वार्षिक प्रतिवेदन

Annual Report 2023

भा.कृ.अनु.प.–राष्ट्रीय अनार अनुसंधान केन्द्र

ICAR-National Research Centre on Pomegranate

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Preface

ICAR-National Research Centre on Pomegranate, Solapur, has completed 18 years of journey on September 25, 2023. The Centre has accomplished its objectives with visible outcomes during the period and is proud to be the driving force behind the sprawling pomegranate sector in India. The pomegranate sector has recorded constant increase in area, production and productivity since last 9 years. In 2022-23, the pomegranate was cultivated over 2.76 lakh ha, production of 31.96 lakh MT with productivity of 11.41 t/ha and the export was 99.04 thousand MT.

ICAR-NRCP has significantly contributed in improving pomegranate scenario in India through its technologies for combating major diseases, improving fruit yield and quality, providing quality planting material, identifying suitable pomegranate growing areas in India, developing sound package of practices, acting as repository of germplasm for breeding new varieties, giving value addition technologies for complete utilization of fruit, dissemination, commercialization and transfer of technologies, imparting on-site and in-house trainings to stakeholders, etc. The Centre has implemented Government of India schemes, and introduced pomegranate cultivation in different states through Tribal Sub Plan, (TSP), Mera Gaon Mera Gaurav (MGMG) and Scheduled Caste Sub Plan (SCSP) by demonstrations, inputs, Soil Health Cards and technical guidance. The positive feedback of different stakeholders including farmers is the driving force keeps us move forward with commitment.

For introduction of pomegranate cultivation in states of North India, it is urged to explore the feasibility of pomegranate cultivation in non-traditional areas that paves the way for enhanced production. This would be a boon in improving economic status of the farmers in these states. Though India is the largest producer of pomegranate, its export share in world trade of pomegranate is lesser (around 14%) in comparison to China (34%) and Iran (29%) with respectively 50% and 33% less area than India. The Centre has a challenging task ahead to improve export through breeding large size variety and pesticide residue free production; work on these aspects is in progress. I am sure ICAR-NRCP will continue to move forward with confidence to achieve new milestones. To be a part of the institute that aims to raise the standard of living of pomegranate farmers of the country is a matter of great privilege to the staff of ICAR-NRCP.

I wish to place on record my sincere gratitude to Dr Himanshu Pathak, Secretary, DARE and Director General, ICAR for his encouragement. I am highly obliged to Dr.TR Sharma, DDG (HS) I/c for his moral support and guidance, which encourages us to move forward with confidence. The cooperation and support rendered by Dr VB Patel ADG (HS) and Dr Sudhakar Pandey ADG (HS) all the staff members of SMD (HS) to this Centre is thankfully acknowledged. I am grateful to Hon'ble Chairman and members of RAC for guidance and keen interest shaping the research activities of the institute. The Centre would not have achieved its milestones without constant support and cooperation of all scientific, administrative, technical and supporting staff as well as senior research fellows, young professionals in various research projects. I am grateful to all for their unflinching support and express my sincere thanks for the help rendered in betterment of this Centre.

Dr. R.A. Marathe,

Director, ICAR-NRCP

Introduction

Indian Horticulture has moved from rural confines to commercial venture and the scenario has become very encouraging recently. Horticultural production in 2001-02 was only 145.8 million tonnes, which was much lower than food grain production (212.9 million tonnes). In 2009-10 to 2011-12 both were at par. Later horticulture production has surpassed than food grain production with continuous increase recording 342.33 million tonnes in 2021-22, whereas food grain production was only 285.71 million tonnes (http://agricoop.nic.in). Today percentage share of horticulture output in agriculture has become 33%. Globally India is second largest producer of fruits and vegetables and first in Mango, Banana, lime, lemon, pomegranate, papaya and okra/ladies finger.

In India, pomegranate crop is considered as strategic crop to mitigate the future challenges like global warming, drought, alleviating the poverty by creating livelihood and improving the farmers income.Therefore, in order to tap the vast potential of this crop by increasing pomegranate production, export and there by economic growth of India. Indian Council of Agricultural Research established ICAR-National Research Centre on Pomegranate during 2005 at Kegaon, Solapur (Maharashtra) a premier institute mainly for carrying out both basic and strategic research on pomegranate.

About two decades back consumer awareness towards innumerable health benefits of pomegranate increased market demand, resulting in constant increase in area and production of this crop. Alluring monetary returns from this horticulture crop were recorded, especially in India. The average increase in area, production and productivity was 157.94%,323.69 % and 64.41% respectively, over the last 12 years. Looking into the impressive past scenario and keeping in mind the climate change and promising technologies available, it is expected that in the coming years the pomegranate can become one of the most important horticultural crops of India.

India is the largest producer with around 48% share globally. India in 2022-23, occupies an area of 2.76 lakh hectares with production of 31.96 lakh tonnes. The other major countries after India are China, Iran and Turkey. Rest of the pomegranate growing countries like USA, Tunisia, Morocco, Spain, Israel, Greece, Italy, South Africa etc. have lower area and production. The global pomegranate scenario clearly indicates that India has the advantage to come up with promising pomegranate technologies for the benefit of Indian population. Its estimated more than 2.5 lakh families are earning livelihood from this crop in arid and semi-arid regions of India. Envisioning the economic importance of pomegranate for the farmers in arid and semi-arid regions, the ICAR-NRCP addressed these hurdles on priority and gave solutions to major challenges. Noteworthy technologies for promotion of pomegranate include:

(i) The 'Field Gene bank' having 338 germplasm lines including indigenous and exotic lines established at ICAR-NRCP, Solapur which serves collection of genes for diverse characters.
(ii) Bio-hardened micro-propagation technology for propagation of disease free planting material.
(iii) Cost effective, eco-friendly integrated nutrient, water, disease & insect pest management schedule with the use of bio-formulations and preventive strategies, resulting in quality fruit production.
(iv) Novel bio-formulation for potassium fertilizer supplement, with *Penicillium pinophilum,* that reduces 70% requirement of potassium to pomegranate, saves ~Rs.40,000/ha on fertilizers cost and increases yield by 25%.
(v) Processing technologies for total utilization of pomegranate for diversification of utilization pattern, and higher returns. These are pomegranate juice and ready to serve drink from low market value fruits; minimally processed pomegranate arils with shelf life of 14 days; high pharmaceutical value seed oil from dried seeds of cv. Bhagawa (28% w/w oil) and Ganesh (26.43 % w/w oil); hi-fibre cookies from de-oiled seed cake of pomegranate; sparkling pomegranate wine from pomegranate juice.
(vi) Bio-fortified pomegranate variety, 'Solapur Lal' developed through breeding matures in 160-165 days, has 25-35% higher yield over cv. Bhagawa and is nutritionally rich with more iron, zinc, ascorbic acid and anthocyanin contents over the ruling cv. Bhagawa. This bio-fortified variety is a boon to combat nutritional deficiencies in human beings with TSS around 17.6 is a boon for processing industries too.
(vii) Bio-fortified pomegranate variety, 'Solapur Anardana' developed through breeding & fruits mature in 140-148 days after anthesis, fruit surface is red, the arils are deep red and sour due to high Titrable acidity (4.80%). TSS (16.60°Brix). It has higher anthocyanins (456 mg/100g) and ascorbic acid (18.20 mg/100g) compared to standard check, Amlidana.
(viii)The Centre in collaboration with NBSS&LUP, Nagpur has accomplished mapping of pomegranate growing areas based on soil type and climatic conditions. This will help promote pomegranate cultivation in areas suitable for its cultivation but not yet growing pomegranate, for promoting crop diversification and improving economy of the farmer.

The centre has popularized its promising technologies through licensing, consultancy extension activities, distribution of NRCP publications, digital mobile app 'Solapur Anar', demonstrations on farmers field, providing on campus and off campus trainings to farmers and entrepreneurs,TV shows, etc.
Due to highest BC ratio of pomegranate, this ancient health fruit with available technologies can be considered as an ideal crop for diversification under climate resilience and developing rural economy with the technologies available, cluster approach and government intervention. Government support for encouraging community farming and putting up processing units for value addition of unmarketable produce during natural calamities and poor market value will go a long way in improving economic status of farmers. Pomegranate cultivation in arid and semi-

arid regions and tribal areas will not only be beneficial in monitory terms but its consumption will ensure nutritional security of the rural and tribal population, hence it should be promoted as an important crop for diversification in agriculture/horticulture in these areas.

ICAR-NRC on Pomegranate has developed infrastructure with state-of-art facilities for conducting basic, strategic and applied research and take it to the beneficiaries through extension activities, publications in popular languages, digital apps in multi-languages to fulfil the vision of Hon'ble Prime Minister of India ie., Digital India and Atmanirbhar Bharat.

Mandate:

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

Mission:

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

Vision:

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

कार्यकारी सारांश

अनार किसानों और अनार उद्योग के अन्य हितधारकों के मुद्दों को संबोधित करने में आईसीएआर-राष्ट्रीय अनार अनुसंधान केंद्र, सोलापुर का अपरिहार्य योगदान है।

2023 की रिपोर्टिंग अवधि के दौरान, केंद्र ने कई संस्थागत परियोजनाओं, बाह्य वित्त पोषित परियोजनाओं, दो अंतर-संस्थागत सहयोगात्मक परियोजनाओं, एक अनुसूचित जाति उप-योजना (एससीएसपी) और एक जनजातीय उप-योजना (टीएसपी) योजना को संभाला है। सोलह संस्थागत परियोजनाओं में से तीन परियोजनाएं सफलतापूर्वक पूरी हो चुकी हैं। प्रमुख उपलब्धियों का सारांश नीचे दिया गया है।

जननद्रव्य संसाधन:

- आईसीएआर-एनआरसीपी, सोलापुर के फ़ील्ड जीन बैंक में 171 स्वदेशी और 167 विदेशी संग्रहों से युक्त कुल 338 अनार जर्मप्लाज्म परिग्रहण बनाए रखा गया है।
- सर्वेक्षण में उत्तराखंड के 38 स्थानों से 50 नए अनार जर्मप्लाज्म परिग्रहण एकत्र किए गए हैं। जिनमें से 25 बच गए और उचित वृद्धि और विकास के बाद प्रमुख जैविक और अजैविक तनावों के प्रतिरोध के लिए उनका मूल्यांकन किया जाएगा।
- उत्तराखंड के 38 स्थानों से, सर्वेक्षण सह अन्वेषण के माध्यम से 50 नए जर्मप्लाज्म एकत्र किए गए, और 50 जीवित जर्मप्लाज्म में से 25 को प्रमुख जैविक और अजैविक तनावों के प्रति उनके प्रतिरोध का आकलन करने के लिए नर्सरी में रखा गया है।
- जंगली प्रजननकर्ता के अलावा अच्छे फलों के आकार और आकर्षक रंग वाली अंतरराष्ट्रीय स्तर पर अग्रणी किस्मों के आयात के लिए एनबीपीजीआर, नई दिल्ली के माध्यम से अफगानिस्तान, चीन, ईरान, इज़राइल, इटली, मोरक्को, स्पेन, ट्यूनीशिया, तुर्की, संयुक्त राज्य अमेरिका जैसे देशों से अनुरोध किया गया है।
- अनार के 32 ईसी और 4 आईसी सहित 36 जर्मप्लाज्म को एक्सएपी-118 कल्चर (108 पीएफयू/एमएल; ओडी: 0.154 के साथ अतिसंवेदनशील जांच संस्करण भगवा) के साथ चुनौती टीकाकरण से पता चला कि उनमें से कोई भी बैक्टीरियल ब्लाइट के लिए प्रतिरोधी नहीं था।
- सुपर भगवा x IC-318718 (33 F1s) की संकर आबादी की स्क्रीनिंग और F2 (NRCPH-06 x Self के 490 F2s) और NRCPH-12 x Self के 14 F2s) और BC1F1 (NRCPH-06 के 29 BC1F1s) की उन्नत प्रजनन लाइनें एक्स (जीएक्सएनएक्सडी)) चुनौती टीकाकरण के तहत बैक्टीरियल ब्लाइट रोग के खिलाफ बीबीडी के लिए अतिसंवेदनशील प्रतिक्रिया के प्रति संवेदनशील दिखाया गया है। बीमारी की गंभीरता के लिए आनुवंशिक परिवर्तनशीलता अलग-अलग और बैकक्रॉसिंग आबादी की तुलना में संकीर्ण एफ1 देखी गई।
- ईएमएस द्वारा उपचारित (एनआरसीपीएच-06 एक्स सेल्फ) के 52 व्यक्तिगत एफ2एस और भगवा एक्स दारू क्रॉस के 42 एफ2एस की बैक्टीरियल ब्लाइट के खिलाफ जांच की गई और उनमें से कोई भी प्रतिरोधी नहीं था। हालाँकि रोग की गंभीरता के लिए व्यापक परिवर्तनशीलता देखी गई।
- रोपण के आठवें वर्ष के दौरान 25 एनआरसीपी संकरों के मूल्यांकन से टेबल उद्देश्य के लिए एक आशाजनक अनार संकर एनआरसीपी एच-14 और अनारदाना उद्देश्य के लिए एनआरसीपी एच-4 की पहचान हुई।
- टेबल उद्देश्य के लिए अनार की गुलाबी एरिल किस्म: एनआरसीपी एच-14 (पीपीवी&एफआरए/ आरईजी/2016/1748) और अनारदाना उद्देश्य के लिए एक अन्य गुलाबी एरिल किस्म: एनआरसीपी एच-4 (पीपीवी&एफआरए/आरईजी/2016/1749) को पीपीवी और के साथ पंजीकृत किया गया था। एफआरए, नई दिल्ली और पंजीकरण प्रमाणपत्र जारी (डीओएफ: 20.10.2016; डीओजी: 12.12.2023)।
- भगवा की तुलना में 'सोलापुर तपोरत्न' में प्रारंभिक परिपक्व संस्करण, रूपात्मक और जैव रासायनिक परिवर्तन फलों के वजन, फलों की मात्रा में उल्लेखनीय वृद्धि का खुलासा किया; फलों की संख्या; 100 एरिल वजन; फल का व्यास; एरिल लंबाई; एरिल चौड़ाई; छिलके की मोटाई; टीएसएस; परिपक्वता के 70वें से 80वें दिन तक छिलके का रंग (ए*) दर्ज किया गया, जबकि परिपक्वता के 80वें से 90वें दिन तक फल की लंबाई में उल्लेखनीय वृद्धि देखी गई। अम्लता% में कमी की प्रवृत्ति देखी गई, जल्दी पकने वाले वेरिएंट के मामले में परिपक्वता के 70वें से 80वें दिन में महत्वपूर्ण कमी देखी गई। प्रारंभिक किस्म के मामले में परिपक्वता के 50वें से 60वें दिन के दौरान एरिल रंग में महत्वपूर्ण परिवर्तन देखा गया, जिसमें इस अवधि में * मूल्य में उल्लेखनीय वृद्धि हुई।
- अनार के बगीचों के सर्वेक्षण के दौरान कर्नाटक के हसन जिले से आकर्षक फल गुणवत्ता मानकों के साथ भगवा का एक नया संस्करण एकत्र किया गया है।
- किसान किस्म "शरद किंग" को 12 जून, 2023 से प्रभावी पीपीवी एंड एफआर अधिनियम 2001 के तहत पंजीकृत और संरक्षित किया गया है।
- 2023-24 के अंबे बहार के दौरान 18 फल रूपात्मक और भौतिक-रासायनिक लक्षणों के लिए 51 एनआरसीपी प्रजनन लाइनों के क्षेत्र मूल्यांकन से स्वीकार्य फल के साथ आशाजनक जीनोटाइप "एच-34 जीएक्सएन(एफ3)2/3 - 1120" की पहचान हुई है। ऐसे लक्षण जिनका इसकी उपज क्षमता का

परीक्षण करने के लिए प्रतिकृति परीक्षण में आगे मूल्यांकन किया जा सकता है और अनार के आनुवंशिक सुधार कार्यक्रमों में मूल सामग्री के रूप में भी उपयोग किया जा सकता है।

- चरण विशिष्ट 15 डीयूएस लक्षणों के लिए किसान किस्मों 'लखुरी अनार' और 'अनार' का ऑन-साइट डीयूएस लक्षण वर्णन लखुरी (वी) और बहेराडीह (वी), जांजगीर-चांपा, छत्तीसगढ़ में किया गया था।

फसल सुधार:

- 148 भौतिक रूप से मैप किए गए ट्यूनीशिया मार्करों के स्थानों की तुलना डाबेंज़ी, ताइशानहोंग और भगवा अनार की किस्मों की संपूर्ण जीनोम असेंबली से की गई थी। हमारे निष्कर्षों से पता चला है कि आठ ट्यूनीशियाई गुणसूत्रों में बिखरे हुए आम इनडेल मार्करों में भगवा (100%) और डाबेंज़ी (97.97%) असेंबली के साथ महत्वपूर्ण ऑर्थोलॉजी और सिन्टेनिक संबंध थे, इसके बाद ताइशानहोंग (97.30%) थे।
- कुल 32 एलील्स को प्रवर्धित किया गया, जिसमें प्रति जीनोटाइप में औसतन दो एलील्स थे। अपेक्षित He 0.23 से 0.50 के बीच था, जिसका औसत मान 0.42 था। PIC मान 0.24 से 0.51 तक भिन्न-भिन्न है, जिसका औसत मान 0.44 है। 16 अनार जीनोटाइप में, औसत शैनन का सूचना सूचकांक 0.61 था।
- उनके स्पष्ट प्रवर्धन प्रोफाइल के साथ 46 एसएसआर मार्करों का उपयोग किया गया था। दो मार्करों (अज्ञात स्थानों) को छोड़कर, ट्यूनीशिया के आठ गुणसूत्रों में 44 मार्करों का अच्छा वितरण पाया गया। अधिकतम 19 मार्कर chm_4 से संबंधित थे, 8 मार्कर chm_3 से, और 7 मार्कर chm_1 से संबंधित थे।

फ़सल उत्पादन:

- 0.5 मिलीग्राम/लीटर बीएपी + 0.25 मिलीग्राम/लीटर एनएए + 50 मिलीग्राम/लीटर एडेनिन सल्फेट के साथ संशोधित एमएस माध्यम ने 3.38 संख्या में साइड शूट और 4.75 जीआई के साथ उच्चतम औसत शूट वृद्धि (6.95 सेमी) का उत्पादन किया, लेकिन साइड शूट की अधिकतम संख्या (3.82) एक ही माध्यम पर लेकिन उन्नत एडेनिन सल्फेट (100 मिलीग्राम/लीटर) के साथ पंजीकृत किए गए थे।
- कटिंग में सबसे अधिक सफलता (80.0%) तने को रिंग करने और ढकने तथा कोकोपीट + वर्मीक्यूलाइट + पर्लाइट पर कटिंग लगाने से प्राप्त हुई।
- कटिंग के अंकुरण के लिए, बोरिक एसिड (1%) को IBA (500 पीपीएम) के साथ 30 मिनट तक लेने से सर्वोत्तम परिणाम (84.44%) मिले, जो कि ZnSO4 + IBA, CaCl2 + IBA, KH2PO4 + IBA और केवल IBA वाले उपचारों के बराबर था और अन्य सभी उपचारों से काफी बेहतर है। हालाँकि, 24 घंटे के लिए IAA (100 पीपीएम) और 30 मिनट (क्रमशः 14.73 और 14.99 दिन) के लिए CaCl2 (2%) + IBA (500 पीपीएम) से उपचारित कटिंग में अंकुरण के दिन सबसे पहले थे और T14 के बराबर थे (साइट्रिक एसिड 100 पीपीएम + एस्कॉर्बिक एसिड 100 पीपीएम + आईबीए 500 पीपीएम 30 मिनट के लिए) अन्य उपचारों से बेहतर थे ।
- फूलों के झड़ने के प्रबंधन के लिए 2, 4-डी सांद्रता @ 20 पीपीएम अत्यधिक फायदेमंद पाई गई। इसके अलावा, 2, 4-D@20ppm में न्यूनतम फूल गिरावट (19.8 फूल/पेड़), प्रतिशत फल गिरावट (10.67%), इसके अलावा उच्चतम फल सेट (59.12%) और फलों की संख्या (97.90 फल/पेड़) भी दर्ज की गई, और उच्चतम उपज (26.59 किग्रा/वृक्ष) प्राप्त हुई।
- वाई-ट्रेलिस प्रणाली में औसत फल का वजन (232 ग्राम/फल) और फल की उपज (14.22 किग्रा) अन्य प्रणालियों की तुलना में अधिकतम थी के बाद डबल-टी ट्रेलिस प्रणाली थी।
- विकास अवलोकनों से पता चला कि अनार की वृद्धि विभिन्न प्रकार की है। सोलापुर लाल ने सभी उपचारों में भगवा की तुलना में पेड़ की ऊंचाई, पेड़ के फैलाव, तने की परिधि और पेड़ की मात्रा के संबंध में उत्कृष्ट प्रदर्शन किया है।
- आनुवंशिक सहसंबंध विश्लेषण ने फलों के टूटने और फल के डंठल/डंठल के व्यास (0.49*) के बीच महत्वपूर्ण सकारात्मक सहसंबंध की उपस्थिति का संकेत दिया; सापेक्ष छिलके में नमी की मात्रा (0.69**)। जबकि फलों के टूटने और छिलके की झिल्ली की थर्मल स्थिरता (-0.505*) के बीच एक महत्वपूर्ण नकारात्मक सहसंबंध दर्ज किया गया था।
- जिन जीनोटाइप के फलों में छिलका थर्मल झिल्ली स्थिरता (आरटीएमएस) अधिक होती है, उनमें फलों के टूटने की संभावना कम होती है। अध्ययन किए गए जर्मप्लाज्म में, IC-1201, IC-318718 में फलों के टूटने के प्रतिरोध के साथ उच्च RTMS है।

फसल सुरक्षा:

- अनार पर लक्षित कीटों को नियंत्रित करने में मेटारिज़ियम एनिसोप्लिया और ब्यूवेरिया बैसियाना के उपयोग की आशाजनक संभावनाएँ है।
- सायनट्रानिलिप्रोल 10.26% ओडी के छिड़काव से कोकिनेलिड्स (65.32%) और (68.35%) क्राइसोपरला (ग्रब) की मृत्यु दर सबसे अधिक थी, इसलिए अनार में इस कीटनाशक का उपयोग सीमित था।
- शॉट होल बोरर (एसएचबी) बीटल से निकाले गए पांच फंगस आइसोलेट्स को फ्यूसेरियम ऑक्सीस्पोरम और पेसेलोमाइसेस मैक्सिमस के रूप में सत्यापित किया गया है।
- ईपीएन के 250-300 आईजे (संक्रामक किशोर) के टीकाकरण के परिणामस्वरूप टीकाकरण के 48 घंटे बाद ग्रीन स्टिंक बग के शिशुओं की औसत मृत्यु दर 60.75% से 64.05% और 72 घंटों के बाद 97.35% से 97.95% हो गई।
- विभिन्न उपचारों में सीओसी ने उपचार (डीएटी) के 10, 20 और 30 दिनों के बाद शॉट होल बोरर बीटल के बने रहने पर कम प्रभाव दर्ज किया। अन्य उपचार ने सहजीवी कवक विकास को रोककर बीटल के अस्तित्व और स्थायित्व को प्रभावित किया है।
- बैक्टीरियल ब्लाइट रोग के प्रभावी प्रबंधन के लिए, वर्तमान में उपयोग किया जा रहा मानक रसायन बैक्ट्रोनोल प्रभावी पाया गया है जो पहले सीज़न में रोग के संक्रमण को 48.27 जबकि दूसरे सीज़न में 62.57 तक कम करता है।
- क्षेत्र की परिस्थितियों में, स्कैब रोग के नियंत्रण के लिए, गंभीरता को कम करने के लिए उपचारों में ट्राइसाइक्लाज़ोल 18%+मैन्कोज़ेब 62% WP @ 2.5 ग्राम/लीटर और डिफ़ेनोकोनाज़ोल 12.5% + एज़ोक्सीस्ट्रोबिन 20% SC @ 2ml/l को सर्वोत्तम पाया गया।
- ज़ैंथोमोनस एक्सोनोपोडिस पीवी के नियमित विश्लेषण और पता लगाने के लिए एक किफायती, सरल, तेज़ और संस्कृति-स्वतंत्र विधि विकसित की गई थी। प्यूनिका (एक्सएपी) जो अनार में बैक्टीरियल ब्लाइट का कारण बनता है।
- इन जैव एजेंटों के विरोध का परीक्षण सेराटोसिस्टिस फिम्ब्रिएटा, फ्यूसेरियम एसपीपी सहित अनार के प्रमुख मुरझाने वाले फंगल रोगजनकों के खिलाफ किया गया था। साथ ही अन्य कवक रोगज़नक़ जैसे कि कैलोनेक्ट्रिया हॉक्सवर्थी और लासियोडिप्लोडिया थियोब्रोमे क्रमशः कॉलर रोट और स्टेम कैंकर का कारण बनते हैं और अल्टरनेरिया जैसे पत्तेदार रोगजनक भी होते हैं, और कोलेटोट्राइकम जिससे फल सड़ जाते हैं।
- इन विट्रो स्थिति के तहत सेराटोसिस्टिस फिम्ब्रिएटा का परीक्षण अनार के अन्य कवक रोगजनकों जैसे कि लैसियोडिप्लोडिया थियोब्रोमे के खिलाफ किया गया, जो अनार के तने को कैंसर पैदा करता है; कैलोनेक्ट्रिया हॉक्सवर्थी, अनार के कॉलर रॉट का रोगज़नक़ और फ्यूजेरियम एसपीपी, राजस्थान और गुजरात में अनार के कुछ बगीचों में पाया जाने वाला एक छोटा मुरझाने वाला रोगज़नक़ है।
- जैसे-जैसे कल्चरल फिल्ट्रेट की सांद्रता/एक्सपोज़र अवधि बढ़ती है, रूट नॉट नेमाटोड मृत्यु दर बढ़ती है। 2.5% सांद्रता पर, 18% मृत्यु दर देखी गई, जो एक्सपोज़र की अवधि 24 घंटे से बढ़ने पर 84% तक बढ़ गई, 48 घंटे तक. फ्लुओपाइरम 34.48% एससी के संपर्क में आने से जे2 के संपर्क में आने के 24 घंटों के भीतर 100% हो जाती है।

कटाई उपरांत प्रौद्योगिकी

- दोनों भंडारण तापमान पर संग्रहीत सूखे बीजों में 3 महीने तक कोई सूक्ष्मजीवी वृद्धि नहीं हुई। कुल एरोबिक प्लेट गिनती स्वीकार्य सीमा (5 लॉग सीएफयू/जी) से अधिक हो गई है और कुल खमीर और मोल्ड गिनती एफएसएसएआई दिशानिर्देशों के अनुसार सूखे उत्पादों के लिए स्वीकार्य सीमा (4 लॉग सीएफयू/जी) के भीतर थी।
- कमरे के तापमान पर 3 महीने की भंडारण अवधि में फ्रीज में सुखाए गए अनार पाउडर के एसी में दोगुनी कमी देखी गई।
- पेनिसिलियम एसपी और एस्परगिलस एसपी के विरुद्ध अनार के छिलके के पाउडर (8%), पोटेशियम सोर्बेट (0.1%) और कैल्शियम प्रोपियोनेट (0.5%) की इन-विट्रो एंटीफंगल गतिविधि का ज़हरीली खाद्य तकनीक का उपयोग करके मूल्यांकन किया गया था। पीपीपी ने पीएस और सीपी के समान मीडिया प्लेट पर सूक्ष्मजीवों के विकास में देरी करके एंटी-फंगल गतिविधि देखी गई।
- अनार, करोंदा और आंवला जूस की पोषण संरचना का मूल्यांकन किया गया और अनार और आंवला जूस की तुलना में करोंदा जूस में आयरन (20.87 मिलीग्राम/लीटर) अधिक पाया गया। हालाँकि, आँवला जूस (185 mg/100ml) में एस्कॉर्बिक एसिड की मात्रा सबसे अधिक पाई गई।
- अनुकूलित अनार आयरन युक्त पेय के पोषण मूल्यांकन से पता चला है कि नियंत्रण की तुलना में अनुकूलित अनार आयरन युक्त पेय में आयरन की मात्रा 31.91% और एस्कॉर्बिक एसिड की मात्रा 10.66% बढ़ गई थी।
- दालचीनी के अर्क के साथ मिलाए गए अनार के रस पर आधारित आरटीएस ने नियंत्रण और नमूने की तुलना में कुल फिनोल (45.54 मिलीग्राम जीएई/100 मिली), एंटीऑक्सीडेंट गतिविधि (68.67%) और एंटीऑक्सीडेंट क्षमता (34.83 मिलीग्राम/100 मिली) के संदर्भ अन्य मसाला अर्क में बेहतर पोषण मूल्य दिखाया दिया है।

अन्य गतिविधिया:

- केंद्र ने महाराष्ट्र, राजस्थान, छत्तीसगढ़, मध्य प्रदेश राज्यों में एससीएसपी, टीएसपी और एमजीएमजी के माध्यम से प्रदर्शन, इनपुट की आपूर्ति, मृदा स्वास्थ्य कार्ड प्रदान करने, प्रशिक्षण और तकनीकी मार्गदर्शन प्रदान करके लगभग 915 किसानों को लाभान्वित करते हुए अनार की खेती को बढ़ावा दिया है।
- आईसीएआर-एनआरसीपी ने उद्यमियों के लिए तीन प्रौद्योगिकियों का व्यावसायीकरण किया और छह प्रदर्शनियों में अपनी गतिविधि प्रदर्शित की, इसके अलावा किसानों, छात्रों और अन्य हितधारकों सहित 1200 आगंतुकों को आकर्षित किया, जिन्होंने जानकारी प्राप्त करने के लिए केंद्र का दौरा किया।
- स्वच्छ भारत अभियान, अंतर्राष्ट्रीय महिला दिवस, किसान दिवस आदि के तहत विभिन्न संस्थागत गतिविधियाँ शुरू की गई।
- केंद्र ने अनार की खेती में शामिल किसानों और विभिन्न हितधारकों के लिए कार्यशालाएं और प्रशिक्षण कार्यक्रम भी आयोजित किए। इसके अलावा, विभिन्न हितधारकों तक आईसीएआर-एनआरसीपी प्रौद्योगिकियों का प्रसार करने के लिए विभिन्न संगठनों के सहयोग से विभिन्न इंटरैक्टिव बैठकें आयोजित की गई।
- केंद्र ने सहकर्मी समीक्षा वाली पत्रिकाओं में 8 शोध पत्र (एनएएएस रेटिंग में 8), 4 पुस्तक अध्याय, 13 लोकप्रिय लेख, इसके अलावा सम्मेलनों में 12 प्रस्तुतियाँ और 2 पोस्टर प्रस्तुतियाँ प्रकाशित की हैं।
- केंद्र के वैज्ञानिकों को सर्वश्रेष्ठ मौखिक/पोस्टर प्रस्तुति पुरस्कारों के अलावा पेशेवर सोसायटी जैसे पुरस्कार/फैलोशिप से मान्यता मिली।

Executive Summary

The ICAR-National Research Centre on Pomegranate, Solapur has indispensable contribution in addressing the issues of pomegranate farmers and other stakeholders of pomegranate industry.

During the reporting period of 2023, the Centre has handled several Institutional Projects, Externally Funded Projects, three Inter-Institutional Collaborative Projects, one Schedule Castes Sub-Plan (SCSP) and one Tribal Sub-Plan (TSP) Scheme. Out of sixteen Institutional Projects, three projects have been successfully completed. The major achievements are summarized below.

Genetic Resources:

- In total 338 pomegranate germplasm accessions consisting of 171 Indigenous and 167 Exotic Collections have been maintained at the FGB of the Centre.
- Survey cum exploration has been made and collected 50 new pomegranate germplasm accessions from 38 locations of Uttarakhand. Out of which 25 were survived and will be evaluated for resistance to major biotic and abiotic stresses after proper growth and development.
- From 38 locations of Uttarakhand, 50 new germplasm were collected through survey cum exploration, and 25 out of 50 surviving germplasm are maintained in the nursery for assessing them for their resistance to major biotic and abiotic stresses.
- For import of internationally leading varieties with good fruit size and attractive colour besides wild progenitor, request has been placed to countries viz., Afghanistan, China, Iran, Israel, Italy, Morocco, Spain, Tunisia, Turkey, USA through NBPGR, New Delhi.
- Challenge inoculation of 36 germplasm of pomegranate including 32 EC and 4 IC with XAP-118 culture (10^8 pfu/ml; OD: 0.154 along with susceptible check var. Bhagawa, revealed that none of them were resistant to bacterial blight.
- Screening of hybrid population of Super Bhagawa x IC-318718 (33 F_1s) and advanced breeding lines of F_2 (490 F_2s of NRCPH-06 x Self) & 14 F_2s of NRCPH-12 x Self) & BC_1F_1 (29 BC_1F_1s of NRCPH-06 x (GXNXD)) against bacterial blight disease under challenge inoculation showed susceptible to highly susceptible reaction to BBD. The genetic variability for disease severity was observed to be narrow F1s in comparison to segregating and backcrossing population.
- EMS treated 52 individual F_2s of (NRCPH-06 x Self) and 42 F_2S of Bhagawa x Daru crosses were screened against bacterial blight and none of them was resistant. However wide variability for disease severity was observed.
- Evaluation of 25 NRCP hybrids during ninth year of planting led to the identification of one promising pomegranate hybrid NRCP H-14 for table purpose and NRCP H-4 for anardana purpose.
- The pink aril variety of pomegranate for table purpose: NRCP H-14 (PPV&FRA/ REG/2016/1748) and another pink aril variety for anardana purpose : NRCP H-4

(PPV&FRA/ REG/2016/1749) were registered with PPV & FRA, New Delhi and Registration Certificate issued (DoF: 20.10.2016; DoG: 12.12.2023).

- Morphological and biochemical changes in the early maturing variant, namely 'Solapur Taporatna' in comparison with cv. Bhagawa revealed significant increase for fruit weight, fruit volume; number of arils/fruits; 100 arils weight; fruit diameter; aril length; aril width; rind thickness; TSS; rind colour (a*) was recorded from 70th to 80th day of maturity, whereas significant increase in fruit length was observed from 80th to 90th day of maturity. Decreasing trend was observed for acidity %, significant decrease was observed at 70th to 80th day of maturity in case of early maturing variant. Significant change in aril colour was observed during 50th to 60th day of maturity in case of early variant, wherein a* value significantly increased in this period.
- One new variant of Bhagawa with attractive fruit quality parameters from Hassan District of Karnataka has been **collected** during the survey of pomegranate orchards.
- Farmer variety "Sharad King" has been **registered** and protected under PPV&FR Act 2001 with effective from 12 June, 2023.
- Field evaluation of 51 NRCP breeding lines for 18 fruit morphological and physico-chemical characters during *Ambe* bahar of 2023-24, has led to the identification of the promising genotype "H-34 G X N(F3)2/3 – 1120" with acceptable fruit traits which can be further evaluated in replicated trial for testing its yielding capacity and can also be used as parent material in genetic improvement programmes of pomegranate.
- On-Site DUS characterization of farmer varieties 'Lakhuri Anar' and 'Anaar' for stage specific 15 DUS traits was carried out at Lakhuri (V) and Baheradih (v), Janjgir-Champa, Chattisgarh.

Crop Improvement:

- The locations of the 148 physically mapped Tunisia markers were compared to those on the complete genome assemblies of the Dabenzi, Taishanhong, and Bhagawa pomegranate cultivars**.** Our findings showed that common InDel markers scattered throughout eight Tunisian chromosomes had significant orthology and syntenic relationships with Bhagawa (100%) and Dabenzi (97.97%) assemblies, followed by Taishanhong (97.30%)**.**
- A total of 32 alleles were amplified, with two alleles on average per genotype. The expected *He* ranged from 0.23 to 0.50, with a mean value of 0.42. PIC values varied from 0.24 to 0.51, with a mean value of 0.44. Among 16 pomegranate genotypes, the average Shannon's information index was 0.61.
- 46 SSR markers with their clear amplification profiles were used. A good distribution of 44 markers was found across eight chromosomes of Tunisia, with the exception of two markers (unknown locations). The maximum number of 19 markers belonged to chm_4, 8 markers to chm_3, and 7 markers to chm_1.

Crop production:

- The modified MS medium with 0.5 mg/l BAP + 0.25 mg/l NAA + 50 mg/l adenine sulphate produced the highest average shoot growth (6.95 cm) with 3.38 number of side shoots and 4.75 GI but the maximum number of side shoots (3.82) were registered on the same medium but with enhanced adenine sulphate (100 mg/l).
- The highest final cutting success (80.0 %) was obtained with ringing and covering of stem and planting of cutting on cocopeat + vermiculite + perlite.
- For the sprouting of cuttings, Boric acid (1%) with IBA (500 ppm) for 30 minutes displayed the best results (84.44%) which was at par with treatments having ZnSO4 + IBA, $CaCl_2$ + IBA, KH_2PO_4 + IBA and only IBA but significantly superior to all other treatments. However, days to shoot emergence was earliest in cuttings treated with IAA (100 ppm) for 24 hrs and $CaCl_2$ (2 %) + IBA (500 ppm) for 30 min (14.73 and 14.99 days, respectively) and were at par with T14 (Citric Acid 100 ppm + Ascorbic Acid 100 ppm + IBA 500 ppm for 30 min) but significantly earlier to other treatments.
- The 2, 4-D concentration @20ppm was found to be highly beneficial for management of flower drop. Apart from this, 2, 4-D@ 20ppm also recorded the minimum flower drop (19.8 flowers/tree), percent fruit drop (10.67%), besides highest fruit set (59.12%) and number of fruits (97.90 fruits/tree) and highest yield (26.59 kg /tree).
- The average fruit weight (232 g/fruit) and fruit yield (14.22 kg) was maximum and in Y-Trellis system followed by Double – T trellis system at normal spacing compared with other systems of training.
- Growth observations revealed that the growth of pomegranate var. Solapur Lal has excelled with respect to tree height, tree spread, stem girth and tree volume compared with Bhagwa across the treatments.
- The genetic correlation analysis indicated the presence of significant positive correlation between fruit cracking and fruit stalk/peduncle diameter (0.49*); relative rind moisture content (0.69**). While a significant negative correlation was recorded between fruit cracking and rind membrane thermal stability (-0.505*).
- Fruits of those genotypes which has higher rind thermal membrane stability (RTMS) has less percentage of fruit cracking chances. Among the studied germplasm, IC-1201, IC-318718 has higher RTMS with resistance to fruit cracking.

Crop Protection:

- Promising potential for the utilization of *Metarrhizium anisopliae* and *Beauveria bassiana* in controlling the targeted insect pests on pomegranate.
- Spraying of Cyantraniliprole 10.26% OD had the highest percent mortality of Coccinellids (65.32%) and (68.35%) Chrysoperla (grubs) therefore limited use of this insecticide in pomegranate.
- Five fungus isolates extracted from the shot hole borer (SHB) beetle have been verified as *Fusarium oxysporum* and *Pacelomyces maximus*.
- An inoculation of 250-300 IJs (Infective Juveniles) of EPN resulted in an average percentage mortality of 60.75% to 64.05% for nymphs of the green stink bug 48 hours after inoculation, and 97.35% to 97.95% after 72 hours.

- Among the various treatment COC recorded less effect on the perpetuation of the shot hole borer beetle 10, 20 and 30 days after treatment (DAT). The other treatment has affected the survival and perpetuation of the beetle by inhibiting the symbiotic fungal growth.
- For effective management of Bacterial blight disease, standard chemical being currently used Bactronol was found to be effective which reduces disease infestation by 48.27 in first season whereas 62.57 in the second season.
- Under field conditions, for the control of Scab disease, Tricyclazole 18 %+Mancozeb 62 % WP @ 2.5 g/l and Difenoconazole 12.5 % + Azoxystrobin 20 % SC @ 2ml/l were found best among the treatments in reducing the severity.
- An economical, simple, rapid, and culture-independent method was developed for routine analyses and detection of *Xanthomonas axonopodis* pv. *punicae* (Xap) that causes bacterial blight in pomegranate.
- Antagonism of these bio agents was tested against the major wilt causing fungal pathogens of pomegranate including *Ceratocystis fimbriata*, *Fusarium* spp. as well as other fungal pathogens such as *Calonectria hawksworthi* and *Lasiodiplodia theobromae* causing collar rot and stem canker respectively and also foliar pathogens such as *Alternaria* spp. and *Colletotrichum* spp. causing fruit rots.
- *Ceratocystis fimbriata* under *in vitro* condition were tested against other fungal pathogens of pomegranate such as *Lasiodiplodia theobromae* causing stem canker of pomegranate; *Calonectria hawksworthii,* pathogen of Collar rot of pomegranate and *Fusarium spp*, a minor wilt pathogen observed in some of the orchards in pomegranate in Rajasthan and Gujarat.
- Root knot nematode mortality increases as concentration of cultural filtrate / exposure duration increases. At 2.5% concentration, 18% mortality observed, which increased to 84% when exposure duration is increased from 24 hrs. to 48 hrs. Exposure to Fluopyrum 34.48% SC cause 100% morality within 24 hrs of J2 exposure.

Post-Harvest Technology

- There was no microbial growth up to 3 months in dried arils stored at both storage temperature. The total aerobic plate count has exceeded the acceptable limits (5 log cfu/g) and the total yeast and mold count was within acceptable limit (4 log cfu/g) for dried products as per FSSAI guidelines.
- A twofold decrease in AC was observed for freeze dried pomegranate powder over a storage period of 3 months at room temperature.
- The *in-vitro* antifungal activity of pomegranate peel powder (8%), potassium sorbate (0.1%) and calcium propionate (0.5%) was assessed against *Penicillium* sp. and *Aspergillus* sp. using poison food technique. The PPP showed the anti-fungal activity by delaying the growth of microorganism on media plate similar to the PS and CP.
- The nutritional composition of pomegranate, karonda and aonla juice were evaluated and karonda juice was found rich in iron (20.87mg/l) as compared to pomegranate and aonla juice. However, ascorbic acid content was found highest in aonla juice (185 mg/100ml).

- The nutritional evaluation of the optimized pomegranate iron rich drink showed that, the iron content was increased by 31.91% and ascorbic acid content by 10.66% as compared to control.
- The pomegranate juice based RTS added with cinnamon extract showed the improved nutritional value in terms of the total phenols (45.54 mg GAE/100ml), antioxidant activity (68.67%) and antioxidant capacity (34.83mg/100ml) as compared to control and sample with other spice extract.

Others activities

- The Centre has taken up promotion of pomegranate cultivation in the states of Maharashtra, Rajasthan, Chhattisgarh, Madhya Pradesh through SCSP, TSP and MGMG through demonstration, supplying inputs, providing Soil Health Card, imparting trainings and technical guidance benefitting around 915 farmers.
- ICAR-NRCP **commercialized three** technologies to entrepreneurs and displayed its activity in six exhibitions besides attracting 1200 visitors including farmers, students and other stakeholders who visited the centre for seeking information.
- Various institutional activities were undertaken under Swachch Bharat Abhiyan, International Women's Day, Farmers' Day etc.
- The Centre also organized workshops and training programmes for farmers and various stakeholders involved in pomegranate cultivation. Apart from this, various interactive meetings were conducted in collaboration with different organizations to disseminate the ICAR-NRCP technologies to different stake holders.
- The Centre has published 8 research papers in peer reviewed journals (8 in > 10 NAAS rating), 3 book chapters, 13 popular articles, besides 12 presentations in conferences and 2 poster presentations.
- Scientists of the centre got recognitions from professional Societies viz., Awards/ Fellowships, besides best oral / poster presentation awards.

