesh Gaikwad. (2014). Pomegranate processing and value addition technologies. Paper presented in Workshop on Quality Production of Pomegranate & Processing Opportunities On 27th December 2013 at Agrovision 2013, Nagpur, Maharashtra.

CONTRIBUTION MADE IN COMPILATION / DOCUMENTATION:

ANNUAL REPORT:

1. Pal, R.K., Babu, K.D., Suroshe, S.S. Maity, A. and Singh, N.V. (2013). NRCP Annual Report 2012-13. National Research Centre on Pomegranate, Solapur, 124p.
2. Pal, R.K., Sharma, J., Singh, N.V., Chaudhary, D.T. and Shinde, Y.R. (2013). NRCP Annual Report (Hindi) 2012-13. National Research Centre on Pomegranate, Solapur, 95p.

EXTENSION FOLDERS :

1. Chandra, R. Singh, N.V., Maity, A., Meshram, D.T. and Pal, R.K. (2013). Establishment of Pomegranate Orchard. 4p.
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3. Sharma, J., Suroshe, S.S. Marathe, R.A., Maithy, A. Shinde, Y.R. and Pal, R.K. (2013) *Mrig Baharateel Dalimb Pikavaril Telya Rogache Vyavasthapan. 8p.*
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5. Meshram, D. T., Singh, N. V., Suorshe, S. S., and Pal, R. K. (2013) Water Requirement for Pomegranate 4p.
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7. Meshram, D. T., Singh, N. V., and Suorshe, S. S., and Pal, R. K. (2013) Drip Irrigation for Pomegranate. 4p.
8. Meshram, D. T., Singh, N. V., and Suorshe, S. S., and Pal, R. K. (2013) Dalimbamadhil Thibak Sinchan. 4p.
9. Suroshe, S.S., Singh, N.V., Maity, A., Meshram, D.T., Shinde, Y.R. and Pal, R. K. (2013) Fruit sucking moth and their management. 4p.
10. Suroshe, S.S., Singh, N.V., Maity, A., Meshram, D.T. Shinde, Y. R. and Pal, R.K. (2013). Dalimbamadhil ras sosnara patang ani vyvasthapan. NRCP/EXTN-2013/8. 4p.
11. Maity, A. Chandra, R., Suroshe, S.S., Singh, N.V., Shinde, Y.R. and Pal, R.K. (2013). Dalimbam adhilsukshm annadravye vyavsthapan. 4p.
12. Maity, A. Chandra, R., Suroshe, S.S., Singh, N.V., Shinde, Y.R. and Pal, R.K. (2013). Micronutrient Management in Pomegranate. 4p.
13. Singh, N.V., Chandra, R., Dhinesh Babu, K., Meshram, D.T., Suroshe, S.S., Maity, A., Shinde, Y. R. and Pal, R.K. (2013). Quality Planting Material for Pomegranate Production. 4p.
14. Singh, N.V., Chandra, R., Dhinesh Babu, K., Meshram, D.T., Suroshe, S.S., Maity, A., Shinde, Y. R. and Pal, R.K. (2013). Dalimbatil Darjedar rope nirmiticha padhati. 4p.

OTHERS :

Video Film :

1. Pal, R. K. (2013). Produced video films in Hindi and Marathi for management of bacterial blight in pomegranate which was released by National Research Centre on Pomegranate, Solapur.
2. Sharma, J. (2013). *Anar me Bacterial Blight Ka Prabadhan*. A short (9 min.) video film in Hindi, released by National Research Centre on Pomegranate, Solapur

PATENT :

Nilesh N. Gaikwad and Rahul Kumar Anurag. (2013). Bael/Wood Apple Pulper. Submitted to ITMU CIPHET, Ludhiana.

12. JOINING / PROMOTION / RELIEVING

Joining

- Dr. N.N. Gaikwad, Scientist, Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab joined as Scientist at NRC on Pomegranate, Solapur on 06.08.2013
- Mr. Diwakar Sawaji, Technical Assistant, Central Institute for Temperate Horticulture, Srinagar, J&K joined as Technical Assistant at NRC on Pomegranate, Solapur on 18.04.2013

Promotion

- Dr. D.T. Meshram, Scientist promoted as Senior Scientist w.e.f 18.03 .2013
- Dr. N.V. Singh, Scientist promoted from RGP ₹ 6000/- to RGP ₹ 7000/- w.e.f 10. 02 .2013
- Mr. R. B. Rai, promoted from Assistant to Assistant Administrative Officer w.e.f 01.03 .2014

Relieving

- Dr. R.A. Marathe, Principal Scientist, NRC on Pomegranate relieved on 29.10.13 upon transfer to National Research Centre for Citrus, Nagpur
- Dr. S. S. Suroshe, Scientist, NRC on Pomegranate relieved on 29.06.13 upon promotion as Senior Scientist to Indian Agricultural Research Institute, New Delhi
- Mr. K.S. Sharma, Assistant Administrative Officer, NRC on Pomegranate, retired from the service on 28.02.2014

13. BUDGET ESTIMATE

Financial Outlay 2013-14

Head of Account	Rupees in lakh			
	Plan		Non-Plan	
	RE	Expenditure	RE	Expenditure
A. Recurring				
Estt. Charges	0.00	0.00	214.00	186.97
T.A	6.00	5.77	5.00	4.99
Other Charges	143.50	143.16	140.00	140.00
Total A	149.50	148.93	359.00	331.96
B. Non-Recurring				
Equipment	70.50	70.50	8.11	7.66
Major Works	191.00	3.62	2.00	1.89
Library	0.00	0.00	1.89	1.89
Furniture	00.00	00.00	5.00	4.44
Total B	261.50	74.12	17.00	15.88
C. P. Loans & Advances	0.00	0.00	5.00	5.40
D. Pension	0.00	0.00	24.00	4.26
E. Vehicles and Vessels	0.00	0.00	13.50	0.00
Grand Total (A+B+C+D)	411.00	223.05	418.50	357.50