Research Programmes & Projects

INSTITUTE RESEARCH PROJECTS

S. No.	Project Title	PI	Co-PIs	Status	Duration DoS-DoE
1.	Breeding for bacterial blight resistance in pomegranate	Dr. Shilpa P.	Dr. Jyotsana Sharma, Dr. K. Dhinesh Babu, Dr. Prakash G. Patil, Dr. P. Roopa Sowjanya, Dr. Nilesh N. Gaikwad, Dr. Pinky Raigond	Ongoing	(1/08/2019-31/07/2024)
2.	Draft genome sequencing of pomegranate (*Punica granatum* L.) cv. Bhagwa	Dr. P. Roopa Sowjanya	Dr. N. V. Singh, Dr. Prakash G. Patil, Dr. Shilpa Parashuram	Ongoing	(21/02/2017-20/01/2025)
3.	Development of genetic resources resistant to wilt complex in pomegranate	Dr. P. Roopa Sowjanya	Dr. K. Dhinesh Babu, Dr. Manjunatha N, Dr. Somnath Pokhare, Dr. Shilpa Parashuram, Dr. R. A. Marathe	Ongoing	(01/09/2022-31/8/2027)
4.	Genetic mapping of bacterial blight and fruit quality traits in pomegranate	Dr. Prakash G. Patil	Dr. J. Sharma, Dr. Shilpa P, Dr. N. V. Singh, Dr. K. Dhinesh Babu	Completed	(01/01/2018-31/01/2023)
5.	Combating stresses and improving quality in pomegranate (*Punica granatum* L.) by exploiting rootstocks	Dr. Chandrakant Awachare	Dr. P. Roopa Sowjanya, Dr. Prakash G. Patil, Dr. Manjunatha N,	Ongoing	(20/08/2020-19/08/2025)

			Dr. K. Dhinesh Babu, Dr. Somnath Pokhare, Dr. Chandrakant Awachare, Dr. R.A. Marathe		
6.	Crop regulation practices for improving productivity of pomegranate	Dr. K. Dhinesh Babu	Dr. N.V. Singh, Dr. Sharma J.	Completed	(01/04/2018-31/12/2023)
7.	Package of practices for organic cultivation of pomegranate	Dr. J. Sharma	Dr. Gaikwad N.N, Dr. Mallikarjun, H.	Ongoing	(01/08/2018-31/07/2024)
8.	Post-harvest management and value addition in pomegranate for entrepreneurship development	Dr. Gaikwad N.N.	Dr. Namrata Giri, Dr. K. Dhinesh Babu,	Ongoing	(01/07/2019-30/06/2024)
9.	Development of functional food products and waste utilization from pomegranate.	Dr. Namrata A. Giri	Dr. Nilesh N. Gaikwad, Dr. Manjunatha N, Dr. Pinky Raigond	Ongoing	(20/08/2020-31/07/2025)
10.	Development of technologies for sustainable management of important insect pest of pomegranate	Dr. Mallikarjun M.H	Dr. Manjunatha N, Dr. Somnath S. Pokhare, Dr. Rajiv A. Marathe	Ongoing	(01/09/2020-31/08/2025)
11.	Studies on wilt complex in pomegranate	Dr. Somnath Pokhare	Dr. Manjunatha N, Dr.Mallikarjun M. H, Dr. R. A. Marathe	Ongoing	(01/01/2021-31/12/2026)

12.	Epidemiology and sustainable management of economically important phylloplane diseases of pomegranate	Dr. Manjunatha N.	Dr. Jyotsana Sharma, Dr. Somnath S. Pokhare, Dr. Mallikarjun M. H, Dr. Prakash G. Patil, Dr. Maity A, Dr. R. A. Marathe	Ongoing	(01/01/2021-31/12/2026)
13.	Flagship project on Integrated approach to eradicate bacterial blight	Dr. Jyotsana Sharma	Dr.N.V.Singh, Dr.Shilpa P, Dr.K. Dhinesh Babu, Dr.Prakash G. Patil, Dr. Kumar A, IARI, New Delhi, Dr.Manjunatha N, Dr. Mestha R. K, UHS, Bagalkot	Completed	(01/10/2014-31/12/2023)
14.	Biotic stress induced biochemical and epigenetic changes associated with major insect pest and diseases in diverse pomegranate (*Punica granatum* L.) genotypes	Mr. Rahul Damale	Dr. R. A. Marathe, Dr. Shilpa P, Dr. N. V. Singh, Dr. K. Dhinesh Babu, Dr. Mallikarjun Harsur, Dr. Manjunatha N, Dr. Pinky Raigond	Ongoing	(01/06/2021-31-05/2026)
15.	Canopy architecture management and high density planting in pomegranate	Dr. Chandrakant Awachare	Dr. N.V. Singh, Dr. R.A. Marathe, Dr. K.D. Babu, Dr. Pinky Raigond	Ongoing	(01/01/2022-31/12/2025)

16	Fertigation scheduling of major nutrient with reference to crop-soil environment in pomegranate cv.Bhagwa	Dr. P.S. Shirgure	Dr. K.D. Babu Dr. Manjunatha N, Dr. Mallikarjun H	Ongoing	(01/09/2022-31/08/2026)

INTER-INSTITUTIONAL COLLABORATIVE PROJECTS

S. No.	Project Title	Collaborative Institute	PI	Co-PIs	Status	Duration DoS-DoE
1.	Unraveling the mechanism and developing mitigation strategies for aril browning and fruit cracking in pomegranate	ICAR-NIASM, Baramati	Dr. Pinky Raigond	Dr. N.V. Singh, Dr. Shilpa Parashuram, Dr. K. Dhinesh Babu, Dr. R.A. Marathe, Mr.Rahul Damale, Dr. Namrata Giri	Ongoing	(01/02/2019-31/12/2024)
2.	Valorization of fruit and vegetable wastes for aquafeed	ICAR - Central Institute of Fisheries Education, Mumbai, Maharashtra	Dr. Shamna N.	Parimal Sardar, Ashutosh D. Deo, Manish Jayant, Subodh Gupta, Md. Aklakur, Babitha Rani A.M, Manjusha L, Jeena K, Namrata A. Giri	Ongoing	(2022-2025)

3.	Introduction and evaluation of pomegranate germplasm in Humid and Sub-humid regions of Uttarakhand, India	ICAR – Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand	Dr. Shilpa P, Dr. R. A. Marathe (Project Director), Dr. Lakshmikant (Project Director)	Dr. Roopa Sowjanya P, Dr. Manjunatha N, Dr. Chandrakant Awachare, Dr. N. K. Hedau, Dr. Rahul Dev	Ongoing	(2023-2028)

SCHEDULED CASTES SUB-PLAN

S. No.	Project title	PI	Co-PI	Status
1.	Schedule Caste Sub Plan	Dr. Pinky Raigond (Jan-June 2023) Dr. Chandrakant Awachare (July-Dec 2023)	Dr. Shilpa P, Mr. Mahadev S. Gogaon, Dr. Mallikarjun, Dr.Chandrakant C, Dr. Shilpa P, Mr. Mahadev S. Gogaon, Mr. R.B.Rai, Mr. V. Shinde	Ongoing

TRIBAL SUB-PLAN

S. No.	Project title	PI	Co-PIs	Status
1.	Schedule Tribe Component	Dr. Mallikarjun M. H	Dr. Shilpa Parashuram, Mr. Rahul Damale	Ongoing (12.0 Lakh)

EXTERNALLY FUNDED PROJECTS

S. No	Funding agency	Project Title	PI	Co-PIs	Status	Duration DoS-DoE & Amount (Lakhs)
1.	ICAR	ICAR-All India Coordinated Research Project on Arid Zone Fruits	Dr. K. Dhinesh Babu	Dr. N.V. Singh, Dr. Mallikarjun M.H	Ongoing	01.04.2015 - Ongoing
2.	Commisionerate of Agriculture (Horticulture Department, Govt.of MS Pune.)	Horticulture Crop Pest Surveillance and Advisory Project (HORTSAP), Sub Scheme under Crop Surveillance and Advisory Project (Scheme CROPSAP)	Dr. Mallikarjun M.H	Dr. Manjunatha, N	Ongoing	2023 (8.0)
3.	RKVY, Govt. India, Maharashtra	Setting up of biocontrol production laboratory to demonstrate and popularize the use of biocontrol agents for sustainable pest management in pomegranate	Project Director: Dr. R. A. Marathe, PI: Dr. Mallikarjun M.H	Dr. Manjunatha N, Dr. Somnath Pokhare	Ongoing	2023-2025 (346.8)
4.	RKVY, Govt. India, MS	Establishment of Plant Health Clinic in pomegranate growing regions of Maharashtra	Dr. Manjunatha N	Dr. Somnath Pokhare, Dr. Mallikarjun M.H	Ongoing	2023-2025 (311.10)
5.	ADB funded MAGNET Project of MSAMB, Govt. of MS	Development and evaluation of spray and freeze dried pomegranate juice powder and its reconstitution	Project Director: Dr. R. A. Marathe, PI: Dr. Nilesh Gaikwad	Dr. Namrata Giri	Ongoing	2023-2025 (49.92)

6.	DST - SERB , GOI	Genome wide association mapping in Pomegranate to identify novel genes	Dr. P. Roopa Sowjanya	Dr. NV Singh, Dr. Manjunatha N, Dr. Shilpa Parashuram	Ongoing	24/8/2022 - 23/8/2025 (49,97)
7.	DAE – BRNS , GOI	Induced mutagenesis in pomegranate for biotic stress resistance	Dr. P. Roopa Sowjanya	Dr. Suvendu Madal, BARC (Program Collaborator)	Ongoing	1/6/2022- 31/3/2025 (27,77)
8.	PPV&FR A, New Delhi	Establishment of DUS centre at ICAR-NRCP, Solapur	Dr. Shilpa P.	Dr. Roopa P. Sowjanya	Ongoing	2011- Ongoing (7.70)
9.	ADB funded MAGNE T Project Governm ent of Maharash tra	Evaluation and identification of new exportable varieties in pomegranate (*Punica granatum* L.)	Dr. Shilpa P	Dr. R. A. Marathe, Dr. K. Dhinesh Babu, Dr. Pinky Raigond, Dr. Manjunatha N, Dr. Mallikarjun M. H	Ongoing	01/04/2023 - 31/03/2026 (50 lakhs)
10.	ICAR	National Agriculture Innovation Fund	Dr. Nilesh N. Gaikwad	-	Ongoing	2021-2026 (9.15)
11.	RCF Nano Urea (NU)	Evaluation of RCF Nano Urea (NU) using fertigation and foliar techniques on growth, yield and fruit quality of Pomegranate	PD:RA Marathe, Director PI: Dr. P.S.Shirgur e	Dr.K.Dhines h Babu	Ongoing	Duration (Oct 2022 to Sept 2024) Budget 29.42

CONTRACTUAL RESEARCH PROJECTS

S. No	Funding agency	Project Title	PI	Co-PIs	Status	Duration DoS-DoE & Amount (Lakhs)
1.	Bayer Crop Science Pvt. Ltd.	Evaluation of Spirotetramat 150 g/L OD for bio-efficacy against thrips in pomegranate	Dr. Mallikarjun M.H	Dr. K. Dhinesh Babu, Dr. R.A. Marathe	Ongoing	2022-2024 (22.84)
2.	Bayer Crop Science Pvt. Ltd.	Evaluation of Betacyfluthrin 90 G/L + Imidacloprid 210 G/L OD (Solomon) for bio-efficacy against thrips and aphids in pomegranate	Dr. Mallikarjun M.H	Dr. K. Dhinesh Babu, Dr. R.A. Marathe	Ongoing	2023-2025 (23.63)
3.	Tessenderlo Kerley India Private Limited, Gurgaon, Haryana	Study the effect of Surround-WP® foliar sprays on preventing sunburn and cracking for increasing quality fruit yield of pomegranate	Dr. Chandrakant Awachare	-	Ongoing	Duration Budget: (24.65)
4.	Contract Research Project funded by Willowood Chemical Limited, New Delhi.	Evaluation of bio-efficacy and phyto-toxicity of □-Sitosterol & Stigmasterol 0.05% DF (WILBOND) on Pomegranate crop	Dr. Pinky Raigond	-	Ongoing	Duration 2023-24 Budget: (10.05)
5.	Smartchem Technologies LTD.	Response of customized WSF (Water Soluble Fertilizers) Grades on growth, yield & Quality of Pomegranate	Dr. R.A. Marathe	Dr.P.S.Shirgure Dr.K.Dhinesh Babu, Shri.D.T. Chaudhari	Ongoing	Duration (01/02/.2023 to 01/02/2025) Budget: 29.65 Lakh
6.	Bayer Crop Science LTD.	Efficacy evaluation of fluopicolide 62.5G/propamocarb hydrochloride 625 G/L SC (Infinito) on Pomegranate fungal fruit rots	Dr. Manjunatha N	Dr. Somnath Pokhare, Shri. Vijay Lokhande	Ongoing	Duration 01/07/2023-30/06/2025 Budget: 23.39 Lakh

7.	Sponsored by UPL Pvt Ltd	Bio-efficacy evaluation of fungicides AVANCER GLOW (Azoxystrobin 8.3% + Mancozeb 66.7% WG) and CUPROFIX DISPERSS (Copper sulphate 47.15%+Mancozeb 30% WG) against disease complex of pomegranate	Dr. Manjunatha N.	Dr. Somnath Pokhare	Completed	(2021-2023) 31.0 Lakh
8.	Sponsored by Fertis India Pvt Ltd	Bio-efficacy of EcoLaid freedom Microbicide against bacterial blight of pomegranate	Dr. Manjunatha N.	Dr. Somnath Pokhare	Completed	(2021-2023) 17.8 lakhs
9.	Bayer Crop Science Pvt. Ltd.	Evaluation of products (i) Isotinail 7 % +Fosetyl Al 70 % WG (Tiviant) (ii) Fluopyram 250 G/L+ Trifloxystrobin 250 G/L SC (Luna sensation) for bio-efficacy against bacterial and fungal diseases of pomegranate	Dr. Manjunatha N.	-	Completed	2021-2023 36.27 lakhs
10.	Bayer crop science Pvt. Ltd.	Evaluation of IDIPM schedules using new molecules for export quality pomegranate production And Demonstration of Bayer's plant protection schedules on model pomegranate orchard for quality production	Dr. Jyotsana Sharma Dr. Chandrakant Awachare	Dr. Manjunatha N.	Ongoing	2022-2024 42.82 lakhs
11.	UPL Pvt.Ltd.	Management modules of pomegranate foliar and fruit disease using new fungicide molecules	Dr. Manjunatha N.	Dr. Somnath Pokhare	ongoing	2023-2025 31.3 lakhs

12.	Bayer Pvt Ltd.	Efficacy evaluation of fluopicolide 62.5G/Propamocarb hydrochloride 62.5G/L SC (Infinito) on pomegranate fungal fruit rots	Dr. Manjunatha N.		ongoing	2023-2025 23.40 lakhs
13.	Indofil Pvt.Ltd.	Evaluation of bio-efficacy and phytotoxicity of IFFC010 (Triazoles+carbamate group) against fungal elaf and fruit disease complex in pomegranate	Dr. Manjunatha N.		ongoing	2022-2024 18.53 lakhs

1. Crop Improvement

1.1 PROJECT: IDENTIFICATION OF PROMISING HYBRIDS FOR TABLE AND PROCESSING PURPOSE

1.1.1 *Development and/or evaluation of hybrids developed at ICAR-NRCP,* Solapur

1.1.1.1 Hybridization between commercial varieties and elite lines having less incidence of bacterial blight

Four elite lines P-5, P-16, IC-318716 and IC-318718 were selected from the germplasm and involved in hybridization programme. Among these, IC-318716, IC-318718 (0.70%) has showed moderately resistant reaction to BBD severity (%), while P-5 (27%), P-16 (31%) showed less BBD severity as compared to other commercial varieties that are crossed with the few selected commercial varieties i.e. Super Bhagawa, Kandhari Seedless, Sharad King, and Solapur Taporatna etc.

1.1.1.2 Evaluation of hybrids developed from ICAR-NRCP

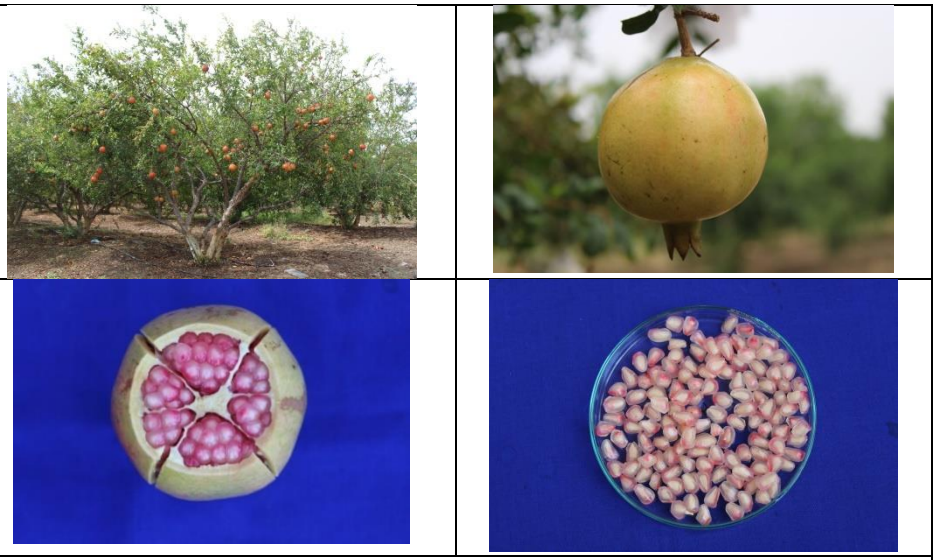
Evaluation of nine NRCP hybrids during eighth year of planting led to the identification of one promising pomegranate hybrid NRCP H-14 for table purpose.

Table 1.1 Evaluation of sweet type NRCP hybrids for yield and quality parameters

Hybrid	No. of fruits /tree	Fruit weight (g)	Fruit yield (kg/tree)	100 Aril weight (g)	Rind thickness (mm)	TSS (°Brix)	Acidity (%)
NRCP H-2	101.4	284.5	28.85	29.5	3.2	16.2	0.51
NRCP H-5	115.2	278.5	32.08	30.5	2.85	16	0.45
NRCP H-6	135	276	37.26	40.2	3.3	17.6	0.4
NRCP H-8	108.6	288	31.28	36.4	3.7	17.8	0.72
NRCP H-10	120.4	275.2	33.13	30.8	2.84	16.5	0.45
NRCP H-14	125.8	281.2	35.37	32.8	2.8	17.8	0.41
NRCP H-19	103.2	265.8	27.43	30.4	2.72	15.3	0.58
NRCP H-22	118	275.5	32.51	35.8	3.2	16.4	0.46
NRCP H-24	126.2	276.5	34.89	36.9	3.22	16.9	0.4
Bhagawa (Check var.)	89.6	284.5	25.49	35.6	3.24	15.6	0.45

Table 1.2 The salient features of pomegranate hybrid NRCP H-14 as compared to Bhagawa

Parameter	NRCP H-14	Bhagawa
Maturity (days)	165.0	180.2
No. of fruits/plant	125.2	89.6
Fruit weight (g)	281.2	284.5
Fruit yield (kg/plant)	35.37	25.49
100 Aril weight (g)	32.8	35.6
TSS (°Brix)	17.8	15.6
Titrable acidity (%)	0.41	0.45
Vitamin C (mg/100g)	19.0	14.0
Anthocyanin (mg/100g)	127.6	352.4



NRCP H-14

Fig 1.1 Pomegranate hybrid NRCP H-14

Evaluation of 16 NRCP hybrids during eighth year of planting led to the identification of NRCP H-4 for anardana purpose.

Table 1.3 Evaluation of sour type NRCP hybrids for yield and quality parameters

Hybrid	No. of fruits /tree	Fruit weight (g)	Fruit yield (kg/Tree)	100 Aril weight (g)	Rind thickness (mm)	TSS (°Brix)	Acidity (%)
NRCP H-1	104.5	280.4	29.30	34.6	3.92	17.4	3.56
NRCP H-3	140.2	262.5	36.80	33.2	3.30	17.1	3.12
NRCP H-4	120.4	278.5	33.53	30.0	3.00	15.9	5.60
NRCP H-7	111.2	258.0	28.69	41.0	2.98	16.8	1.06
NRCP H-9	113.0	270.4	30.56	36.7	3.78	16.0	2.70
NRCP H-11	102.4	273.4	28.00	30.9	3.11	15.6	4.32
NRCP H-12	112.0	276.0	30.91	40.8	3.10	16.8	4.80
NRCP H-13	108.2	274.3	29.68	41.0	3.50	17.9	2.10
NRCP H-15	109.0	281.4	30.67	36.8	2.84	15.8	3.54
NRCP H-16	117.2	273.2	32.02	35.8	3.13	15.9	2.36
NRCP H-17	114.0	262.4	29.91	37.0	2.96	16.6	2.30
NRCP H-18	108.2	287.2	31.08	41.6	2.80	17.4	2.90
NRCP H-20	102.4	270.2	27.67	33.2	3.36	16.4	1.60
NRCP H-21	120.4	269.4	32.44	33.6	3.12	16.4	3.40
NRCP H-23	120.4	268.2	32.29	33.4	3.14	16.6	3.48
NRCP H-25	124.2	278.2	34.55	34.2	3.16	16.7	3.56
Amlidana (Check var.)	67.6	232.0	15.68	36.4	2.84	15.7	4.20

Table 1.4 The salient characters of pomegranate hybrid NRCP H-4 as compared to Amlidana

Parameter	NRCP H-4	Amlidana
Maturity (days)	140.4	145.2
No. of fruits/plant	120.4	67.6
Fruit weight (g)	278.5	232.0
Fruit yield (kg/plant)	33.53	15.68
100 aril weight (g)	30.0	36.4
TSS (^{0}Brix)	15.9	15.8
Titrable acidity (%)	5.60	4.20
Vitamin C (mg/100g)	18.9	14.6
Anthocyanin (mg/100g)	65.8	68.5

NRCP H-4

Fig 1.2 Pomegranate hybrid NRCP H-4

Table 1.5. Registration details of NRCP pomegranate varieties with PPV &FRA

Variety	Solapur Lal (NRCP H-6)	Solapur Anardana (NRCP H-12)	NRCP H-14	NRCP H-4
Date of filing	20/10/2016	20/10/2016	20/10/2016	20/10/2016
Date of grant	24/02/2021	24/02/2021	12/12/2023	12/12/2023
Registration	PPV&FRA/ REG/1747	PPV&FRA/ REG/1750	PPV&FRA/ REG/1748	PPV&FRA/ REG/1749
Purpose	Table Purpose	Anardana Purpose	Table Purpose	Anardana Purpose

1.1.1.3 Evaluation of early maturing variety for morphological and physiological parameters in pomegranate

Morphological and biochemical changes in the early maturing variant (Solapur Taporatna) has been studied by comparing with cv. Bhagawa. Early Bhagawa showed significant increase for fruit weight, fruit volume; number of arils/fruit; 100 arils weight; fruit diameter; aril length; aril width; rind thickness; TSS; rind colour (a*) when recorded from 70th to 80th day of maturity. While significant increase in fruit length was observed from 80th to 90th day of maturity. For acidity %, significant decrease was observed at 70th to 80th day of maturity in case of early maturing variant.

Significant change in aril colour was observed during 50th to 60th day of maturity in case of early variant, wherein a* value significantly increased in this period.

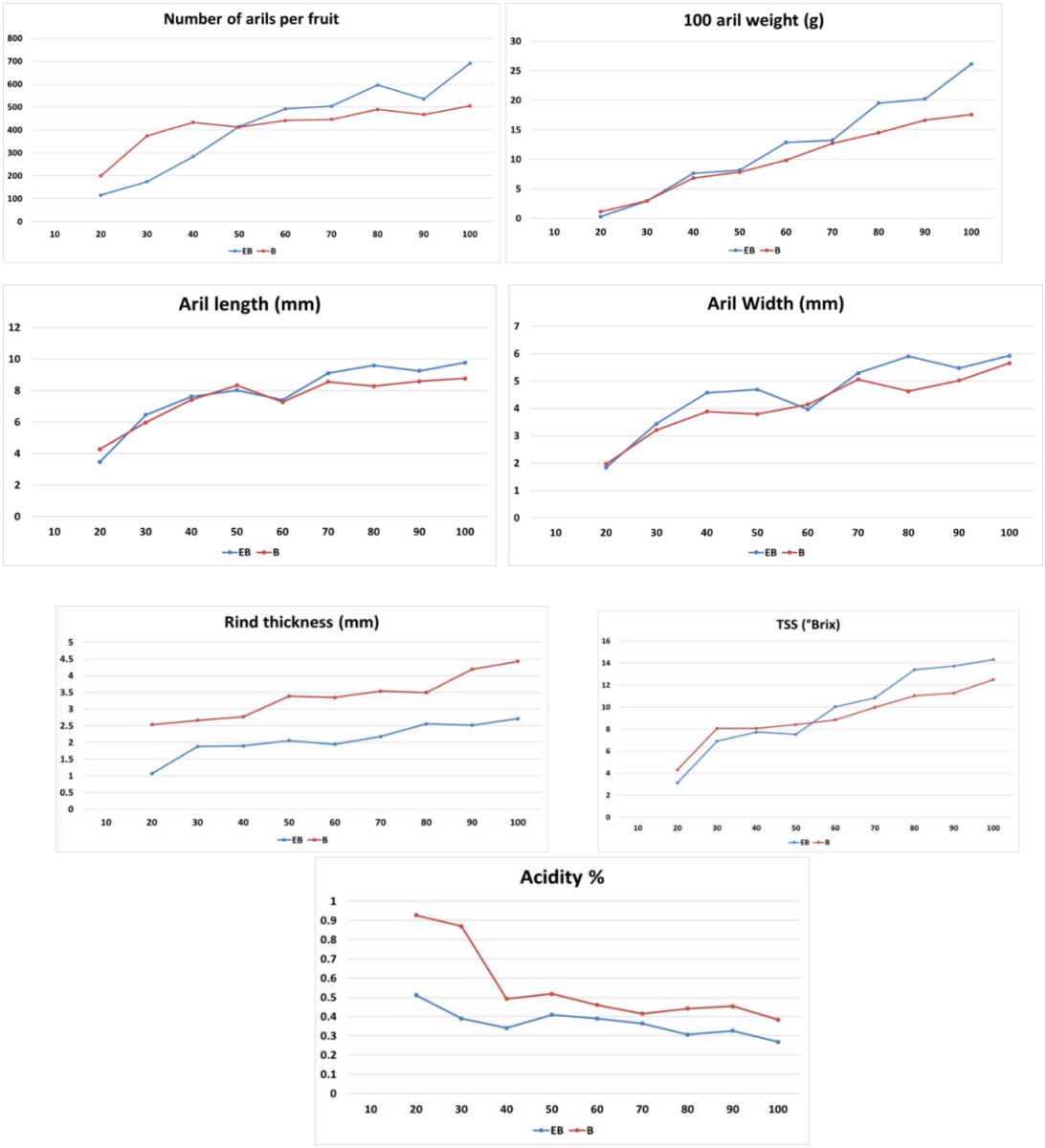
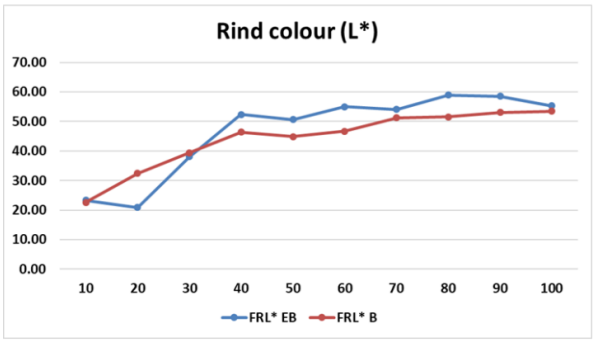
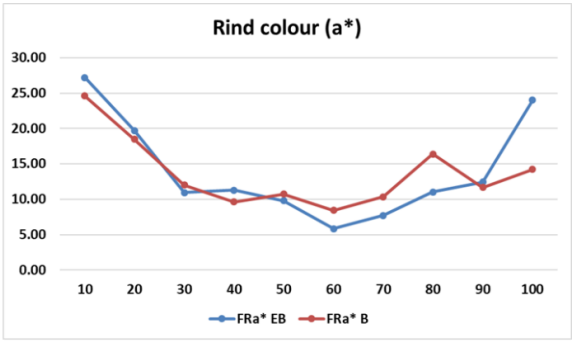


Fig 1.3 Fruit morphological changes in pomegranate





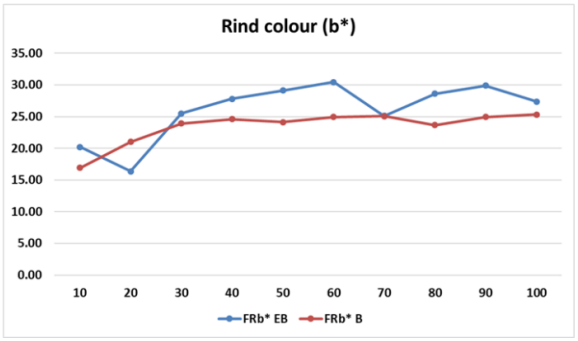
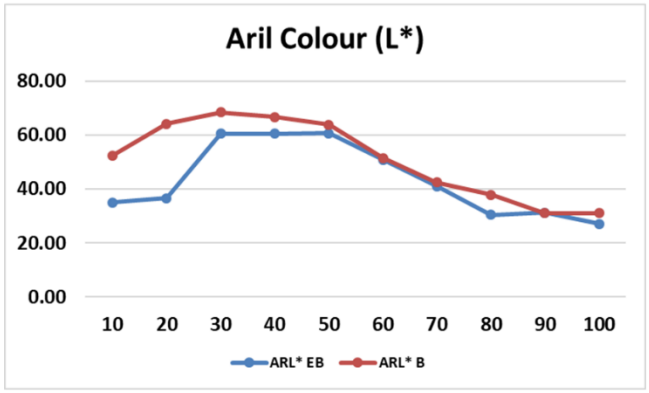
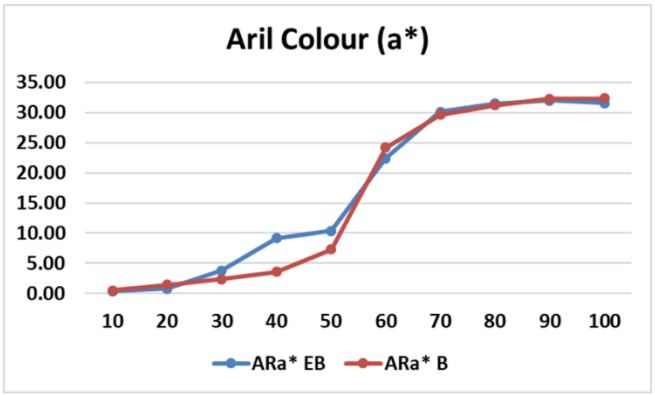


Fig 1.4 Fruit rind changes in pomegranate





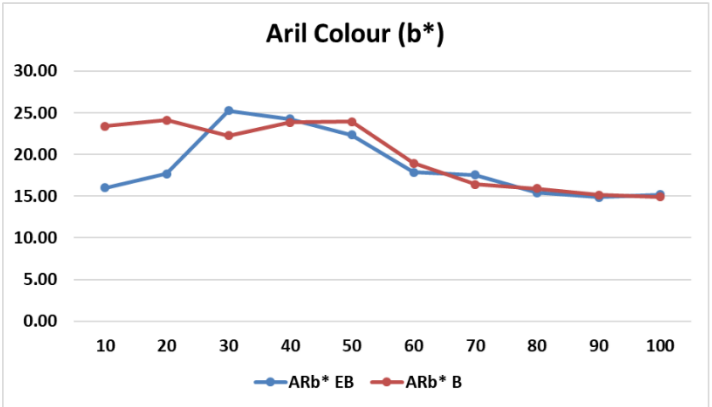


Fig1.5 Aril colour changes in pomegranate

1.1.1.4.Biochemical changes in Bhagawa and Early type Bhagawa during fruit growth and maturity

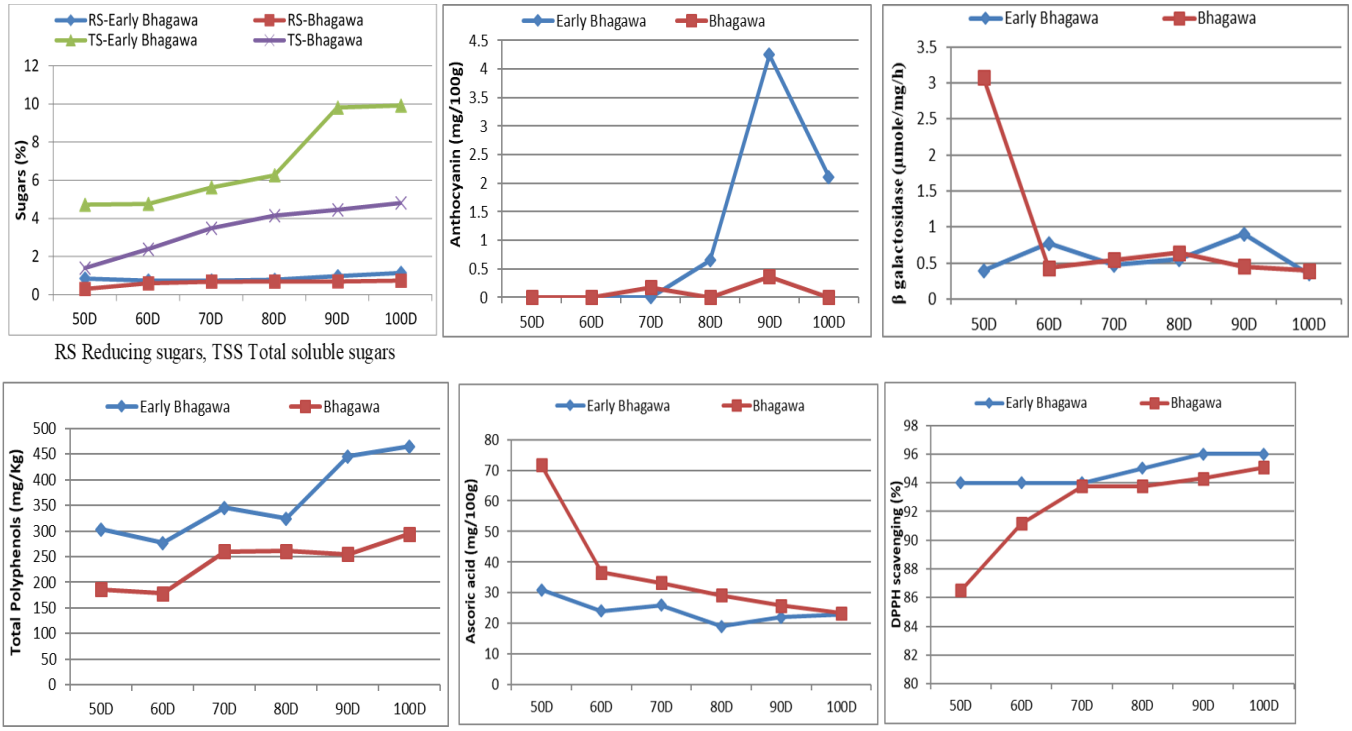


Fig 1.6 Biochemical changes in Bhagawa and Early type Bhagawa during fruit growth and maturity

Solapur Taporatna

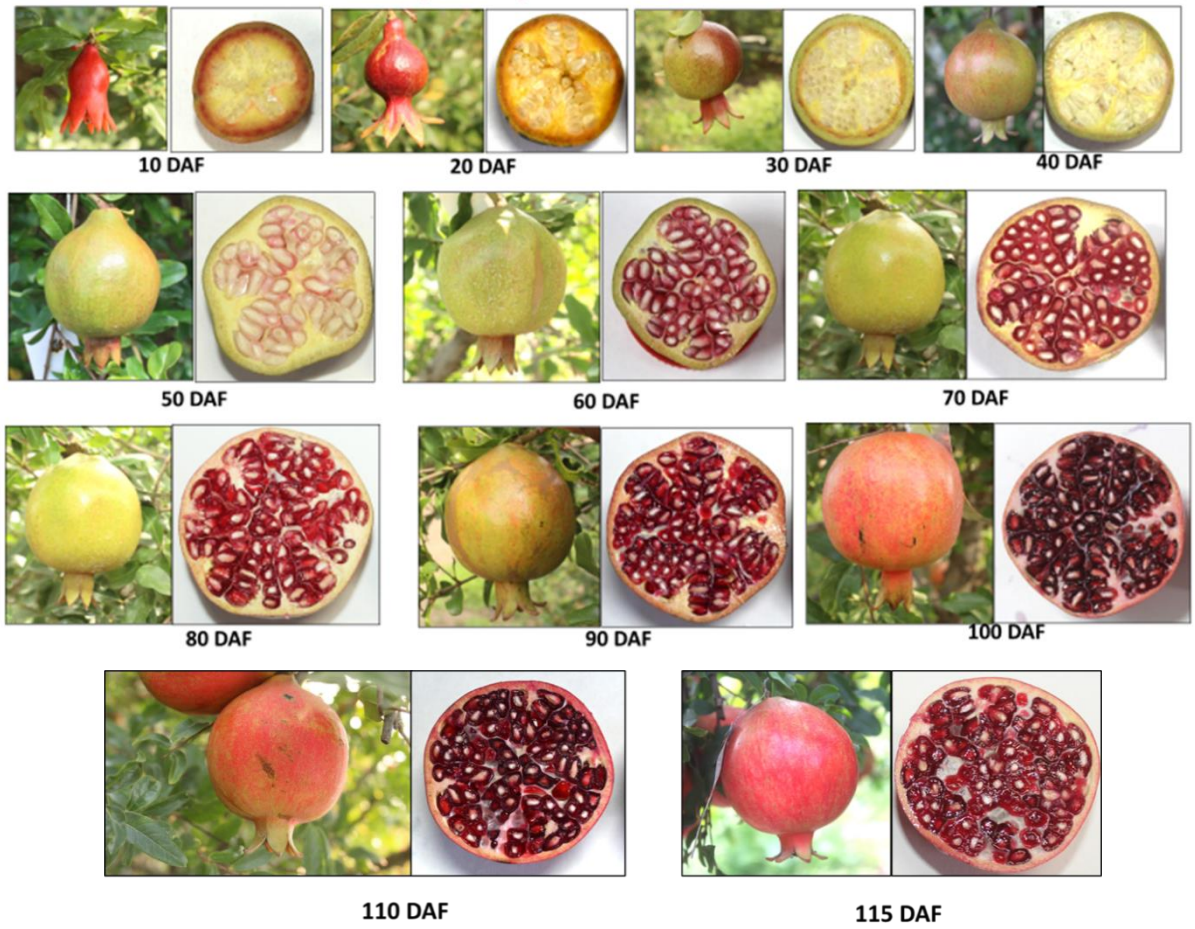


Fig.1.7 Biochemical changes in Solapur Taporatna during fruit growth and maturity

Bhagawa

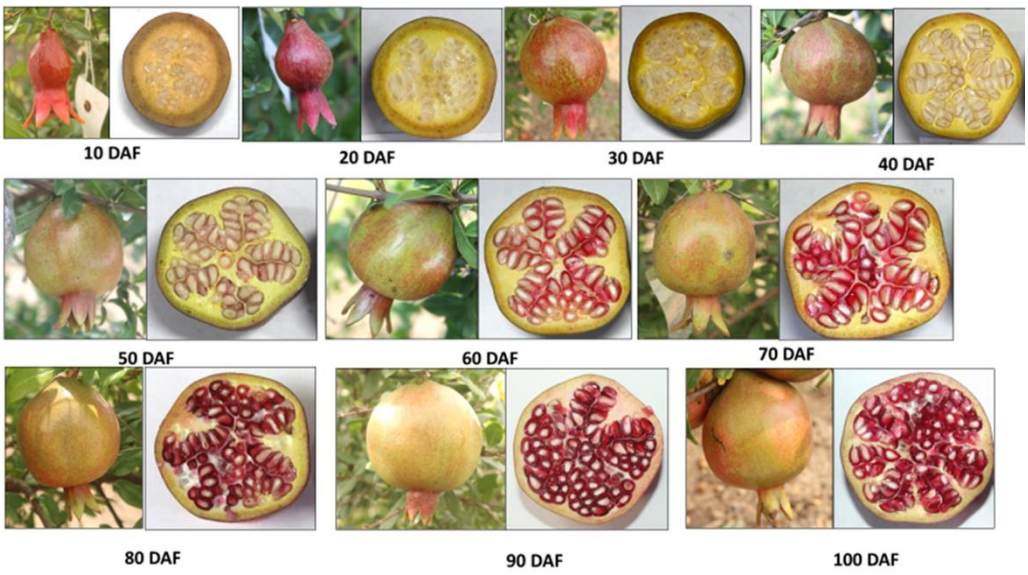


Fig.1.8 Biochemical changes in Bhagawa during fruit growth and maturity

1.2 PROJECT: BREEDING FOR BACTERIAL BLIGHT RESISTANCE IN POMEGRANATE (*Punica granatum* L.)

1.2.1 Survey and Collection of New pomegranate germplasm

Survey cum exploration has been made and collected 50 new pomegranate germplasm accessions from 38 locations of Uttarakhand. Out 50 accessions 25were successfully sprouted which will be evaluated for resistance to various biotic and abiotic stresses after their proper growth and development.

Fig. 1.9 Germplasm survivability at 64 days after planting

Fig. 1.10 Survey and collection of pomegranate germplasm from different locations of Uttarakhand

1.2.1 Screening of pomegranate germplasm and breeding materials against BBD

1.2.2.1 Screening of Indigenous & Exotic germplasm of pomegranate accessions against BBD

- A total 36 germplasm accessions including 32 exotic accessions and 4 indigenous accessions were evaluated for their genetic reaction to bacterial blight disease under challenge inoculation to against XAP-118 culture (108 pfu/ml; OD: 0.154) and compared with the susceptible check variety "Bhagawa". All the germplasm has showed susceptible to highly susceptible reaction with incidence % ranging from 93.6-100% and severity grade from 3.6- 5.

Table 1.6 Screening of Indigenous & Exotic germplasm of pomegranate accessions against BBD

Statistical parameters	BBD Incidence%	BBD Severity Grade
Mean	98.85	4.28
Min	93.60	3.60
Max	100.00	5.00
SD	1.56	0.33
CV%	1.58	7.82
SEm	0.26	0.06
Fprob	0.016*	0.44
CD (0.05)	9.44	NS

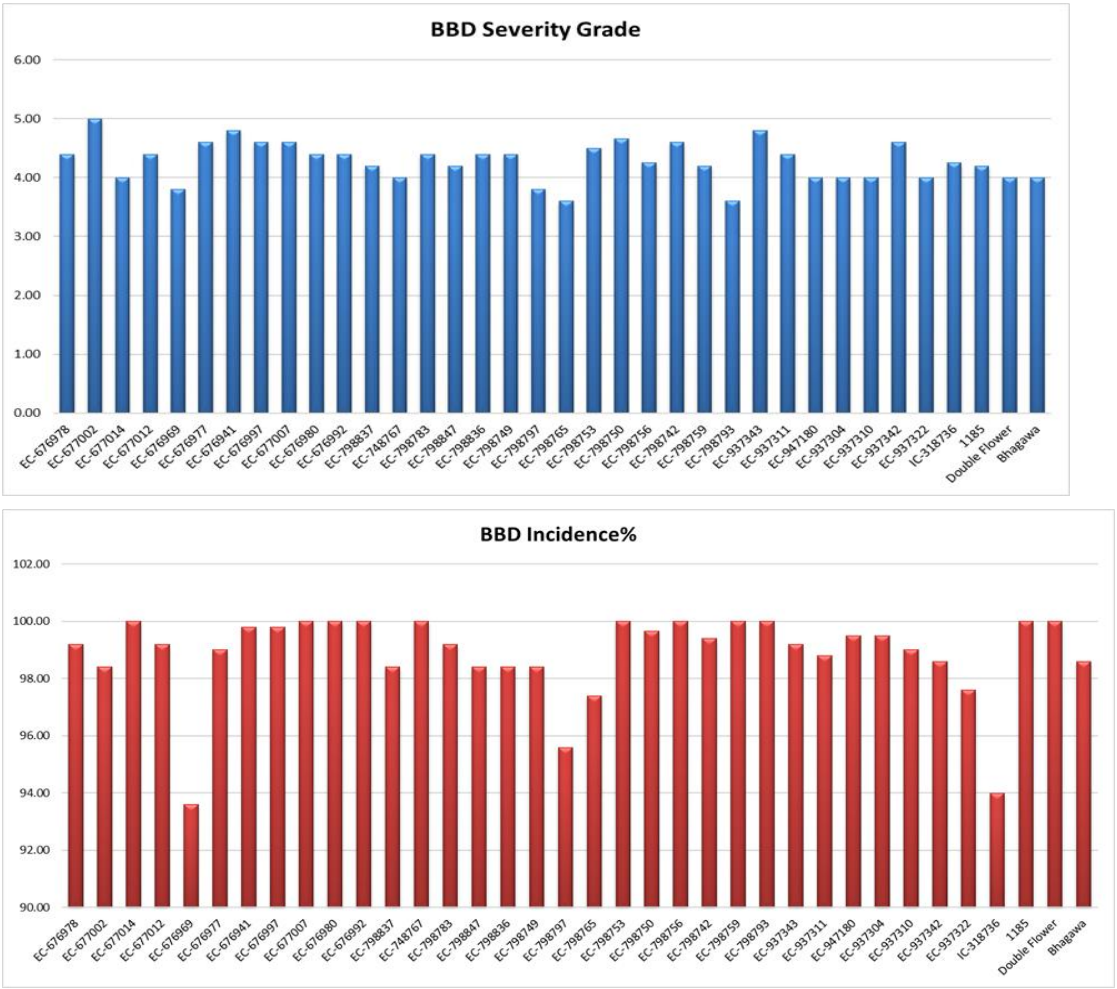
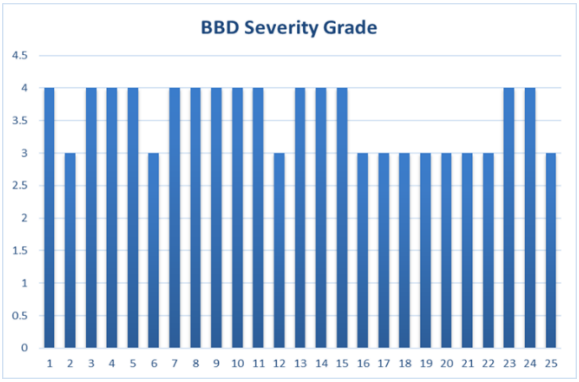


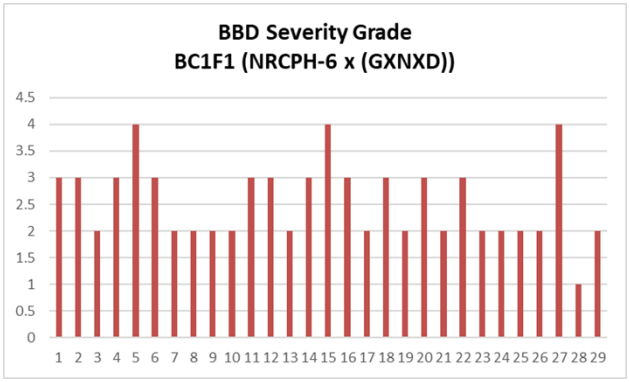
Fig.1.11 Severity grade and BBD incidence % of pomegranate accessions against BBD

1.2.2.2. Screening of hybrids and advanced breeding lines against BBD

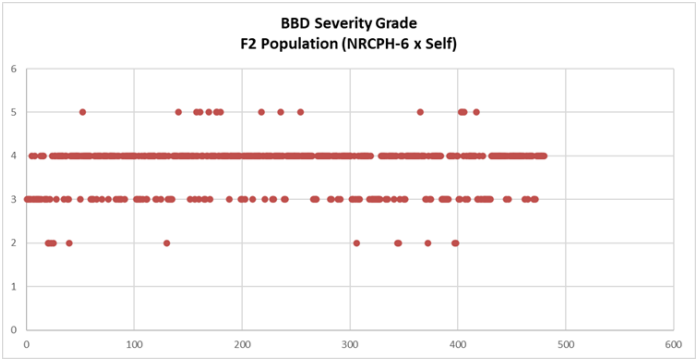
Hybrid population of 33 F_1s of Super Bhagawa x IC-318718 and advanced breeding lines 490 F_2 individuals of NRCPH-06 x Self and 14 F_2s of NRCP H-12 x Self, and 29 BC_1F_1s of cross NRCP H-06 x (GXNXD) have been screened against XAP-118 culture (10^8 pfu/ml; OD: 0.154) and compared with the susceptible check variety "Bhagawa". They have showed susceptible to highly susceptible reaction to BBD. The genetic variability for disease severity was observed to be narrow in F_1s as compared to segregating and backcrossing populations.

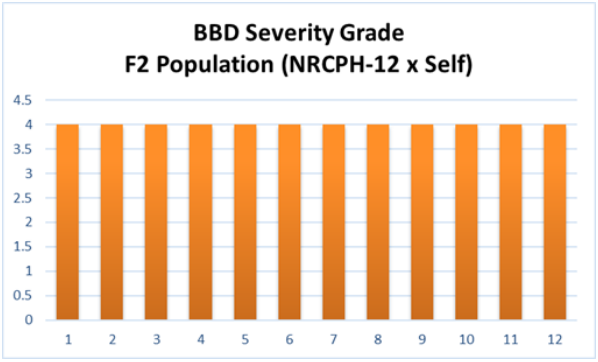


F_1 population screened against BBD



BC_1F_1 population screened against BBD





F_2 population screened against BBD

Fig 1.12 Screening of hybrids and advanced breeding lines against BBD

1.2.2.3 Identification of bacterial blight resistant variants from the population derived through chemical mutagenesis

EMS treated 52 individual F_2s of (NRCPH-06 x Self) and 42 F_{2S} of Bhagawa x Daru crosses were screened against bacterial blight disease under challenge inoculation to XAP-118 culture (10^8 pfu/ml; OD: 0.154). None of the resistant lines were found, however wide variability for disease severity was observed.

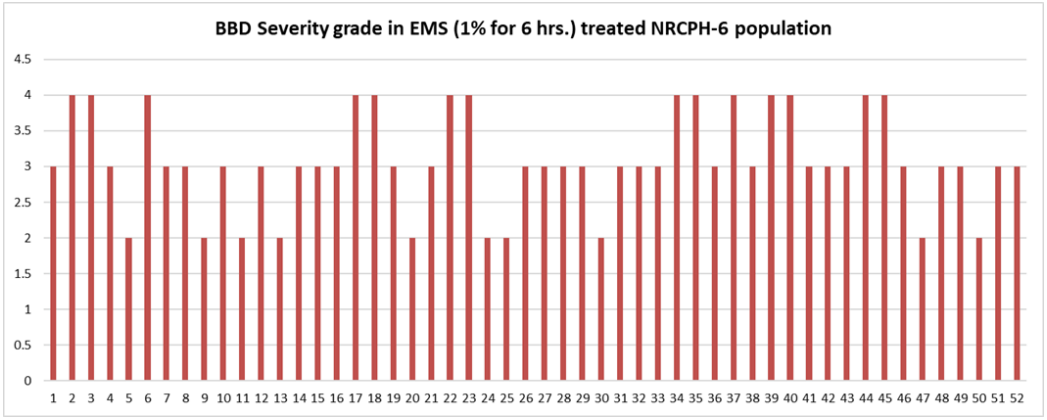


Fig 1.13. BBD severity grade in EMS treated NRCP H-6 population

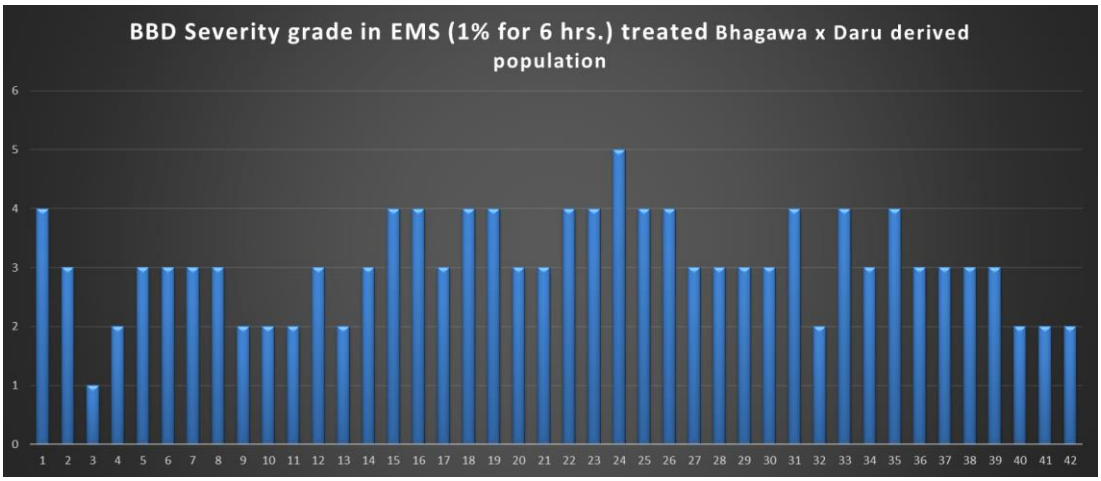


Fig 1.14. BBD severity grade in EMS treated Bhagwa x Daru derived population

1.3 PROJECT: GENETIC MAPPING OF BACTERIAL BLIGHT AND FRUIT QUALITY TRAITS IN POMEGRANATE

1.3.1 Development of 245 InDel markers in relation to growth and development in Pomegranate

1.3.1.1 *Designing of InDel markers specific to gene families*

To identify and design InDel markers, 140 genes from seven key pomegranate gene families involved in growth and development *i.e*. SWEET (20 genes), SUS (5), SUT (10), TALE (17), YABBY (6), ARF (17), and PgbZIP (65) genes were retrieved. Multiple sequence alignment for each gene in the four pomegranate genomes resulted in the discovery of several structural variants, including both SNPs and InDels. Based on sequence alignments, the consensus region (>8bp) around the InDel variations for each gene was chosen for the primer design. Consequently, a total of 245 InDel primers were designed; the SWEET gene family had maximum designed primers (61), followed by PgbZIP (56), SUT (36) and TALE (37). The YABBY gene family had the fewest designed primers (13), followed by the SUS (16) and ARF (26) gene families.

Table 1.7 Details of gene families targeted for development of InDel markers in pomegranate

Sl. No	Gene family	No. of genes	Indel primers designed	Genome	Trait	References
1.	**SWEET**	**20**	**61**	Taishanhong	Plays important roles in plant growth and development and physiological processes	Zhang *et al.*, 2022
2.	**SUS**	**5**	**16**	Tunisia	Role in C allocation, biomass accumulation, and sink strength	Liu and Zheng, 2022
3.	**SUT**	**10**	**36**	Tunisia	Sucrose transporter (SUT) plays a key role in plant growth, development and crop yield	Poudel *et al.*, 2020
4.	**TALE**	**17**	**37**	Taishanhong	A pivotal transcription factor that regulates the development of flower organs, flower meristem formation, organ morphogenesis and fruit development	Wang *et al.*, 2020
5.	**YABBY**	**6**	**13**	Taishanhong	Play significant roles in regulation of diverse developmental processes, such as formation of adaxial-adaxial polarity, lamina expansion and floral organ development	Zhao *et al.*, 2020
6.	**ARF**	**17**	**26**	Tunisia	Involved in pomegranate seed coat development	Yu *et al.*, 2020
7.	**bZIP**	**65**	**56**	Taishanhong	Play crucial roles in various abiotic stress responses and anthocyanin accumulation	Wang *et al.*, 2022
	Total	**140**	**245**			

Furthermore, e-PCR mapping of 245 InDel markers on Tunisia chromosomes revealed that 148 (60.41%) markers have been effectively validated. The frequency distribution of physically mapped InDel markers was found higher on chromosome 8 (37 markers, 25%) and lower on chromosome 7 (6, 4.05%). Out of 148 InDel primers, 84 produced one to two alleles that target various genes from seven gene families.

1.3.1.2 Physical map based on InDel markers

A high-density physical map was created using the physical start positions of 148 InDel markers on each chromosome. According to the map, Chm_8 had the most markers (37), followed by Chm_2 (23), and Chm_3 (21); these markers were all located in the same region. The least number of markers were found in Chm_7, which had six, followed by Chm_1 (13), Chm_6 (15), Chm_5 (16), and Chm_4 (17).

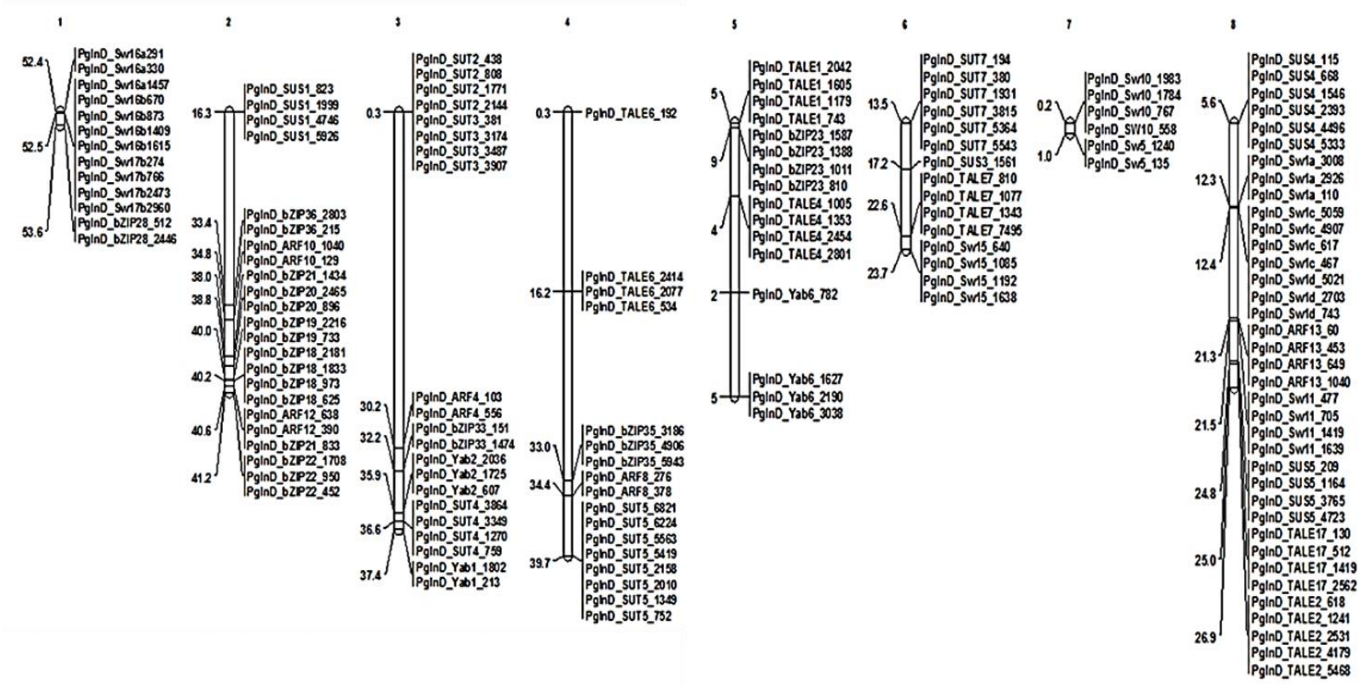


Fig 1.15 Physical linkage map based on 148 InDel markers on Tunisia genome

1.3.1.3 ePCR validation of InDel markers across pomegranate genomes

Initially, 245 InDel primer pairs were evaluated on the 'Tunisia' genome using e-mapping to assess the amplification effectiveness and specificity of the InDel markers. Over eight Tunisian chromosomes, a total of 148 (60.41%) primers were verified and mapped, producing one to three alleles. In contrast to 64 primers, which produced three alleles, the 84 primers produced one to two amplicons of the expected size. Following that, 148 markers were validated on three genome assemblies viz., “Dabenzi”, “Taishanhong”, and “Bhagawa”. Interestingly, we noticed that Dabenzi (148, 100%) and Bhagawa (148, 100%) received validation for all 148 InDel markers, while Taishanhong (145, 98%) did not.

Table 1.8 ePCR-based marker statistics for 148 InDel primers assayed on four pomegranate genomes

ePCR validation of 148 Indel primers for genotyping applications																		
			Allele No				Allele No				Allele No				Allele No			
			Tunisia genome				Dabenzi genome				Taishanhong genome				Bhagawa genome			
	Size (Mb)	Indel Primers	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total
Chm_1	55.56	13	1	6	6	13	1	6	6	13	3	5	5	13	1	6	6	13
Chm_2	44.57	23	0	10	13	23	4	10	9	23	4	9	9	22	4	10	9	23
Chm_3	39.96	21	4	10	7	21	8	7	5	20	7	8	6	21	8	8	5	21
Chm_4	40.13	17	3	7	7	17	1	8	8	17	1	8	8	17	3	6	8	17
Chm_5	31.53	16	2	6	8	16	3	7	6	16	3	7	6	16	3	10	3	16
Chm_6	28.33	15	0	5	10	15	2	5	7	14	0	4	10	14	0	6	9	15
Chm_7	28.78	6	2	3	1	6	2	1	3	6	2	1	3	6	2	1	3	6
Chm_8	27.99	37	8	17	12	37	8	16	12	36	8	15	12	35	5	20	12	37
Total	**296.85**	**148**	**20**	**64**	**64**	**148**	**29**	**60**	**56**	**145**	**28**	**57**	**59**	**144**	**26**	**67**	**55**	**148**

The various amplicons found using ePCR for these 148 primer pairs throughout the four genomes were recorded in order to further compute the marker parameters, demonstrating the informative nature of these InDel markers. The four genomes had 107 (72.29%) InDel markers those were polymorphic in nature. Across all eight chromosomes, 394 alleles were obtained. The average number of alleles per locus was 2.66, with the number of alleles (Na) ranging from 2 to 5. Major allelic frequency (MAF) per locus ranged from 0.25 to 0.88, with an average of 0.52. PIC values ranged from 0.19 to 0.70, with an average of 0.62. Out of 148 InDel primer pairs, 89 InDel markers had PIC values > 0.50. The average Shannon information index for the four examined genomes was 0.87. At the chromosomal level, we compared each marker parameter. Chm_8 had the highest average Na value (94), the most polymorphic marker count (27) among all the eight chromosomes. Chm_7, however, exhibited fewer polymorphic markers (6) and a lower average Na (19) value. However, all of the other parameters i.e. Ne, I, Ho, He, and PIC showed greater average values across all chromosomes. The average PIC values for the markers belonging to Chm_7 and Chm_1 were higher, at 0.67 and 0.66, respectively.

1.3.1.4 Determination of conserved motifs, gene structure among different gene families and phylogenetic analysis

On the gene structure display serve (GSDS), the gene structures for 43 genes from seven different gene families were examined. The PgSUS and PgSUT gene families, among the other gene families, were found to have the most exons and introns. Higher differences in exon and intron lengths were seen in the PgTALE, PgSWEET, and PgSUT gene families. We also identified the conserved motifs in these gene sequences and discovered that the PgSUS and PgSUT gene families contain more conserved motifs than other gene families. PgSWEET and PgTALE gene families displayed higher variability in terms of changes to conserved motifs. We carried a phylogenetic analysis based on protein sequences to comprehend the evolutionary relationships between members of these seven gene families. With a few exceptions, the phylogenetic tree clearly placed each member in the appropriate gene family.

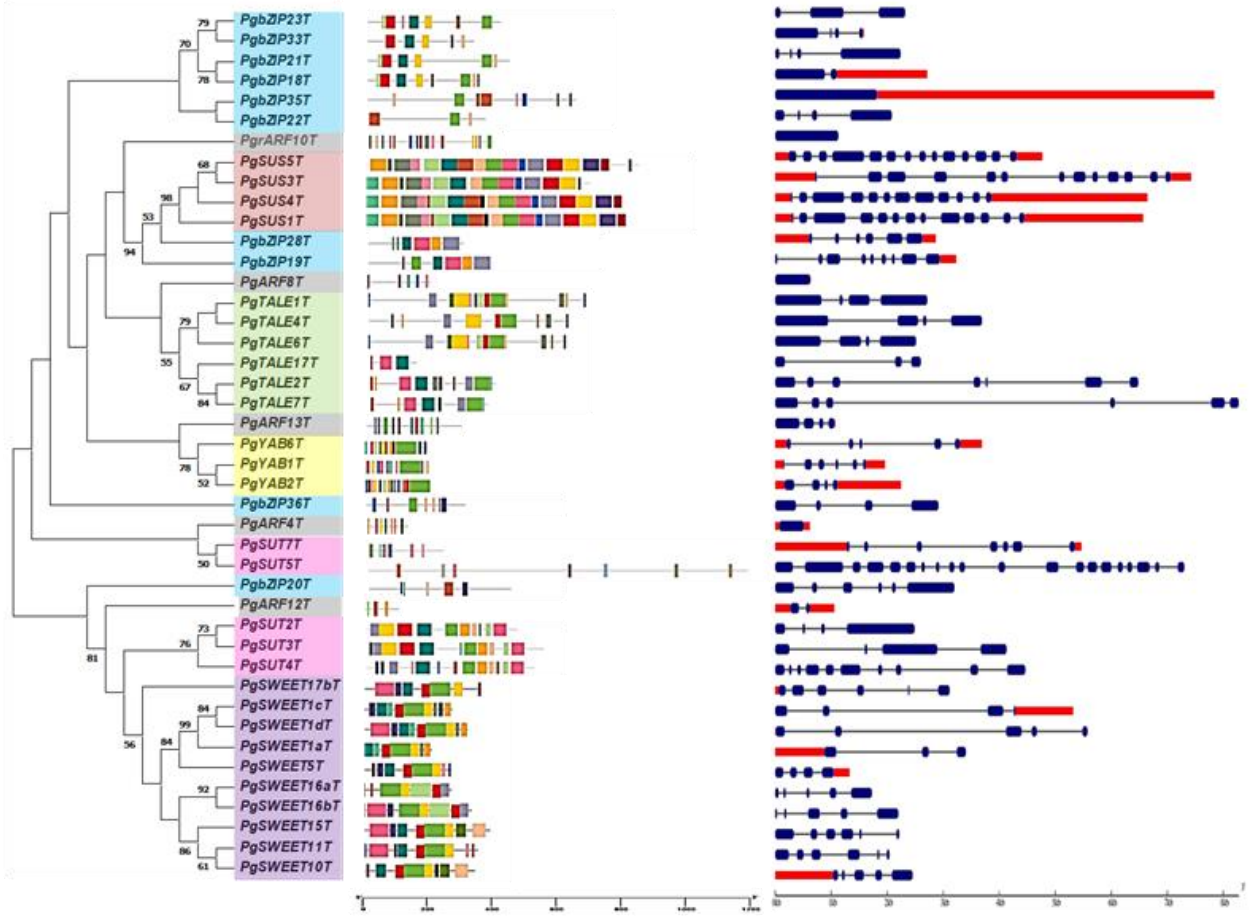


Fig 1.16 Phylogenetic tree, conserved motifs and gene structures of 43 genes that belonged to seven different genes families of Tunisia genome

1.3.1.5 Phylogenetic analysis among members of seven gene families that belonged to Tunisia and Bhagawa genomes

Additionally, we conducted phylogenetic analyses for seven gene families for genes from the Tunisia and Bhagawa genomes. As a result, we noticed that each gene's paired grouping (T-Tunisia; B-Bhagawa) belonged to distinct gene families with high bootstrap values, as shown in the phylogenetic tree. All of the PgARF (5 genes) genes, a small number of PgbZIP (4 genes), and PgSUT(2) genes were dispersed in different clusters. Major cluster I consisted of the PgSWEET (10 genes) and PgSUT (3) genes, while major cluster II had all other gene families. According to the radial tree, each gene family, namely PgYAB, PgbZIP, PgTALE, and PgSUS, had distinct sub-clusters inside the major cluster II. Interestingly, the PgYAB and PgbZIP gene families' genes were grouped together, then the PgTALE and PgSUS gene families.

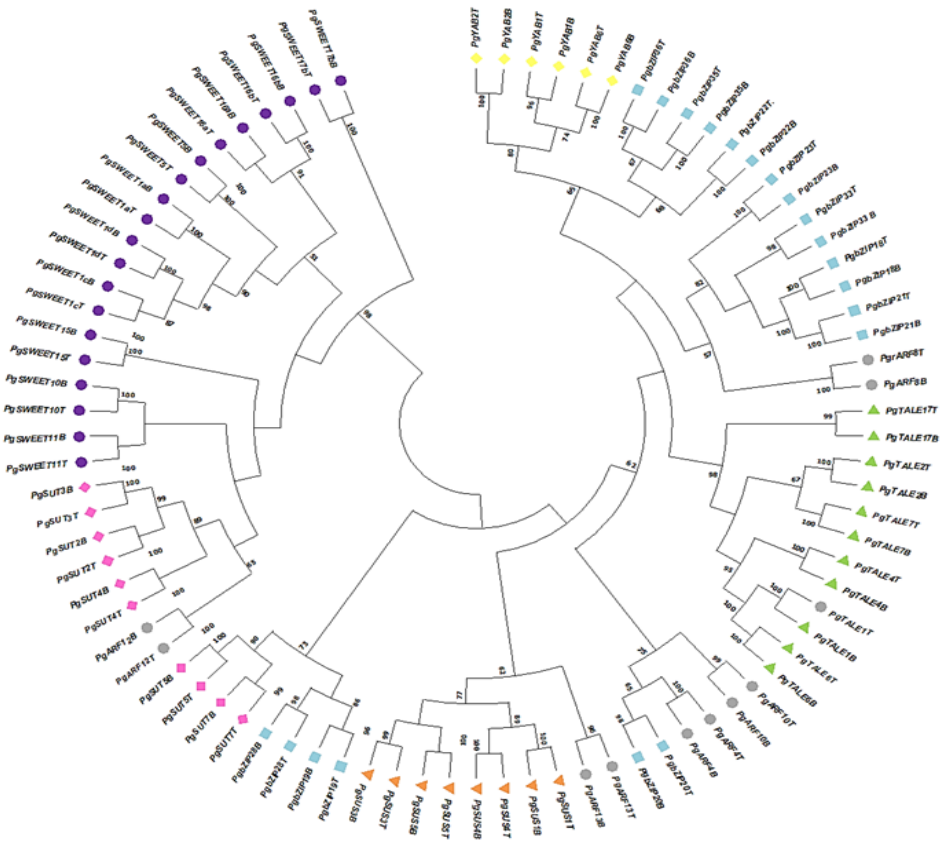


Fig 1.17 The uprooted phylogenetic tree depicting clustering of 86 genes that are part of seven important gene families of two pomegranate genomes Tunisia *vs* Bhagawa

1.3.1.6 Wet-lab validation of InDel markers through PCR

We got synthesized a set of 54 InDel markers at random for wet lab validation. A PCR analysis of these markers on six genotypes of pomegranate showed that 52 (96.30%) of the InDel markers could generate gene-specific amplicons. Of these, 15 InDel markers were monomorphic and 37 (71.15%) displayed polymorphism across six genotypes. However, five markers (Indel_16, Indel_87, Indel_93, Indel_141 & Indel_76), showed amplification in two to three genotypes, but Indel_114 and Indel_20 did not show amplifications. Gel photo illustrates marker genotyping using selected InDel markers. In six pomegranate genotypes, we found 89 alleles, and PIC values varied from 0 to 0.60 with a mean value of 0.32**.** It is noteworthy that 24 InDel markers had PIC values ≥0.48.

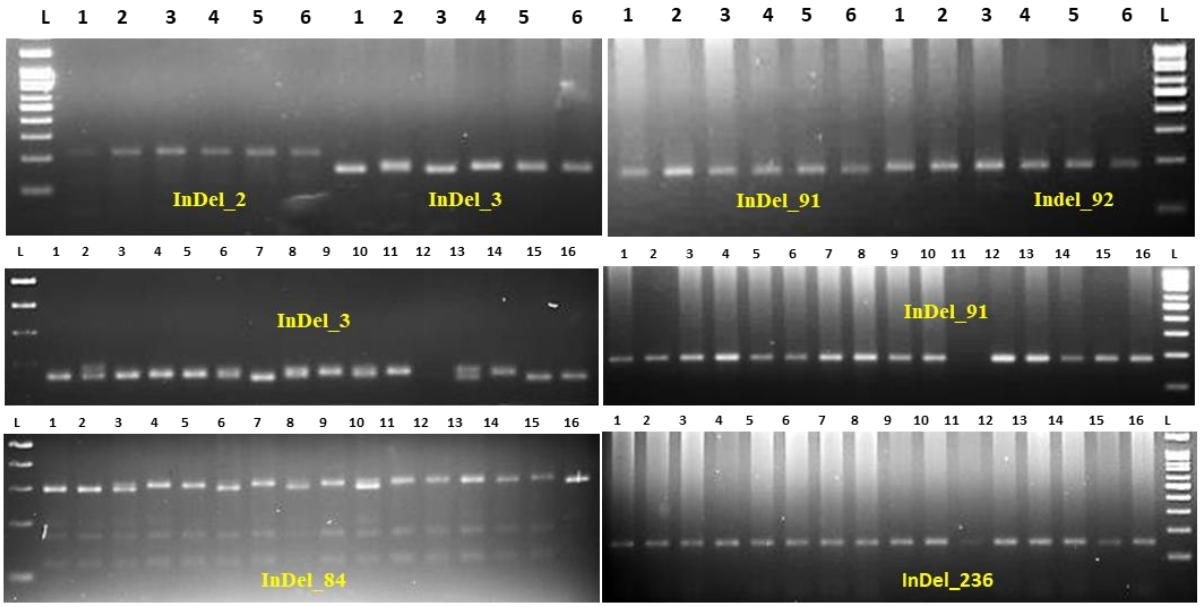
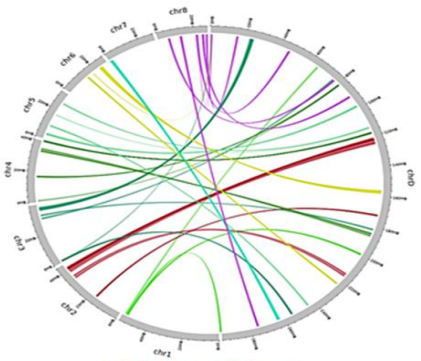


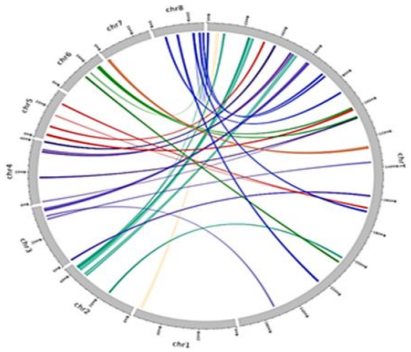
Fig 1.18 Allelic variations revealed by InDel markers when assayed on six pomegranate genotypes on 3% agarose gels (A), InDel markers, InDel_3, InDel_91, InDel_84 and InDel_236 on 16 pomegranate genotypes (B)

1.3.1.7 *Comparative syntenic analysis for InDel markers between pomegranate genomes*

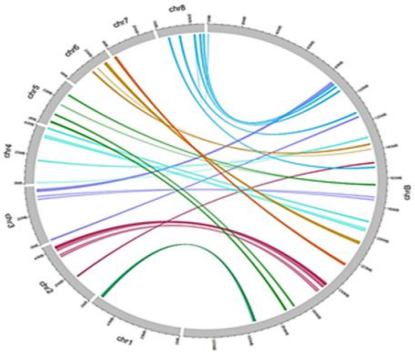
The locations of the 148 physically mapped Tunisia markers were compared to those on the complete genome assemblies of the Dabenzi, Taishanhong, and Bhagawa**.** Our findings showed that common InDel markers scattered throughout eight Tunisian chromosomes had significant orthology and syntenic relationships with Bhagawa (100%) and Dabenzi (97.97%) assemblies, followed by Taishanhong (97.30%)**.**



Tunisia *vs.* Dabenzi



Tunisia *vs.* Taishanhong



Tunisia *vs.* Bhagawa

Tunisia chromosomes	No. of InDel markers	No. of markers mapped on the assemblies		
		Dabenzi	Taishanhong	Bhagawa
Chm_1	13	13 (100%)	13 (100%)	13 (100%)
Chm_2	23	23 (100%)	22 (95.65%)	23 (100%)
Chm_3	21	20 (95.24%)	21 (100%)	21 (100%)
Chm_4	17	17 (100%)	17 (100%)	17 (100%)
Chm_5	16	16 (100%)	16 (100%)	16 (100%)
Chm_6	15	14 (93.33%)	14 (93.33%)	15 (100%)
Chm_7	6	6 (100%)	6 (100%)	6 (100%)
Chm_8	37	36 (97.30%)	35 (94.59%)	37(100%)
Total	**148**	**145 (97.97%)**	**144 (97.30%)**	**148 (100%)**

Fig 1.19 Syntenic relationships between Tunisia in comparison to Dabenzi, Taishanhong and Bhagawa genomes based on 148 Indel markers

1.3.1.8 Genetic diversity

Based on clear amplification and polymorphism on six genotypes, we chose a set of 16 InDel markers to screen on 16 pomegranate genotypes. A total of 32 alleles were amplified, with two alleles on average per genotype. The expected *He* ranged from 0.23 to 0.50, with a mean value of 0.42. PIC values varied from 0.24 to 0.51, with a mean value of 0.44. Among 16 pomegranate genotypes, the average Shannon's information index was 0.61.

In the NJ tree, all the cultivars (8) and exotic lines (4) were equally distributed in to the two major clusters**.** It was interesting to observe that out of the four wild collections, three were of Himachal provenance and were grouped together in major cluster I, whereas one was in major cluster II. Similar to this, the PCA plot also separated the 16 genotypes into two main clusters. The principal coordinates (PCos) 1 and 2 accounted for 44.55% of the overall variation and explained 24.86 and 19.69%, respectively, of the total variance among the genotypes.

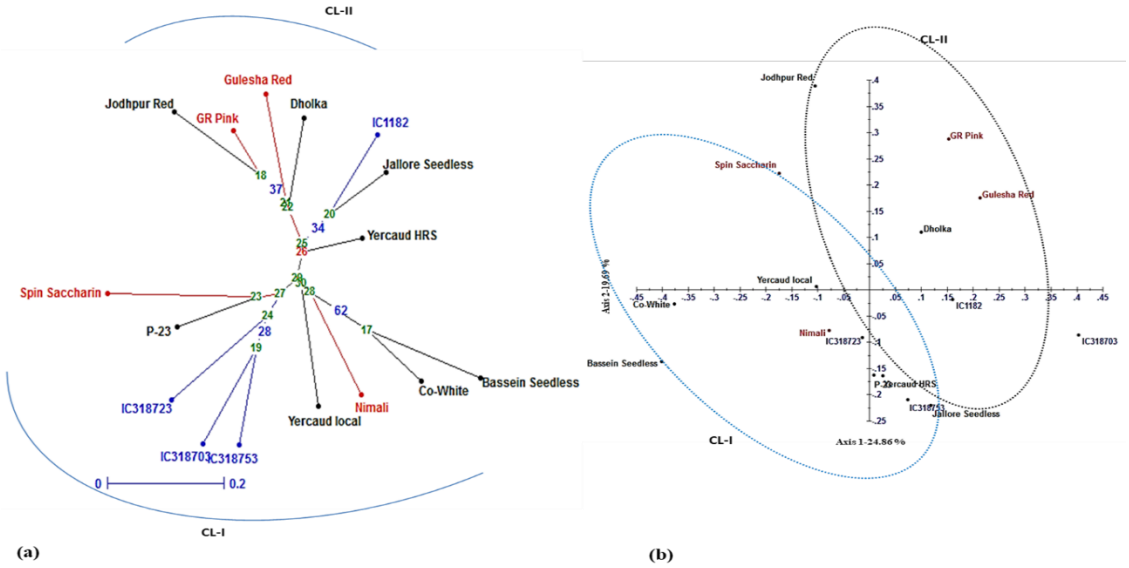


Fig 1.20 Genetic relationships among 16 pomegranate genotypes based on 16 InDel markers: (a) Neighbor-joining tree and (b) Principal coordinate analysis

1.3.1.9 Phenotypic and genotypic correlations with the traits

Ten fruit morpho-biochemical features were subjected to phenotypic correlations; as a consequence, we found substantial positive correlations between five of the traits, fruit weight, fruit length, fruit diameter, 100 aril weight (HAW), and aril length (AL). Furthermore, we used the InDel markers to do single marker analyses for each of these variables across 16 genotypes. As a result, 9 markers out of the 16 examined demonstrated significant associations with the various traits. Through the present analysis, we discovered that three InDel markers belonging to the SW family, three of the SUT family, two of the bZIP family, and one of the YAB families are highly informative. InDel_2 (PgInDel_Sw 10_767), a member of the SWEET gene family, was very significant in its association with the majority of fruit attributes, including FW, FL, FD, HAW, AL, AW, and TSS, indicating that it is the most informative marker within the group.

Table 1.9 Genetic correlations for InDel marker with the fruit quality traits based on single marker analysis (SMA)

Sl. No	InDel	Primer code	Chm location	Na	MAF	Ne	I	He	PIC
1	InDel_3	PgInDel_Sw 10 _1784(10)	7	2	0.57	1.97	0.68	0.49	0.51
2	InDel_84	PgInDel_SUT2 _808(11)	3	2	0.59	1.93	0.68	0.48	0.50
3	InDel_91	PgInDel_SUT4 _759(7)	3	2	0.53	1.99	0.69	0.50	0.51
4	InDel_236	PgInDel_bZIP33 _1474(8)	3	2	0.75	1.60	0.56	0.38	0.39
5	InDel_101	PgInDel_SUT5 _6224(8)	4	2	0.67	1.80	0.64	0.44	0.46
6	InDel_65	PgInDel_SUS1 _5926(8)	2	2	0.62	1.88	0.66	0.47	0.48
7	InDel_239	PgInDel_bZIP35 _4906,4931(18,12)	4	2	0.69	1.75	0.62	0.43	0.44
8	InDel_95	PgInDel_SUT5 _752(8)	4	2	0.81	1.44	0.48	0.30	0.31
9	InDel_2	PgInDel_Sw 10 _767(8)	7	2	0.81	1.44	0.48	0.30	0.31
10	InDel_6	PgInDel_Sw5 _1240(8)	7	2	0.62	1.88	0.66	0.47	0.48
11	InDel_160	PgInDel_Yab6 _782(7)	5	2	0.69	1.75	0.62	0.43	0.44
12	InDel_23	PgInDel_Sw17b _2473(8)	1	2	0.87	1.30	0.39	0.23	0.24
13	InDel_31	PgInDel_Sw1d _743(7)	8	2	0.69	1.75	0.62	0.43	0.44
14	InDel_87	PgInDel_SUT3 _381(10)	3	2	0.62	1.88	0.66	0.47	0.48
15	InDel_94	PgInDel_SUT4 _3864(7)	3	2	0.62	1.88	0.66	0.47	0.48
16	InDel_213	PgInDel_bZIP20 _2465(8)	2	2	0.62	1.88	0.66	0.47	0.48
	Mean			**32 (2.00)**	**0.67**	**1.76**	**0.61**	**0.42**	**0.44**

1.3.2 Varietal barcoding in pomegranate using hypervariable SSR markers

1.3.2.1 Varietal fingerprinting using chromosome-specific hyper variable SSR markers

For varietal fingerprinting twelve pomegranate varieties which are popularly grown in India were selected. Based on initial screening experiments, 46 SSR markers with their clear amplification profiles were used. A good distribution of 44 markers was found across eight chromosomes of Tunisia, with the exception of two markers (unknown locations). The maximum number of 19 markers belonged to chm_4, 8 markers to chm_3, and 7 markers to chm_1. The least number of markers, one on each were belonged to Chm_2 and Chm_7, followed by three each to Chm_5 and

Chm_8. The amplicon profile as produced using hypervariable SSR markers for the twelve varieties is shown below

Sl. No	Samples
1.	Ganesh
2.	Mridula
3.	Arakta
4.	Ruby
5.	Super Bhagwa
6.	Dholka
7.	Kandhari
8.	Solapur Lal
9.	Jallore Seedless
10.	Jyoti
11.	Bhagawa
12.	Yercaurd-I

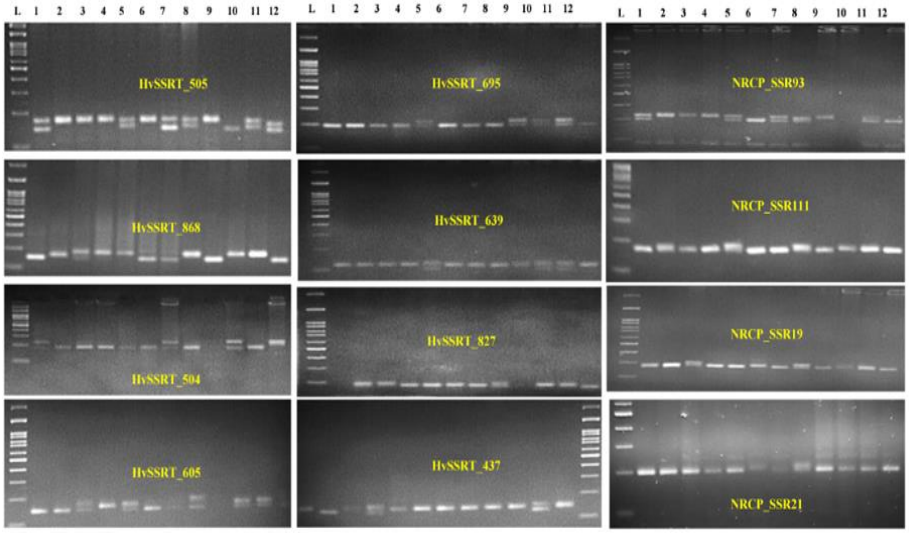


Fig 1.21 Gel profile showing DNA fingerprints for 12 pomegranate varieties using hyper variable SSR markers (Where, L=100bp ladder, lanes 1-12 are pomegranate varieties listed on the side)

1.3.2.2 Allelic variations and polymorphism for SSR markers

The 46 SSR markers generated 102 alleles in total, ranged from 2 to 4 alleles with an average of 2.22 alleles per marker. PIC ranged from 0.08 to 0.67, with an average of 0.31. The average *He* and *I* value of 0.30 and 0.49, respectively was observed. Additionally, the statistics of probability of identity (PI) and in siblings (PIsibs) were determined to further evaluate the fingerprinting capability of 46 markers. The PI of each locus ranged from 0.20 to 0.85, with a mean value of 0.56 and PIsibs ranged from 0.48 to 0.92 with a mean of 0.74.

1.3.2.3 Detection of unique and rare alleles

1.3.2.3.1 Unique alleles

A total of 102 alleles were produced by 46 SSR markers, of which 24 were unique alleles identified by 24 primers that are specific to eight different varieties, this includes varieties *viz.*, Ganesh, Mridula, Arakta, Ruby, Dholka, Solapur Lal, Bhagawa, and Yercaud-I. The highest number of unique alleles (9) was found in Solpaur Lal, followed by Yercaud-I (6), two alleles each was observed for Ganesh, Mridula, Dholka, and one allele each for Arakta, Ruby and Bhagawa.

1.3.2.3.2 Rare alleles

In this study, total 15 rare alleles were detected which appeared in two or more cultivars and had allelic frequency of ≤ 20%. The 210 bp allele at locus HvSSRT_695 appeared in four varieties (Super Bhagawa, Jallore Seedless, Jyoti and Bhagawa); the 180 bp amplicon generated at HvSSRT_505 (Super Bhagawa, Solapur Lala and Bhagawa); 180bp at HvSSRT_868 (Mridula, Arakta and Solpaur Lal), 130 bp at HvSSRT_437 (Mridula, Ruby and Bhagawa) and 240bp at NRCP_SSR97 (Ruby, Dholka and Solapur Lal) appeared in three varieties. The remaining ten primers NRCP_SSR30$_{300}$, NRCP_SSR21$_{210}$, HvSSRT_827$_{200}$, HvSSRT_700$_{200}$, HvSSRT_322$_{200}$, HvSSRT_348$_{200}$, HvSSRT_605$_{190}$, NRCP_SSR52$_{190}$, HvSSRT_504$_{180}$ and NRCP_SSR13$_{180,}$ yielded rare alleles to distinguish two varieties each. Total 16 primers were found highly useful for developing varietal barcodes to differentiate 12 pomegranate varieties.

Table 1.10 Varietal specific unique/rare alleles as identified by 36 SSR primers

Unique Alleles			Rare Alleles		
Primer	**Size (bp)**	**Varieties**	**Primer**	**Size (bp)**	**Varieties**
NRCP_SSR62	140	Ganesh	NRCP_SSR30	300	Solapur Lal, Bhagawa
HvSSRT_81	250		NRCP_SSR21	210	Dholka, Solapur Lal
HvSSRT_432	140	Mridula	HvSSRT_827	200	Arakta, Solpaur Lal
NRCP_SSR83	500		HvSSRT_700	200	Super Bhagwa, Bhagawa
NRCP_SSR11	270	Arakta	HvSSRT_322	200	Dholka,Solapur Lal
NRCP_SSR9	260	Ruby	HvSSRT_348	200	Jallore Seedless,Yercaud
NRCP_SSR20	220	Dholka	HvSSRT_605	190	Kandhari, Solapur Lal
NRCP_SSR61	320		NRCP_SSR52	190	Solapur Lal,Yercaud
HvSSRT_110	230	Solapur Lal	HvSSRT_504	180	Jyoti, Bhagawa
NRCP_SSR91	190		HvSSRT_868	180	Mridula, Arakta, Solpaur Lal
NRCP_SSR34	270		HvSSRT_505	180	Super Bhagawa, Solapur Lala, Bhagawa
HvSSRT_826	140		NRCP_SSR13	180	Dholka, Yercaud
HvSSRT_18	100		HvSSRT_437	130	Mridula, Ruby, Bhagawa
HvSSRT_91	190		HvSSRT_695	210	Super Bhagawa, Jallore Seedless, Jyoti, Bhagawa
HvSSRT_259	190		NRCP_SSR97	240	Ruby, Dholka, Solapur Lal
HvSSRT_324	200		HvSSRT_81	250	Ganesh
HvSSRT_463	220				
HvSSRT_746	200	Bhagawa			
NRCP_SSR28	280	Yercaud-I			
NRCP_SSR50	280				
NRCP_SSR82	390				
HvSSRT_504	210				
HvSSRT_827	180				
HvSSRT_505	160				

Out of 35 primers, 16 SSRs were determined to be particularly suited for varietal barcoding because they produced rare alleles and physically located on chromosomes.

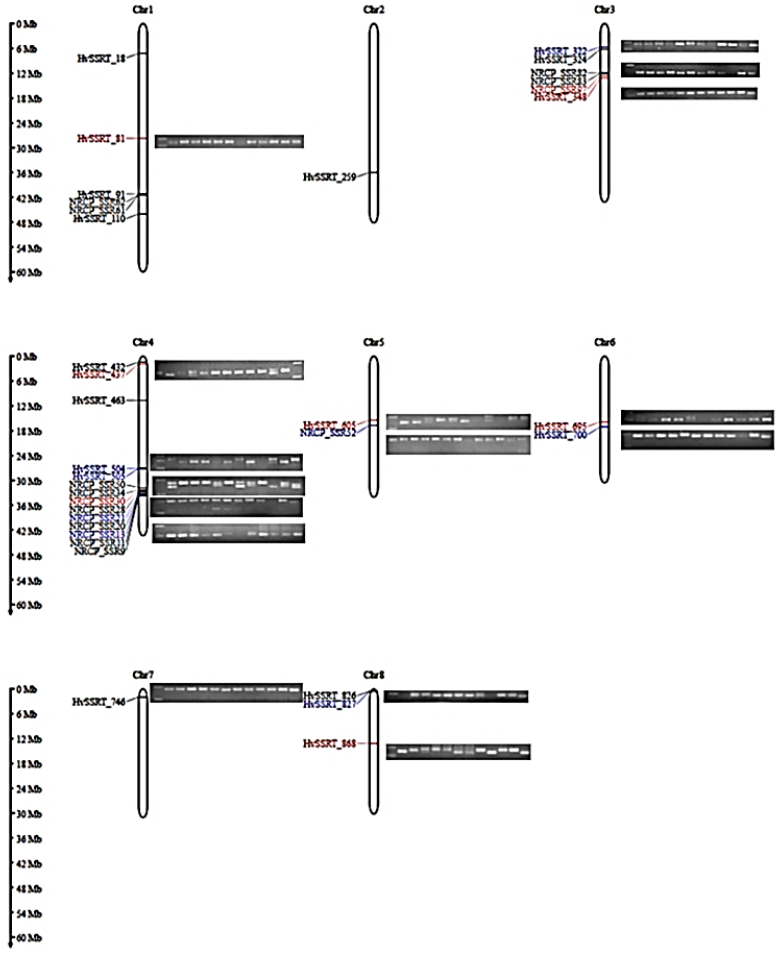


Fig 1.22 The physical distribution of 35 informative markers across 8 chromosomes, blue font/gel profile for 16 markers that are found feasible for varietal barcoding and red font/gel profile for 8 core SSRs deployed for barcoding.

These markers include HvSSRT_348, HvSSRT_505, HvSSRT_700, HvSSRT_322, HvSSRT_437, HvSSRT_504, HvSSRT_605, HvSSRT_695, HvSSRT_81, HvSSRT_827, HvSSRT_868, NRCP_SSR97, NRCP_SSR13, NRCP_SSR21, NRCP_SSR30, and NRCP_SSR52. For these 16 validated barcoding loci, the values of PI and PIsibs revealed that the likelihood of finding two random individuals with identical genotypes at all the loci was reduced to 2.6 $x10^{-6}$ and 2.1$x10^{-3}$, respectively.

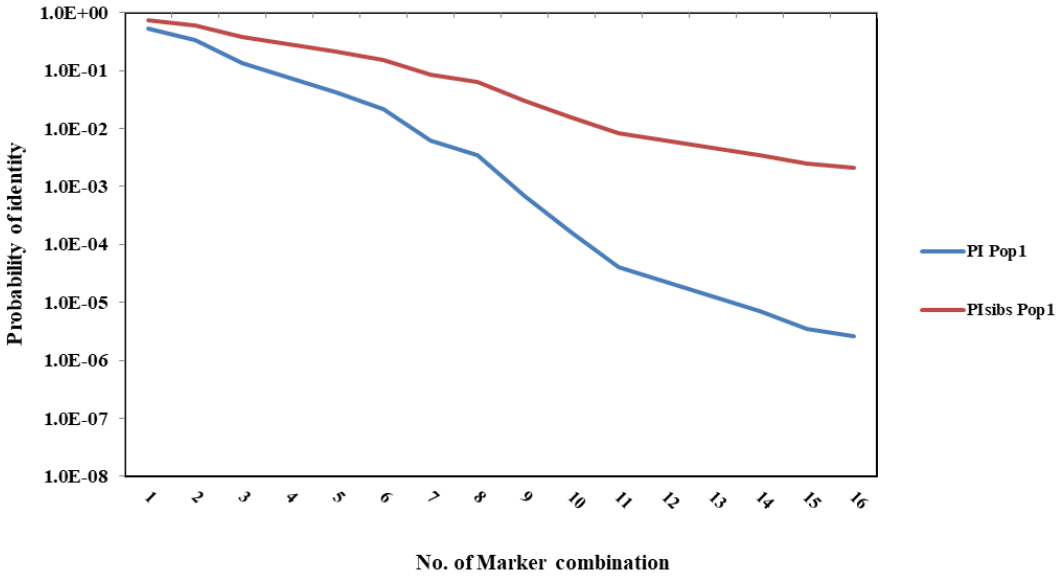


Fig 1.23 The down trend of PI and PIsibs values in 12 pomegranate varieties with the increase of marker combinations

1.3.2.4 Construction of DNA barcode

To develop a preliminary barcode, we have chosen eight core SSR markers (NRCP_SSR30, HvSSRT_81, NRCP_SSR97, HvSSRT_695, HvSSRT_348, HvSSRT_605, HvSSRT_868, and HvSSRT_437) that have distinguished all the 12 pomegranate varieties. Once we obtained allele profiles for all the varieties using eight SSR primers, the alleles at each locus were assigned with numbers (1, 2, 3…) in the order of increasing size of the amplicons. These numbers were employed to generate 8-digit marker codes for each variety. The digits from left to right corresponded to the allele at loci NRCP_SSR30, HvSSRT_81, NRCP_SSR97, HvSSRT_695, HvSSRT_348, HvSSRT_605, HvSSRT_868 and HvSSRT_437, in this order. For instance, if the marker code for the variety Ganesh is 11112112, then from the left to right signifies 1st, 1st, 1st, 1st, 2nd, 1st, 1st and 2nd allele of NRCP_SSR30, HvSSRT_81, NRCP_SSR97, HvSSRT_695, HvSSRT_348, HvSSRT_605, HvSSRT_868 and HvSSRT_437, respectively. Finally, using the online Tec-IT Barcode studio generator (https://barcode.tec-it.com/en/Code11), the markers codes of each variety were transformed into digital barcodes.

Table 1.11 Varietal specific barcodes as developed based on eight hyper variable SSR markers

Sl.No	Variety	Marker code	Barcode	Fruit morphology
1	Ganesh	11112112	11112112	
2	Mridula	12112121	12112121	
3	Arakta	12112222	12112222	
4	Ruby	12212231	12212231	
5	Super Bhagawa	12122232	12122232	
6	Dholka	12212132	12212132	
7	Kandhari	12112332	12112332	
8	Solapur Lal	22212322	22212322	
9	Jallore Seedless	12121212	12121212	
10	Jyoti	02122232	02122232	
11	Bhagawa	22122231	22122231	
12	Yercaud-I	12111212	12111212	

1.3.2.5 Marker for Multiplex assay

Microsatellite profiling usually amplifies more than two alleles per locus, making it challenging to analyse and compare different varieties. Therefore, in order to depict more clearly the examined pomegranate varieties, SSR allele sizes were converted to barcodes. The allele size bars are

drawn to a linear scale for all of the analyzed varieties to develop barcode representation for multiplex assays. As a result, we propose the multiplex assays with two to four primer combinations to identify pomegranate cultivars *i.e.* Mridula, Ruby, Solapur Lal, Jallore Seedless, and Bhagawa. The maximum of four primer combinations can be used for multiplex assays for Solapur Lal (NRCP_SSR30, NRCP_SSR97, HvSSRT_605and HvSSRT_868), three for Bhagawa (NRCP_SSR30, HvSSRT_695 and HvSSRT_437), and two each for Mridula (HvSSRT_868 and HvSSRT_437), Ruby (NRCP_SSR97 and HvSSRT_437) and Jallore Seedless (HvSSRT_695 and HvSSRT_348).

SSR Locus	Allele (bp)	Ganesh	Mridula	Arakta	Ruby	Super Bhagawa	Dholka	Kandhari	Solapur Lal	Jallore Seedless	Jyoti	Bhagawa	Yercaurd-I
NRCP_SSR30	300								—			—	
HvSSRT_81	250	—											
NRCP_SSR97	240				—		—		—				
HvSSRT_695	210					—				—	—	—	
HvSSRT_348	200									—			—
HvSSRT_605	190							—	—				
HvSSRT_868	180		—	—					—				
HvSSRT_437	130		—		—							—	

Fig 1.24 SSR markers deployed for barcode development and their feasibility for multiplex assay in pomegranate

1.4 PROJECT: DRAFT GENOME SEQUENCING OF POMEGRANATE (*Punica granatum* L.) CV. BHAGAWA

1.4.1.Hi C – Bhagwa of Pomegranate genome Sequencing

The HiC sample's library was prepared using Phase Genomics Proximo Kit and later sequenced on Illumina NovaSeq 6000 platform. Low quality data was removed from the sequenced dataset using fastp to trim adapters, remove low quality bases using a sliding window approach.

1.4.1.1.Scaffolding with HiC Data:

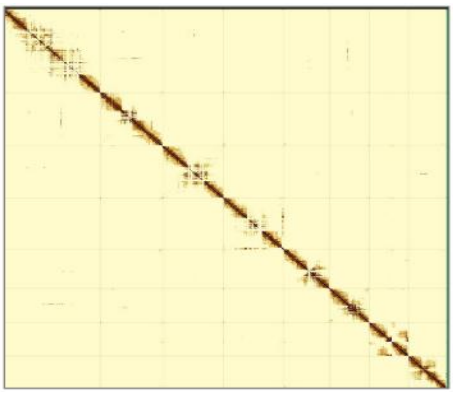
Initially, the data was mapped onto the finalized Bhagawa assembly created by a Hybrid scaffold combination of PacBio Reads +10X data +BioNano Maps; followed by a round of gapfilling with PBJelly2 using PacBio reads and Illumina short reads. We used the parameter recommended for mapping from Phase Genomics for mapping, namely: "bwa mem -5SP" followed by duplicate read remove via "samblaster" and obtained an aligned bam of the HiC reads. With the least amount of misjoins and chimeric scaffolding has been completed.

Validation of the assembly was done to obtain a completion of 93.05% on the single-copy orthologs. Finally, able to assemble the Bhagwa genome at very highly contiguous chromosomal scale, i.e putting the hybrid assembly into 8 chromosomes.The assembly was subsequently polished by adding the mitochondrial genome, plastid genome and the alternative haplotypes to perform a phased polishing with PacBio datasets followed by short-read datasets to remove any further artifactual errors like InDels, SNPs and Gaps in the assembly.

1.4.1.1.1The statistics of the input Bhagwa assembly

Table 1.12 The statistics of Bhagwa assembly

Assembly	Bhagawa (Curated)
Total length	346123143
Number	8
Mean length	43265392.88
Longest	76078731
Shortest	29941172
N Count	4984021
Gaps	476
N50	47017384
N50n	4
N70	35447661
N70n	5
N90	30434120
N90n	7



HI – C Contact Map

Assembly	Primary	Haplotypes
total_length	345235241	97437270
number	10	663
mean_length	34523524.1	146964.21
longest	75783313	1691397
shortest	158773	157
N_count	4971624	0
Gaps	393	0
N50	46791700	267955
N70	35363818	150494
N90	30365286	62592

1.4.1.2 Validation of the assembly:

Subsequent to the manual curation and iterative polishing, we performed the assembly validation at multiple levels:

BUSCO at embryophyta lineage:

BUSCO uses tblastn intially to identify the regions with Single Copy Orthologs alignments, uses Augustus and HMMER to extract and predict the completion of the predicted Orthologs. The predictions showing as complete are then used to retrain Augustus, repredict using the newer parameters and are used to finally validate the genome.

Functional Annotation of Predicted Genes:

The predicted proteins were annotated using InterProScan, eggNOG at Viridiplantae lineage.

Table 1.13 Functional Annotation Summary

Annotation Source	Values
InterPro	38090
EggNOG	39939

c. ***non-Coding Gene Prediction:***

The chromosomal scale genome was analyzed using the Infernal toolkit: cmscan using the RFAM database to predict the non-coding genes in the Bhagwa genome. We took a threshold score of 60 in order to retain the predicted genes.

Table 1.14 nonCoding Genes Annotation Summary

Lnc RNA Features	Counts
miRNA	105
rRNA	841
snoRNA	257
snRNA	88
tRNA	345

We obtained a completion of 93.05% on the single-copy orthologs.

1.4.2 Standardization of PCR program for SRAP markers

SRAP (Sequence -Related Amplified Polymorphism) is a PCR based marker developed by Li and Qurios. It is found to be SRAP is found to be simple and highly reproducible DNA through marker technique useful for both mapping and gene tagging in plant. This technique preferential amplifies open reading frame (ORF) of genes. The ORF sequence are targeted by primer combination of first primer (F) 17 bp with 14 nucleotides fixed sequence C and G rich sequence at 3' end, this primer amplified exotic region. Second primer (R) is 18 bp contains 15 nucleotides A and T rich, this amplifies intronic region and promoter region. Through this experiment we successfully standardized SRAP techniques in pomegranate. The representative gel images are shown below.

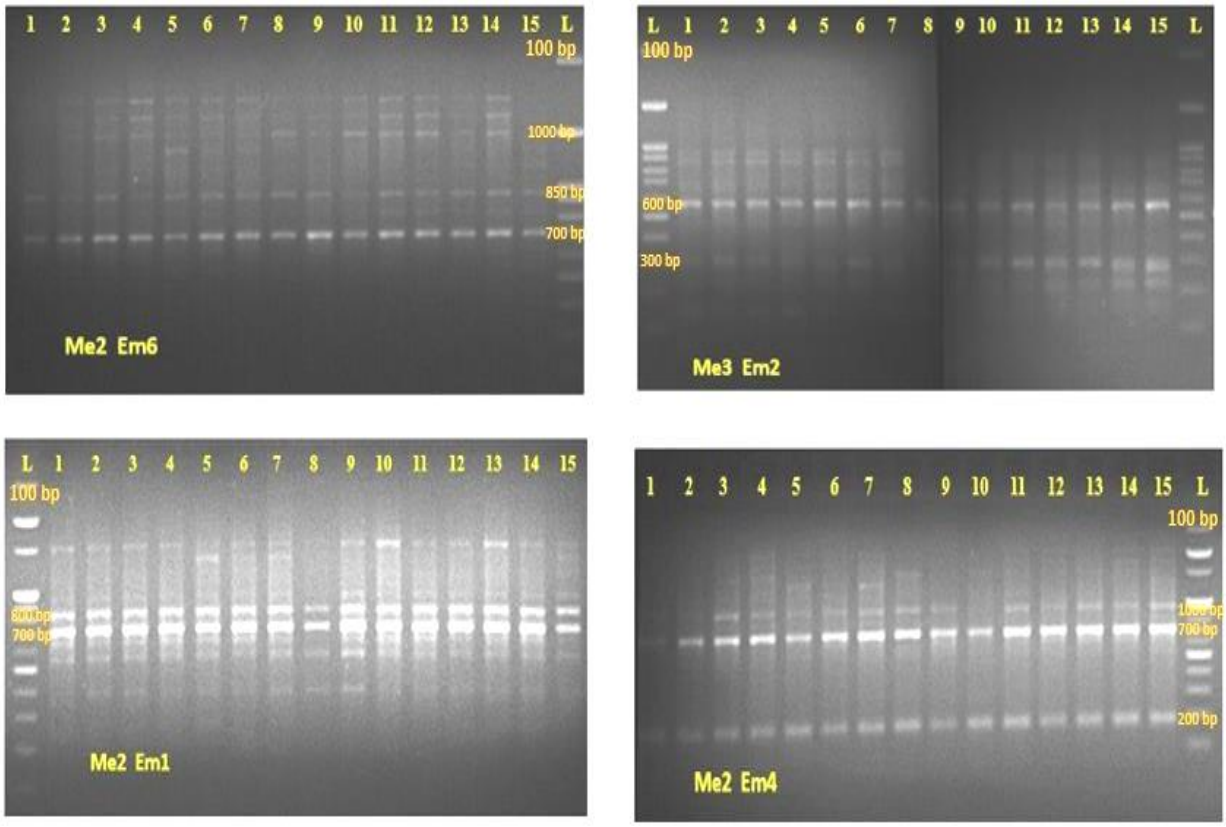


Fig 1.25 Amplification of SRAP markers to conduct genetic diversity studies

1.5 PROJECT: DEVELOPMENT OF GENETIC RESOURCES RESISTANT TO WILT COMPLEX IN POMEGRANATE

1.5.1 Screening of germplasm under wilt Sick Plot

A set of 80 indigenous collections, 39 Exotic collections and 54 Advanced breeding lines. These have been multiplied To screen against wilt pathogen with sick soil load 2×10^8cfu /g maintained to evaluated the developed material and after well establishment the cuttings has been planted in the wilt sick plot and recorded the observations on 30 DAP. Based on disease scoring the plants has been grouped and presented in the following tables.