Revenue Receipt 2013-14

	Items	Amount (Rs.)
1	Income from Farm Produce	110781/-
2	Income from Royalty and Publications	242760/-
3	Income from other sources	119445/-
4	Interest on loans and advances	5466/-
5	Interest earned on short term deposits	1116845/-
6	Recovery of loans and advances	331425/-
7	Application fees from candidate	71450/-
	Total Revenue Receipt	1998172/-

14. STAFF POSITION

(As on 31.03.2014)

Category	Sanctioned during XIIth Plan	Staff in position	Vacant
RMP	1	1	0
Scientific	14	8	6
Technical	6	6	0
Administrative	11	5	6
Supporting	2	2	0
Total	34	22	12

Appendix I

Institute Management Committee of NRCP

(As on 31.03.2014)

Chairman

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

Members

2. Dr. Ram Chandra
   Principal Scientist
   NRCP, Solapur

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

4. Dr. Abraham Verghese
   Principal Scientist
   IIHR, Bangalore

5. Dr. A.K. Misra
   Project Coordinator (STF)
   CISH, Lucknow

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

7. Director of Horticulture
   Govt. of Maharashtra
   K.S. Joshi Marg
   Shivaji Nagar
   Pune-411055

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

9. Dr. D.P. Waskar
   Associate Dean and Principal
   College of Agriculture
   Latur-413513

10. Shri Ram AvtarParashar
    F&AO, NIASM
    Baramati-413115

Member–Secretary

11. Shri A.A. Goswami
    Administrative Officer
    NRCP, Solapur

Research Advisory Committee of NRCP

(As on 31.03.2014)

Chairman

1. Dr. C.D. Mayee
   Former Chairman, ASRB, New Delhi
   50 K, Bharat Nagar, Amaravati Road
   Nagpur-33

Members

2. Dr. O.P. Pareek
   A-239, Karni Nagar
   LalGarh, Bikaner-334001

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

4. Dr. V. Rajagopa l
   Former Director, CPCRI
   Flat No. 102, Sreekarkasham Street
   A 18-4-60, Railway Colony
   Thirupathi-517501

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

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

7. Dr. S.K. Malhotra
   ADG (Hort. II)
   ICAR, KAB-II
   Pusa, New Delhi

Member Secretary

8. Dr. R.A. Marathe
   Principal Scientist
   NRC on Pomegranate
   Solapur-413255 (MS)

Appendix II

Institute Research Council of NRCP

(As on 31.03.2014)

Chairman

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

Members

2. Dr. (Mrs.) Jyotsana Sharma
   Principal Scientist (Plant Pathology)
   NRCP, Solapur

3. Dr. K.K. Sharma
   Principal Scientist (Plant Pathology)
   NRCP, Solapur

4. Dr. R.A. Marathe
   Principal Scientist (Soil Science)
   NRCP, Solapur

5. Dr. K. Dhinesh Babu
   Senior Scientist (Hort.-Fruit Science)
   NRCP, Solapur

6. Dr. D.T. Meshram
   Scientist SS (SWCE)
   NRCP, Solapur

7. Dr. AshisMaity
   Scientist (Soil Science)
   NRCP, Solapur

8. Dr. N.V. Singh
   Scientist (Hort.-Fruit Science)
   NRCP, Solapur

9. Dr. NileshGaikwad
   Scientist (ASPE)
   NRCP, Solapur

Member Secretary

10. Dr. Ram Chandra
    Principal Scientist (Hort.)
    NRCP, Solapur

Institute Joint Staff Council of NRCP

(As on 31.03.2014)

Chairman

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

Members (Official side)

2. Dr.K. Dinesh Babu
   Sr. Sceintist,
   NRCP,Solapur

3. Dr. AshisMaity
   Scientist,NRC
   P Solapur

4. Dr. N. V. Singh
   Scientist,
   NRCP, Solapur

5. Shri. V.A. Shinde
   Assist. Fin. & Acc. Offices
   NRCP Solapur

Member-Secretary (Official Side)

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

Member (Staff Side)

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

Member (CJSC)

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

Member-Secretary (Staff Side)

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

Appendix III

Personnel

(As on 31.03.2014)

RMP

Dr. R. K. Pal
Director

Scientific Staff

Dr. Ram Chandra
Pr. Scientist
(Horticulture)

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

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

Dr. K. DhineshBabu
Sr. Scientist
(Hort.-Fruit Sciences)

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

Dr. AshisMaity
Scientist
(Soil Science-Pedology)

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

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

Mrs. PrativaSahu
Scientist
(Hort.-Fruit Sciences)

Technical Staff

Sh. D. T. Chaudhari
Sr. Tech. Asst.

Sh. Yuvraj R. Shinde
Tech. Asst.

Sh. Diwakar V. Sawaji
Tech. Asst.

Sh. M.S. Gogaon
Sr. Technician

Sh. GovindSalunke
Technician

Sh. Vijay Lokhande
Technician

Administrative Staff

Sh. A. A . Goswami
AO

Sh. Shinde V. A.
AFAO

Sh. R. B. Rai
AAO

Sh. KiranKhatmode
LDC

Sh. A. S. Babar
LDC

Supporting Staff

Sh. ShaileshBayas
SSS

Sh. Vishal Gangane
SSS

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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