Multiplication | Planting of well established cuttings | Screening of cuttings in wilt sick plot

Fig 1.26 **Screening of germplasm under wilt Sick Plot**

Sr.no	Score	Indigenous collections
1	0	IC-318705,1180,Double Flower,KA-2,IC-677009,IC 318712,ACC-10,Orange China,Alandi MPKV,ACC-11,Surat Anar,1252,IC-318718,Maha,Bedana Sadana,ACC-12,Spendanadar,ACC – 2,EC 677014,ACC – 4,IC 318706,Mukteshwar,1184,IC 318734,IC-318724,1197,Red Nana,Yellow Nana,IC-318712,IC-318716,1267,1259,Ganesh &Bhagwa
2	10-15	Jodhpur Red, Yercord HRS, IC 318793, 1262, Bulthana Local, kandhaari, Dorsoda,
3	15-30	IC 318716,1263,IC-318724,Amildana,1194,Boscalinsi,JR Pink,EC-677025,Spincaskharin,1255,IC-318734,Arkta, 1195, Jodhapur Collection,IC -318735
4	30-50	IC-31878,IC-318744,kabul Cannor, Kabul Yellow,Acc-9,Solapur Lal,IC 318749,1181,1267, Tabesta
5	> 50	IC-318720,Co- White, IC-318767, IC-318707, IC-318753, 1185

Table 1.15. Advanced Breeding lines

Sr.no	Score	Advanced Breeding lines
1	0 – 10	BBSC-6,EMS Bhagawa,F2 (NRCPH-12 x Self),SBGT-3,SPH-15,SPH-21
2	10-15	BGT-1, F2 (NRCPH-6 x Self), SBGT-1, BGT-3, SPH-36,
3	15-30	SPH-18, BGT-5, SPH-9, Bhagawa, SPH-45, SPH-39, SBGT-4, BGT-4,
4	30-50	SBGT-2, BGT-2, SETB-T3, SET-B-T4, SET-B-T7, SET-A-T10, SET-A-T11, SET-A-T4, SET-A-T7, SET-A-T8,SET-B-T11, SETC-T2, SPH-16, BBSC-3, SET-B-T2, SET-B-T5, SET-B-T8
5	> 50	, SPH-12, SET-A-T1, SET-A-T6, SETA-T9, SET-B-T10, SET-C-T5, SET-B-T11, SET-B-T6, SET-B-T9, SPH-10, SBGT-5, SET-A-T2, SET-A-T5, SETC-T1, SET-C-T3, SET-C-T4, SET-A-T3, SET-C-T6

2. Plant Propagation

2.1 PROJECT: COMBATING STRESSES AND IMPROVING QUALITY IN POMEGRANATE (*Punica granatum* L.) BY EXPLOITING ROOTSTOCKS

2.1.1 *Evaluation of pomegranate germplasm against salinity*

The tolerance of germplasm against salinity as compared to the commercial variety Bhagwa was evaluated in a pot culture experiment. Irrigation with 200 mM (20.8 dsm^{-1}) NaCl solution (1:1) at every 3-4 days for 90 days. The biomass reduction under saline condition in IC-318733, Acc.-2, Patna-5 and IC-318712 was found considerable lower as compared to 'Bhagwa'. In genotype IC-318733 very meagre visual symptoms of leaf necrosis and dryness were observed under saline conditions where as symptoms were quite pronounced in 'Bhagwa'. The enhanced proline concentration and epicuticular wax under influence of salinity were found in wild genotypes as compared to 'Bhagwa'. The total chlorophyll reduction under influence of salinity among the genotypes were 2.25% in Patna-5, 10.45% in IC-318733, 12.67% in IC-318735, as compared to 33.50% in 'Solapur Lal' and 45.25% in 'Bhagwa'. Leaf stomatal density, length and width were also found to be influenced by salinity.

Table 2.1: Response of pomegranate genotypes against salinity

Accessions/ Varieties	Shoot weight (g)		Root weight (g)	
	0 mM	200 mM	0 mM	200 mM
IC-318733	62.31	55.67(moderate reduction by 10.66%)	38.56	34.23 (meagre reduction by 11.23%)
ACC-6	67.65	62.59 (meagre reduction by 7.48%)	41.94	36.31
Solapur Anaradana	45.12	41.58 (meagre reduction by 7.85%)	32.29	24.19
IC-318712	52.31	46.31(moderate reduction by 11.47%)	27.77	21.89
EC-676960	42.28	29.38 (drastic reduction by 30.51%)	19.28	14.29(drastic reduction by 25.88%)
Bhagwa	39.13	29.31 (drastic reduction by 25.10%)	21.22	16.11(drastic reduction by 24.08%)
Solapur Lal	37.58	27.52 (drastic reduction by 26.76%)	24.34	18.31 (drastic reduction by 24.77%)
IC-318735	41.24	36.11	26.88	19.69
Patna-5	42.36	37.82 (moderate reduction by 10.72%)	20.18	17.49 (moderate reduction by 13.33%)
$CD_{0.05}$	8.35	7.46	7.01	5.98

Table 2.2: Physiological and biochemical parameters of germplasm as influenced by imposed salinity treatment

Accessions	Proline Content (µg / 100 g FW)		RWC (%)		MSI (%)		ECW (mg / cm^2)	
	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM
IC-318733	5.27	9.46 (increase by 79.51%)	67.64	63.63	89.44	79.64	0.29	0.38(up by 31.03%)
ACC-6	5.45	6.87	75.25	50.08	62.86	50.08	0.24	0.27
Solapur Anardana	4.82	8.28	63.84	47.09	77.46	57.09	0.27	0.29
IC-318712	5.69	10.00 (increase by 73.64%)	68.57	45.16	77.52	65.17	0.25	0.28
Bhagwa	4.13	6.21 (meagre increase by 50.36%)	65.56	52.54	85.01	52.54	0.20	0.22(up by only 10.00%)
Solapur Lal	3.96	6.51	68.4	58.22	68.51	48.22	0.32	0.35
IC-318735	5.03	7.28	68.64	65.21	81.72	65.20	0.17	0.19
Patna-5	4.58	10.89 (drastic increase by 138%)	67.42	62.17	93.82	86.38	0.18	0.24
CD 0.05	1.21	1.84	5.04	9.72	9.17	9.72	0.01	0.01

Table 2.3: Visual leaf deformities in germplasm due to salinity treatment

Accessions	Plant height (m)		Foliar Salt Damage					
			Leaf abscission		Leaf necrosis		Leaf dryness	
	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM
IC-318733	2.35	2.17	**No abscission**	**Very low**	**Very low**	**Low**	**Very low**	**Very low**
ACC-6	2.61	2.26	No abscission	low	Low	Medium	Very low	High
Solapur Anaradana	2.66	2.17	No abscission	High	No necrosis	High	No dryness	Very high
IC-318712	2.63	2.19	No abscission	Low	Very low	Low	Medium	Medium
IC-318707	2.10	1.76	No abscission	Medium	Very low	High	Low	High
IC-318728	2.56	2.31	Low	High	Very low	High	Medium	Low
EC-676960	2.79	2.48	No abscission	Medium	Very low	High	Very Low	Low
Bhagwa	2.34	1.92	No abscission	High	No necrosis	High	No dryness	Very high
Solapur Lal	2.21	1.86	No abscission	Low	No necrosis	High	No dryness	Very high
IC-318735	2.68	2.35	No abscission	High	Low	Medium	Very low	Medium
Patna-5	1.87	1.68	**No abscission**	**Very low**	**No necrosis**	**Very low**	**Very low**	**Low**

Table 2.4: Leaf chlorophyll content as influenced by salinity treatment

Accessions	Chlorophyll a (mg / g FW)		Chlorophyll b (mg / g FW)		Total Chlorophyll (mg / g FW)		Chlorophyll a/b (mg / g FW)	
	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM
IC-318733	1.23	0.97	0.50	0.41	1.73	1.37	2.47	2.43
ACC-6	1.06	0.90	0.47	0.42	1.54	1.31	2.24	2.18
Solapur Anaradana	1.23	0.81	0.57	0.47	1.80	1.29	2.17	1.72
IC-318712	1.29	0.87	0.45	0.34	1.74	1.21	2.84	2.63
Bhagwa	1.27	0.66	0.52	0.32	1.79	0.98	2.44	2.08
Solapur Lal	1.32	0.81	0.58	0.46	1.91	1.27	2.26	1.76
IC-318735	0.95	0.85	0.47	0.39	1.42	1.24	2.01	2.17
Patna-5	0.90	0.89	0.42	0.36	1.33	1.30	2.15	2.57
CD $_{0.05}$	0.08	0.07	0.07	NS	0.10	0.09	0.40	0.33

Table 2.5: Leaf stomatal features as influenced by salinity treatment

Accessions	Stomatal density (cm^2)		Stomatal Length (µm)		Stomatal Width (µm)	
	0 mM	200 mM	0 mM	200 mM	0 mM	200 mM
IC-318733	4.87	3.41	9.34	8.21	6.05	4.67
ACC-6	4.43	3.15	8.91	7.71	5.82	4.48
Solapur Anaradana	5.61	3.08	9.56	8.53	6.58	5.81
IC-318712	5.69	3.70	11.71	9.41	8.18	6.78
IC-318707	5.18	3.09	10.52	8.68	7.54	6.24
IC-318706	5.38	3.43	10.49	8.46	6.53	5.23
IC-318728	6.05	3.76	11.52	9.58	7.92	6.57
IC-676960	5.14	2.79	10.23	8.05	7.28	6.13
Bhagawa	5.74	**3.19**	11.47	9.47	7.84	6.72
Solapur Lal	4.37	2.84	9.18	7.15	5.21	3.99
IC-318735	5.84	3.79	11.68	10.08	8.06	6.85
Patna-5	5.13	**4.29**	10.29	9.56	8.01	6.76
CD $_{0.05}$	1.02	0.86	1.57	NS	1.38	1.47

2.1.2 Hard wood cutting success as influenced by potting mixture, ringing, growth regulators and other pre-treatments

Different experiments were executed to visualize the influence of potting mixture, ringing, growth regulators and other pre-treatments of cutting success in pomegranate. Eight to twelve mm in diameter, 20-25 cm long and about 6-8 months old hardwood cuttings were used during semi-dormant conditions for the execution of the experiments (February-March under Solapur Maharashtra Conditions). In all the experiment, cuttings were maintained after planting under polyhouse conditions with 27±2 °C and 80 % RH with alternate day light irrigation with tap water.

For the potting experiment different potting mixtures were used- T1 (Cocopeat), T2 (Red Soil), T3 (Cocopeat + Red soil, 4:1, v/v), T4 (Cocopeat + Sand, 2:1, v/v), T5 (Cocopeat + Vermiculite + Perlite, 2:1:1, v/v/v), T6 (Cocopeat + Neem cake, 4:1, v/v), T7 (Sand + Soil+ FYM, 2:1:2, v/v/v) & T8 (Cocopeat + Vermiculite + Perlite + Red Soil in the proportion of 4:2:2:1, v/v/v/v). The pH and EC of different rooting media was estimated at the time of planting of cuttings.

Table 2.6 Effect of stem ringing and potting mixture on cutting success

Potting Mixture (PM)*		RC[#] NDSE*	No RC NDSE	Avg	RC MSC[@] (%)	No RC MSC (%)	Avg.	RC FCS[&] (%)	No RC FCS (%)	Avg.
Cocopeat (T1)		15.32	14.88	15.10	90.00	45.56	67.78	70	28.89	49.40
Red soil (T2)		15.63	14.71	15.17	91.67	61.11	76.39	73.33	33.89	53.61
Cocopeat + Red soil (T3)		14.82	14.06	14.44	96.67	78.89	87.78	71.67	39.44	55.56
Cocopeat + Vermiculite + Perlite (T5)		11.25	13.21	12.23	96.67	73.33	85.00	80.00	61.67	70.83
Sand + Soil + FYM (T7)		17.88	16.62	17.25	55.00	35.56	45.28	38.33	23.33	30.83
Average		15.55	15.04		81.43	58.73		62.38	37.70	
CD (p≤0.05)	**PM**	0.86			7.52			7.29		
	RC	1.62			14.07			13.63		
	PM x RC	2.29			19.90			19.28		

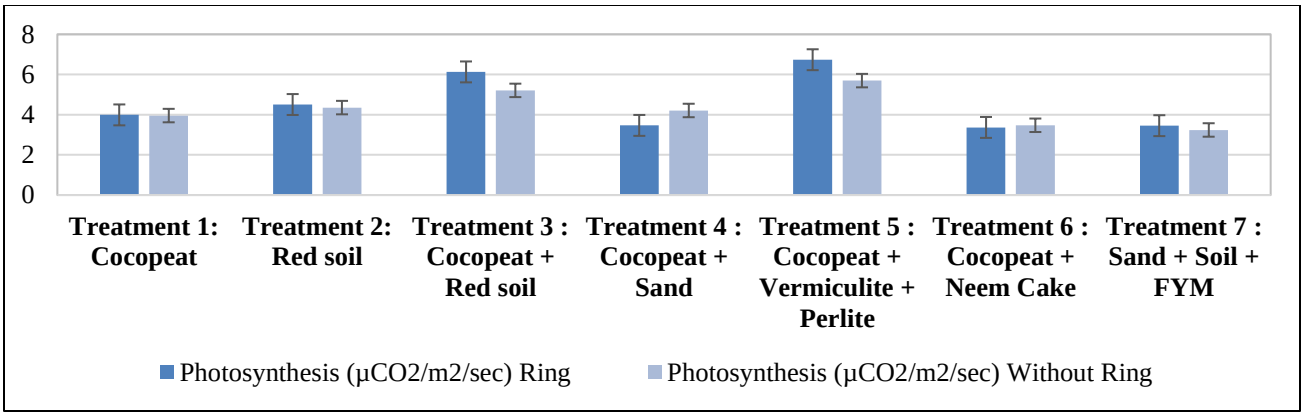


Fig. 2.1 Ringing and cutting, *Number of days to shoot emergence, @Maximum sprouting of cuttings, &Final cutting success

The cuttings planted on rooting media consisting of cocopeat + vermiculite + perlite (T5) took minimum days to shoot emergence (12.23), the highest cutting success (70.83 %), highest shoot and root biomass (3.69 g and 0.68g for shoot and root fresh weight, respectively), the maximum leaf chlorophyll content and photosynthesis (3.68 mg/g FW, 6.74 µmol CO2/m2/s, respectively). However, treatment comprised of cocopeat + red soil (T3) registered maximum sprouting (87.78%, but at par with T5, 85.00%). Independent of rooting media, the ringing and covering of stem one week before planting of cuttings registered significantly higher sprouting (81.43%) and cutting success (62.38 %) as compared to no ringing and covering. The highest final cutting success (80.00 %) was obtained with ringing and covering of stem and planting of cutting on cocopeat + vermiculite + perlite (T5). Interaction study between different growing media and cuttings success in pomegranate cultivar ‘Super Bhagawa’ revealed that among the different media and different media combinations, sand + cocopeat (1:1) showed the highest survival percentage (86.61%) followed by cocopeat (77.67%).

Table 2.7 Effect of various pre-treatments on cutting success

Treatment	Average number of days to shoot emergence	Maximum Sprouting of Cuttings (%)	Final Cutting Success (%)
Treatment 1: IBA 2500 ppm (1 min)	19.78	70.00	63.33
Treatment 4: IBA 500 ppm (30 min)	15.47	66.67	53.33
Treatment 5: IBA 100 ppm (24 hrs)	15.5	43.33	43.33
Treatment 9: Zinc Sulphate 1% + IBA 500 ppm (30 min)	**15.73**	**86.67**	**70.00**
Treatment 10: Boron 1 % + IBA 500 ppm (30 min)	15.57	86.67	60.00
Treatment 11: $CaCl_2$ 2 % + IBA 500 ppm (30 min)	16.95	76.67	60.00
Treatment 12: KH_2PO_4 2% + IBA 500 ppm (30 min)	18.60	76.67	60.00
Treatment 13: Ammonium Sulphate 2% + IBA 500 ppm (30 min)	17.54	76.67	66.67
Treatment 14: Citric Acid 100 mg/L + Ascorbic Acid 100 mg/L + IBA 500 ppm (30 min)	15.48	70.00	56.67
CD ($p \leq 0.05$)	3.16	16.32	20.32

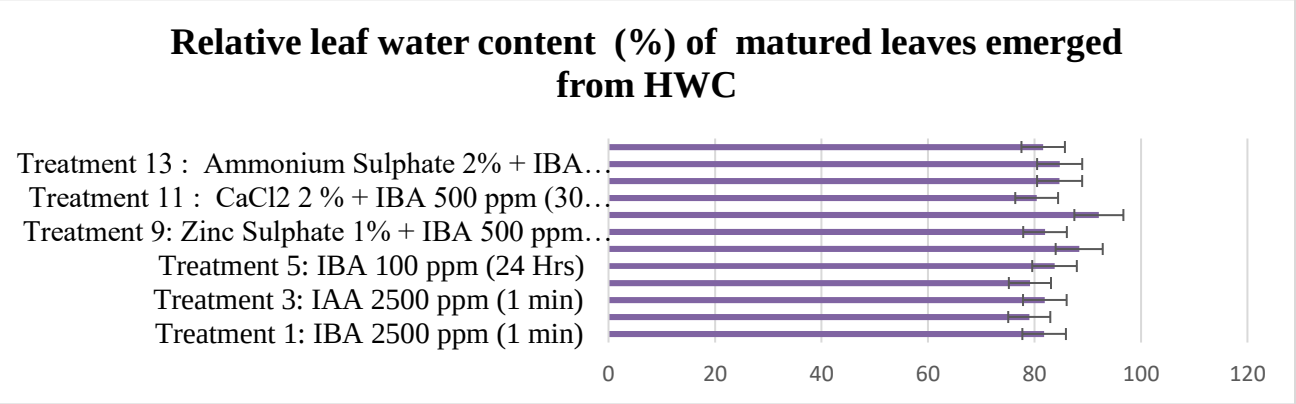


Fig. 2.2 Relative leaf water content per cent of matured leaves emerged from HWC

Among various pretreatments given to the hardwood cutting before the planting of cutting in the nursery bags, cuttings treated with combination of Zinc sulphate (1%) with Indole-3-butyric acid (IBA) (500 ppm) for 30 minutes registered highest cutting success (73.33%) and it was at par with the treatments T10, T14 and T1 but significantly better than rest of the treatments. As far as sprouting of cuttings are concerned Boric acid (1%) with IBA (500 ppm) for 30 minutes displayed the best results (84.44%) which was at par with treatments having ZnSO4 + IBA, $CaCl_2$ + IBA, KH_2PO_4 + IBA and only IBA but significantly superior to all other treatments. However, days to

shoot emergence was earliest in cuttings treated with IAA (100 ppm) for 24 hrs and $CaCl_2$ (2 %) + IBA (500 ppm) for 30 min (14.73 and 14.99 days, respectively) and were at par with T14 (Citric Acid 100 ppm + Ascorbic Acid 100 ppm + IBA 500 ppm for 30 min) but significantly earlier to other treatments. Total fresh and dry biomass of root and shoot was found to be the highest in cutting treated with ammonium sulphate (2%) + IBA (500 ppm) for 30 min (T13- 4.53g and 1.32 g for shoot and root fresh wt., respectively) which was at par with T8, T11 and T14 but significantly better to other treatments. The total leaf chlorophyll content was found to be the highest in T5 (4.01 mg/g FW) which was at par with T3, T11 and T9.

Table 2.8 Length and maturity of wood influencing the cutting success, propagability shoot & root fresh and dry biomass

Length of Cutting	Average number of days to shoot emergence	Maximum Sprouting of Cuttings (%)	Final Cutting Success (%)	Shoot Fresh Wt. (g)	Root Fresh Wt. (g)	Shoot Dry Wt. (g)	Root Dry Wt. (g)
T1 (Hardwood 4 nodes-20 cm)	14.26	73.33	60.00	2.42	0.87	0.87	0.15
T2 (Hardwood 2 nodes-10 cm)	21.64	53.33	33.33	0.93	0.28	0.35	0.07
T3 (Hardwood single node-5 cm)	16.88	40.00	20.00	0.37	0.27	0.14	0.07
T4 (Semi hardwood 4 nodes-20 cm)	13.87	63.33	33.33	1.28	0.34	0.44	0.06
T5 (Semi hardwood 2 nodes-10 cm)	15.78	50.00	36.67	0.78	0.30	0.27	0.06
T6 (Semi hardwood single node)	14.72	33.33	33.33	0.14	0.01	0.04	0.01
CD ($p \leq 0.05$)	NS	23.35	19.67	0.52	0.20	0.24	0.05

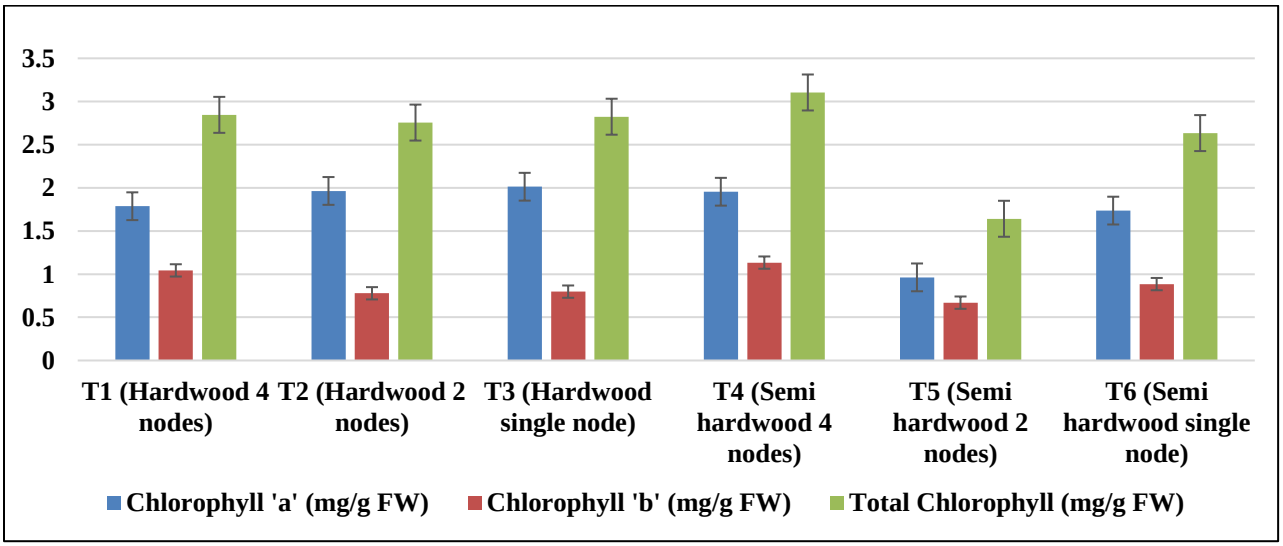


Fig. 2.3 Leaf chlorophyll content as influenced length and maturity of the wood

The length of the cutting and maturity of the wood are two important considerations for enhacing cutting success, among various length of cuttings (4 nodal-20 cm, 2 nodal-10 cm; single nodal-5 cm) and wood maturity (hardwood, 8-12 mm diameter and more than 6 months old & semi-hardwood, 4-6 mm in diameter, 4-6 months old), 4 nodes long harwood cutting registered the maximum cutting success (60.00%) and treatment 1 (4 nodal hard wood cuttings) 3and 4 (4 nodal semi-hardwood cuttings) performed at par for leaf total chlorophyll content (2.85 and 3.10 mg/g FW) but interestingly, RLWC (%) was higher in semi-hardwood cutting with two nodes and the result was at par with treatment 1 and 3 .

2.1.3 *In vitro* shoot proliferation and rooting of 'Super Bhagwa'

Table. 2.9 *In vitro* shoot proliferation as influenced by BAP, NAA and adenine sulphate

Treatment	BAP (mg/ml)	NAA (mg/ml)	Adenine Sulphate	Treatment	Net Shoot Growth (cm)	Number of Side Shoots	Greenness Index
Modified MS (Reduced NH_4NO_3 and enhanced $CuSO_4$, $CoCl_2$, $FeSO_4$-EDTA and Thiamine) + $AgNO_3$ + Ascorbic acid	0.3	0.15	50	**T1**	5.72	2.30	3.75
	0.3	0.15	100	**T2**	5.05	1.81	4.50
	0.5	0.25	50	**T3**	5.41	1.70	4.00
	0.5	0.25	100	**T4**	5.35	1.55	4.00
	1.0	0.5	50	**T5**	6.20	1.35	3.75
	1.0	0.5	100	**T6**	4.66	1.53	3.50
	0.3	0.15	50	**T7**	3.22	3.17	3.75
	0.3	0.15	100	**T8**	4.13	2.65	3.75
	0.5	**0.25**	**50**	**T9**	**6.95**	3.38	**4.75**
	0.5	0.25	100	**T10**	3.77	**3.82**	3.50
	1.0	0.5	50	**T11**	3.74	1.43	4
	1.0	0.5	100	**T12**	3.47	3.14	3.5
CD (p=0.05)					NS	1.08	NS

The modified MS medium with 0.5 mg/l BAP + 0.25 mg/l NAA + 50 mg/l adenine sulphate produced the highest average shoot growth (6.95 cm) with 3.38 number of side shoots and 4.75 GI but the maximum number of side shoots (3.82) were registered on the same medium but with enhanced adenine sulphate (100 mg/l).

In the present study three different basal media (having fixed concentration of activated charcoal- 1 g/l) with and without IBA were used to promote *in vitro* rooting of pomegranate micro-shoots, previously identified rooting medium (RP-6 WPM+AC 500mg/l+ 0.5 mg/l IBA) was kept as control. All the treatment registered better *in vitro* rooting as compared to control which suggests that increasing activated charcoal from 500 mg to 1.0 g/l is beneficial for *in vitro* rooting of rooting. Interestingly, addition of IBA to the rooting medium did not found to improve *in vitro* rooting of micro-shoots. DKW-Juglans basal medium and reduced strength MS medium (half macro salts) with 1.0 g/l activated charcoal and with or without IBA was found better.

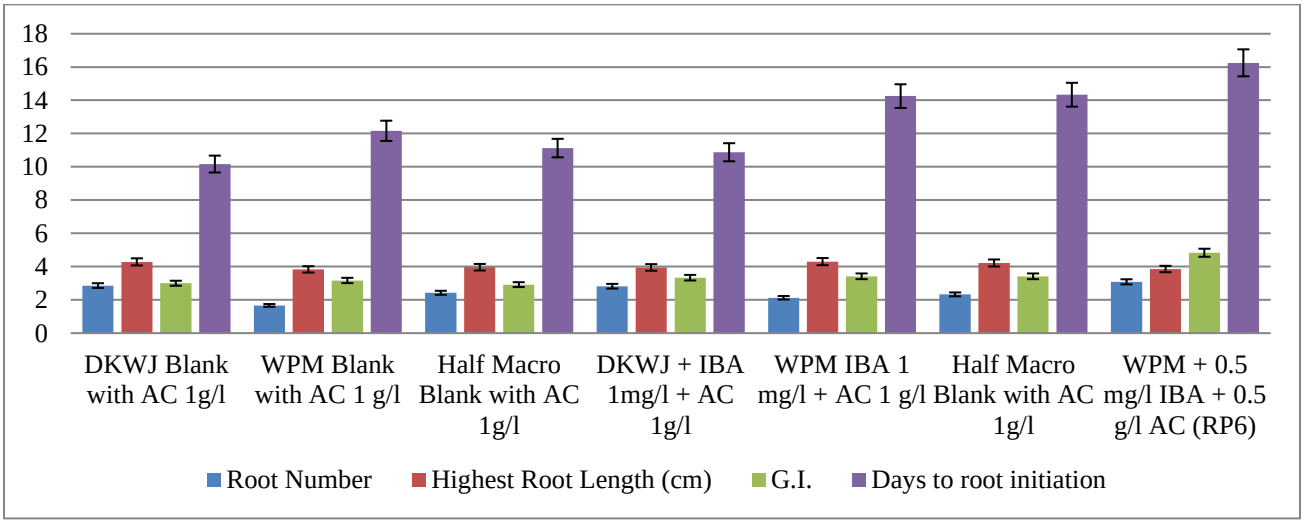


Fig. 2.4 *In vitro* shoot proliferation and rooting

3. Crop Production

3.1. PROJECT: CROP REGULATION PRACTICES FOR IMPROVING PRODUCTIVITY OF POMEGRANATE

3.1.1. Crop load optimization through thinning in pomegranate variety Solapur Lal

Pomegranate var. Solapur Lal is vigorous in nature. Upon crop regulation, it produces profuse flowers and surplus fruits throughout the tertiary branches, resulting in medium sized fruits. To improve the fruit size, the surplus fruits beyond a limit has to be removed at the time of fruit set, through fruit thinning. An experiment was conducted in Solapur Lal by adopting six thinning levels viz., very light thinning (121-135 fruits/tree), light thinning (106-120 fruits/tree), medium thinning (91-105 fruits/tree), heavy thinning (76-90 fruits/tree), very heavy thinning (61-75 fruits/tree) and control ie., without thinning (>135 fruits/tree). The results revealed that light thinning of fruits resulted in optimum no. of fruits (116.8 fruits/tree), fruit weight (276.40g/fruit) and optimum yield (32.28kg/tree), which is superior over the control. The Benefit Cost Ratio was highest in light thinning (5.0:1), whereas it was lowest in control (3.89: 1).

Table 3.1 Effect of different levels of thinning on yield and quality of Solapur Lal

Thinning Level	No. of fruits/ tree	Mean fruit weight (g)	Yield (kg/ plant)	Yield (ton/ ha)	TSS (°Brix)	Titrable Acidity (%)	TSS- Acid Ratio
Control (without thinning)	140.5	252.2	35.43	26.22	17.4	0.42	40.95
Very light thinning	129.2	264.5	34.17	25.29	17.5	0.42	42.68
Light thinning	116.8	276.4	32.28	23.89	17.6	0.40	44.00
Medium thinning	95.2	278.6	26.52	19.63	17.6	0.40	44.00
Heavy thinning	86.1	281.2	24.21	17.92	17.7	0.39	45.38
Very heavy thinning	72.42	282.5	20.46	15.14	17.8	0.39	45.64

Table 3.2 Increase in Export Grade Fruit (EGF) due to thinning in Solapur Lal

Thinning Level	Total yield (ton/ha)	Export Grade Fruits of >250 g (%)	Domestic Grade Fruits of >250 g (%)	Export Grade Fruits of <250 g (%)	Domestic Grade Fruits of <250 g (%)	Price of EGF (Rs/kg)	Price of DGF (Rs/kg)
Control (without thinning)	26.4	5.0	95.0	1.3	25.0	25.0	22.0
Very light thinning	25.1	20.0	80.0	5.0	20.1	35.0	30.0
Light thinning	23.3	30.0	70.0	7.0	16.3	42.0	36.0
Medium thinning	20.1	34.0	66.0	6.8	13.3	45.0	40.0
Heavy thinning	17.8	37.0	63.0	6.6	11.2	48.0	45.0
Very heavy thinning	15.0	40.0	60.0	6.0	9.0	50.0	50.0

Table 3.3 **Benefit Cost Ratio of fruit thinning in Solapur Lal**

Thinning Level	Income from EGF/ha (Rs)	Income from DGF/ha (Rs)	Total Income/ ha (Rs)	Thinning cost*/ tree (Rs.)	Thinning cost*/ ha (Rs.)	Others cost/ha (Rs)	Total cost/ha (Rs.)	Benefit to Cost Ratio
Control (without thinning)	32950	550924	583874	0	0	150000	150000	3.89
Very light thinning	175700	602400	778100	30	22200	150000	172200	4.52
Light thinning	293076	586252	879228	35	25900	150000	175900	5.00
Medium thinning	307989	531432	839421	40	29600	150000	179600	4.67
Heavy thinning	315240	503212.5	818453	45	33300	150000	183300	4.47
Very heavy thinning	300800	451200	752000	50	37000	150000	187000	4.02

Control | **Light thinning**

Fig 3.1 Crop load optimization through thinning in Solapur Lal

3.1.2 Effect of 2, 4 -D on flower drop

An experiment was conducted to manage the flower drop in pomegranate variety Bhagawa during hasth bahar. Foliar application of the growth regulator 2, 4-D at six concentrations (5, 10, 15, 20, 25 and 30ppm) at the onset of flowering and 7 days after anthesis. The increase in concentration of 2, 4-D significantly reduced the flower drop. The growth regulator 2,4-D concentration @ 20ppm was found to be highly beneficial for management of flower drop. Besides, 2, 4-D@ 20ppm recorded the minimum flower drop (19.2 flowers/tree), percent flower drop (10.41%), and highest fruit set (58.38%) and number of fruits (96.50 fruits/tree) and highest yield (27.06 kg /tree). A higher concentration of 2,4-D beyond 20ppm was not beneficial in enhancing the yield.

Table 3.4 Effect of 2, 4-D on flower drop and fruit set of pomegranate

Concen. of 2,4-D (ppm)	Total No. of bisexual flowers/ tree	No. of bisexual flowers dropped/ tree	Percent dropped flowers (%)	No. of bisexual flowers retained	No. of fruits / plant	Fruit set (%)
5 ppm	190.6	36.2	18.99	154.4	80.4	52.07
10 ppm	193.2	32.4	16.77	160.8	85.2	52.99
15 ppm	188.6	26.0	13.79	162.6	90.4	55.60
20 ppm	184.5	19.2	10.41	165.3	96.5	58.38
25 ppm	183.2	19.8	10.81	163.4	94.2	57.65
30 ppm	184.4	20.5	11.12	163.9	91.6	55.89
Control (Unsprayed)	179.2	40.0	22.32	139.2	71.2	51.15

Control | **2,4-D@20ppm**

Fig 3.2 Effect of 2, 4-D on control of flower drop in pomegranate

Table 3.5. Effect of 2, 4-D on fruit weight, yield and quality of pomegranate:

Concentration of 2,4-D (ppm)	No. of fruits/ Tree	Fruit weight (g)	Yield (kg/tree)	Yield (t/ha)	TSS (ºBrix)	Titrable acidity (%)
5 ppm	80.4	265.2	21.32	15.78	15.4	0.47
10 ppm	85.2	269.4	22.95	16.99	15.5	0.46
15 ppm	90.4	272.5	24.63	18.23	15.6	0.46
20 ppm	96.5	280.4	27.06	20.02	15.8	0.45
25 ppm	94.2	274	25.81	19.10	15.8	0.45
30 ppm	91.6	270.4	24.77	18.33	15.8	0.44
Control (Unsprayed)	71.2	250.2	17.81	13.18	15.2	0.48

3.2 PROJECT: CANOPY ARCHITECTURE MANAGEMENT AND HIGH DENSITY PLANTING IN POMEGRANATE

3.2.1 Canopy architecture management through the use of training systems in Pomegranate

The plants are trained with single stem system and being maintained as per recommended pomegranate production and plant protection practices. Installed Y- Trellis, Double – T Trellis and Overhead Gable system of canopy management in both Solapur Lal and Bhagwa as per envisaged technical programme.

Initial observations on growth suggested that the pomegranate var. Solapur Lal was found to be vigorous with respect to tree height, tree spread and tree volume compared with Bhagwa and note significant differences among different systems of training with respect to growth and gas exchange parameters.

Initial data on fruit yield suggested that the average fruit weight (232 g) and fruit yield (14.22 kg) was maximum and in Y- Trellis system followed by Double – T trellis system at normal spacing compared with other systems of training.

Also recorded initial cost involved in installation of different trellis systems and farm inputs

Fig. 3.1 Canopy architecture management through the use of training systems

Table 3.6. Growth performance of Pomegranate var. Solapur Lal under different training system

Treatments	Plant Height (m)		Canopy spread (m)				Tree Spread (m^2)		Tree volume (m^3)	
			(N –S)		(E – W)					
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T 1	2.31^{a}	1.96^{a}	2.09^{a}	2.16^{a}	1.89^{b}	1.92^{a}	1.97^{a}	2.08^{a}	3.73^{a}	3.65^{a}
T 2	2.19^{ab}	1.93^{a}	1.56^{b}	1.65^{b}	1.99^{a}	1.83^{a}	1.56^{b}	1.54^{b}	2.82^{b}	2.63^{b}
T 3	2.02^{b}	1.89^{b}	1.95^{a}	1.54^{b}	1.94^{ab}	1.81^{a}	1.84^{a}	1.35^{b}	3.17^{ab}	2.19^{b}
T 4	1.92^{b}	1.98^{a}	1.99^{a}	1.67^{b}	1.86^{b}	1.65^{b}	1.87^{a}	1.41^{b}	3.23^{ab}	2.28^{b}
CD @	0.21	0.14	0.19	0.19	0.09	0.13	0.17	0.31	0.60	0.71
CV (%)	5.97	1.38	6.42	6.93	2.81	4.62	5.92	12.21	11.61	14.43

Where, T1: Y-Trellis system; T2: Double-T system; T3: Overhead Gable system, T4: Conventional training system, S1: spacing at 4.5 x 3.0 m and S2: spacing at 4.5 x 1.5 m

Table 3.7. Initial yields of Solapur Lal under different training systems

Sl. No.	Variety	Planting material / Trellis stems	Spacing	Yield (Kg / tree)	Yield (t / ha)	Average fruit weight (g)
1.	Solapur Lal	Air Layered / rooted cuttings	4.5 m x 3.0 m	11.38	8.42	189
			4.5 m x 1.5 m	8.48	12.55	196
2.	Solapur Lal	Tissue cultured plants	4.5 m x 3.0 m	10.11	7.48	184
			4.5 m x 1.5 m	9.32	13.79	178
3.	Solapur Lal	Y – Trellis system (Air Layered plants)	4.5 m x 3.0 m	14.22	10.52	232
			4.5 m x 1.5 m	11.28	16.69	228
3.	Solapur Lal	Double T – Trellis system (Air Layered plants)	4.5 m x 3.0 m	12.11	8.91	221
			4.5 m x 1.5 m	9.67	14.22	208
4.	Solapur Lal	Overhead Gable Trellis system (Air Layered plants)	4.5 m x 3.0 m	13.29	9.8	217
			4.5 m x 1.5 m	9.22	13.64	211

3.2.2 High density planting in Pomegranate

In high density planting (HDP) trial, the rooted cuttings of Solapur Lal and Bhagwa were field planting on 30th November, 2022 as per envisaged technical programme (4.5 x 3.0 m-T1; 3.6 x 2.5 m-T2; 3.6 x 2.0 m-T3; 3.6 x 1.5 m-T4 and 3.6 x 1.0 m-T5).

Growth observations revealed that the growth of pomegranate var. Solapur Lal has excelled with respect to tree height, tree spread, stem girth and tree volume compared with Bhagwa across the treatments.

Table 3.8. Growth performances of Solapur Lal and Bhagwa at different planting densities

Treat-ments	Plant Height (m)		Canopy spread (m)				Stem girth (mm)		Tree spread (m^2)		Tree volume (m^3)	
			(N –S)		(E – W)							
	SL	BG	SL	BG	SL	BG	SL	BG	SL	BG	SL	BG
T 1	1.48^{ab}	1.01^{a}	1.00	0.79^{bc}	1.08^{a}	0.79^{b}	28.11^{b}	23.91	0.58^{ab}	0.37^{a}	0.74^{a}	0.25^{ab}
T 2	1.41^{bc}	0.88^{b}	0.98	0.77^{c}	1.04^{a}	0.76^{b}	29.84^{b}	26.19	0.61^{a}	0.29^{c}	0.65^{abc}	0.21^{b}
T 3	1.52^{a}	1.03^{a}	1.03	0.87^{a}	1.02^{a}	0.80^{ab}	31.69^{a}	25.93	0.52^{bc}	0.34^{ab}	0.66^{ab}	0.29^{a}
T 4	1.38^{c}	0.98^{a}	0.96	0.85^{ab}	0.97^{ab}	0.85^{a}	28.98^{b}	24.25	0.51^{bc}	0.35^{ab}	0.61^{bc}	0.28^{a}
T5	1.40^{c}	1.01^{a}	1.01	0.88^{a}	0.87^{b}	0.76^{b}	29.34^{b}	24.83	0.46^{c}	0.32^{bc}	0.53^{c}	0.27^{a}
CD @ 0.05	0.08	0.08	NS	0.08	0.12	0.05	1.81	NS	0.07	0.05	0.12	0.04
CV (%)	3.84	5.36	3.05	5.88	7.23	4.62	3.98	7.36	8.64	9.87	11.91	11.31

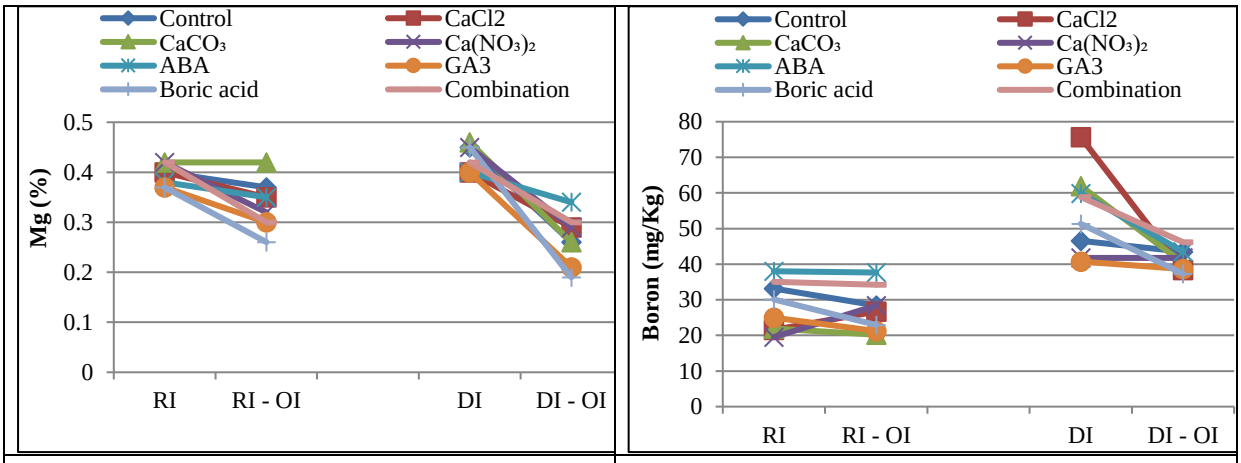
Where, T1: 4.5 x 3.0 m; T2: 3.6 x 2.5 m; T3: 3.6 x 2.0 m; T4: 3.6 x 1.5 m; T5: 3.6 x 1.0 m; SL: Solapur Lal and BG: Bhagwa.

3.3 PROJECT: UNRAVELING MECHANISM AND DEVELOPING MITIGATION STRATEGIES FOR ARIL BROWNING AND FRUIT CRACKING IN POMEGRANATE

3.3.1Study on effect of irrigation level and chemicals on pomegranate rind constituents

To carry out the study five year old Bhagawa plants were used. Foliar sprays of three calcium sources (2.5%), Abscisic acid (ABA 90µM), Gibberellic acid (GA 60ppm), Boric acid (BA 0.3%), and a combination of $CaCl_2$(2.5%)+BA(2.5%)+GA(60ppm)+ABA(90µM) were applied to the Bhagawa variety that was devoid of irrigation for 20 days (DI) at the almost fruit maturity stage, followed by overirrigation for five days. Rind of matured fruits from over-irrigated, delayed-irrigated, and regularly-irrigated plants were analyzed for cell wall constituents.

The results showed that Magnesium content in pomegranate peel was significantly affected by both irrigation level and chemical treatments. However the interaction of chemical treatment and irrigation level showed non-significant effect. Over-irrigation to delayed irrigation plants drastically decreased magnesium content. In these plants sprays of abscisic acid significantly increased the magnesium content. Boron content in pomegranate peel was significantly affected by both irrigation level and chemical treatments. However the interaction of chemical treatment and irrigation level showed non-significant effect. Over-irrigation to delayed irrigation plants drastically decreased magnesium content. The decrease was minimum in Boron with combination treatment.

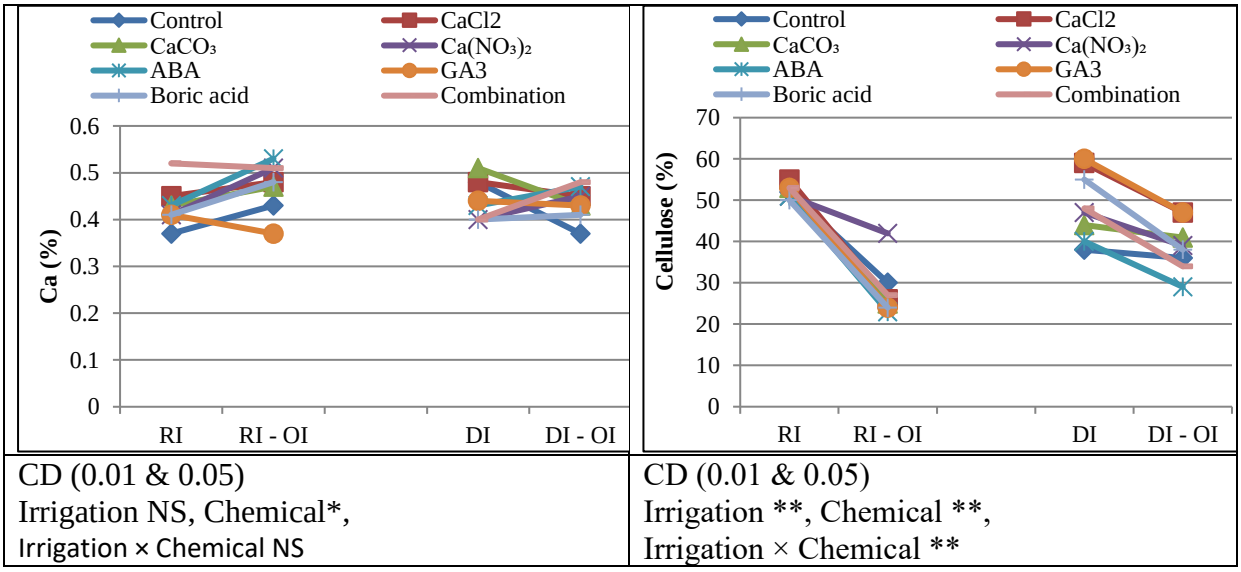


CD (0.01 & 0.05) Irrigation **; Chemical * Irrigation × Chemical NS	CD (0.01 & 0.05) Irrigation **, Chemical * Irrigation × Chemical: NS

Figure 3.5 Effect of irrigation levels and chemical treatments on Magnesium and Boron content (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

Calcium content was non-significantly affected by irrigation treatments, but significantly by chemical treatments. Calcium decreased in over-irrigated plants that were left devoid of water. Combination treatment followed by abscisic acid treatment significantly increased the

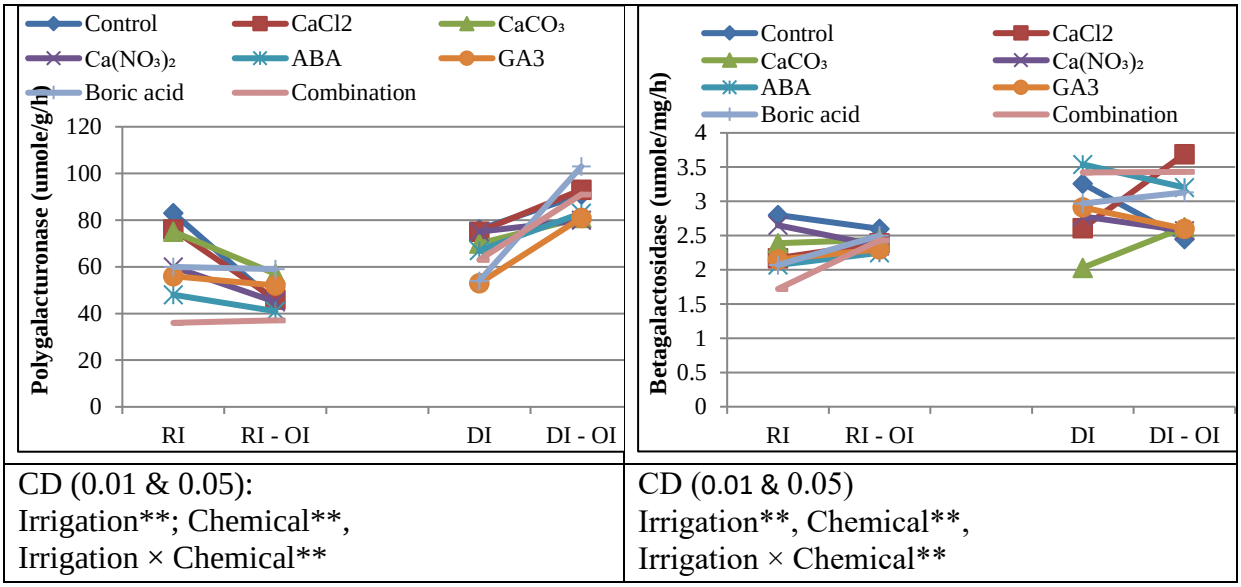
calcium content in over-irrigated plants. All the other chemical treatments also increased Calcium content compared to control plants. Irrigation treatment, chemical treatment and their interaction affected the cellulose content significantly. In both, regularly irrigated and delayed irrigated plants, overirrigation significantly reduced the cellulose content in pomegranate rind. Among all the treatments only GA could retain cellulose levels even after overirrigation of delayed irrigated plants, whereas rest of the chemical treatments were not effective for cellulose content.



CD (0.01 & 0.05) Irrigation NS, Chemical*, Irrigation × Chemical NS	CD (0.01 & 0.05) Irrigation **, Chemical **, Irrigation × Chemical **

Figure 3.6 Effect of irrigation levels and chemical treatments on Calcium and Cellulose content (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

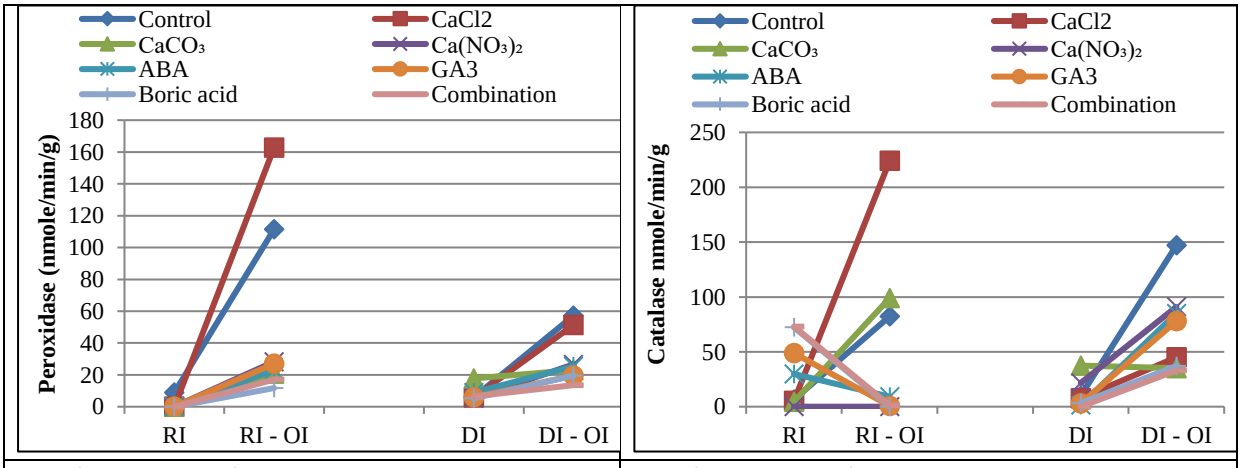
Polygalacturonase is an enzyme responsible for cell wall degradation and is involved in fruit softening. Its low concentrations are desirable in rind. However results showed that overirrigation to delayed irrigated plants increased the polygalacturonase activity significantly. Calcium, GA and ABA treatments to overirrigated plants reduced the polygalacturonase levels compared to control plants. Betagalactosidase was also significantly affected by irrigation and chemical treatments along with their interaction. GA3 reduced the activity of this enzyme, whereas calcium chloride enhanced the activity significantly. Among irrigation treatments, fruits with delayed irrigation showed maximum content of betagalactosidase.



CD (0.01 & 0.05): Irrigation**; Chemical**, Irrigation × Chemical**	CD (0.01 & 0.05) Irrigation**, Chemical**, Irrigation × Chemical**

Figure 3.7: Effect of irrigation levels and chemical treatments on Polygalacturonase and Betagalactosidase activity (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

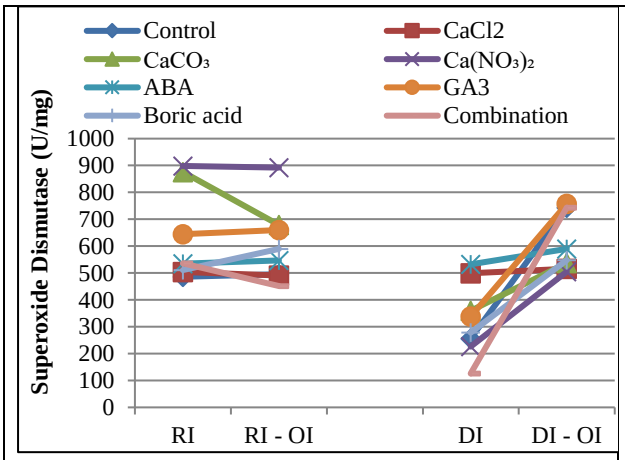
Irrigation treatments significantly affected the peroxidase activity. Overirrigated plants contained higher activity of peroxidase compared to regularly irrigated and delayed irrigated plants indicating stress level in overirrigated plants. Among the chemical treatments combination treatment was best to reduce the peroxidase activity indicating release in stress. Irrigation, chemical treatment and their interaction affected the Catalase activity significantly. Like peroxidase, activity of catalase was the maximum in overirrigated plants. Among chemical treatments, though all treatments reduce the activity compared to control, combination treatment was best to reduce the catalase activity in fruit rind of overirrigated plants.



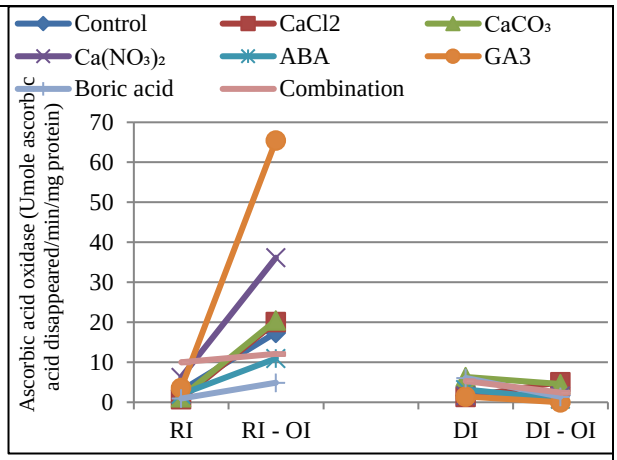
CD (0.01 & 0.05) Irrigation **, Chemical NS, Irrigation × Chemical NS	CD (0.01 & 0.05) Irrigation **, Chemical **, Irrigation × Chemical**

Figure 3.8 Effect of irrigation levels and chemical treatments on Peroxidase and Catalase activity (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

Superoxide dismutase activity (SOD) activity gets significantly affected by irrigation, chemical treatment and their interaction. Activity was least in delayed irrigated planted and increased significantly after overirrigation. Among chemical treatments, calcium chloride and calcium nitrate decreased the activity significantly. Ascorbic acid oxidase was significantly affected by irrigation and chemical treatments. The activity showed high increase in overirrigation of regularly irrigated plants. GA3 and ABA reduced the activity significantly.



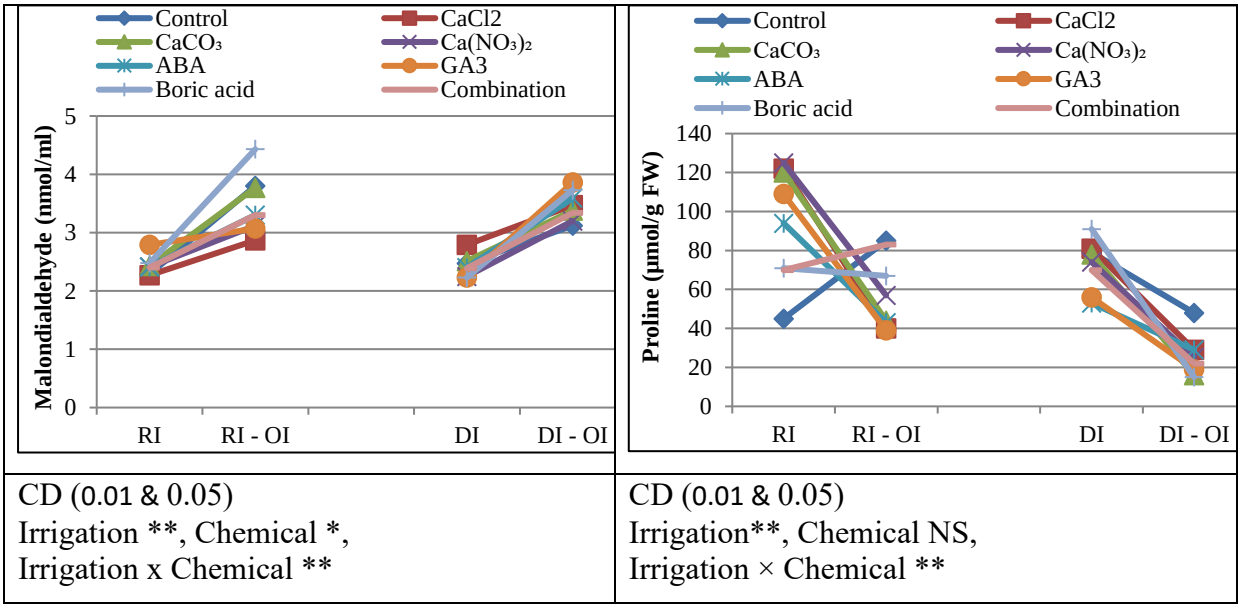
CD (0.01 & 0.05)
Irrigation **, Chemical **,
Irrigation × Chemical**



CD (0.01 & 0.05)
Irrigation **, Chemical*,
Irrigation x Chemical: NS

Figure 3.9 Effect of irrigation and chemical treatments on Superoxide dismutase and Ascorbic Acid Oxidase activity (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

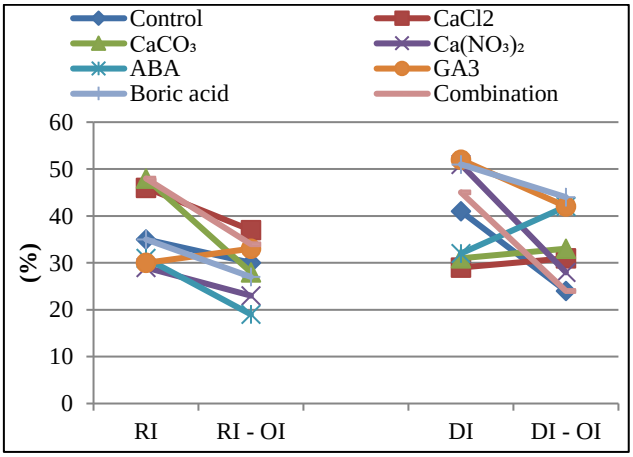
Malondialdehyde, a stress indicator, was the maximum in overirrigated plants. Irrigation, chemical treatment and their interaction affected the malondialdehyde content significantly. Among the tried chemicals, no treatments could reduce its content. Proline content decreased in overirrigated plants. Irrigation treatment and interaction of irrigation and chemical treatment significantly affected the proline content. Calcium carbonate and boric acid decreased proline content to maximum extent.



CD (0.01 & 0.05) Irrigation **, Chemical *, Irrigation x Chemical **	CD (0.01 & 0.05) Irrigation**, Chemical NS, Irrigation × Chemical **

Figure 3.10 Effect of irrigation and chemical treatments on Malondialdehyde and proline content (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

Membrane thermal stability decreased after overirrigation, indication more stability of membranes under low water content. Irrigation treatment and interaction of irrigation and chemical treatment significantly affected the membrane thermal stability content. Boric acid, ABA and GA3 were most effective to enhance membrane thermal stability in overirrigated plants.

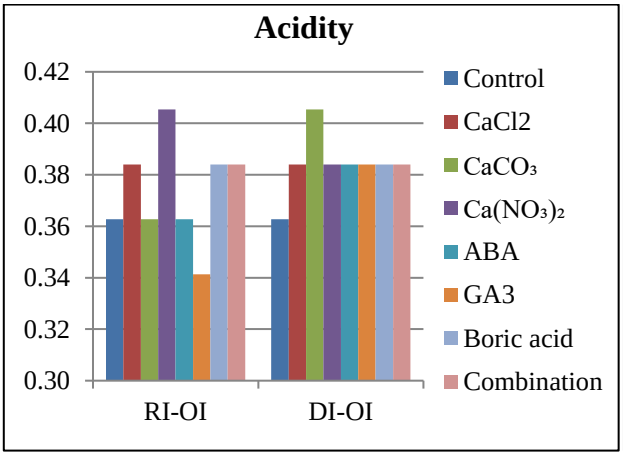


CD (0.01 & 0.05)
Irrigation**, Chemical NS,
Irrigation × Chemical**

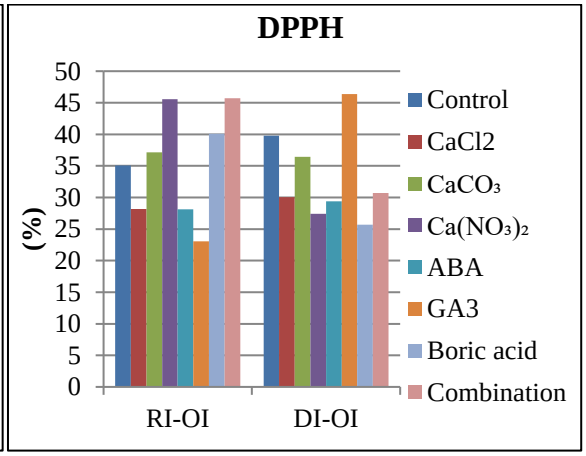
Figure 3.11 Effect of irrigation and chemical treatments on Membrane Thermal Stability (RI regularly irrigated, RI-OI regular irrigation followed by overirrigation, DI Delayed irrigation, DI-OI delayed irrigation followed by overirrigation)

Impact of irrigation and chemical treatments on nutritional quality

Fruits of treated plants were analyzed for fruit quality. The results showed that acidity was non-significantly affected by irrigation and chemical treatments. The effect of interaction of both the treatments was also no significant. Antioxidant activity in terms of DPPH was also non-significantly affected by irrigation and chemical treatment but their interaction showed significant results. Reducing sugars varied significantly by both irrigation and chemical treatments but their interaction had non-significant effect. However total soluble sugars were significantly affected by only irrigation treatment but not by the chemical treatments. Overirrigation in delayed irrigated plants showed significant reduction in reducing sugars and total soluble sugars. Only chemical treatments significantly affected the phenols content. Among chemicals treatments, calcium carbonate had significantly enhanced the phenols in overirigated plants. Anthocyanins were significantly affected by both the treatments and their interaction. Overirrigation of delayed irrigated plants enhanced the anthocyanins significantly. However the chemical treatments decreased its content. Ascorbic acid remained non-significantly affected.

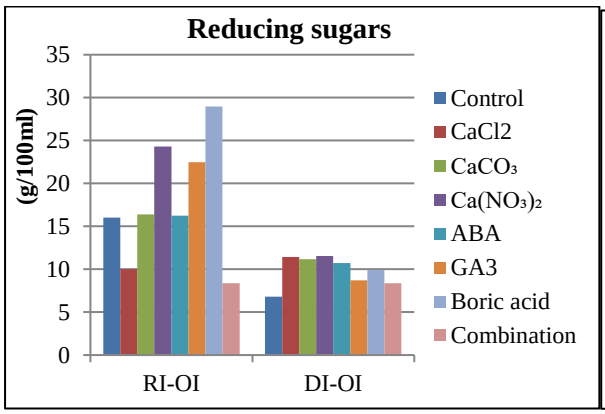


CD @ 0.01 & 0.05
Irrigation NS; Chemical NS;
Irrigation × Chemical: NS

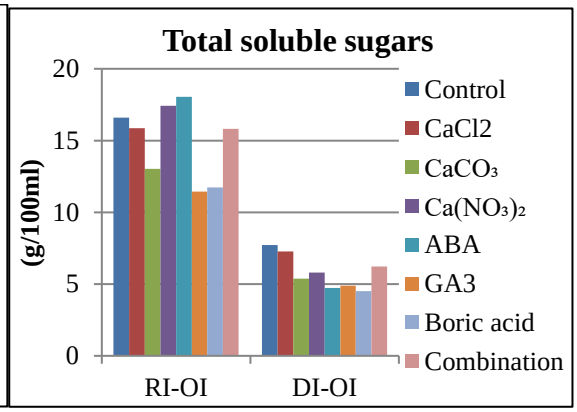


CD @ 0.01 & 0.05
Irrigation NS; Chemical NS
Irrigation × Chemical: *

Figure 3.12 Effect of irrigation and chemical treatments on acidity and DPPH scavenging activity

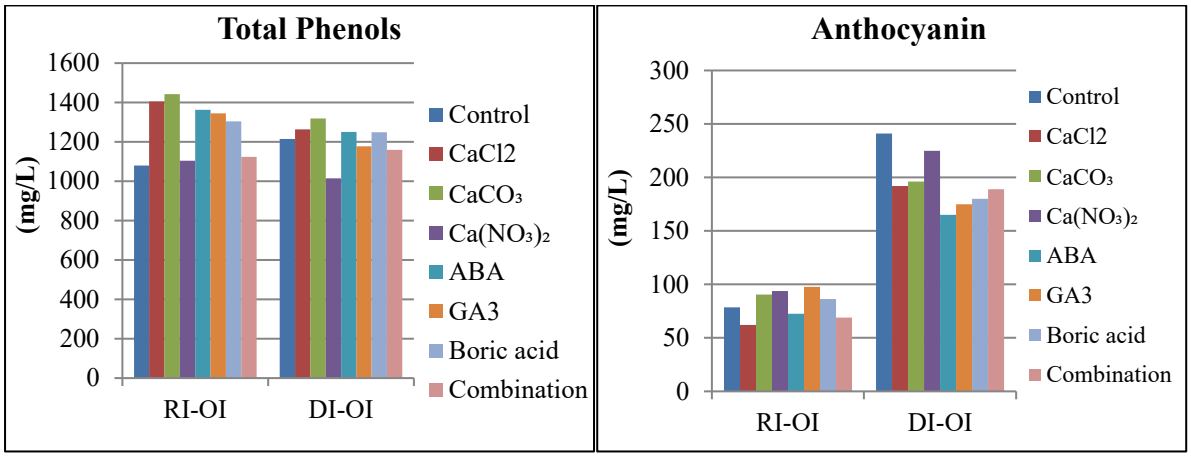


CD @ 0.01 & 0.05
Irrigation **; Chemical **
Irrigation x Chemical: NS



CD @ 0.01 & 0.05
Irrigation **; Chemical NS
Irrigation x Chemical: NS

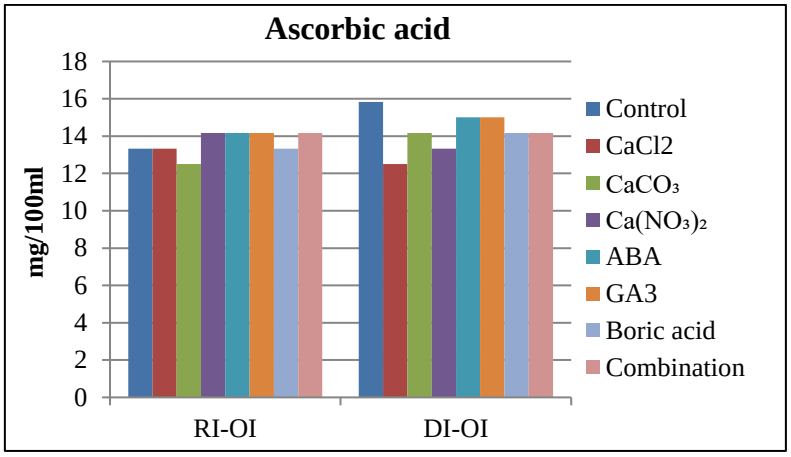
Figure 3.13 Effect of irrigation and chemical treatments on reducing sugars and total soluble sugars



CD @ 0.01 & 0.05
Irrigation NS; Chemical*
Irrigation x Chemical: NS

CD @ 0.01 & 0.05
Irrigation ** Chemical *
Irrigation x Chemical:*

Figure 3.14 Effect of irrigation and chemical treatments on total phenols and anthocyanin

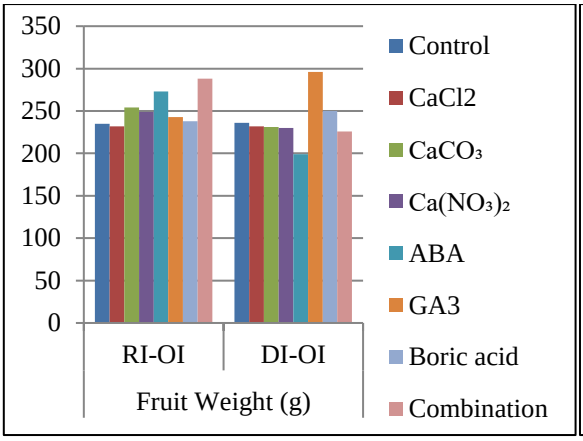


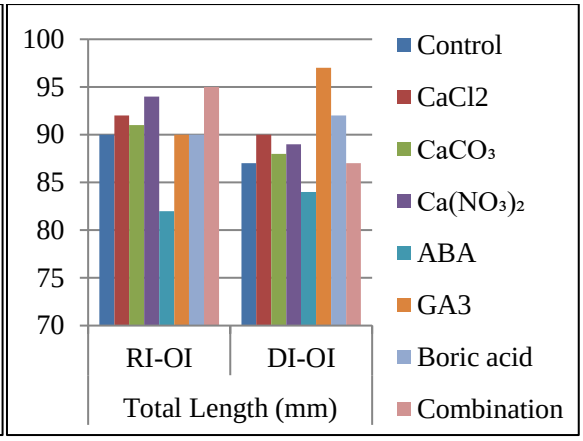
CD @ 0.01 & 0.05
Irrigation NS; Chemical: NS
Irrigation x Chemical: NS

Figure 3.15 Effect of irrigation and chemical treatments on ascorbic acid content

Impact of treatments on Fruit Quality

Irrigation treatment and interaction of irrigation and chemical treatment significantly affected fruit weight, whereas total fruit length was non-significantly affected. Interaction of chemical and irrigation treatment had significant effect on total aril weight. Irrigation and interaction of irrigation and chemical treatment significantly affected the rind weight, whereas rind thickness was only affected by irrigation treatments significantly. After overirrigation of delayed irrigated plants, GA3 significantly enhanced the total aril weight and rind weight significantly.

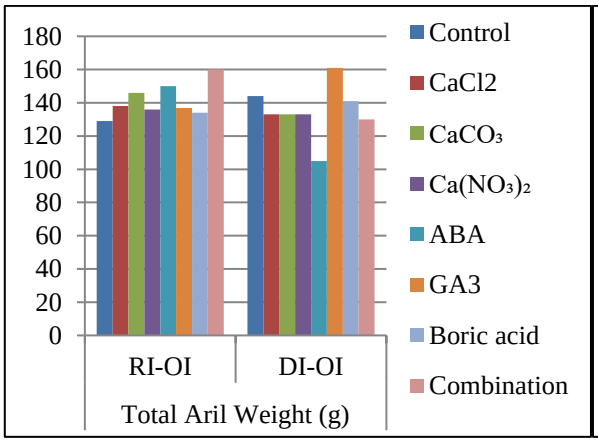


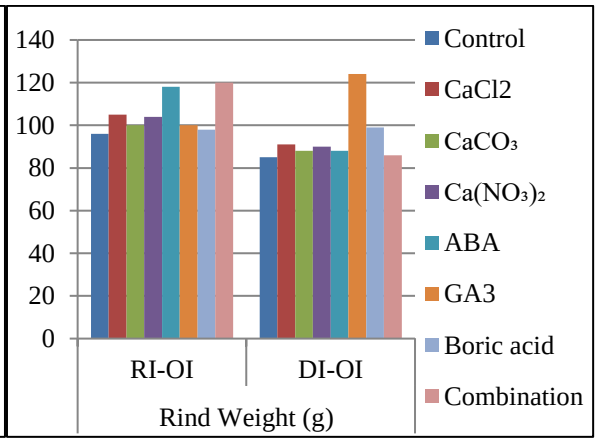


CD @ 0.01 & 0.05
Irrigation*, Chemical NS
Irrigation x Chemical:**

CD @ 0.01 & 0.05
Irrigation NS, Chemical NS
Irrigation x Chemical:NS

Figure 3.16 Effect of irrigation and chemical treatments on Fruit weight and length

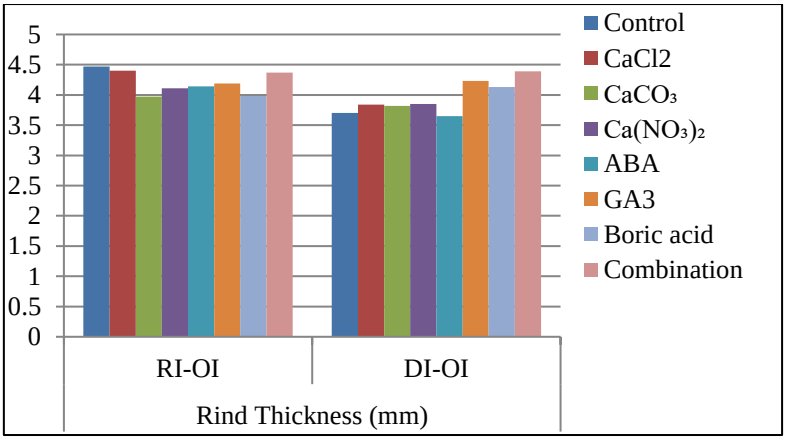




CD @ 0.01 & 0.05
Irrigation NS, Chemical NS
Irrigation x Chemical:**

CD @ 0.01 & 0.05
Irrigation **, Chemical NS
Irrigation x Chemical:**

Fig 3.17 Effect of irrigation and chemical treatments on total aril weight and rind weight



CD @ 0.01 & 0.05
Irrigation*, Chemical NS
Irrigation x Chemical NS

Figure 3.18 Effect of irrigation and chemical treatments on rind thickness

3.3.2 Role of cell wall components and minerals in fruit cracking

Dried rind of cracked and uncracked fruits of 6 germplasm was evaluated for crude fibre content, calcium, magnesium, cellulose and pectin content. Fibre content varied from 27-58% in all germplasm. In uncracked fruits, fibre was maximum in germplasm Yercaud, followed by P16. Fruit crack percent showed positive correlation (r 0.433) with rind fibre content. Cellulose varied from 1.7% (P-16) to 3.9% (Mridula) in rind of uncracked fruits. Cellulose content showed negative correlation (r -0.245) with fruit cracking percent. Pectin content varied from 0.0776 g (Jyoti) to 0.1078 g (Mridula) in dried rind of uncraked fruits. Pectin exhibited negative correlation (r -0.198) with fruit cracking percent.

Calcium varied from 0.16% (Kabuli yellow) to 0.4% (Mridula) in rind of uncracked fruits. Cracked fruits contained lower calcium content than uncracked fruits. Magnesium varied from 0.192% (318754) to 0.288% (Mridula) in rind of uncracked fruits. Magnesium either retained at par or slightly decreased in cracked fruits. Fruit cracking percent showed significant negative correlation with both Calcium (r -0.687) and Magnesium (r -0.623). Study showed that Mridula contained higher content of cellulose, pectin, Calcium and Magnesium which correlated well with its lower cracking percent (4%).

3.3.3 Study of genetic Correlation between fruit cracking with selected morphological and physiological parameters in pomegranate germplasm

In total 18 pomegranate accessions which exhibited diverse genetic reaction to fruit cracking (0 - 32.47 %) were evaluated for two morphological traits, four physiological parameters and 20 SSR primers during *ambe* bahar at ICAR -National Research Centre on Pomegranate, Solapur. The genetic correlation analysis indicated the presence of significant positive correlation between fruit cracking and fruit stalk/peduncle diameter (0.49*); relative rind moisture content (0.69**). While a significant negative correlation was recorded between fruit cracking and rind membrane thermal stability (-0.505*).

Descriptive Statistics

Character	N	Mean	Standard Deviation	Std. Error
FC%	18.000	13.684	9.289	2.511
PD(MM)	18.000	4.932	1.318	0.594
PL(mm)	18.000	6.792	2.092	0.803

Pearson Correlation Matrix

	FC%	PD(MM)	PL(mm)
FC%	1.000	0.494^{*}	-0.125^{NS}
PD(MM)	0.494^{*}	1.000	0.090^{NS}
PL(mm)	-0.125^{NS}	0.090^{NS}	1.000

Table 3.9. Correlation between fruit cracking with selected morphological and physiological parameters

Pearson Correlation Matrix

	RRWC%	LRWC%	RMContent(%)	RMTS(in%)	LMTS(in%)	Chla	Chlb	TotalChl	Chla/Chl	FruitCracking%
RRWC%	1.000	0.169^{NS}	0.225^{NS}	-0.090^{NS}	-0.146^{NS}	0.338^{NS}	0.286^{NS}	0.324^{NS}	0.283^{NS}	0.229^{NS}
LRWC%	0.169^{NS}	1.000	0.021^{NS}	0.227^{NS}	0.101^{NS}	-0.218^{NS}	-0.195^{NS}	-0.211^{NS}	0.055^{NS}	-0.103^{NS}
RMContent(%)	0.225^{NS}	0.021^{NS}	1.000	-0.579*	-0.057^{NS}	0.273^{NS}	0.246^{NS}	0.266^{NS}	0.189^{NS}	0.452^{NS}
RMTS(in%)	-0.090^{NS}	0.227^{NS}	-0.579*	1.000	-0.009^{NS}	-0.071^{NS}	-0.067^{NS}	-0.065^{NS}	-0.057^{NS}	-0.505*
LMTS(in%)	-0.146^{NS}	0.101^{NS}	-0.057^{NS}	-0.009^{NS}	1.000	-0.083^{NS}	-0.105^{NS}	-0.090^{NS}	0.026^{NS}	0.072^{NS}
Chla	0.338^{NS}	-0.218^{NS}	0.273^{NS}	-0.071^{NS}	-0.083^{NS}	1.000	0.981**	0.999**	-0.222^{NS}	0.259^{NS}
Chlb	0.286^{NS}	-0.195^{NS}	0.246^{NS}	-0.067^{NS}	-0.105^{NS}	0.981**	1.000	0.990**	-0.394^{NS}	0.249^{NS}
TotalChl	0.324^{NS}	-0.211^{NS}	0.266^{NS}	-0.065^{NS}	-0.090^{NS}	0.999**	0.990**	1.000	-0.268^{NS}	0.254^{NS}
Chla/Chl	0.283^{NS}	0.055^{NS}	0.189^{NS}	-0.057^{NS}	0.026^{NS}	-0.222^{NS}	-0.394^{NS}	-0.268^{NS}	1.000	0.006^{NS}
FruitCracking%	0.229^{NS}	-0.103^{NS}	0.452^{NS}	-0.505*	0.072^{NS}	0.259^{NS}	0.249^{NS}	0.254^{NS}	0.006^{NS}	1.000

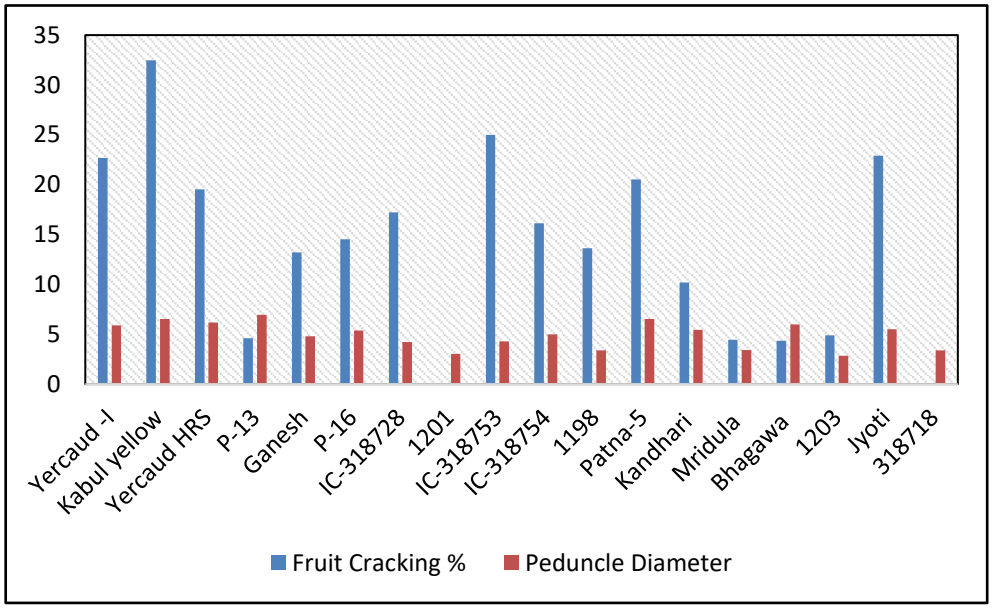


Figure 3.19 Relation between fruit cracking and peduncle diameter

Genetic Correlation between fruit cracking with various physiological characteristics of pomegranate germplasm (Normal fruits):

The results showed significant but negative relationship between Rind membrane thermal stability (RMTS) and fruit cracking in normal fruits. Correlation coefficient was found to be -0.505* as this negative sign indicates the negative or inverse relation between them. This correlation clearly points out that fruits of those genotypes which has higher rind thermal membrane stability (RTMS) has less percentage of fruit cracking chances. Among the studied germplasm, IC-1201, IC-318718 has higher RTMS showed resistance to % of fruit cracking.

Table 3.10. Genetic Correlation between fruit cracking with various physiological characteristics of pomegranate germplasm (Normal fruits

Descriptive Statistics

Character	N	Mean	Standard Deviation	Std. Error
RRWC%	18.000	88.833	7.377	0.783
LRWC%	18.000	83.011	4.513	0.495
RMContent(%)	18.000	67.617	5.964	0.725
RMTS(in%)	18.000	19.942	8.250	1.847
LMTS(in%)	18.000	49.902	14.633	2.071
Chla	18.000	1.369	0.444	0.379
Chlb	18.000	0.459	0.160	0.236
TotalChl	18.000	1.837	0.604	0.446
Chla/Chl	18.000	3.026	0.250	0.143
FruitCracking%	18.000	13.684	9.289	2.511

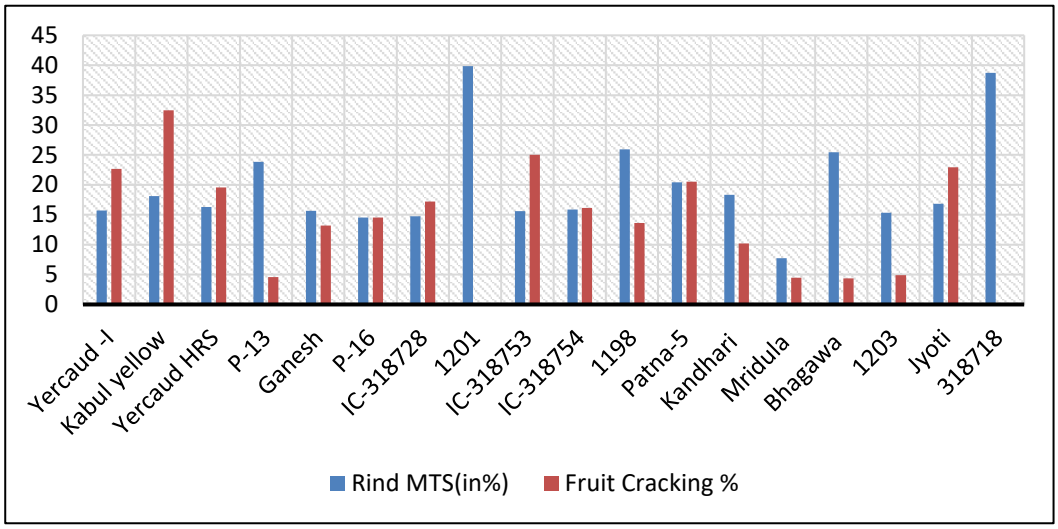


Figure 3.20 Relation between fruit cracking and Rind membrane thermal stability

Genetic Correlation between fruit cracking with various physiological characteristics of pomegranate germplasm (Cracked fruits):

The correlation study showed significant and positive relationship between Relative Rind Moisture Content and fruit cracking percentage in cracked fruit (0.688**). As indicated in the graph, the germplasm with high percentage of fruit cracking like Jyoti, Yercaud HRS, Kabuli Yellow, IC-318754 and Patna-5 showed high RMC.

Table 3.11. Genetic Correlation between fruit cracking with various physiological characteristics of pomegranate germplasm

Descriptive Statistics

Character	N	Mean	Standard Deviation	Std. Error
RRWC%	13.000	87.716	7.596	0.811
LRWC%	13.000	83.127	5.002	0.549
RMC(%)	13.000	65.420	6.082	0.752
RMTS(%)	13.000	20.425	10.209	2.259
LMTS(%)	13.000	46.425	11.203	1.644
Chla	13.000	1.706	0.630	0.482
Chlb	13.000	0.589	0.236	0.308
TChl	13.000	2.308	0.856	0.563
Chla/Chlb	13.000	2.973	0.295	0.171
FC%	13.000	14.298	9.362	2.476

Pearson Correlation Matrix

	RRWC%	LRWC%	RMC(%)	RMTS(%)	LMTS(%)	Chla	Chlb	TChl	Chla/Chlb	FC%
RRWC%	1.000	0.088^{NS}	0.261^{NS}	0.386^{NS}	0.247^{NS}	-0.362^{NS}	-0.372^{NS}	-0.371^{NS}	0.148^{NS}	-0.097^{NS}
LRWC%	0.088^{NS}	1.000	-0.248^{NS}	0.142^{NS}	0.356^{NS}	-0.087^{NS}	-0.189^{NS}	-0.119^{NS}	0.277^{NS}	-0.251^{NS}
RMC(%)	0.261^{NS}	-0.248^{NS}	1.000	-0.125^{NS}	0.205^{NS}	-0.161^{NS}	0.086^{NS}	-0.095^{NS}	-0.495^{NS}	0.688^{**}
RMTS(%)	0.386^{NS}	0.142^{NS}	-0.125^{NS}	1.000	-0.287^{NS}	-0.140^{NS}	0.007^{NS}	-0.101^{NS}	-0.162^{NS}	-0.400^{NS}
LMTS(%)	0.247^{NS}	0.356^{NS}	0.205^{NS}	-0.287^{NS}	1.000	-0.041^{NS}	-0.137^{NS}	-0.068^{NS}	0.343^{NS}	0.252^{NS}
Chla	-0.362^{NS}	-0.087^{NS}	-0.161^{NS}	-0.140^{NS}	-0.041^{NS}	1.000	0.913^{**}	0.993^{**}	0.019^{NS}	0.030^{NS}
Chlb	-0.372^{NS}	-0.189^{NS}	0.086^{NS}	0.007^{NS}	-0.137^{NS}	0.913^{**}	1.000	0.954^{**}	-0.360^{NS}	0.185^{NS}
TChl	-0.371^{NS}	-0.119^{NS}	-0.095^{NS}	-0.101^{NS}	-0.068^{NS}	0.993^{**}	0.954^{**}	1.000	-0.088^{NS}	0.073^{NS}
Chla/Chlb	0.148^{NS}	0.277^{NS}	-0.495^{NS}	-0.162^{NS}	0.343^{NS}	0.019^{NS}	-0.360^{NS}	-0.088^{NS}	1.000	-0.401^{NS}
FC%	-0.097^{NS}	-0.251^{NS}	0.688^{**}	-0.400^{NS}	0.252^{NS}	0.030^{NS}	0.185^{NS}	0.073^{NS}	-0.401^{NS}	1.000

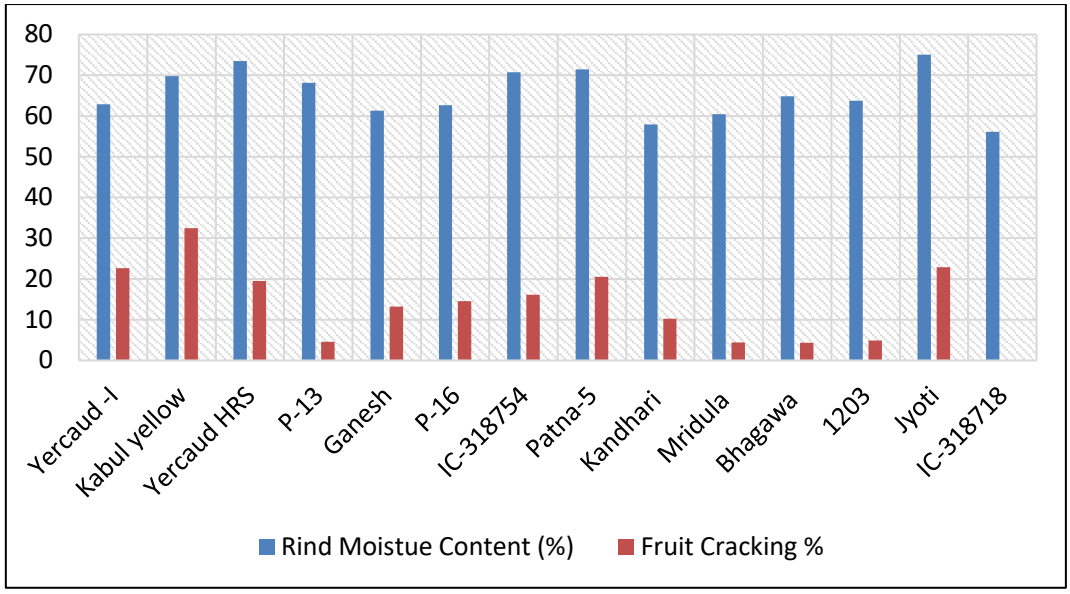


Figure 3.21 Relation between fruit cracking and Rind Moisture Content

3.3.4 Identification of polymorphic SSR markers for fruit cracking in pomegranate

Selected 8 germplasm were genotyped with 20 SSR primers out of which 11 were found polymorphic. These polymorphic primers could able to produce **27 alleles** with an **average of 2.25 alleles/primer.** Polymorphic information content (PIC) value ranged from **0.3 to 0.6** with an **average of 0.35.** The observed heterozygosity value ranged from **0.38 to 0.66** with the **mean value of 0.43.** The highest PIC and heterozygosity value noted for '**PgSSR 73' (PIC=0.6, H= 0.66) PgSSR 29 (0.5, 0.6) and PgSSR 23 (0.49, 0.57).** These identified polymorphic SSR primers could be further used for genetic association and linkage analysis studies to map genes/QTLs for fruit cracking in pomegranate.

Gel images showing amplification of SSR markers for 8 genotypes:

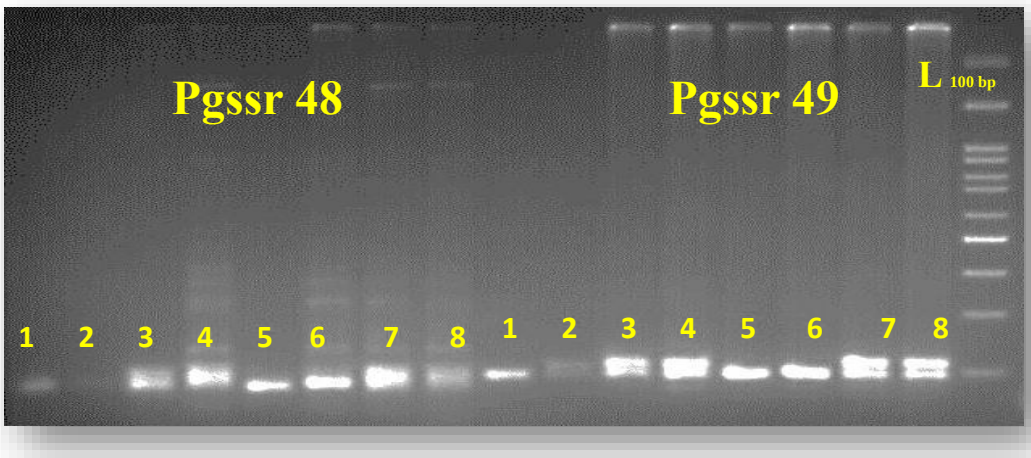


Figure3.22 PCR amplification of polymorphic PgSSR 48 & PgSSR 49 primers among 8 germplasm (1: Patna-5; 2: P-13; 3: Mridula; 4: 1203; 5: Ganesh; 6: P-16; 7: IC-318753; 8: IC-318754

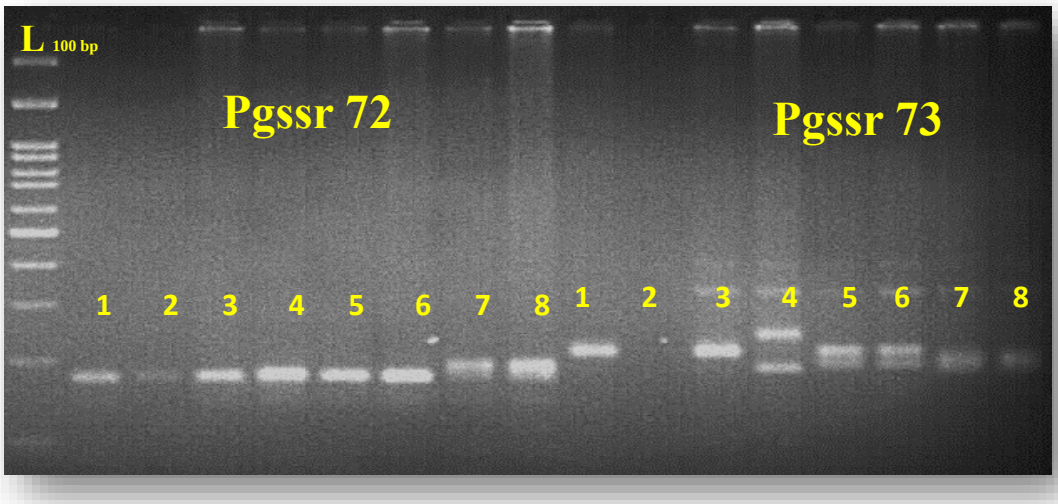
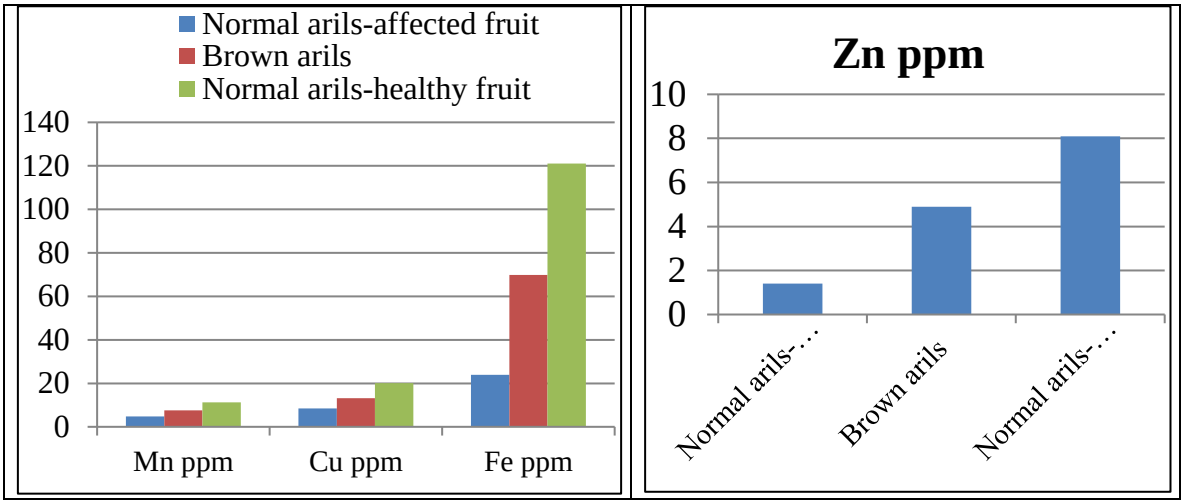


Figure 3.23: PCR amplification of polymorphic PgSSR 75 & PgSSR 73 primers among 8 germplasm (1: Patna-5; 2: P-13; 3: Mridula; 4: 1203; 5: Ganesh; 6: P-16; 7: IC-318753; 8: IC-318754

3.3.5 Seed hardness and membrane thermal stability in browning affected arils

Healthy and browning affected dried arils of four commercial varieties viz. Arakta, Ganesh, Superbhagawa and Mridula were tested for hardness and membrane thermal stability. Rupturing point ranged from 61 to 117N. Healthy seeds exhibited maximum value of rupturing point whereas it was least in browning affected seeds. Among the tested varieties, rupturing point was maximum in Arakta (117N), whereas its brown seeds had 82N rupturing point. In Ganesh rupturing point changed from 113N (healthy seed) to 95N (brown seed). Membrane thermal stability showed reverse trend to rupturing point. Membrane thermal stability ranged from 21% to 45%. The results showed more stability in healthy seeds compared to brown seeds indicating lipid peroxidation leading to leaky membranes in brown seeds.

3.3.6 Mineral composition of aril browning affected fruits of Aril browning affect fruits



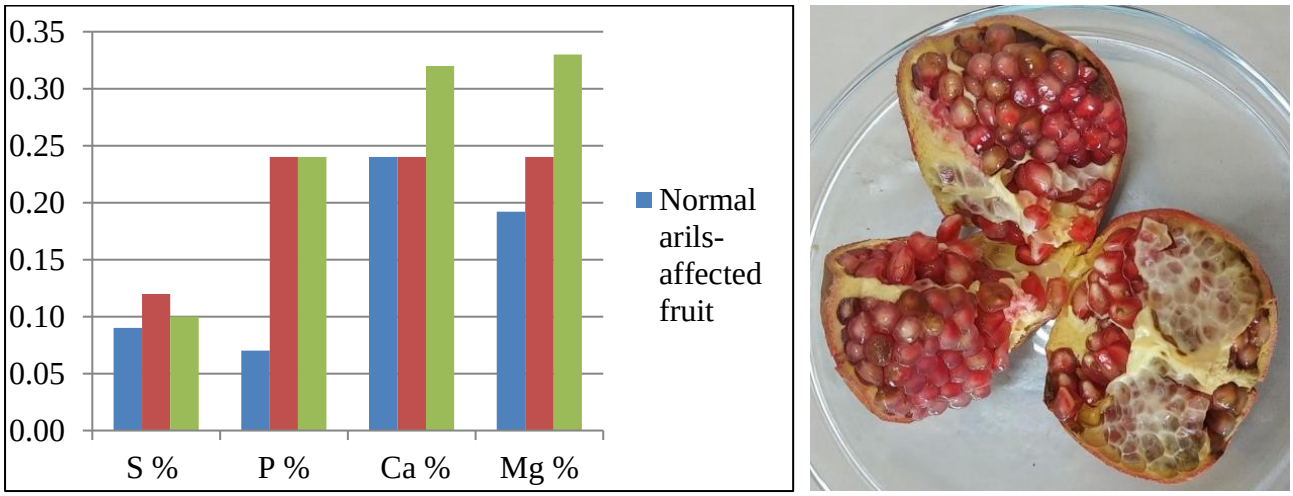


Figure 3.24 variation in mineral content in aril browning affected and healthy arils

3.4 PROJECT: BIOTIC STRESS INDUCED BIOCHEMICAL AND EPIGENETIC CHANGES ASSOCIATED WITH MAJOR INSECT PESTS AND DISEASES IN DIVERSE POMEGRANATE (*Punica granatum* L.) GENOTYPES

3.4.1 Study of biochemical and enzymatic analysis of contrasting pomegranate varieties under wilt infection

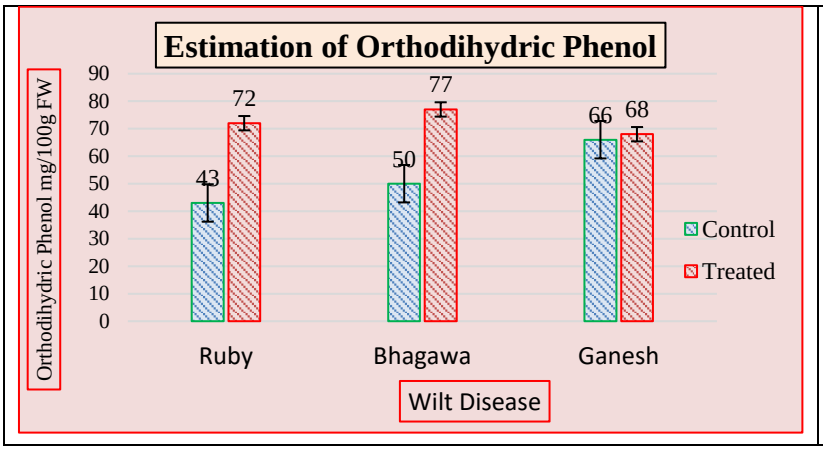
The wilt infected (wilt treated) and healthy (without wilt infected) Bhagawa, Ganesh and Ruby pomegranate leaves samples were collected from H-22 Hiraj research field. The plucked leaves sample immediately kept in ice bath and brought in the lab and stored at -80˚C in refrigerator. The same leaves sample was suspended in liquid nitrogen and used for the various biochemical and enzymatic analysis such as ortho dihydric phenol, hydrogen peroxide, total flavonoid content, total soluble sugar, proline content, total flavanol content, total phenolic content, chlorophyll stability index, total antioxidant activity, lipid peroxidation, total starch estimation, electrolyte leakage, protein estimation, ascorbic acid, membrane stability index, cell membrane injury, total chlorophyll content, chlorophyll-A, chlorophyll-B etc. The biochemical and enzymatic study was conducted in three replications and statistical analysis was also performed with the use of web agriculture stat package (WASP-2) and result was concluded.

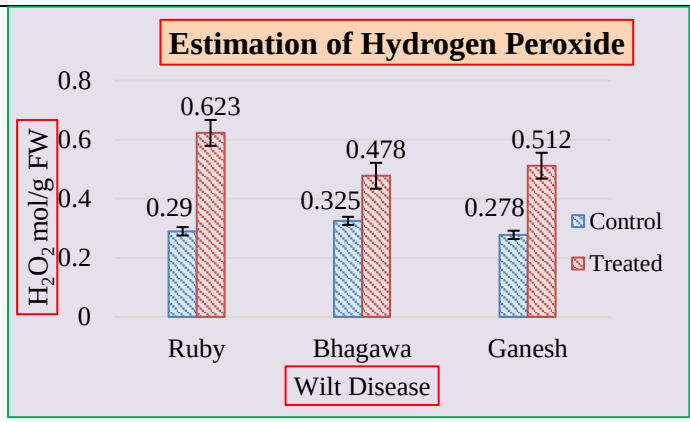
Among all biochemical and enzymatic analysis, hydrogen peroxide, flavonoid content, electrolytic leakage, protein content and total antioxidant activity were found significantly increased in all pomegranate leaves samples whereas total chlorophyll content, chlorophyll A and chlorophyll B were found significantly decreased in all the three varieties of pomegranate leaves samples and starch content, ascorbic acid were significantly decreased in only Bhagawa pomegranate leaves after wilt infection. The ortho dihydric phenol, total flavanol content, total phenolic content was significantly increased in Bhagawa and Ruby varieties but not in Ganesh leaves samples.

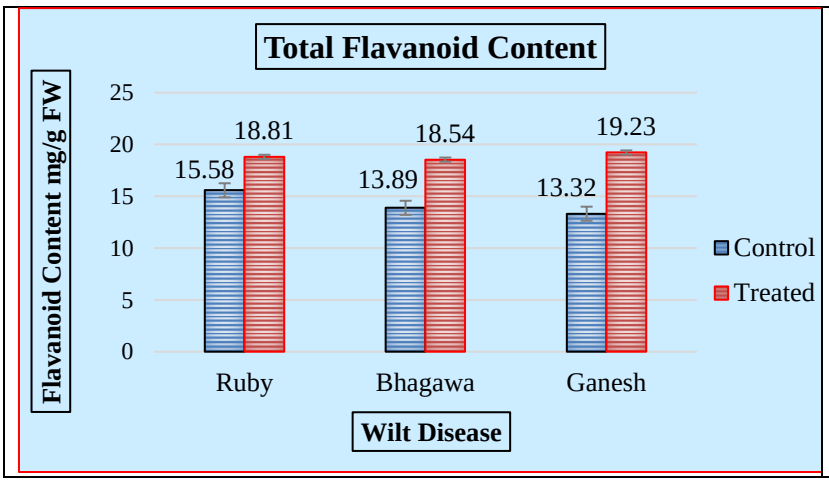
In comparison of three pomegranate varieties, out of nineteen biochemical and enzymatic parameters analysis, Ruby variety sample was shown significantly increased trend in twelve biochemical parameters such as ortho dihydric phenol, hydrogen peroxide, flavonoid content, total soluble sugar, total flavanol content, total antioxidant activity, chlorophyll stability index, electrolyte leakage, protein content, total phenolic content, cell membrane injury and ascorbic acid but Bhagawa and Ganesh varieties shown significantly increased trend in only nine biochemical parameters. Hence, based

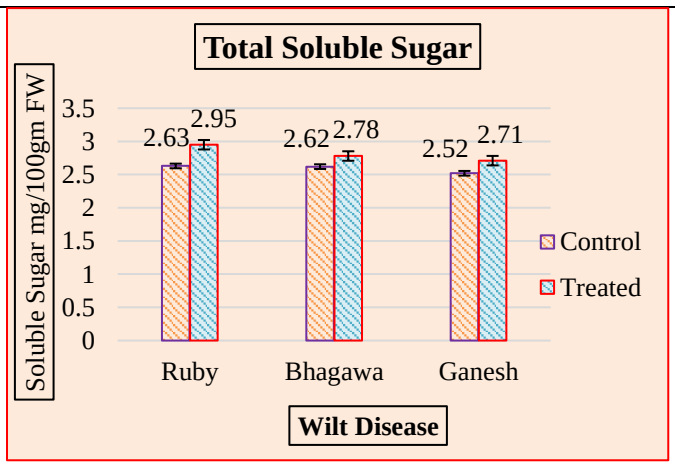
on scientific biochemical and enzymatic data we may conclude that out of these three varieties, Ruby variety is comparatively more tolerant to the wilt.

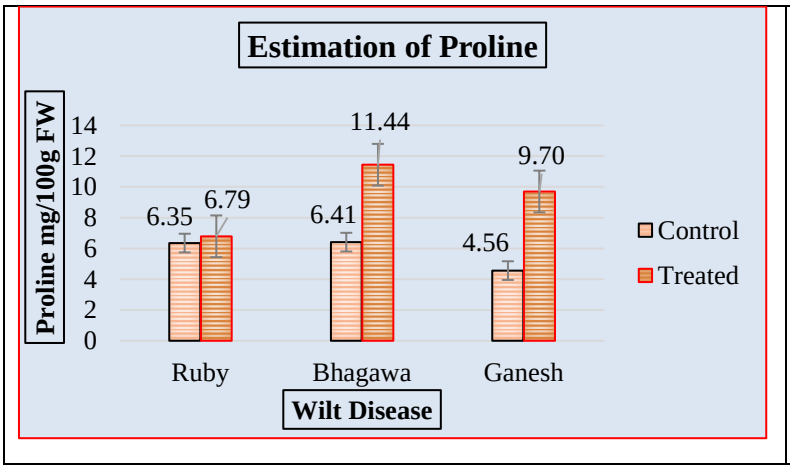
Present study conclude that, prior detection of wilt infection hydrogen peroxide, flavonoid content, electrolyte leakage, protein content biochemical parameters can be identified as a biochemical markers to avoid further infection of wilt.

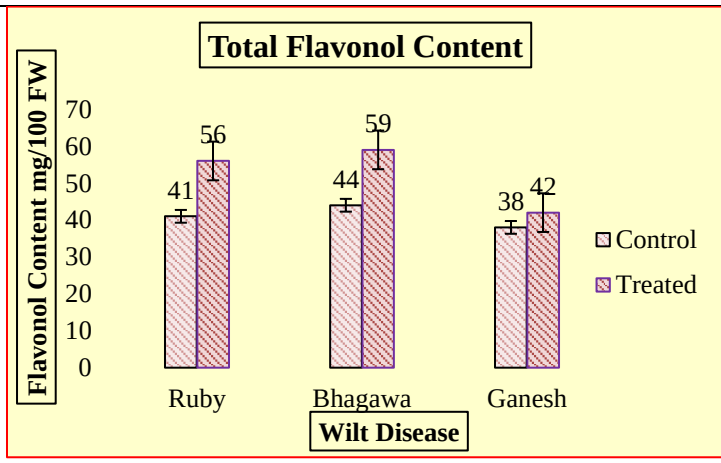


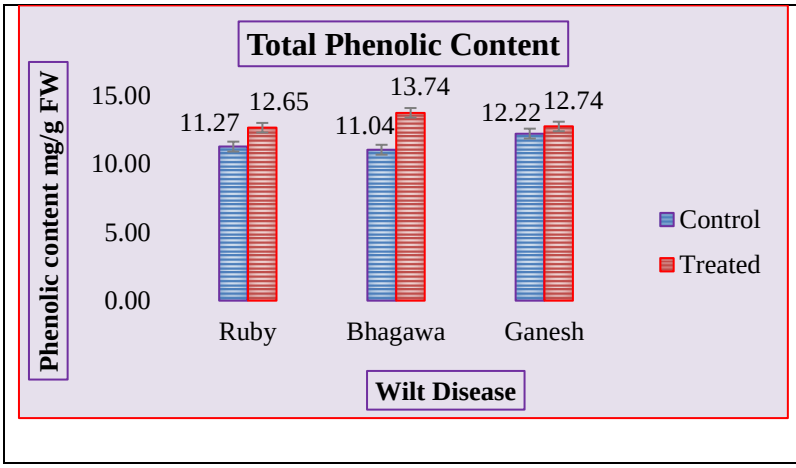


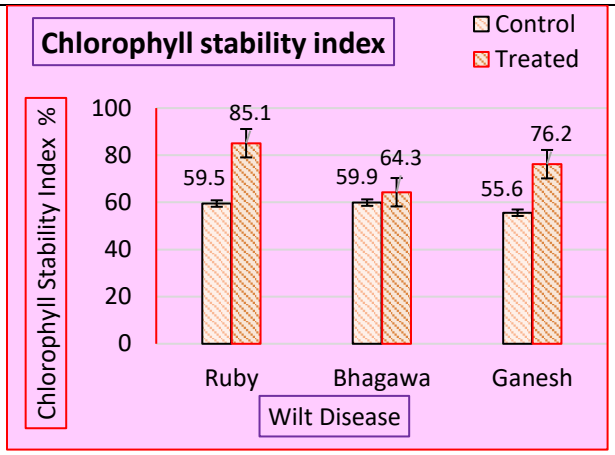


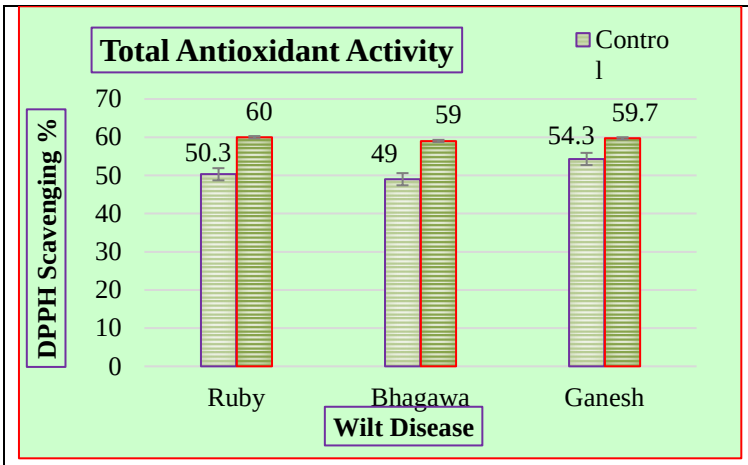


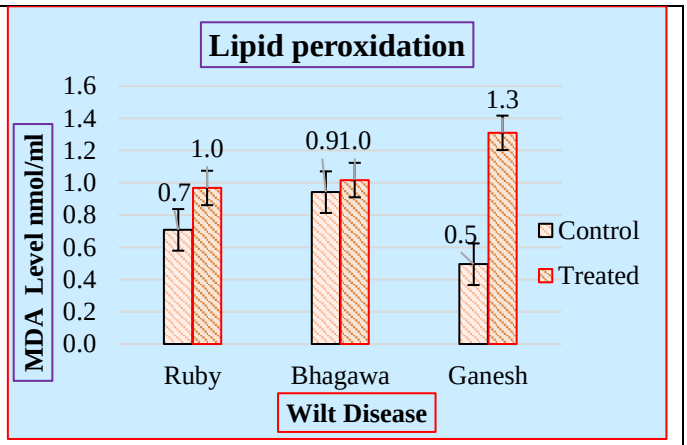


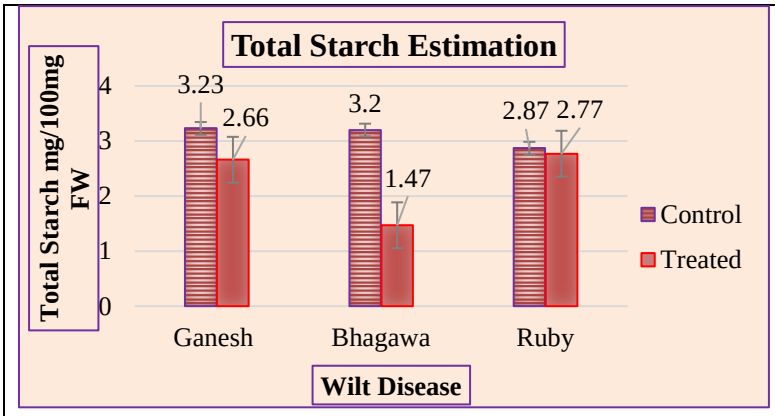


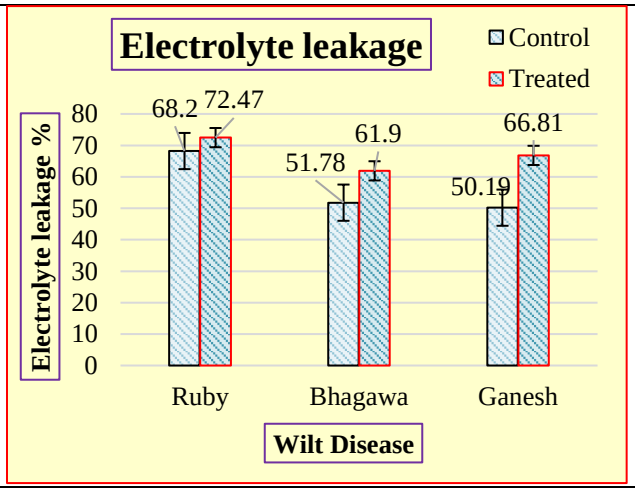

Total Phenolic Content
Phenolic content mg/g FW
15.00
10.00
5.00
0.00
11.27
12.65
11.04
13.74
12.22
12.74
Ruby
Bhagawa
Ganesh
Control
Treated
Wilt Disease

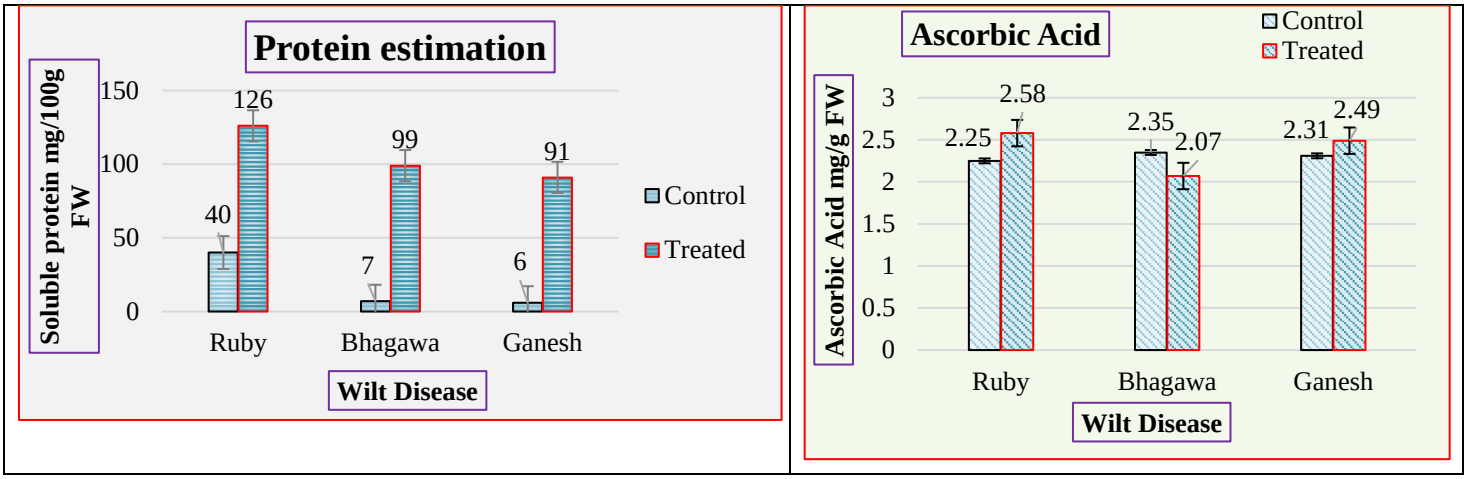

Chlorophyll stability index
Control
Treated
Chlorophyll Stability Index %
100
80
60
40
20
0
59.5
85.1
59.9
64.3
55.6
76.2
Ruby
Bhagawa
Ganesh
Wilt Disease

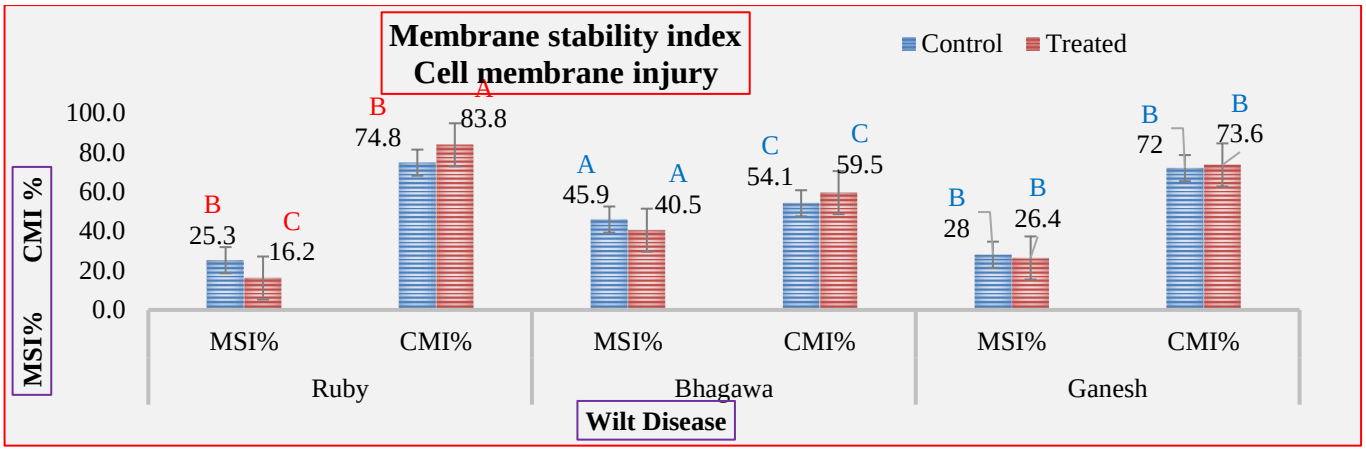

Total Antioxidant Activity
Contro
l
DPPH Scavenging %
70
60
50
40
30
20
10
0
50.3
60
49
59
54.3
59.7
Ruby
Bhagawa
Ganesh
Wilt Disease


Lipid peroxidation
MDA Level nmol/ml
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.7
1.0
0.91.0
0.5
1.3
Control
Treated
Ruby
Bhagawa
Ganesh
Wilt Disease


Total Starch Estimation
Total Starch mg/100mg FW
4
3
2
1
0
3.23
2.66
3.2
1.47
2.87
2.77
Control
Treated
Ganesh
Bhagawa
Ruby
Wilt Disease


Electrolyte leakage
Control
Treated
Electrolyte leakage %
80
70
60
50
40
30
20
10
0
68.2
72.47
51.78
61.9
50.19
66.81
Ruby
Bhagawa
Ganesh
Wilt Disease





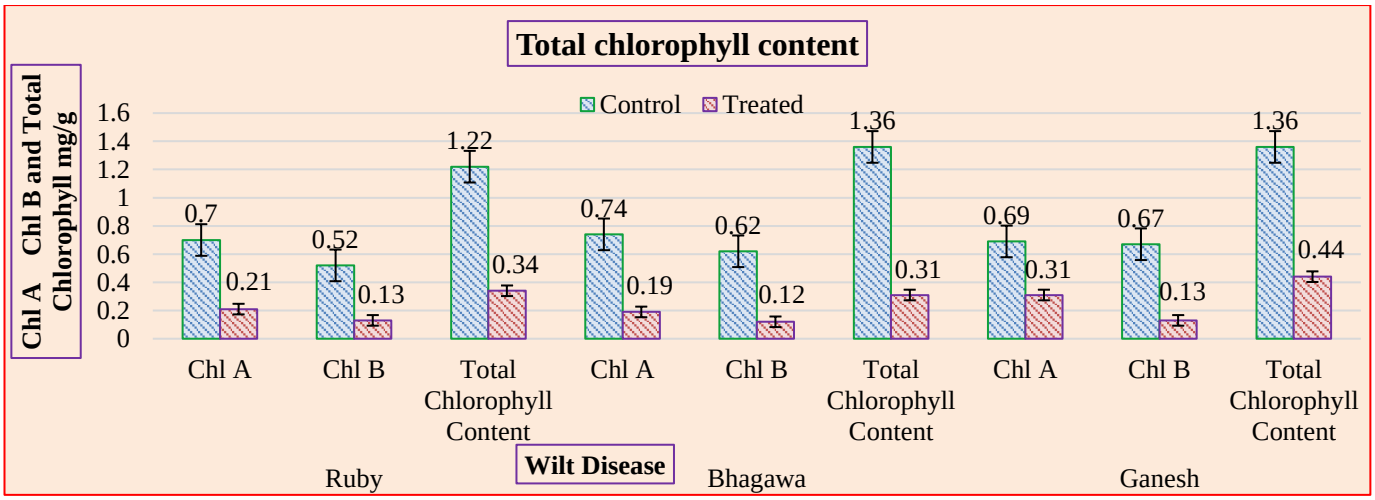


Fig.3.25 Biochemical and enzymatic analysis of contrasting pomegranate varieties under wilt infection

3.5.2 **Study of biochemical and enzymatic analysis of contrasting pomegranate varieties under bacterial blight infection:**

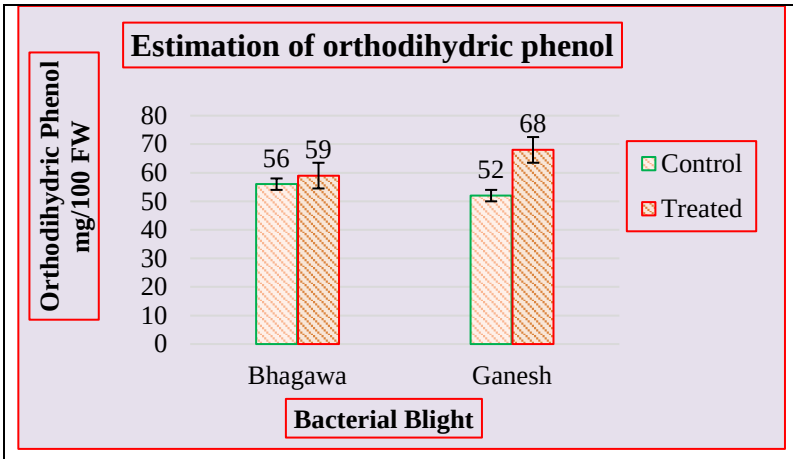
The bacterial blight infected (bacterial blight treated leaves) and healthy (without bacterial blight infecttion) Bhagawa and Ganesh pomegranate leaves samples were collected from H-22 Hiraj research field. The collected leaves sample was immediately kept in ice bath and brought in the lab and stored at -80˚C in refrigerator. The same leaves sample was suspended in liquid nitrogen and used for the various biochemical and enzymatic analysis such as ortho dihydric phenol, hydrogen peroxide, total flavonoid content, total soluble sugar, proline content, total flavanol content, total phenolic content, chlorophyll stability index, total antioxidant activity, lipid peroxidation, total starch estimation, electrolyte leakage, protein estimation, ascorbic acid, membrane stability index, cell membrane injury, total chlorophyll content, chlorophyll-A, chlorophyll-B etc. The biochemical and enzymatic study was conducted in three replications and statistical analysis was also performed with the use of web agriculture stat package (WASP-2) and result was concluded.

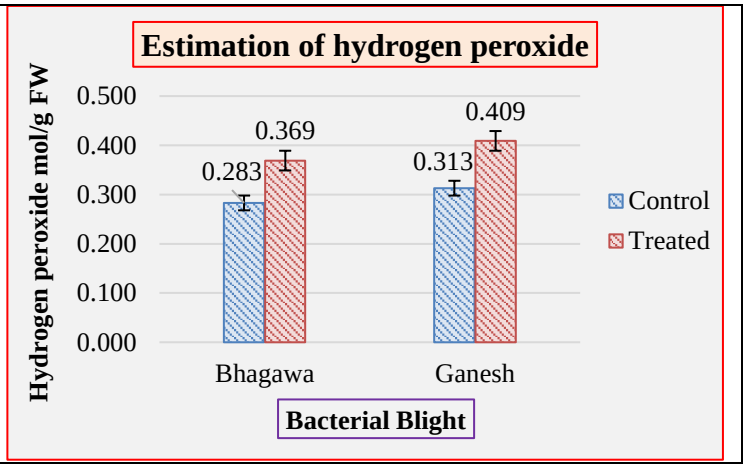
Among all biochemical and enzymatic analysis, hydrogen peroxide, flavonoid content, proline content, lipid peroxidation, electrolyte leakage, protein content, total phenolic content, cell membrane injury were found significantly increased in Bhagawa as well as Ganesh pomegranate leaves samples whereas membrane stability index, total chlorophyll content, chlorophyll A and chlorophyll B were found significantly decreased in Bhagawa and Ganesh pomegranate leaves samples and ascorbic acid content was significantly decreased only in Bhagawa and starch content was significantly decreased in Ganesh pomegranate leaves after bacterial blight infection. The total soluble sugar, total antioxidant activity was significantly increased in Bhagawa whereas ortho dihydric phenol, chlorophyll stability index was significantly increased in Ganesh but not in Bhagawa.

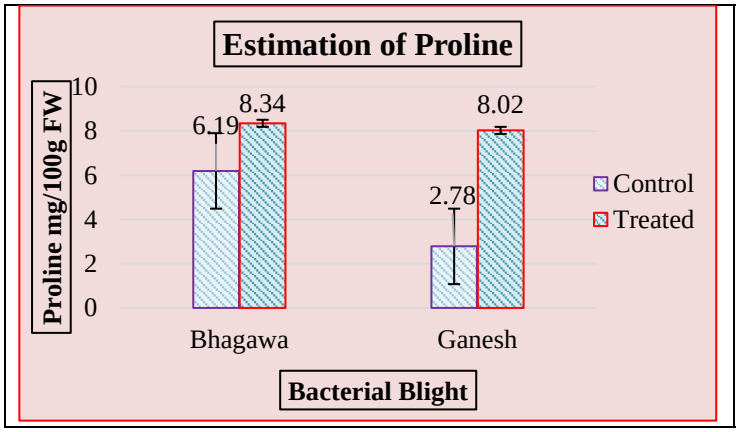
In comparison of Bhagawa and Ganesh two pomegranate varieties, out of nineteen biochemical and enzymatic parameters analysis Ganesh bacterial blight infected leaves sample was shown significantly increased trend in eleven biochemical parameters such as ortho dihydric phenol, hydrogen peroxide, flavonoid content, proline, chlorophyll stability index, lipid peroxidation, electrolyte leakage, protein content, total phenolic content, cell membrane injury and ascorbic acid but Bhagawa variety was shown significantly increased trend only in

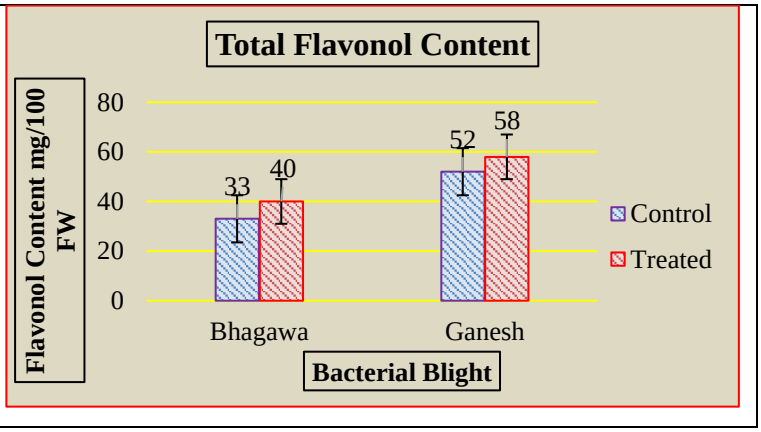
ten biochemical parameters. Hence, we may conclude that out of these two varieties, Ganesh is comparatively more tolerant to the bacterial blight.

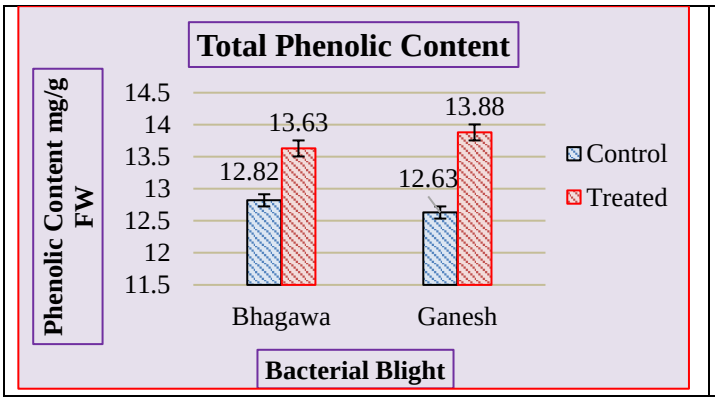
Present study conclude that, prior detection of bacterial blight incidence cell membrane injury, proline content, lipid peroxidation, protein content, electrolyte leakage, hydrogen peroxide and flavonoid content biochemical parameters can be reported as a biochemical markers to avoid further infection of bacterial blight.

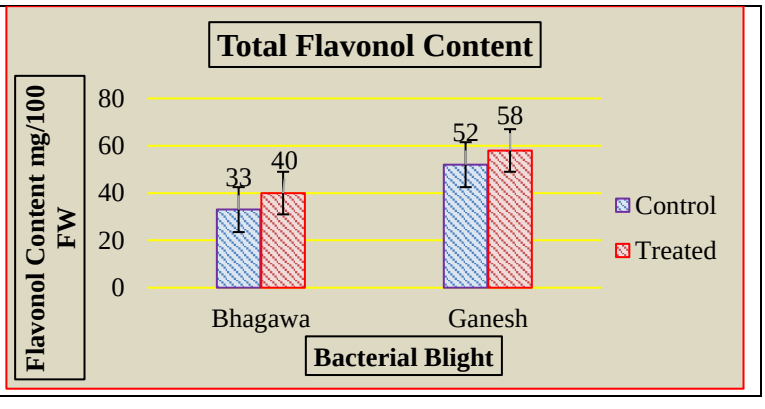


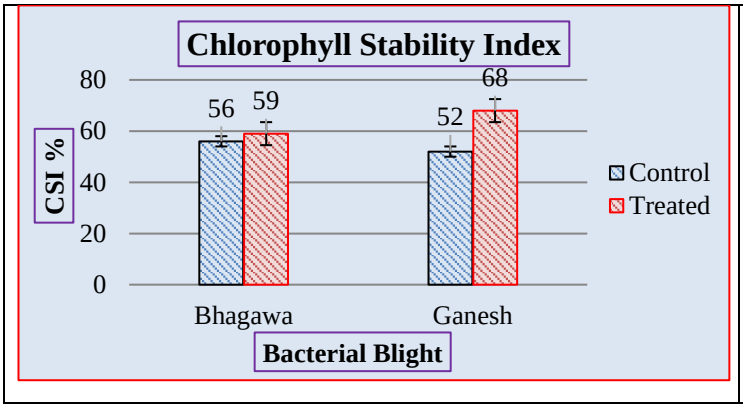


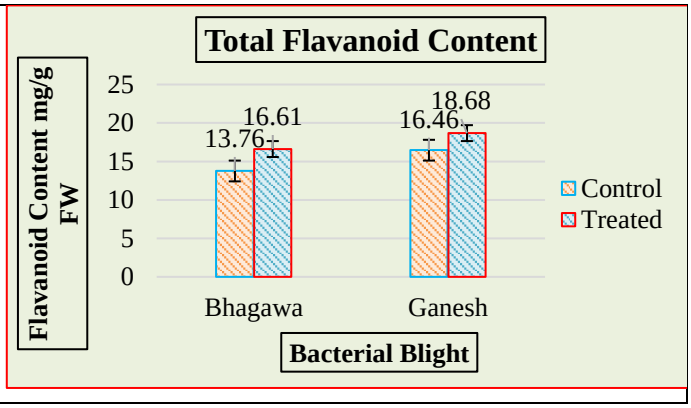


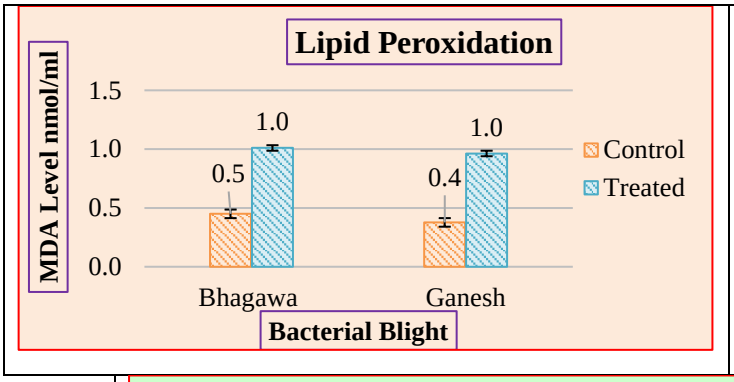


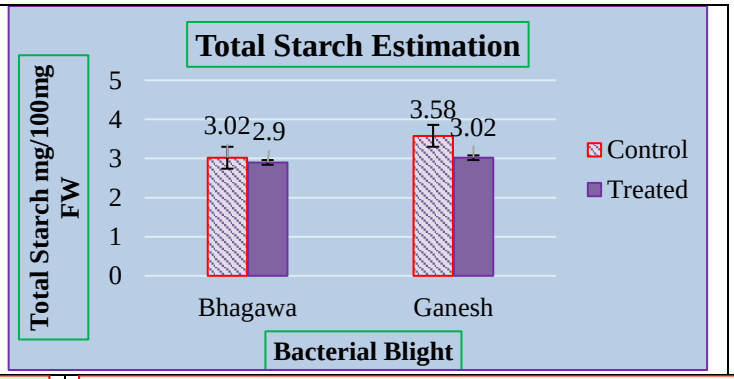


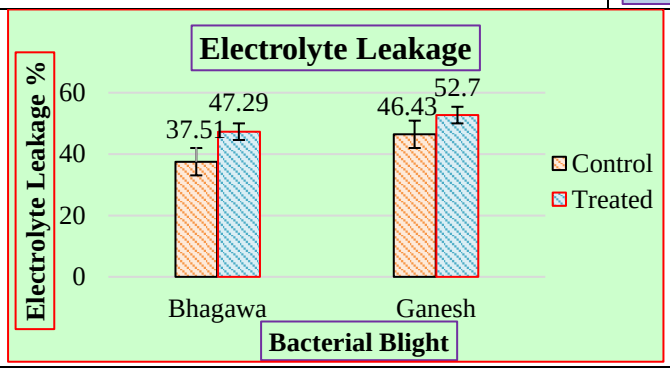


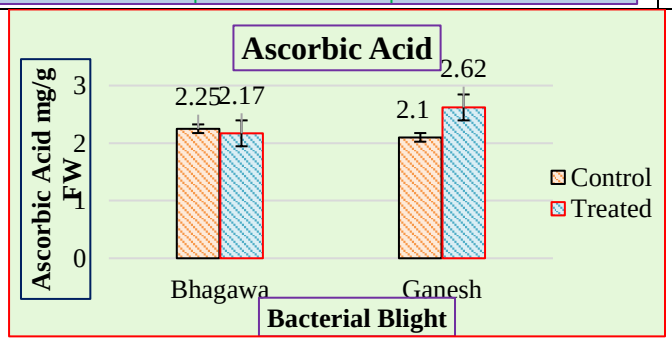

Chlorophyll Stability Index
CSI %
80
60
40
20
0
56
59
52
68
Bhagawa
Ganesh
Bacterial Blight
Control
Treated

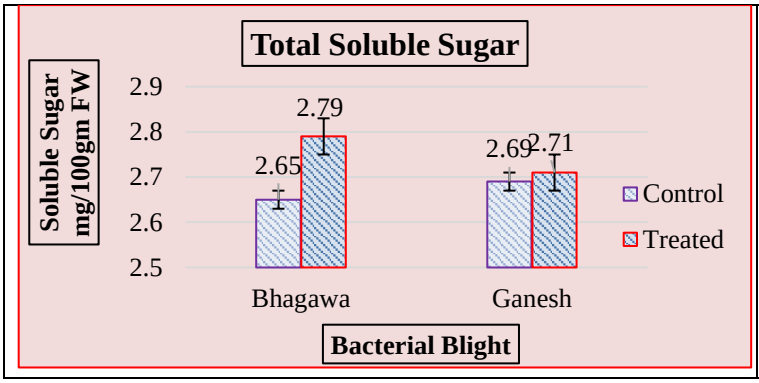

Total Flavanoid Content
Flavanoid Content mg/g FW
25
20
15
10
5
0
13.76
16.61
16.46
18.68
Bhagawa
Ganesh
Bacterial Blight
Control
Treated

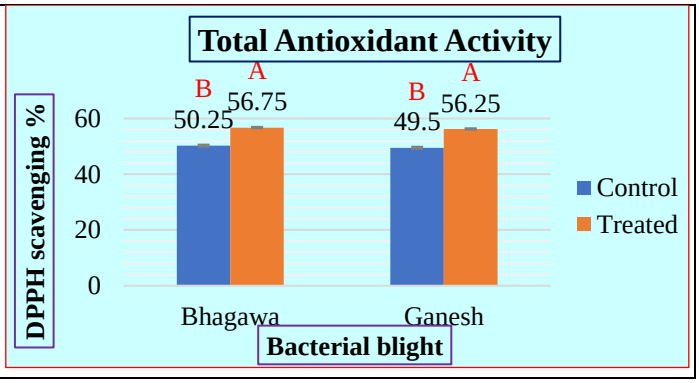

Lipid Peroxidation
MDA Level nmol/ml
1.5
1.0
0.5
0.0
0.5
1.0
0.4
1.0
Bhagawa
Ganesh
Bacterial Blight
Control
Treated

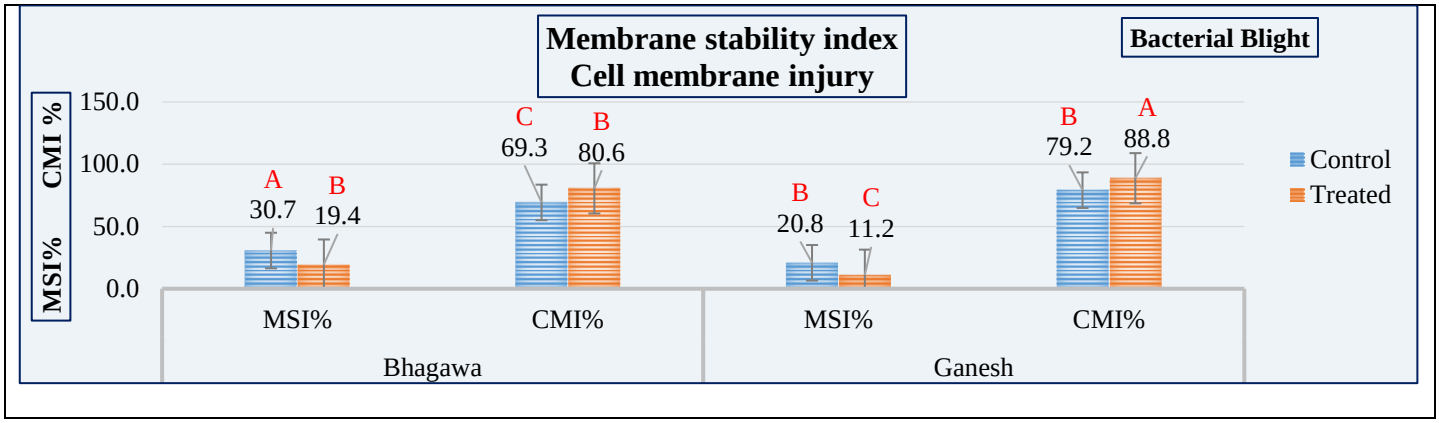

Total Starch Estimation
Total Starch mg/100mg FW
5
4
3
2
1
0
3.02
2.9
3.58
3.02
Bhagawa
Ganesh
Bacterial Blight
Control
Treated


Electrolyte Leakage
Electrolyte Leakage %
60
40
20
0
37.51
47.29
46.43
52.7
Bhagawa
Ganesh
Bacterial Blight
Control
Treated


Ascorbic Acid
Ascorbic Acid mg/g FW
3
2
1
0
2.25
2.17
2.1
2.62
Bhagawa
Ganesh
Bacterial Blight
Control
Treated


Total Soluble Sugar
Soluble Sugar mg/100gm FW
2.9
2.8
2.7
2.6
2.5
2.65
2.79
2.69
2.71
Bhagawa
Ganesh
Bacterial Blight
Control
Treated


Total Antioxidant Activity
DPPH scavenging %
60
40
20
0
B
A
50.25
56.75
B
A
49.5
56.25
Bhagawa
Ganesh
Bacterial blight
Control
Treated



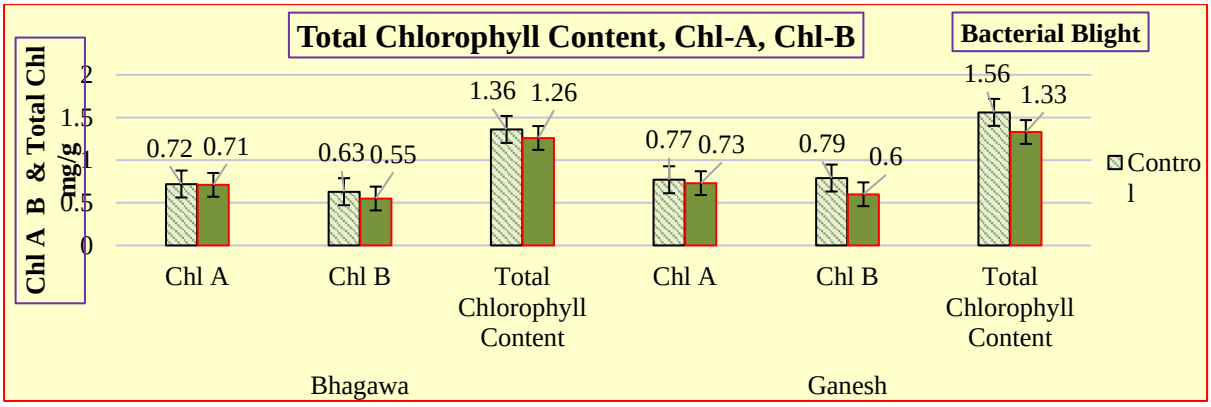


Fig.3.26 Biochemical and enzymatic analysis of contrasting pomegranate varieties under bacterial blight infection

3.5 PROJECT: FERTIGATION SCHEDULING OF MAJOR NUTRIENTS WITH REFERENCE TO CROP-SOIL ENVIRONMENT IN POMEGRANATE (CV.

3.5.1 Standardization of N, P and K dose through fertigation in pomegranate

cv. Bhagawa.

To standerdise the dose of N P and K macro-nutrients in Pomegranate (*cv. Bhagawa*) with the fertigation a field experiment was carried out with 18 treatments, viz. N @ 200, 400, 600,800 and 1000 g /plant with control (N_1 to N_6); P @ 100, 200, 300,500 and 500 g /plant with control (P_1 to P_6); K @ 200, 400, 600,800 and 1000 g /plant with control (K_1 to K_6); in randomized Block Design with four replications. This was laid out in the experimental E-2 block of NRCP Keagaon farm on 3 years old bearing Pomegranate plants. The texture of the experimental soil is sandy loam with 37 cm depth.

The drip irrigation schedule and fertigation is followed in all the treatments and the battery operated fertigation injection pump was used. The pomegranate plants were irrigated with drip system (4 lph/4 plant) and the daily water requirement of the plants was maintained during the non-rainy period. The fertigation is given in the 15 equal splits at 15 days interval starting from October month. The moisture stress was given in December and flowering was observed in January month. The RDF of the Pomegranate as followed earlier with AICRP recommendations is 625 : 25 : 25 (N:P:K). This RDF is for the 4th year and above. The RDF for the 1 to 3 years is 25 %, 50 % and 75 % of RDF respectively. The other cultural operations and plant protection measures were kept same for all the plants.

Table 3.12. The RDF schedule for 1 to 4 year Pomegranate plants.

Pomegranate RDF (N:P:K) g/plant/yr							
					Fertigation dose at 15 days (15		
Age (yr)	% RDF	625	250	250	doses)		
4 yr and above	100	625	250	250	41.67	16.67	16.67
3 yr	75	468.75	187.5	187.5	31.25	12.50	12.50
2 yr	50	312.5	125	125	20.83	8.33	8.33
1 yr	25	156.25	62.5	62.5	10.42	4.17	4.17

The RDF for 3 years old Pomegranate plants during 2022-23 is 468.75 : 187.5 : 187.5 (N:P:K) g/plant. The water soluble fertilizers used for the schedule of fertigation are urea (46:0:0), mono ammonium phosphate (12:61:0), mono potassium phosphate (0:52:34) and murate of potash (0:0:50). The total fertigation doses scheduled are 15 starting from October month (December stress month) till June second week. The fruit crop will be *Ambia* bahar. The amount of N, P and K (g/plant) fertilizers in each treatments along with the combination of the fertilizers is shown below.

Table 3.13. Treatment wise N P K doses and fertilizers (October 2022 to June 2023)

Treatments	N	Urea (46:0:0)	Urea	P	MKP (0:52:34)	MKP	K	MOP (0:0:50)	MOP	UREA	MKP	MOP
N g/tree	g/plant	g/plant	g for 15 plants	g/plant	g/plant	g for 15 plants	g/plant	g/plant	for 15 plants	kg	kg	kg
N_1-150	10	21.74	326.09	12.5	24.038	360.58	12.5	8.65	129.8	0.326	0.361	0.13
N_2-300	20	43.48	652.17	12.5	24.038	360.58	12.5	8.65	129.8	0.652	0.361	0.13
N_3-450	30	65.22	978.26	12.5	24.038	360.58	12.5	8.65	129.8	0.978	0.361	0.13
N_4-600	60	130.43	1956.52	12.5	24.038	360.58	12.5	8.65	129.8	1.957	0.361	0.13
N_5-750	75	163.04	2445.65	12.5	24.038	360.58	12.5	8.65	129.8	2.446	0.361	0.13
N_6-Control	0	0.00	0.00	0	0.000	0.00	0	0.00	0.00	0.000	0.000	0.00
									Total	6.359	1.803	0.65
P_1-75	0.984	30.52	457.75	5	8.20	122.95	12.5	25.00	375.0	0.458	0.123	0.375
P_2-150	1.967	29.53	442.99	10	16.39	245.90	12.5	25.00	375.0	0.443	0.246	0.375
P_3-225	2.951	28.55	428.24	15	24.59	368.85	12.5	25.00	375.0	0.428	0.369	0.375
P_4-300	3.934	27.57	413.48	20	32.79	491.80	12.5	25.00	375.0	0.413	0.492	0.375
P_5-375	4.918	26.58	398.73	25	40.98	614.75	12.5	25.00	375.0	0.399	0.615	0.375
P_6-Control	0.000	0.00	0.00	0	0.00	0.00	0	0	0	0.000	0.000	0.000
									Total	2.141	1.844	1.87
K_1-150	2.459	29.04	377.53	12.5	20.49	266.39	10	20.00	260.0	0.378	0.266	0.260
K_2-300	2.459	29.04	377.53	12.5	20.49	266.39	20	40.00	520.0	0.378	0.266	0.520
K_3-450	2.459	29.04	377.53	12.5	20.49	266.39	30	60.00	780.0	0.378	0.266	0.780
K_4-600	2.459	29.04	377.53	12.5	20.49	266.39	40	80.00	1040	0.378	0.266	1.040
K_5-750	2.459	29.04	377.53	12.5	20.49	266.39	50	100.00	1300	0.378	0.266	1.300
K_6-Control	0.000	0.00	0.00	0	0.00	0.00	0	0	0	0.000	0.000	0.000
									Total	1.888	1.332	3.900

Growth of the plant :

The vegetative growth (plant height, E-W spread and N-S spread) of the Pomegranate plants under the study was recorded during November, 2022 as per the treatments. The plant height, E-W spread and N-S spread varied from 120-158 cm in N fertigated treatments. Similarly 115-153 cm in P fertilizers and 110-146 cm in K fertigated plants respectively. However plant height, E-W spread and

N-S spread parameters varied non-significantly. The E-W spread varied from 114-146 cm, 110-148 cm and 105-142 cm in N, P and K fertigation treatments tespectively. The number of flowers per tree and fruit set percent also varied in all the treatments accordingly the doses of fertilizers. The growth and fruit data was for the initial first year so it showed in-significant.

Table 3.14. Growth, fruit set and flowering in N P K fertigation in Pomegranate cv. *Bhagawa* (2022 - 2023)

Treatments g/tree/year	Plant height (cm)	E-W spread (cm)	N-W spread (cm)	No. of flowers/ tree	Fruit Set (%)	No. of Fruits/tree
N_1-200	140	135	120	94	53.09	50
N_2-400	153	148	133	103	58.20	60
N_3-600	155	150	136	108	60.14	65
N_4-800	156	151	138	111	59.42	66
N_5-1000	158	153	139	115	58.21	67
N_6- Control	120	114	110	88	47.56	42
CD (0.05)	NS	NS	NS	NS	NS	NS
P_1-100	135	130	115	102	53.84	55
P_2-200	148	143	128	110	59.05	65
P_3-300	150	145	131	113	61.03	69
P_4-400	152	147	133	114	61.37	70
P_5-500	153	148	134	113	60.14	68
P_6- Control	115	110	105	92	48.77	45
CD (0.05)	NS	NS	NS	NS	NS	NS
K_1-200	130	125	110	105	55.17	58
K_2-400	143	138	123	110	61.79	68
K_3-600	143	139	124	111	63.04	70
K_4-800	145	140	125	112	62.47	70
K_5-1000	146	142	127	114	62.25	71
K_6- Control	110	105	101	96	49.88	48
CD (0.05)	NS	NS	NS	NS	NS	NS

N_1 - 200 g , N_2 - 400 g, N_3 - 600 g , N_4 - 800 g , and N_5 -1000 g N/plant/year, N_6 - Control

P_1 - 100 g , P_2 - 200 g, P_3 - 300 g , P_4 - 400 g , and P_5 -500 g P/plant/year, P_6 - Control

K_1 - 200 g , K_2 - 400 g, K_3 - 600 g , K_4 - 800 g , and K_5 -1000 g K/plant/year, K_6 - Control

Initial soil and leaf nutrients status :

The initial status of the soil having the physical parameters like pH and EC as well as organic and N, P and K were also recorded and analysed treatment wise. The samples were analysed for the

micro-nutrients like Cu, Zn, Mn and Fe. The 2 sets of the samples were recorded in in N, P and K doses. The initial soil N, P and K was recorded as 100.4—119.2 kg/ha., 100.4-103.5 kg/ha., and 106.6-119.2 kg/ha in various N, P and K fertigated doses respectively. The soil P varied as 4.46-4.95 kg/ha., 6.46-6.87 kg/ha and 5.67-5.94 kg/ha in N, P and K fertigation treatments. Similarly, the soil K varied as 707.8-792.9 kg/ha., 814.4-894.8 kg/ha and 879.2-948.6 kg/ha in various NPK doses. The soil nutrient status being initial state no much variation is observed.

The initial status of the leaf was analysed for organic and N, P and K were also analysed for all treatments. The samples were also analysed for Ca and Mg and the micro-nutrients like Cu, Zn, Mn and Fe. The 2 sets of the samples were recorded in in N, P and K doses. The initial leaf N, P and K was recorded as varied from 1.36-1.41 %., 1.05-1.23 % and 1.13-1.3 % in NPK fertigated treatments respectively. Also the leaf P varied from 0.38-0.41 %., 0.38 % and 0.38-0.44% in NPK fertigated treatments respectively. The leaf K, Ca and Mg, micro-nutrients like Cu, Zn, Mn and Fe were also analysed.

Table 3.15. Initial status of the soil nutrient status (mg/kg) under different treatments

Sample Id	**pH**	**EC**	**Organic carbon**	**Available Nitrogen**	**Available phosphorus**	**Available potassium**	**Cu**	**Zn**	**Mn**	**Fe**
			%	kg/ha	kg/ha	kg/ha	mg/kg	mg/kg	mg/kg	mg/kg
N1	8.02	0.23	0.2	100.4	4.46	707.84	3.114	1.194	1.194	0.98
N2	8.1	0.21	0.18	119.2	4.95	792.96	3.404	0.924	0.964	0.754
P1	8.12	0.17	0.2	103.5	6.87	894.88	3.444	0.888	2.0	1.074
P2	8.08	0.2	0.2	100.4	6.46	814.24	2.784	0.794	1.806	0.824
K1	8.05	0.17	0.23	119.2	5.94	948.64	2.81	0.754	2.432	1.014
K2	8.1	0.19	0.2	106.6	5.67	879.2	3.004	0.824	1.624	0.912

Table 3.16. Initial status of the leaf nutrient composition (mg/kg) under different treatments

Sample Id	Total Nitrogen	Total phosphorus	Total potassium	Ca	Mg	Cu	Zn	Mn	Fe
	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg
N1	1.36	0.41	0.84	1.6	1.15	51.2	28.7	31	320.8
N2	1.41	0.38	0.86	1.68	1.2	43.5	29.6	24.8	241.8
P1	1.05	0.38	0.91	1.6	0.86	51.6	16.4	31.9	221.1
P2	1.23	0.38	0.85	1.56	0.77	49.5	18.3	30.3	230.1
K1	1.13	0.38	0.83	1.72	1.3	40.5	15.5	42.7	203.1
K2	1.3	0.44	0.96	2.08	1.2	48.3	16.4	31.9	297.4

Yield and fruit quality of Pomegranate:

The Pomegranate fruits were harvested in August 2023 and the yield as well as fruit quality attributes were recorded in all the treatments. The number of fruits per tree varied from 42-67; 45-70 and 48-71 in N, P and K fertigated treatments respectively. The fruit yield per tree varied from 10.08-20.13 kg/tree; 10.5-21.3 kg/tree and 33.4-35.9 kg/tree in N, P and K fertigation doses respectively. The fruit quality analysis was also done and the juice percent, TT and acidity was recorded. The TSS/acidity ratio was also calculated and it is observed as 30.6-34.5; 31.4-36.7 and 31.8-37.8 in N, P and K fertigation doses.

Table 3.17. Fruit quality and yield of pomegranate in N P K fertigation cv. *Bhagawa* (2022 - 2023)

Treatment	Number of fruit	Fruit Weight (g)	Yield (kg/tree)	100 Aril weight (g)	Juice Recovery %	TSS (^{0}Brix)	Acidity (%)	TSS/Acid Ratio
N_1-200	50	252	12.6	34.4	38.0	15.20	0.46	33.04
N_2-400	60	286	17.16	35.0	38.8	15.45	0.46	33.59
N_3-600	65	290	18.85	35.4	40.0	15.60	0.44	35.45
N_4-800	66	305	20.13	35.6	40.5	15.55	0.45	34.56
N_5-1000	67	272	18.224	34.8	39.2	15.30	0.46	33.26
N_6- Control	42	240	10.08	33.2	35.4	15.00	0.49	30.61
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
P_1-100	55.6	258.4	14.367	34.5	38.2	15.3	0.46	33.26
P_2-200	65.4	295.2	19.3061	35.1	39.4	15.6	0.44	35.45
P_3-300	69.2	304.2	21.0506	35.4	40.5	15.8	0.43	36.74
P_4-400	70	305	21.35	35.7	41.0	15.7	0.44	35.68
P_5-500	68	263	17.884	34.5	41.0	15.4	0.45	34.22
P_6- Control	45.2	234	10.5768	33.3	36.0	15.1	0.48	31.46
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
K_1-200	58.0	252.5	14.645	34.6	38.5	15.5	0.47	32.98
K_2-400	68	270.4	18.3872	35.2	39.8	15.7	0.44	35.68
K_3-600	70.2	281.0	19.7262	35.5	42.0	15.9	0.42	37.86
K_4-800	70.4	273.2	19.2333	35.9	42.5	15.8	0.43	36.74
K_5-1000	71.4	262	18.7068	34.5	41.5	15.6	0.46	33.91
K_6- Control	48.2	248.0	11.9536	33.4	37.0	15.3	0.48	31.88
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

3.5.2 Standardization of N, P and K dose through fertigation in pomegranate *cv. Solapur Lal.*

To standerdise the dose of N P and K macro-nutrients in Pomegranate (cv. Solapur Lal) with fertigation a field experiment was carried out with 18 treatments, viz. N @ 200, 400, 600,800 and 1000 g /plant with control (N_1 to N_6); P @ 100, 200, 300,500 and 500 g /plant with control (P_1 to P_6); K @ 200, 400, 600,800 and 1000 g /plant with control (K_1 to K_6); in randomized Block Design with four replications. This was laid out in the experimental E-3 block of NRCP Keagaon farm on 2 years old bearing Pomegranate plants. The texture of the experimental soil is sandy loam with 35 cm depth.

The drip irrigation schedule and fertigation is followed in all the treatments and the battery operated fertigation injection pump was used. The pomegranate plants were irrigated with drip system (4 lph/4 plant) and the daily water requirement of the plants was maintained during the non-rainy period. The fertigation is given in the 15 equal splits at 15 days interval starting from October month. The moisture stress was given in December and flowering was observed in January month. The RDF of the Pomegranate as followed earlier with AICRP recommendations is 625 : 25 : 25 (N:P:K). This RDF is for the 4th year and above. The RDF for the 1 to 3 years is 25 %, 50 % and 75 % of RDF respectively. The other cultural operations and plant protection measures were kept same for all the plants.

Table 3.18. The RDF schedule for 1 to 4 year Pomegranate plants

Pomegranate RDF (N:P:K) g/plant/year							
Age (yr)	% RDF	625	250	250	Fertigation dose at 15 days (15 doses)		
4 yr and above	100	625	250	250	41.67	16.67	16.67
3 yr	75	468.75	187.5	187.5	31.25	12.50	12.50
2 yr	50	312.5	125	125	20.83	8.33	8.33
1 yr	25	156.25	62.5	62.5	10.42	4.17	4.17

The RDF for 2 years old Pomegranate plants during 2022-2023 is 312.75 : 125 : 125 (N:P:K) g/plant. The water soluble fertilizers used for the schedule of fertigation are urea (46:0:0), mono ammonium phosphate (12:61:0), mono potassium phosphate (0:52:34) and murate of potash (0:0:50). The total fertigation doses scheduled are 15 starting from October month (December stress month) till June second week. The fruit crop will be *Ambia* bahar. The amount of N, P and K (g/plant) fertilizers in each treatment along with the combination of the fertilizers is shown below.

Table 3.19. Treatment wise N P K doses and fertilizers (October 2022 to June 2023)

Treatments	N	Urea (46:0:0)	Urea	P	MKP (0:52:34)	MKP	K	MOP (0:0:50)	MOP	UREA	MKP	MOP
N g/tree	g/plant	g/plant	g for 15 plants	g/plant	g/plant	g for 15 plants	g/plant	g/plant	for 15 plants	kg	kg	kg
N_1-150	6.66	14.48	217.17	8.34	16.038	240.58	8.34	5.77	86.61	0.217	0.241	0.087
N_2-300	13.33	28.98	434.67	8.34	16.038	240.58	8.34	5.77	86.61	0.435	0.241	0.087
N_3-450	20	43.48	652.17	8.34	16.038	240.58	8.34	5.77	86.61	0.652	0.241	0.087
N_4-600	26.66	57.96	869.35	8.34	16.038	240.58	8.34	5.77	86.61	0.869	0.241	0.087
N_5-750	33.34	72.48	1087.17	8.34	16.038	240.58	8.34	5.77	86.61	1.087	0.241	0.087
N_6-Control	0	0.00	0.00	0	0.000	0.00	0	0.00	0.00	0.000	0.000	0.000
									Total	3.261	1.203	0.433
atments	N (MAP)	N (Urea)	Urea	P	MAP(12:61:0)	MAP	K	0:00:50	MOP	UREA	MAP	MOP
P_2O_5 g/tree	g/plant	g/plant	g for 15 plants	g/plant	g/plant	g for 15 plants	g/plant	g/plant	g for 15 plants	kg	kg	kg
P_1-75	0.655	20.18	302.77	3.33	5.46	81.89	8.34	16.68	250.20	0.303	0.082	0.250
P_2-150	1.310	19.53	292.95	6.66	10.92	163.77	8.34	16.68	250.20	0.293	0.164	0.250
P_3-225	1.967	18.87	283.09	10	16.39	245.90	8.34	16.68	250.20	0.283	0.246	0.250
P_4-300	2.622	18.22	273.27	13.33	21.85	327.79	8.34	16.68	250.20	0.273	0.328	0.250
P_5-375	3.277	17.56	263.44	16.66	27.31	409.67	8.34	16.68	250.20	0.263	0.410	0.250
P_6-Control	0.000	0.00	0.00	0	0.00	0.00	0	0	0	0.000	0.000	0.000
									Total	1.416	1.229	1.251
Teatments	N (MAP)	N (Urea)	Urea	P	MAP(12:61:0)	MAP	K	0:00:50	MOP	UREA	MAP	MOP

K_2O g/tree	g/plan t	g/plan t	g for 13 plants	g/pl ant	g/plant	g for 13 plants	g/pla nt	g/plant	g for 13 plants	kg	kg	kg
K_1-150	1.641	19.20	249.59	8.34	13.67	177.74	6.67	13.34	173.42	0.250	0.178	0.173
K_2-300	1.641	19.20	249.59	8.34	13.67	177.74	13.34	26.68	346.84	0.250	0.178	0.347
K_3-450	1.641	19.20	249.59	8.34	13.67	177.74	20	40.00	520.00	0.250	0.178	0.520
K_4-600	1.641	19.20	249.59	8.34	13.67	177.74	26.67	53.34	693.42	0.250	0.178	0.693
K_5-750	1.641	19.20	249.59	8.34	13.67	177.74	33.33	66.66	866.58	0.250	0.178	0.867
K_6-Control	0.000	0.00	0.00	0	0.00	0.00	0	0	0	0.000	0.000	0.000
									Total	1.248	0.889	2.600

Growth of the plant :

The vegetative growth (plant height, E-W spread and N-S spread) of the Pomegranate plants under the study was recorded during November, 2022 as per the treatments. The plant height, E-W spread and N-S spread varied from 102-139 cm in N fertigated treatments. Similarly 98-353 cm in P fertilizers and 101-135 cm in K fertigated plants respectively. However plant height, E-W spread and N-S spread parameters varied non-significantly. The E-W spread varied from 96-133 cm, 93-128 cm and 98-130 cm in N, P and K fertigation treatments tespectively. The number of flowers per tree and fruit set percent also varied in all the treatments accordingly the doses of fertilizers. The growth and fruit data was for the initial first year so it showed in-significant.

Table 3.20. Plant growth, fruit set and flowering in N P K fertigation cv. *Solapur Lal* (2022 - 2023)

Treatments g/tree/year	Plant height (cm)	E-W spread (cm)	N-W spread (cm)	No. of flowers/ tree	Fruit Set (%)	No. of Fruits/tree
N_1-200	120	115	100	106	61.28	65
N_2-400	133	128	113	112	66.96	75
N_3-600	135	130	116	116	68.97	80
N_4-800	137	131	118	121	67.77	82
N_5-1000	139	133	119	125	67.20	84
N_6- Control	102	96	92	109	54.98	60
CD (0.05)	NS	NS	NS	NS	NS	NS
P_1-100	115	110	95	121	61.96	75
P_2-200	128	123	108	118	67.80	80
P_3-300	130	125	110	119	69.76	83
P_4-400	131	126	112	121	70.26	85
P_5-500	133	128	114	122	68.86	84
P_6- Control	98	93	86	113	55.69	63
CD (0.05)	NS	NS	NS	NS	NS	NS
K_1-200	116	111	97	123	63.40	78
K_2-400	129	124	110	127	69.30	88
K_3-600	131	127	112	125	72.02	90
K_4-800	133	128	114	123	74.01	91
K_5-1000	135	130	115	126	73.83	93
K_6- Control	101	98	90	114	57.85	66
CD (0.05)	NS	NS	NS	NS	NS	NS

Initial soil and leaf nutrient status :

The initial status of the soil having the physical parameters like pH and EC as well as organic and N, P and K were also recorded and analysed treatment wise. The samples were analysed for the micro-nutrients like Cu, Zn, Mn and Fe. The 2 sets of the samples were

recorded in in N, P and K doses. The initial soil N, P and K was recorded as 119.2—122.3 kg/ha., 119.2-116 kg/ha., and 119.2-122.3 kg/ha in various N, P and K fertigated doses respectively. The soil P varied as 4.25-4.43 kg/ha., 5.22-5.36 kg/ha and 4.3-4.73 kg/ha in N, P and K fertigation treatments. Similarly the soil K varied as 464.8-506.2 kg/ha., 535.4-562.2 kg/ha and 632.8-674.2 kg/ha in various NPK doses. The soil nutrient status being initial state no much variation is observed. The initial status of the leaf was analysed for organic and N, P and K were also analysed for all treatments. The samples were also analysed for Ca and Mg and the micro-nutrients like Cu, Zn, Mn and Fe. The 2 sets of the samples were recorded in in N, P and K doses. The initial leaf N, P and K was recorded the leaf N varied from 1.69-1.75 %., 1.79-1.82 % and 1.6-1.68 % in NPK fertigated treatments respectively. Also the leaf P varied from 0.69-0.74 %., 0.68-0.74 % and 0.72-0.84% in NPK fertigated treatments respectively. The leaf K varied from 1.17-1.26 %., 1.08-1.18 % and 0.94-0.98% in NPK fertigated treatments respectively. The leaf K, Ca and Mg, micro-nutrients like Cu, Zn, Mn and Fe were also analysed.

Table 3.21. Initial status of the soil nutrient status (mg/kg) under different treatments

Sample Id	pH	EC	Organic carbon	Available Nitrogen	Available phosphorus	Available potassium	Cu	Zn	Mn	Fe
			%	kg/ha	kg/ha	kg/ha	mg/kg	mg/kg	mg/kg	mg/kg
N1	8.12	0.18	0.18	119.2	4.25	464.8	3.824	1.36	0.482	0.866
N2	8.08	0.2	0.2	122.3	4.43	506.24	3.444	1.042	0.512	1.004
P1	8.1	0.18	0.2	119.2	5.22	562.24	3.682	1.504	0.544	0.658
P2	8.11	0.2	0.2	116	5.36	535.36	3.658	1.22	0.556	0.520
K1	8.12	0.15	0.18	122.3	4.3	632.8	2.442	0.934	0.882	0.568
K2	8.11	0.19	0.18	119.2	4.73	674.24	3.356	1.26	0.644	0.498

Table 3.22. Initial status of the leaf nutrient composition (mg/kg) under different treatments

Sample Id	Total Nitrogen	Total phosphorus	Total potassium	Ca	Mg	Cu	Zn	Mn	Fe
	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg
N1	1.69	0.74	1.17	2.2	1.06	30.8	16.6	45.8	249.4
N2	1.75	0.69	1.26	2.28	1.1	28.9	19	38.4	247.6
P1	1.79	0.74	1.18	2.08	1.06	35.6	17	42	285.6
P2	1.82	0.68	1.08	2.08	1.15	27.1	24.5	37	237
K1	1.68	0.72	0.98	1.52	1.34	42.6	25.7	26.1	181
K2	1.6	0.85	0.94	1.56	1.1	42.4	19.8	24.5	336

4. Crop Protection

4.1 PROJECT: DEVELOPMENT AND REFINEMENT OF INTEGRATED CROP PROTECTION TECHNOLOGIES FOR IMPROVED PRODUCTIVITY OF POMEGRANATE

4.1.1 Efficacy evaluation of Entomopathogens formulation against insect pests of pomegranate

The field experiment was conducted to evaluate the efficacy of four entomopathogenic fungi and one entomopathogenic bacteria against sucking pests, including thrips, aphids, and mealybugs, with Cyantraniliprole 10.26% OD serving as the standard check. Among the seven treatments, Treatment T1 (*Metarhizium anisopliae* 1.0 % W. P. (CFU: 1 × 10^8 / g), provided the highest percentage reduction of thrips (53.25%), aphids (56.45%), and mealybugs (38.5%). This was followed by Treatment T2 (*Beauveria bassiana* - 1.0 % W. P. with a CFU of 1 × 10^9 /g, which exhibited reductions of thrips (51.55%), aphids (49.25%), and mealybugs (40.15%). Treatment T4, utilizing *Pseudomonas fluorescens* – 1.0 % W. P. with a CFU of 1 × 10^8 /g, demonstrated reductions in thrips (46.25%), aphids (51.25%), and mealybugs (38.55%). These results indicate promising potential for the utilization of *Metarhizium anisopliae* and *Beauveria bassiana* in controlling the targeted insect pests on pomegranate.

Table 4.1 Efficacy evaluation of Entomopathogens against insect pests of pomegranate

Treatment details	Dosage (g/ml/l water)
T1: *Metarhizium anisopliae* 1.0 % W. P. (CFU: 1 × 10^8 / g)	5
T2: *Beauveria bassiana* - 1.0 % W. P. CFU 1 × 10^9 /g	5
T3: *Lecanicillium lecanii* - 2.0 % A. S. CFU : 2 × 10^8 /ml	5
T4: *Pseudomonas fluorescens* – 1.0 % W. P. CFU: 1 × 10^8/g	5
T5: *Trichoderma viride* – 1.0 % WP CFU Count : 2 × 10^9 /g	5
T6: Cyantraniliprole 10% OD	0.9
T7: Untreated control (UC)	Water

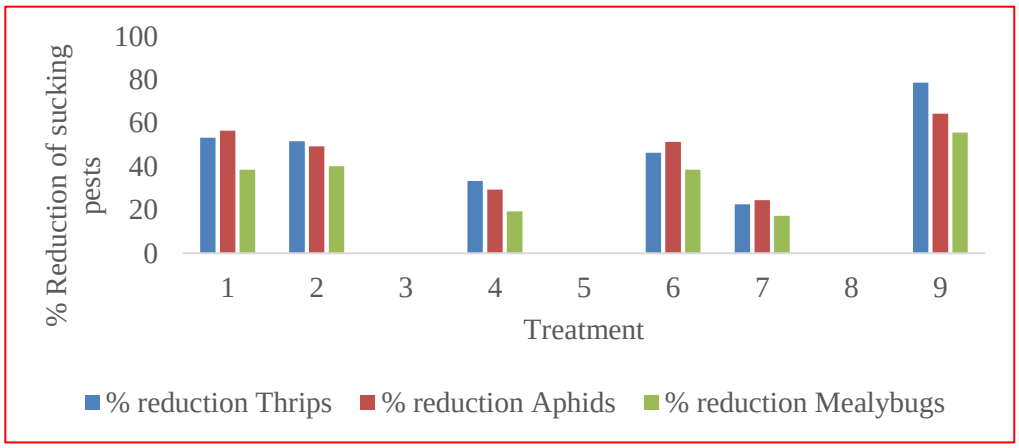


Fig. 4. 1 Efficacy of different Entomopathogens against sucking pest of pomegranate

4.1.1.1 Effect of Entomopathogens on natural enemies of insect pest of pomegranate.

The experiment was conducted to evaluate the effect of four entomopathogenic fungi, one entomopathogenic bacteria with Cyantraniliprole 10.26% OD as the standard check on natural enemies Coccinellids beetle (*Cheilomenese Sexmaculata*) Chrysoperla (*Chrysoperla carnea*). Among the seven treatments, Treatment T4 (Cyantraniliprole 10.26% OD), had the highest percent mortality of Coccinellids (65.32) and (68.35) Chrysoperla (grubs). The remaining treatment effect varied from (9.38 to 14.18) for the Coccinellid beetle and 9.90 to 14.05 for chrysoperla.

Table 4.2 Effect of Entomopathogens on natural enemies of insect pest of pomegranate

Treatment details	**Dosage (g/ml/l water)**
T1: *Metarhizium anisopliae* 1.0 % W. P. (CFU: 1×10^8 / g)	5
T2: *Beauveria bassiana* - 1.0 % W. P. CFU 1×10^9 /g	5
T3: *Verticillium lecanii* - 2.0 % A. S. CFU : 2×10^8 /ml	5
T4: *Pseudomonas fluorescens* – 1.0 % W. P. CFU: 1×10^8/g	5
T5: *Trichoderma viride* – 1.0 % WP CFU Count : 2×10^9 /g	5
T6: Cyantraniliprole 10% OD	0.9
T7: Untreated control (UC)	Water

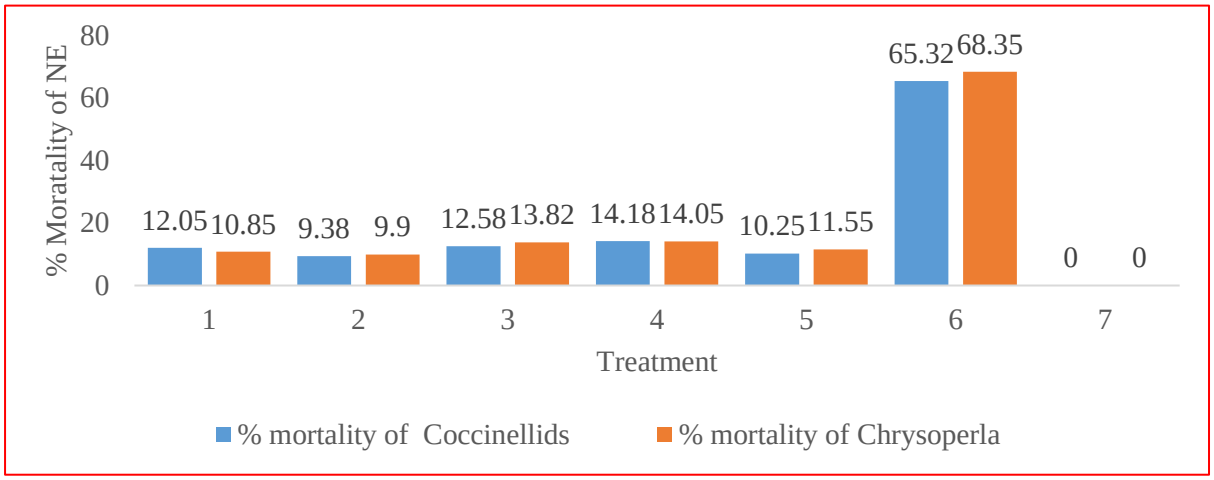


Fig.4.2 Effect of Entomopathogens on natural enemies of insect pest of pomegranate

4.1.1.2 Efficacy evaluation of EPN against Green stink bug

The efficacy of Entomopathogenic nematodes was assessed against the pomegranate fruit borer and the green stink bug (*Nezara viridula*). An inoculation of 250-300 IJs (Infective Juveniles) of EPN resulted in an average percentage mortality of 60.75% to 64.05% for nymphs of the green stink bug 48 hours after inoculation, and 97.35% to 97.95% after 72 hours. Moreover, when applying 250-300 IJs of EPN, an average percentage mortality of 51.02% to 53.75% for adults of the green stink bug was observed after 48 hours, and 64.32% to 65.98% after 72 hours following inoculation. Detailed results of these assessments are provided in fig.10.

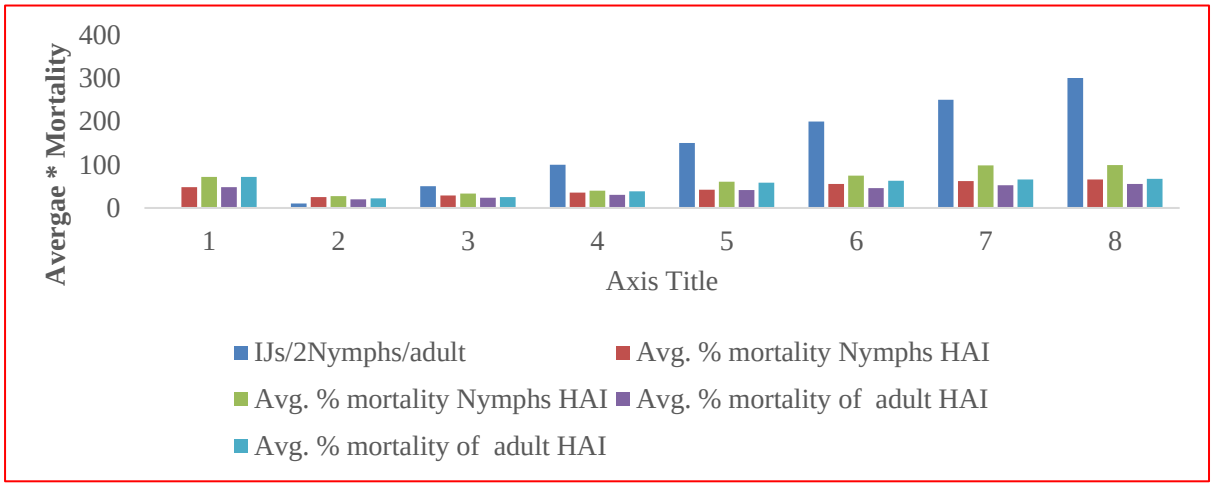


Fig. 4.3 Efficacy of EPN against Green stink bug and Fruit borer

4.1.2 Field evaluation effect of Insecticides (Biological origin) on bioagents

The experiment was conducted to evaluate the effect of t biologically oriented insecticides on the natural enemies of pomegranate insect pests. Cyantraniliprole 10.26% OD served as the standard check. Among the five treatments, Treatment T4: Cyantraniliprole 10.26% OD recorded the highest % mortality of Coccinellids (60.55) and Chrysoperla (66.52) followed by T3 (Flupyradifurone (30.33 and 35.65) respectively for Coccinellids and Chrysoperla.

Table 4.3 Effect of Insecticides (Biological origin) on bioagents

Name of the Insecticide	Dose (ml/l)
T1: Spinetoram 12% SC w/v	1.0
T2: Spinosad 45% SC	0.5
T3: Flupyradifurone	1.0
T4: Cyantraniliprole 10.26% OD	0.9
T5: Control	-

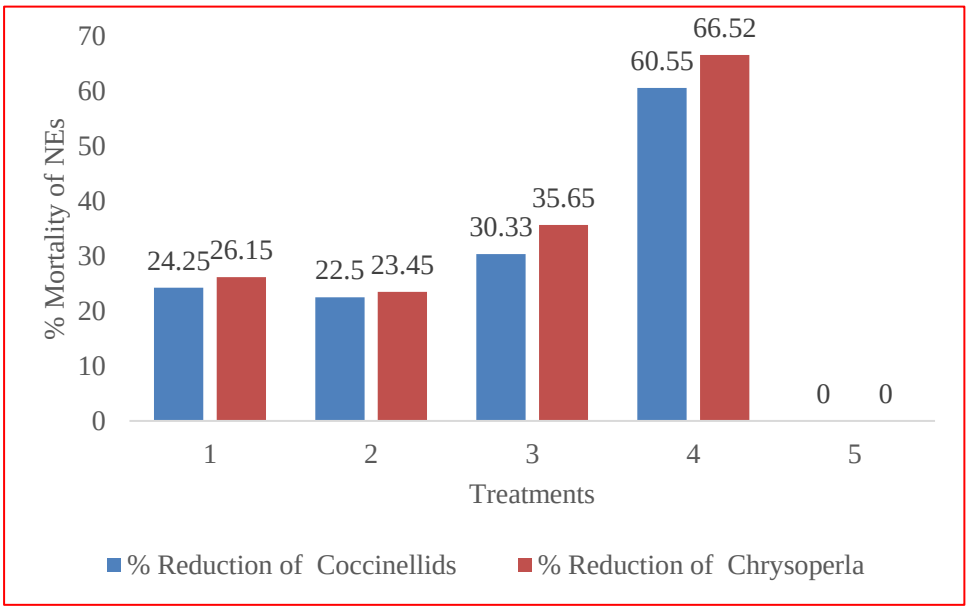


Fig. 4.4 Effect of Insecticides on NE of insect pests of pomegranate

4.1.3 Efficacy evaluation of trap with ethanol and Lure and against shot hole borer

The experiment was conducted to evaluate the efficacy of the trap with ethanol and Lure and against shot hole borer the results are summarized below**.**

1. The three different concentrations of ethanol (99% 70% and 50%) were evaluated against the Shot hole borer. However, no trapping of the beetle was observed in both in vitro and in vivo conditions using the Kisan X mini solar trap (Agshop) and funnel trap.
2. The Pomotrap with Pomo lure from Green Revolution Pvt. Ltd., Sangli, was evaluated. However, under both in vitro and in vivo conditions, no trapping of the shot hole borer was observed.
3. Fungus discs were prepared to assess their effectiveness as attractants. In the controlled setting of a Petri plate, the beetles were consistently drawn to the Fusarium disc, actively creating tunnels within it. The detailed studies will be undertaken for conclusive results.

Mini solar trap

Funnel trap

Pomotrap with Pomo lure

Fig 4.5 Evaluation of trap with ethanol and lure and against shot hole borer

4.1.3.1 Molecular characterization of Fungi associated with SHB

Five fungus isolates extracted from the shot hole borer beetle (SHB) have been verified as *Fusarium oxysporum* and *Pacelomyces maximus*. The sequencing outcomes for the remaining three isolates are pending.

Table 4.4 Characterization of Fungi associated with SHB

Organism	Region Amplified	Sequence ID
Fusarium oxysporum	ITS Sequence	>0523-515_002_PCR_I2_Forward_E07.ab1
Pacelomyces maximus	ITS Sequence	>0723-016_006_PCR_F_Forward_A04.ab1

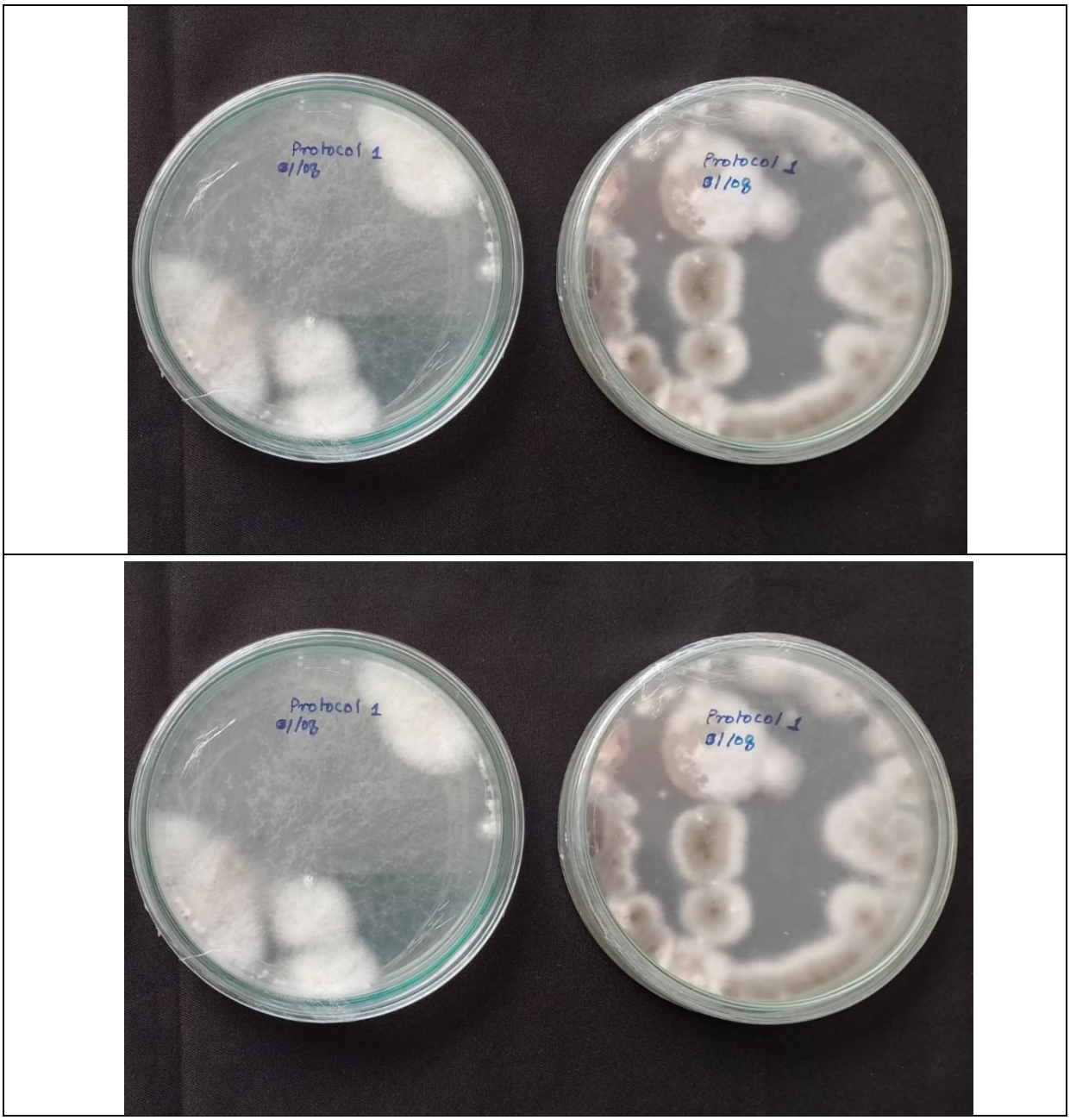
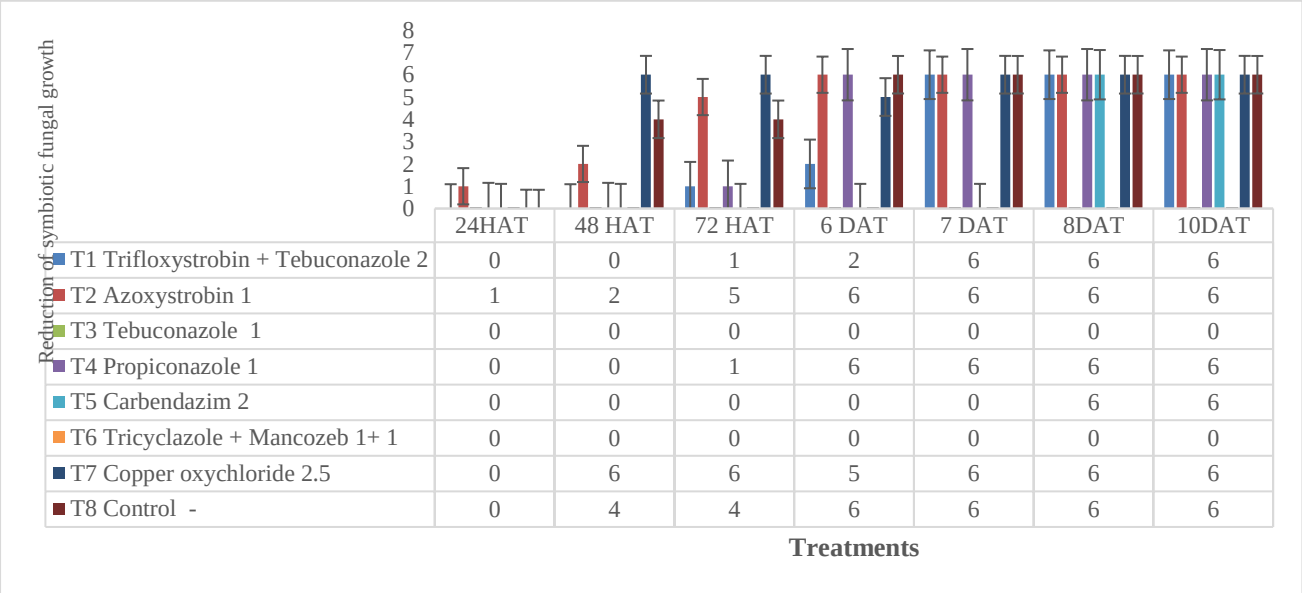


Fig. 4.6 Symbiotic fungi associated with shot hole borer *F. oxysporum and P. maximus*

4.1.3.3 Bioassay of Fungicides against symbiotic fungi of SHB through poison food technique

Invitro Bioassay experiment was conducted to assess the effect of different Fungicides against symbiotic fungi of SHB through poison food technique. Among the eight treatments, T3 (Tebuconozole) and Treatment T6 (Tricyclozole + Mancozeb) recorded the complete inhibition of the symbiotic fungi up to 10 days after treatment. The details are mentionded in the fig. 13.



	24HAT	48 HAT	72 HAT	6 DAT	7 DAT	8DAT	10DAT
T1 Trifloxystrobin + Tebuconazole 2	0	0	1	2	6	6	6
T2 Azoxystrobin 1	1	2	5	6	6	6	6
T3 Tebuconazole 1	0	0	0	0	0	0	0
T4 Propiconazole 1	0	0	1	6	6	6	6
T5 Carbendazim 2	0	0	0	0	0	6	6
T6 Tricyclazole + Mancozeb 1+ 1	0	0	0	0	0	0	0
T7 Copper oxychloride 2.5	0	6	6	5	6	6	6
T8 Control -	0	4	4	6	6	6	6

Fig. 4.7 Bioassay of Fungicides against symbiotic fungi of SHB through poison food Technique.

4.1.3.4 Mass production of Shot Hole Borer (SHB) on Semisynthetic media

The Invitro experiment was conducted to mass produce the pomegranate shot hole borer *Euwallacea fornicatus* on standardized semi-synthetic media.

Table 4.5 Mass production of Shot Hole Borer (SHB) on Semisynthetic media

Trt. details	Total female released/ tube	No. of life cycle completed	Average No. of different stages			
			Eggs	Grubs	Pupae	Adult
Semisynthetic	1	4	10.25	24.25	6.75	4.25

Semisynthetic media ingredients	Quantity (g/mg)
Pomegranate sawdust	45 g
Agar	22 g
Sucrose	6g
Casein	3 g
starch	3 g
Yeast	3g
Wesson's salt mixture	0.6 g
Streptomycin sulphate	0.21 g
Ethanol (100 %)	3ml
Distilled water	300 ml

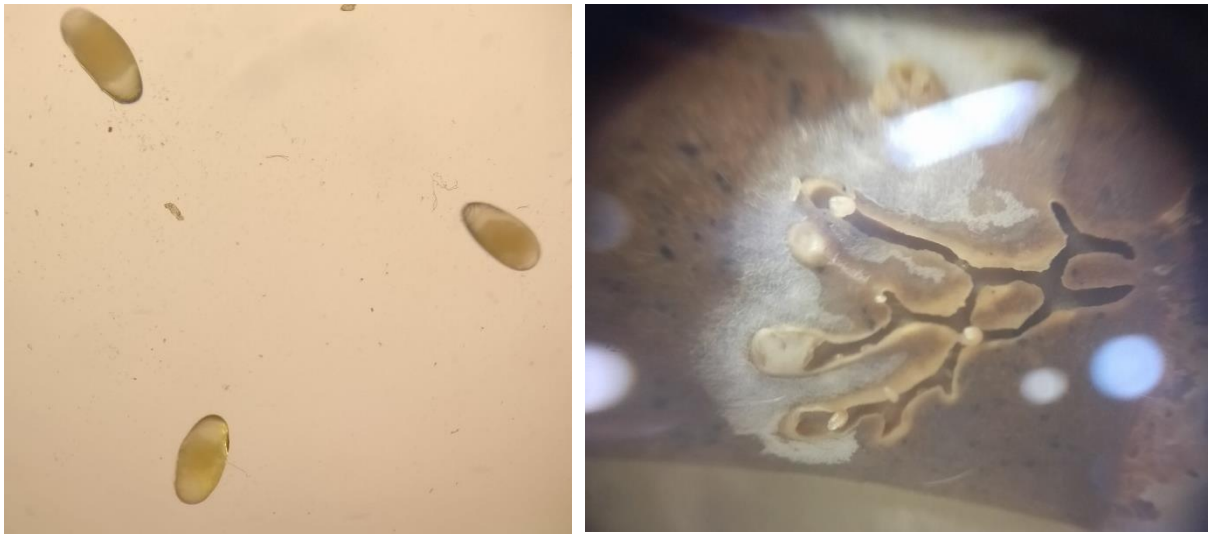


Fig. 4.8 Eggs and gallery of the shot hole borer in semisynthetic media

4.1.3.5 Effect of different fungicides against SHB survival and perpetuation

Invitro Bioassay experiment was conducted to assess the effect of different Fungicides SHB through poison food technique. Among the eight treatments, T7 (COC) and Treatment T8 (Control) recorded less effect on the perpetuation of the shot hole borer beetle 10, 20 and 30 days after treatment (DAT). The other treatment has affected the survival and perpetuation of the beetle by inhibiting the symbiotic fungal growth. The details are mentioned in the below

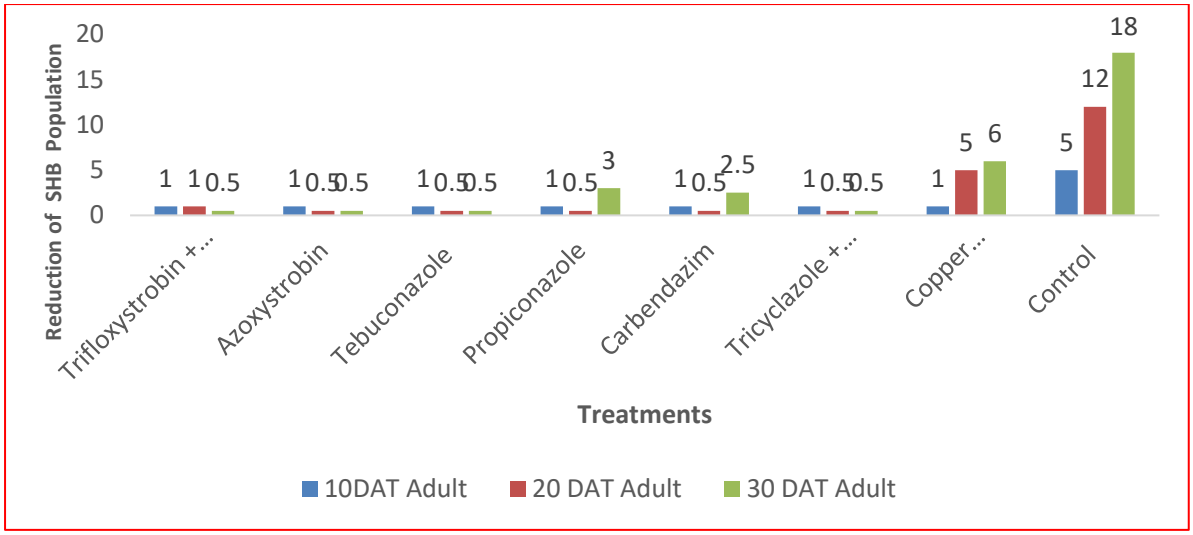


Fig. 4.9 Effect of different fungicides against SHB survival and perpetuation

4.1.4 Incidence and Management of Invasive Mealybug *Nipaecoccus viridis* (Newstead) in Pomegranate Orchards.

The severe infestation of the invasive mealybug *N. virdis* was recorded from the 17 experimental blocks of Kegoan and Hiraj Blocks of NRCP, Solapur. The sample was identified taxonomically as *N. virdis*. Detailed life cycle studies were undertaken on cucumber under Invitro condition. The mealybug completed its one life cycle in 40-50 days.

Table 4.6 The Mealybugs infested blocks

Block No.	Mealybug species identified
H-24	*Nipaecoccus viridis*
H-22	
H-19	
H-13	
H-4	
H-5	
H-6	
H-1	
H-2	
E-4	
E-3	
E-2	
E-1	
A-3	
A-1& B1, B2	

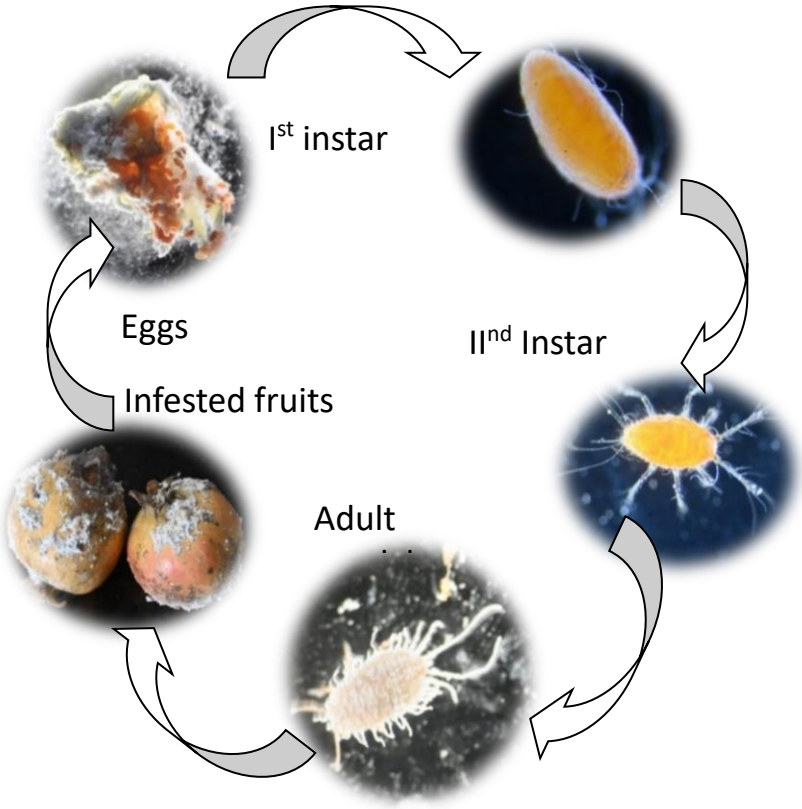


Fig. 4.10 Life cycle of *N. virdis*

Mealybugs (*N. viridis*) are identified by their oval to circular body shape. Adult females are 2-4 mm long, while males are 1-2 mm. Females are yellowish-green to pale-green with darker spots, males are darker. They have a powdery appearance due to a white, waxy substance covering their bodies, often forming a protective layer. Both genders have short antennae and legs, with females sometimes lacking antennae. The life cycle of *N. viridis* begins with oval, transparent eggs laid in clusters. Upon hatching, the nymphs, or crawlers, enter a mobile stage, moving to feeding sites on plant surfaces. They progress through multiple stages, resembling miniature adults, and molt as they grow. Adult females reach a non-mobile stage after completing nymphal stages, while males are small, winged, with a brief window to mate. Overwintering occurs in various life stages, with a primary mode of reproduction being parthenogenesis. Each female lays 90-138 eggs, with egg and nymphal stages lasting 10-13 and 31-43 days, respectively. In pomegranate orchards, there are three generations per year, with mature females laying eggs in September-October, November, and March-April.

Fig. 4.11 *N. viridis* infestation on different parts of the pomegranate plant

Mealybugs, by feeding on plant sap, induce leaf curling and distortion, leading to yellowing and premature leaf fall. Severe infestations can weaken plants, potentially causing death, particularly in young ones. Feeding on developing fruit results in surface scarring and deformities, reducing the market value of pomegranates. The honeydew excreted by mealybugs fosters sooty mold growth, covering leaves, stems, and fruit, hindering photosynthesis and plant health. Ants attracted to honeydew may protect mealybugs from predators and aid their spread to new plants, further compromising fruit quality and marketability.

4.1.4.1 Bioefficacy Evaluation of Newer Insecticides against Invasive Mealybugs

The bioefficacy evaluation of newer insecticides was conducted to assess their effectiveness in controlling invasive mealybugs. The study aimed to determine the percentage reduction in mealybug infestation. Among the 11 treatments, the treatment T10 (Betacyfluthrin 90 G/L + Imidacloprid 210 G/L OD) recorded the highest percentage reduction (72.50%). Flowed by treatment T1 (Thiamethoxam 12.6 % +Lambda cyhalothrin 9.5% ZC) and T9 (Flupyradifurone) recorded 68.5% and 67.5 % respectively.
These findings indicate that the treatments T10, T9 and T1 have higher efficacy in controlling invasive mealybugs and reducing fruit damage. However, further research is necessary to understand the long-term effects of these treatments and their potential impacts on other aspects of crop cultivation.

Table 4.7 Bioefficacy Evaluation of Newer Insecticides against Invasive Mealybugs

Trt.	Insecticides	Dose (ml/g /l water)
T1	Thiamethoxam 12.6 % +Lambda cyhalothrin 9.5% ZC	1.0
T2	Cyantraniliprole 10.26 % OD	1.0
T3	Spinosad 45 % SC	1.0
T4	Spinetoram 11.7% SC	1.0
T5	Tolfenpyrad 15 % EC	1.0
T6	Flonicamid 50% W/W	1.0
T7	Emamectin benzoate 3%+ Thiamethoxam 12% WG	1.0
T8	Difenthiuron 40.1% + Acetamiprid 3.9% WP	1.0
T9	Flupyradifurone	1.0
T10	Betacyfluthrin 90 G/L + Imidacloprid 210 G/L OD.	1.0
T11	Control	Water + Sticker

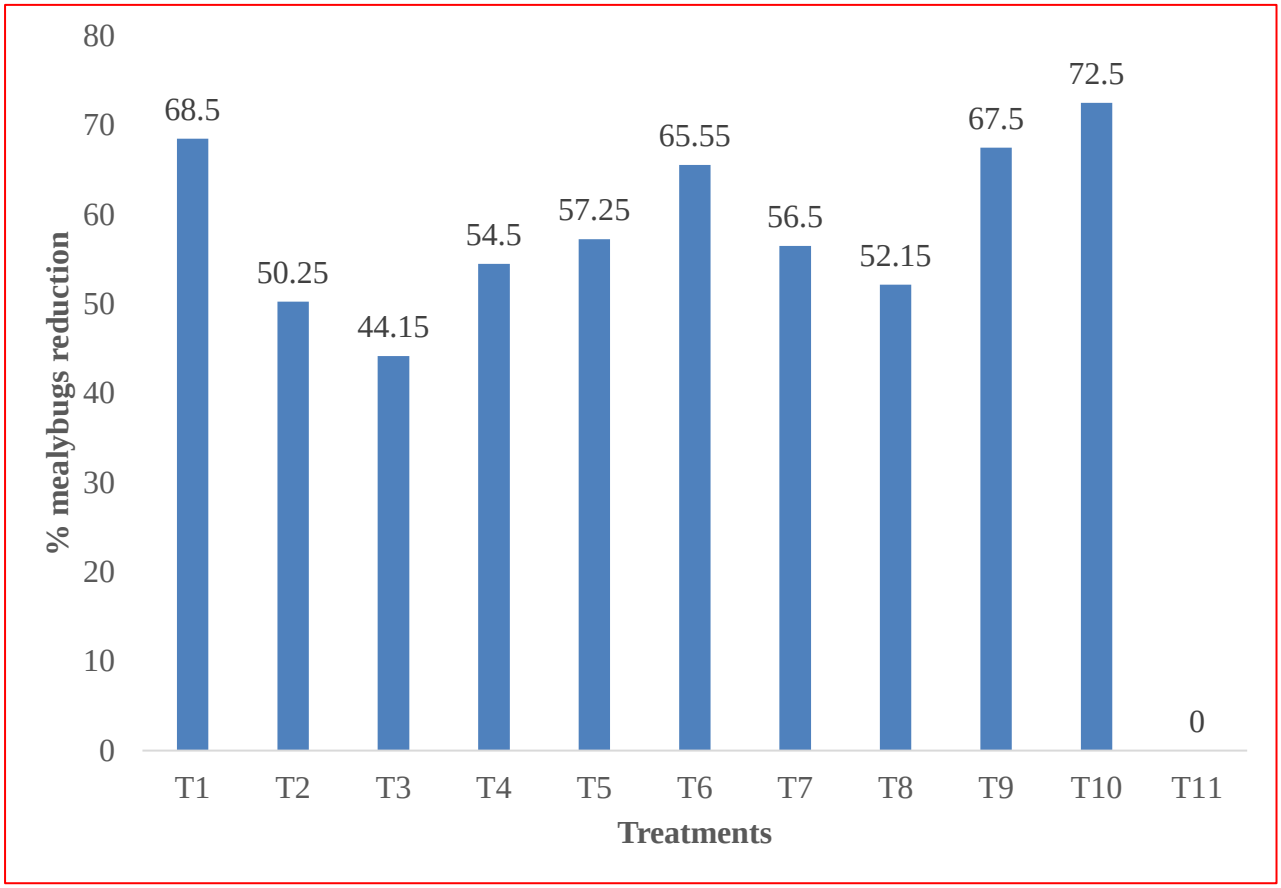


Fig. 4.12 Efficacy of different insecticides against the invasive mealybug *N. viridis*

4.1.5 Isolation EPF from infested FSM larvae and its efficacy evaluation

Entomopathogenic fungi were isolated from infested larvae of the fruit-piercing moth and subsequently tested against the larvae of *Helicoverpa armigera* and the green stink bug (*Nezara viridula*). Detailed results of these evaluations are provided.

Table 4.8 Efficacy evaluation EPF against *Helicoverpa armigera* and *N. viridula*

Dose (SP) ml/l water	Average % mortality of *H. armigera* (24-36 HAT)	Average % mortality of *N. Virdula* (24-36 HAT)
1	12.5	15.23
2	15.55	16.2
3	16.25	19.25
4	25.35	27.25
5	40.45	48.19

4.1.5.1 Molecular characterization of entomopathogenic fungi and bacteria

Six fungi and five bacteria were isolated from soil-baited insect cadavers. Among these one bacterial and one fungal isolate has been characterized through molecular techniques and they were identified as *Verticillium spp.* and *Bacillus spp.* Detailed studies will be taken for the species level identification and their efficacy evaluation against insect pests of pomegranate.

Table 4.9 Characterization of entomopathogenic fungi and bacteria

Sr. no.	Organism	Region Amplified	Sequence ID	Isolate code	Accession number
1	*Verticillium spp.*	ITS	>0622_708_002_PCR_E2_ITS_PI_B05.ab1	E2	MF034654.1
2	*Bacillus spp.*	16S rRNA	>0622_708_009_PCR_E6_16S_RNA_PR_F05.ab1	E6	EU249982.1

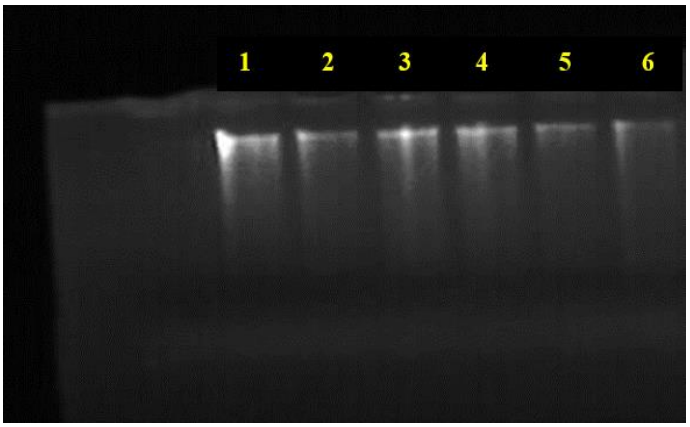


Fig. 4.13 1.S-I, 2.S-II, 3.S-III, 4.S-IV, 5.B-I, 6.B-II

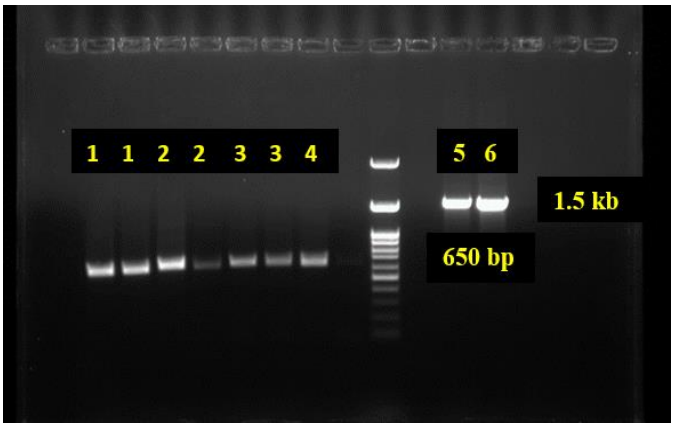


Fig. 4.14 100 bp DNA ladder and 1.S-I, 2.S-II, 3.S-III, 4.S-IV, 5.B-I, 6.B-II

4.1.6 Standardization of protocol for the development of neem leaf aqueous extract

The protocol for extracting neem leaf extract has been standardized, and its efficacy against thrips has been assessed. The neem leaf extract @ 10 ml/l water recorded a 48.55% reduction in thrips.

Table 4.10 Efficacy evaluation of neem leaf aqueous extract against pomegranate thrips

Treatment	Name of the biopesticides	Dose in ml or g/l	% control of thrips
T1	Neem leaf extract	3	31.25
T2	Neem leaf extract	5	40.55
T3	Neem leaf extract	10	48.55
T4	Neem oil 10000ppm	3	50.55
T5	Karanza oil	3	54.38
T6	Control	-	0.0

Fig. 4.15 Neem leaf aqueous extract preparation protocol

4.1.7 Standardization of protocol for the development of Mustard soap solution

The protocol for the development of Mustad soap solutions has been standardized, and its efficacy against thrips has been assessed. Detailed information and results are provided below.

Table 4.11 Efficacy evaluation of Mustard soap solution against pomegranate thrips

Treatment	Name of the biopesticides	Dose in ml or g/l	% control of thrips
T1	Mustard soap solution	2.5	35.33
T2	Mustard soap solution	5.0	45.25
T3	Mustard soap solution	10.0	55.25
T4	Neem oil 10000ppm	3.0	53.55
T5	Control	-	0.0

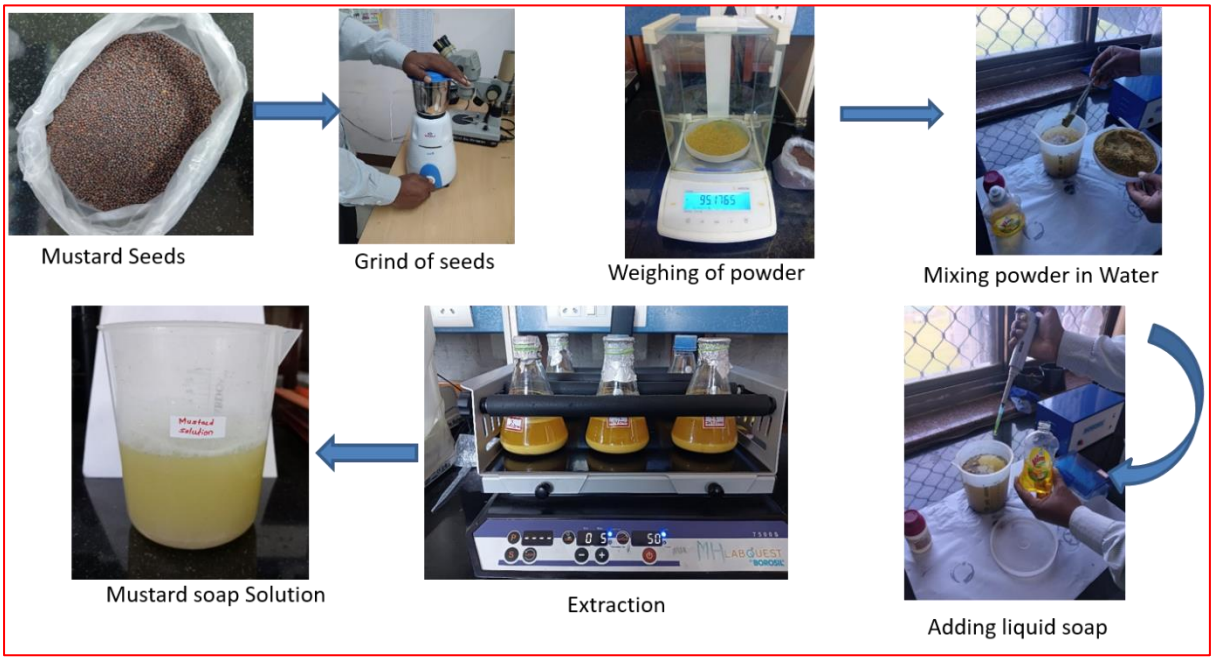


Fig. 4.16 Mustard soap solution preparation protocol

4.1.8 Bioefficacy Evaluation of different insecticides against Pomegranate Stem Borer (*Coelosterna spinator*).

Among the seven insecticide formulations evaluated at 2ml/g/L dose against pomegranate stem borer the treatment T1 (Emamectin benzoate 5% SG) and Treatment T7 (Emamectin benzoate 3%+ Thiamethoxam 12% WG) recorded the 66 % and 100% plants recovery in three different methods of treatment (Injecting, Drenching and Injecting+ Drenching).

Table 4.12 Bioefficacy evaluation of different insecticides against stem borer (*C. spinator*)

Treatments	Treatment details	Dosage/g/ml/l water
T1	Emamectin benzoate 5% SG	2 gm
T2	Imidacloprid 30.5% SC	2 ml
T3	Thiamethoxam 25 % WG	2 gm
T4	Tolfenpyrad 15 % EC	2 ml
T5	Afidopyropen 50 g/L DC	2 ml
T6	Flonicamid 50 WG	2 gm
T7	Emamectin benzoate 3%+ Thiamethoxam 12% WG	2 gm
T8	Control	Water

4.1.8.1 Bioefficacy Evaluation of Different Bioagents against Stem Borer

Among the seven bioagents evaluated @ 10ml/l water against stem borer by stem injecting method the Treatment T1 *Metarhizium anisopliae*, Treatment T3 *Bacillus subtilis*, and

Treatment T7 *Pseudomonas fluorescence* demonstrated high efficacy in controlling the stem borer insect, with recovery rates of 100%.

Table 4.13 Efficacy of different Bioagents against Pomegranate Stem Borer (*C. spinator*).

Treat. no.	Treatment details	Dosage (ml)	Plants recovery (%)
1	*Metarhizium anisopliae* (CFU: 2*108/ml)	10	100
2	*Trichoderma viride* (CFU: 2*108/ml)	10	25
3	*Bacillus subtilis* (CFU: 2*108/ml)	10	100
4	*Azospirillum umbrasilense* (CFU:10*108/ml)	10	25
5	*Verticillium lecani* (CFU: 2*108/ml)	10	25
6	PSB (CFU:10*108/ml)	10	25
7	*Pseudomonas fluorescence* (CFU: 2*108/ml)	10	100
8	Control (Water)	10	0.0

4.2 PROJECT: EPIDEMIOLOGY AND SUSTAINABLE MANAGEMENT OF ECONOMICALLY IMPORTANT PHYLLOPLANE DISEASES OF POMEGRANATE

4.2.1 Field evaluation and formulation of potential endophytes

Field trials have been conducted during *Mrig bahar* for two seasons in the years 2022 and 2023. Endophytes were cultured in nutrient glucose broth for 16 hours. Culture with a CFU of 10^{8} or more was sprayed (10 ml/L) onto plants. The sticker was added to the culture solution and 1 litre was sprayed per plant. Blight incidence and severity were recorded over two months and converted into percent disease index. The plants inoculated with endophyte showed lower PDI as compared to control plants Percent reduction of disease was observed in the range of 47.11-66.88% and 57.48-69.36 % in first and second season respectively. Also, the disease reduction over the standard chemical being currently used/recommended (bactronol) for control of bacterial blight was 48.27 in the first season whereas 62.57 in the second season. The endophyte, *Bacillus haynesii* was significantly reduced the bacterial blight incidence in the both seasons compared to positive (bactronol) and negative control (only water). Remaining two potential endophytes reduced disease severity effectively and results obtained were at par with positive control.

Table 4.14 Field efficacy of tissue culture-derived endophytes against bacterial blight disease

Treatments	Season-I		Season-II	
	PDI	%ROC	PDI	% ROC
Bacillus haynesii (TC-4)	7.83 [c] (2.80)	66.88	8.38 [c] (2.90)	69.36
Bacillus subtilis (TC-6)	12.51 [b] (3.54)	47.11	11.63 [b] (3.41)	57.48
Bacillus tequilensis (TC-310)	10.20 [bc] (3.20)	56.89	10.21 [bc] (3.19)	62.64
Bactronol	12.23 [b] (3.50)	48.27	10.23 [bc] (3.20)	62.57
Control	23.65 [a] (4.85)	-	27.34 [a] (5.22)	
CV	10.326		10.664	
CD (0.05)	2.585		2.727	

Fig 4.17: Field experiment results of endophytes over control (only water spray)

4.2.2 Bio-efficacy of new fungicide molecules against important phylloplane diseases of pomegranate

4.2.2.1 Bio-efficacy under in-vitro conditions

The fungicides which were reported effective against *Alternaria* spp. *Colletotrichum* spp. and *Cercospora* spp. were evaluated in-vitro by applying the poisoned food technique using Potato dextrose agar (PDA) as a basal medium the concentration of the chemical was amended in a sterilized medium and plated (90 mm diameter) was poured with the poisoned media and allow to solidify. A 6 mm disc of the pathogen from 7 days old culture was transferred at the center of the disc with a sterile loop. Three replications for test pathogen and control *i.e.* without addition of the fungicides and plates were incubated in BOD at 28±2°C and the zone of mycelium growth was measured 12 days after incubation. The results revealed that the pattern growth inhibition of all the treatments varied with the fungus. However, most of the combi products used under study significantly (90-100 %) arrested the growth of fungi under in-vitro conditions. Further, we observed complete growth inhibition of all the tested fungi in T8 (Tebuconazole + Trifloxystrobin @ 0.25 g/L).

Table 4.15 Fungicides used for in-vitro studies

Trt No.	Chemical group	Active ingredient	Trade Name Dosage/L	Manufacturer	Type of Formulation
T1	Mandelamides	Mandipropamide	**Revus (1 ml/L)**	Syngenta	SC
T2	Ethylene bisdithiocarbamate (EBDC) + strobilurins	Metiram + Pyraclostrobin	**Cabriotop (3 g/L)**	BASF	WG
T3	Triazole	Propiconazole	**Tilt (1 ml/L)**	Nagarjuna	EC
T4	Aryloxypyrimidine	Azoxystrobin	**Amistar (1 ml/L)**	Syngenta	SC
T5	Strobilurin	Difenoconazole + Azoxystrobin	**Amistar Top (2 ml/L)**	Syngenta	SC
T6	Triazole + Dithiocarbonate	Hexaconazole + Zineb	**Avtar (2.5g/L)**	Indofil	WP
T7	Dinitryl + Strobilurin	Chlorothalonil	**Jataayu (2g/L)**	Coromadel Int. Ltd.	WP
T8	Triazole + Strobilurin	Tebuconazole + Trifloxystrobin	**Nativo (0.25 g/L)**	Bayer	WG
T9	Strobilurin	Fluopyram + Triflozystrobin	**Luna Sensation(0.75 g/L)**	Bayer	SC
T10	Dinitryl + Acylalanines	Chlorothaionil + Metalaxyl-M	**Folio Gold (2.2 ml/L)**	Syngenta	SC

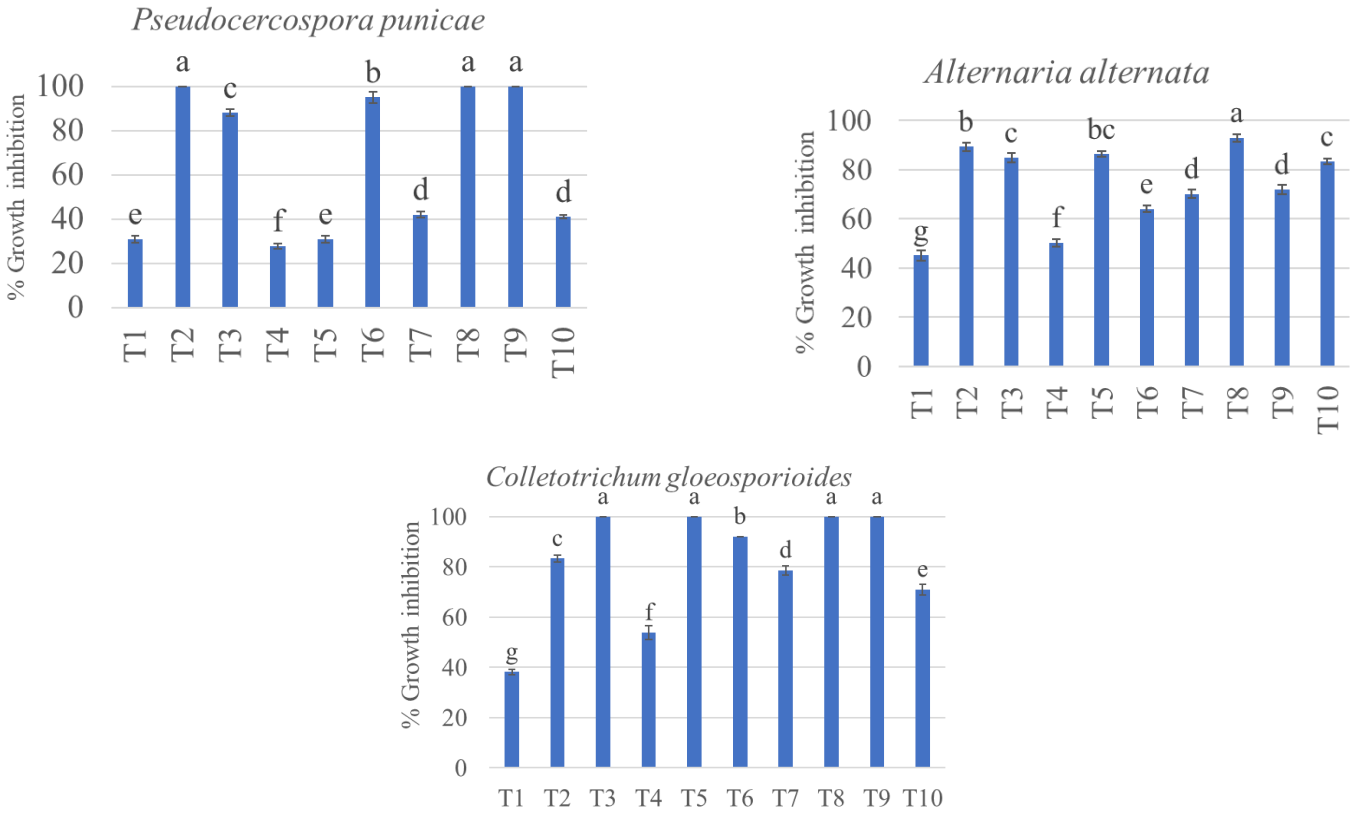
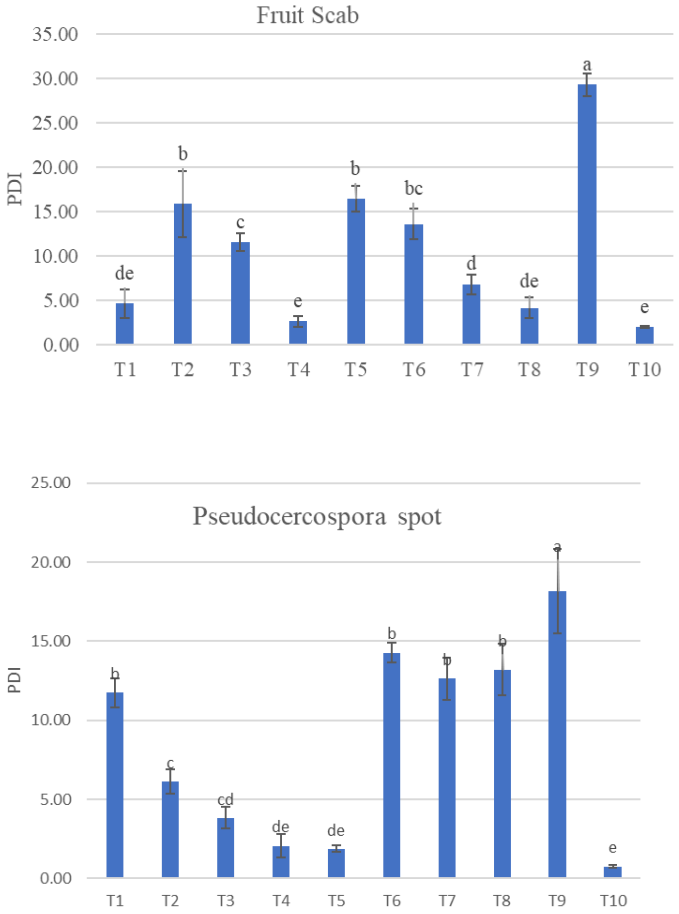


Fig 4.18: *in-vitro* efficacy of different fungicides against spot, Alternaria and Colletotrichum rot pathogen

4.2.2.2 Bio-efficacy under field conditions

The field experiment was carried out to determine the efficiency of different fungicides, an experiment was laid out in RBD (Randomized Block Design) with three replications for each treatment 3 Sprays of chemicals were given at 15-day intervals and observations on the disease were taken from five branches selected in all directions for each plant in each treatment and was converted to disease index (PDI). The results revealed that the efficacy of the fungicides varied with the fungal diseases under field conditions. Tricyclazole 18 %+Mancozeb 62 % WP @ 2.5 g/L and Difenoconazole 12.5 % + Azoxystrobin 20 % SC @ 2ml/L were found best among the treatments in reducing the severity of the scab disease (< 5 % disease severity was recorded. A similar trend of fungicide efficacy was observed against Pseudocercospora fruit spot. The efficacy of fungicides was comparatively less against fruit rot. The minimum disease severity was observed in T6 and T10 as compared to control and other treatments.



Trt No.	Active ingredient	Trade Name Dosage/L
T1	Fluopyram 17.7 % +Triflozystrobin 17.7 % SC	Luna Sensation(0.75 ml/L)
T2	Tebuconazole 50 %+ Trifloxystrobin 25 % SG	Nativo (0.25 g/L)
T3	Tebuconazole 25.9 % EC	Folicur (0.6 ml/L)
T4	Difenoconazole 12.5 % + Azoxystrobin 20 % SC	Amistar Top (2 ml/L)
T5	Fosetyl- AL 80 % WP	Alitte
T6	Hexaconazole 4 % + Zineb 68% WP	Avtar (2.5g/L)
T7	Chlorothalonil 75 % WP	Jataayu (2g/L)
T8	Copper sulphate +Lime	Bordeaux mixture (5 ml/L
T9	Control (Water)	-
T10	Tricyclazole 18 %+Mancozeb 62 % WP	Merger (2.5 g/L

Fig 4.19: Field efficacy of different fungicides against fruit scab of pomegranate

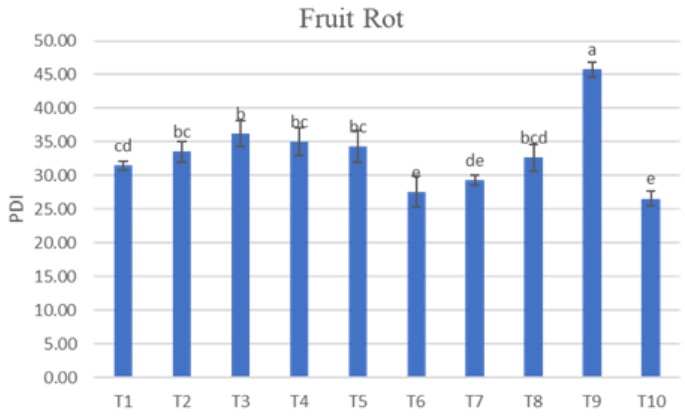


Fig 4.20: Field efficacy of different fungicides against *Pseudocercospora* fruit spot of pomegranate

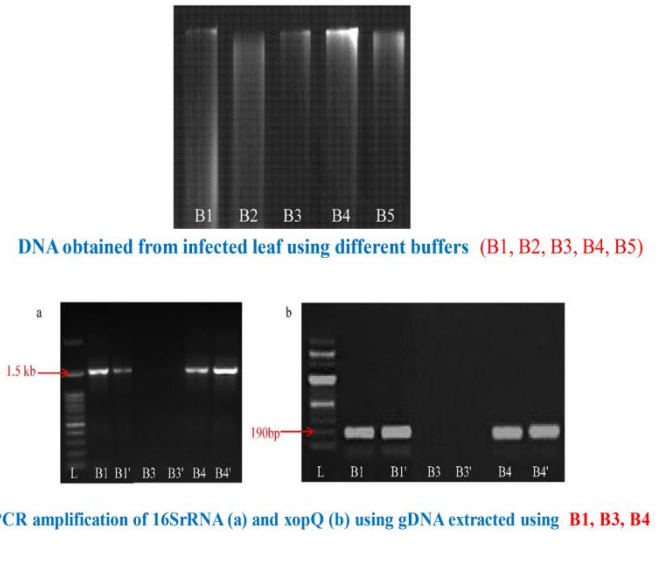


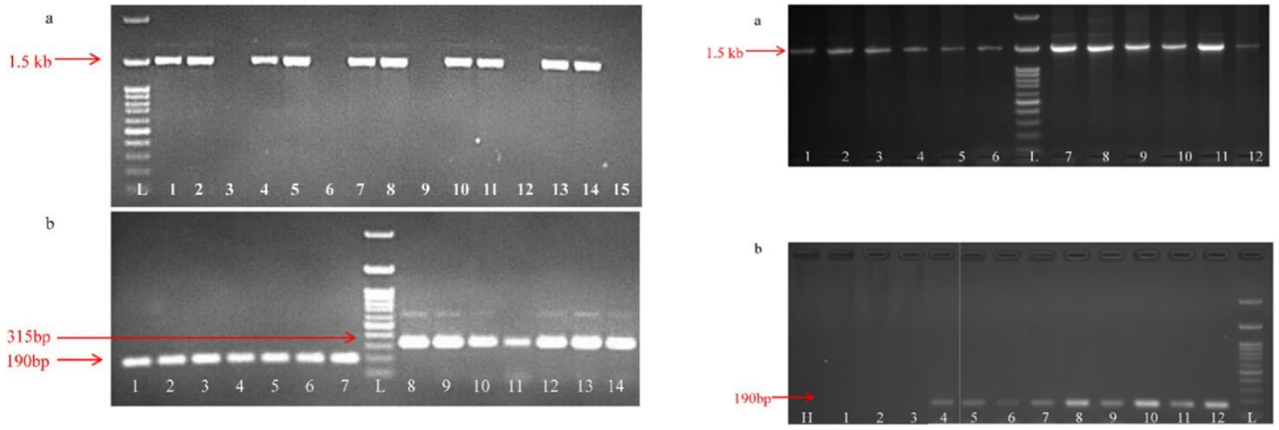
Fig 4.21: Field efficacy of different fungicides against fruit rot of pomegranate

4.2.3 Simple diagnostic protocol for bacterial blight pathogen

An economical, simple, rapid, and culture-independent method was developed for routine analyses and detection of *Xanthomonas axonopodis* pv. *punicae* (Xap) that causes bacterial blight in pomegranate. Five DNA release buffers (B1-B5) were optimized for extracting bacterial genomic DNA (gDNA) directly from (a)symptomatic pomegranate leaves followed by conventional polymerase chain reaction (PCR)-based detection of Xap. B1, B3, and B4 were found suitable to release gDNA, which was subjected to PCR using universal primers for 16S rRNA and *rpsL* genes, and pathogen-specific *xopQ* primers. DNA released from B1 and B4 successfully produced amplicons of expected sizes.

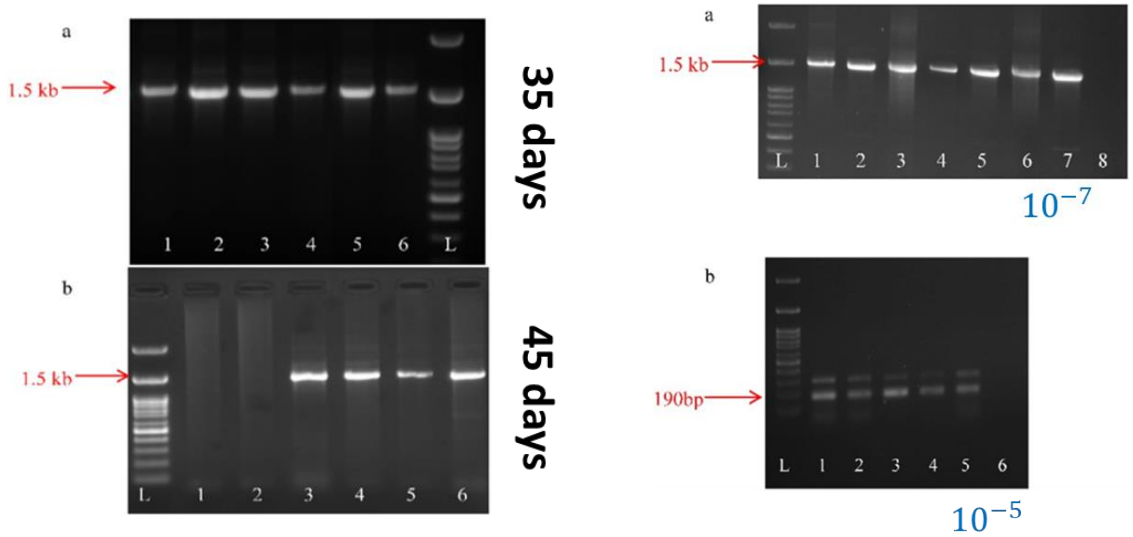
4.2.3.1 Versatility of DNA extraction protocol

To check the versatility of the protocol, different *Xanthomonas* species were used viz., Citrus canker pathogen*: X. citri* pv. *citri* and Sorghum shoot stripe bacterial blight: *X. vasicola* pv. *Holcicola* with positive control Pomegranate bacterial blight*: X. citri* pv.*punicae* . infected leaf samples were collected and DNA was isolated from the potential buffer (B4). The obtained DNA was amplified with universal (16sS rRNA) and specific primers, (*xopQ*, and *rpsL*). The protocol is also used in the detection of pomegranate bacterial blight pathogen in the latent stage



4.2.3.2 Sensitivity and stability of the protocol

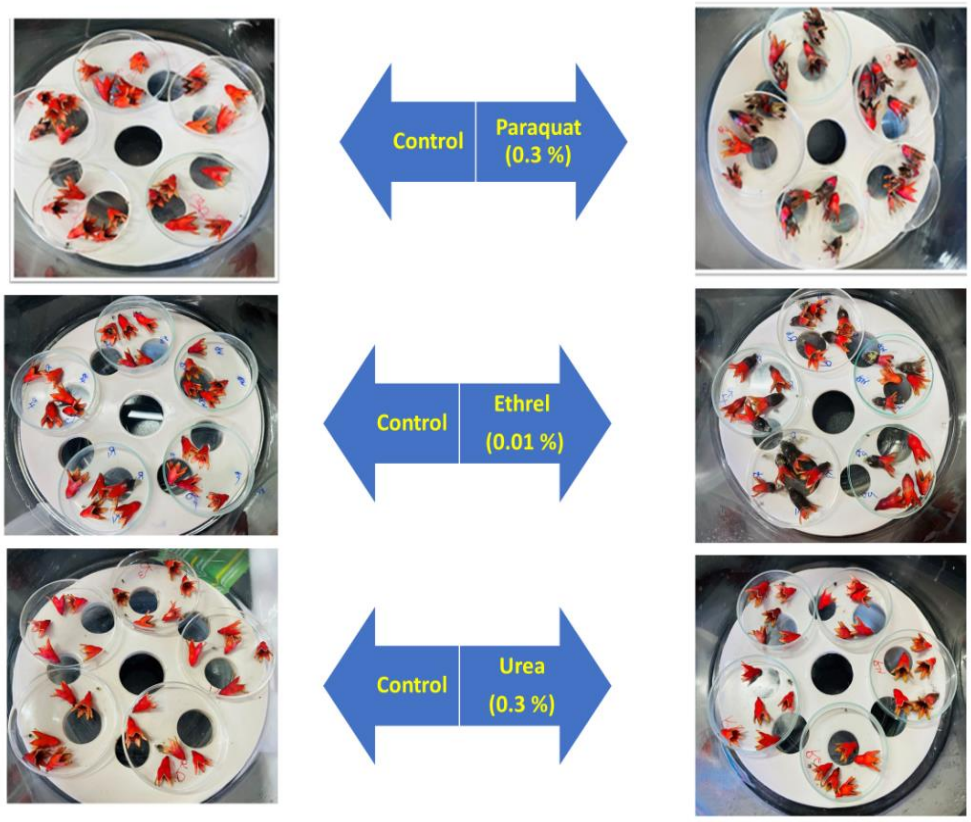
Additional analyses found that DNA released using B4 buffer was stable up to 45 days at −20 °C/−80 °C and 35 days at 4 °C and 8-800 pg DNA could be detected by the PCR-based assay.

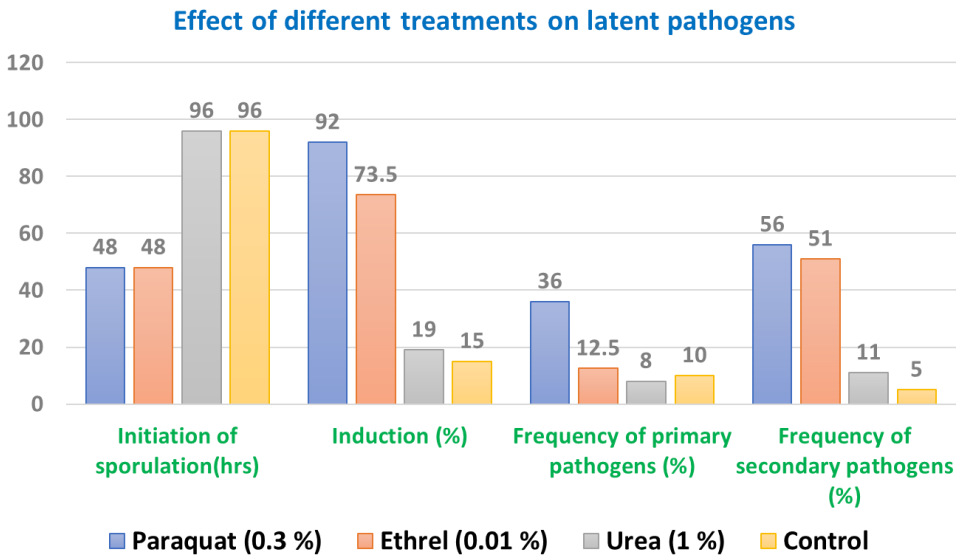


4.2.4 Simple and quick technique for identification of latent infections of fruit rot pathogens of pomegranate

The fungal pathogens typically remained on the host crop as quiescent or latent at different stages of the crop period. Hence it is necessary to diagnose the disease well in advance to know whether they are fit for long-term storage.

To induce the expression of quiescent disease symptoms in pomegranate flowers, an assay was conducted under controlled conditions. Open and asymptomatic flowers were randomly harvested from a commercial orchard located at the National Research Centre on Pomegranate, Solapur. Flowers were superficially disinfected in 1% sodium hypochlorite solution for 1 minute and subsequently washed in distilled water for excess product removal. The following treatments (Graph) were applied to flowers employing immersion for 1 minute. Then, each flower was washed in running water for 3 minutes and individually placed under an incubation chamber at 25℃ and >80% relative humidity. The flowers without chemical treatment served as control. After 48 hours of incubation, an initiation of infection as mycelium and spores were seen on some of the flowers in paraquat (0.3 %) and Ethrel (0.01 %) treatments whereas 96 hrs in urea (0.1 %) treated flowers and control (distilled water sprayed). A maximum number of flowers expressed latent infection after 8 days of incubation in the case of paraquat and Ethrel-treated flowers. Further, it was observed that both primary and secondary pathogens were recovered from paraquat-treated flowers whereas more secondary pathogens were recovered from ethrel-treated flowers.





The utility of paraquat (0.3%) in the detection of quiescent or latent infections of fungal pathogens

The method developed appears to have practical utility to help

- Early detection of fungal infection,
- To design management strategy and
- For disease forewarning systems.

4.3 PROJECT: STUDIES OF WILT COMPLEX IN POMEGRANATE

4.3.1 Identification, selection *in-vitro* evaluation and poly-house studies of *Trichoderma* species against wilt fungi, *Ceratocystis fimbriata*

Fungal bioagents were isolated from healthy/suppressive soil from pomegranate fields in Karnataka and Maharashtra.

Result: Antagonism of these bio agents was tested against the major wilt causing fungal pathogens of pomegranate including *Ceratocystis fimbriata*, *Fusarium* spp. as well as other fungal pathogens such as *Calonectria hawksworthi* and *Lasiodiplodia theobromae* causing collar rot and stem canker respectively and also foliar pathogens such as *Alternaria* spp. and *Colletotrichum* spp. causing fruit rots.

Table 4.16 Bio agents tested against the major wilt causing fungal pathogens of pomegranate

Isolate code	Molecular identity	Mean radial growth (cm)	% inhibition
KA-40	***Aspergillus flavus***	**0.17**	**91.43**
KA- 54	***Trichoderma erinaceum***	**0.31**	**87.72**
KA-19	***Trichoderma harzianum***	**0.41**	**81.34**
MH-1	***Trichoderma asperellum***	**0.17**	**92.39**
KA- 76	***Trichoderma harzianum***	**0.78**	**69.27**

These bioagents were identified based on the homology search against NCBI database based on the sequences of the conserved genetic regions (ITS). The isolates were identified at molecular level as *Aspergillus flavus* (KA-40), three different species of *Trichoderma* (KA-54, KA-19, KA-76 and MH-1). Based on the above studies, we have selected following species for poly-house studies:

Trichoderma asperellum **(MH1)**	***Trichoderma harzianum*** ***(*****KA-19)**	***Trichoderma erinaceum*** **(KA- 54)**

Fig 4.22:: *Trichoderma* species selected for polyhouse study

4.3.2 Antagonistic activity against other soil borne fungal pathogens:

Antagonistic activity of fungal bio agents which were found effective against the wilt fungi i.e. *Ceratocystis fimbriata* under *in vitro* condition were tested against other fungal pathogens of pomegranate such as *Lasiodiplodia theobromae* causing stem canker of pomegranate; *Calonectria hawksworthii*, pathogen of Collar rot of pomegranate and Fusarium spp, a minor wilt pathogen observed in some of the orchards in pomegranate in Rajasthan and Gujarat.

Results: All the 4 species of Trichoderma i.e. *Trichoderma asperellum* (MH-1)*; Trichoderma erinaceum* (KA-54) and 2 species of *Trichoderma harzianum* (KA-19 & KA-76) were inhibiting all the 3 pathogens with varied intensity ranging from 33.3% by *Trichoderma harzianum* isolate KA-19 for Fusarium species to 84.6% by *Trichoderma erinaceum* (KA-54) for the Calonectria pathogen. For Stem canker pathogen, highest inhibition was observed in plates with both *T. harzianum* isolates (71.3% by KA-76 & 65% by KA-19).

All the tested species produced >50% inhibition of stem canker pathogen. For Collar rot pathogen highest inhibition of 84.6% was observed in plates with *T. erinaceum* (KA-54) while other 2 species like Mh-1 & KA-19 were also give >80% inhibition.

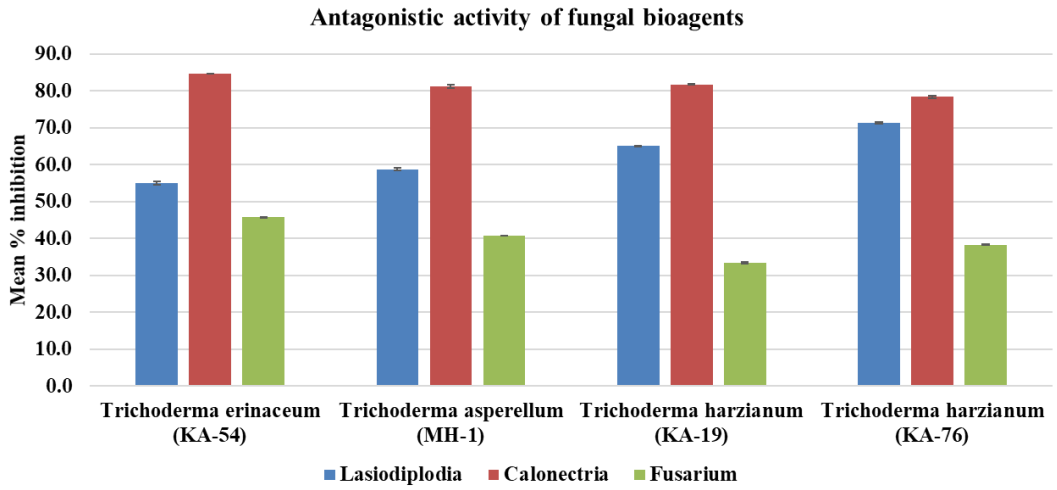


Fig 4.23: Effect of antagonistic activity of fungal bioagents against soil borne fungal pathogens of pomegranate.

In the case of *Fusarium*, highest inhibition of 45.7% was observed in plates with *T. erinaceum*. Surprisingly all the isolates showed less than 50% growth inhibition of *Fusarium* sp. So, based on the in vitro results, selected *trichoderma* species will be carried forward for poly house testing to evaluate their individual and consortial performance for the management of pomegranate diseases.

4.3.3 Sensitivity of *Trichoderma* species for Fungicides:

The fungicides listed below are being commonly used for the management of pomegranate fungal diseases like scab, spots and rots, so we wanted to know the sensitivity of our *trichoderma* species for the commonly used fungicides.

Table 4.17 List of commonly used fungicides in pomegranate

Tr. ment	Name of Chemical (active ingredient)	Dose	Brand Name	Company
T1	Mandipropamid 23.4% SC	1 ml/L	Revus	Syngenta
T2	Metiram 55% + Pyraclostrobin 5% WG	3 g /L	CabrioTop	BASF
T3	Propiconazole 25% EC + Azoxystrobin23% SC	1 ml/L	Result + Amistar	Nagarjuna / Syngenta
T4	Azaoxystrobin 18.2% + Difenoconazol 12.5% SC	2 ml/L	Amistar Top	Syngenta
T5	Chlorothalonil 50% + Metalazxyl M 3.75% SC	2 ml/L	Folio Gold	Syngenta
T6	Bordeaux mixture	0.5%	local	local
T7	Tricyclazole 18% + Mancozeb 62% WP	2.5 g/ L	Merger	Indofil
T8	Zineb 68% + Hexaconazole 4% WP	2.5 g/ L	Avtar	Indofil
T9	Chlorothalonil 75% WP	2 g/ L	Jatau	Coromandal
T10	Propiconazole 25% EC	1 ml/L	Result	Nagarjuna
T11	Copper Oxychloride 45% + Kasugamycin 5%	2.5 g/ L	Conika	Dhanuka
T12	Fluopyram 17.7% + Tebuconazole 17.7% w/w SC	1 ml/L	Luna Experience	Bayer
T13	Tebuconazole 50% + Trifloxystrobin 25% w/w WG (75WG)	0.5 g/L	Nativo	Bayer

Results: All the *Trichoderma* species which were tested against the fungicides were able to survive on most of the fungicides except Propiconazole, Azaoxystrobin and their combinations (T3: Propiconazole 25% EC + Azoxystrobin 23%SC @ 1 ml/L; T4: Azaoxystrobin 18.2% + Difenoconazole 12.5% SC @ 2 ml/L and T10: Propiconazole 25% EC @ 1 ml/L).

The growth of the *Trichoderma* species was slower in these three treatment compared with other fungicide treatments. We have observed the variation in the sensitivity of 3

Trichoderma species which were exposed to the fungicides containing Propiconazole & Azoxystrobin as active ingredient. We found lower sensitivity / more tolerance meaning better growth in *T. erinaceum* species as compared to *T. harzianum* and *T. asperellum*.

T. erinaceum	*T. harzianum*	*T. asperellum*

Fig 4.24: Sensitivity of *Trichoderma* species for commonly used Fungicides.

4.3.4 Compatibility with other fungal bio-agents:

In this experiments we wanted to test the compatibility of our selected Trichoderma species with other commercially available fungal bio agents such as *Aspergillus niger* and *Penicillium pinophilum* used in pomegranate fields. We have co-inoculated our 3 *Trichoderma* species individually with the selected bio agents in each plate with different combinations.

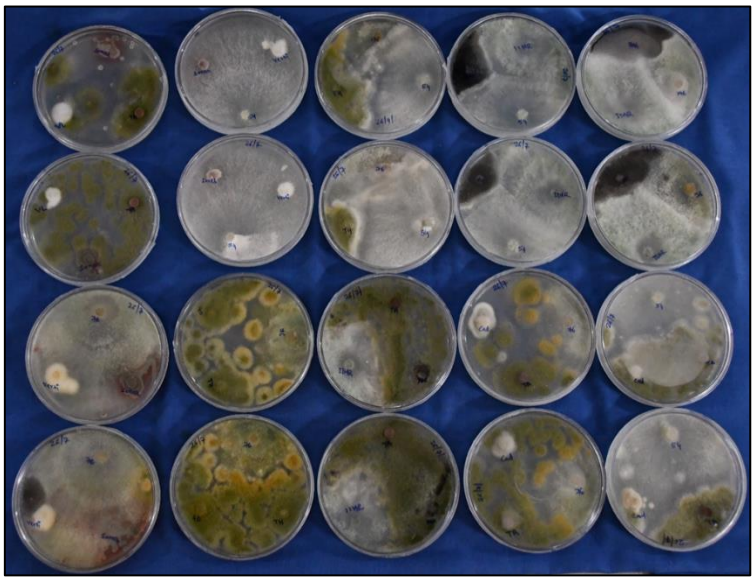


Fig 4.25: Compatibility with *Trichoderma* species other fungal bio-agents.

Result: Our selected bio agents (*T. erinaceum; T. harzianum* & *T. asperellum*) are compatible with commercially available fungal bio-agents such as *Aspergillus niger* & *P. pinophilum.* When added together, they grow and overlap in the same plate and does not form

inhibition zone, clearly indicating their compatibility. This hints the possibility of synergistic effects among the bio agents.

4.3.5 Bacterial endophytes against Root-Knot Nematode:

Three concentrations of culture filtrate (2.5%, 5% & 10%) obtained from 16h old culture of bacterial endophyte consortium (namely TC-4; TC-6 and TC-310 which have shown its efficiency against bacterial blight pathogen of pomegranate) was added to wells containing 100 live J2s. Control contained only water and Fluopyrum 34.48% SC (velum prime) was used as a chemical control. Observations for mortality of nematodes were recorded at 24 h intervals. Data presented is mean % mortality of 3 replicates after 24 and 48h.

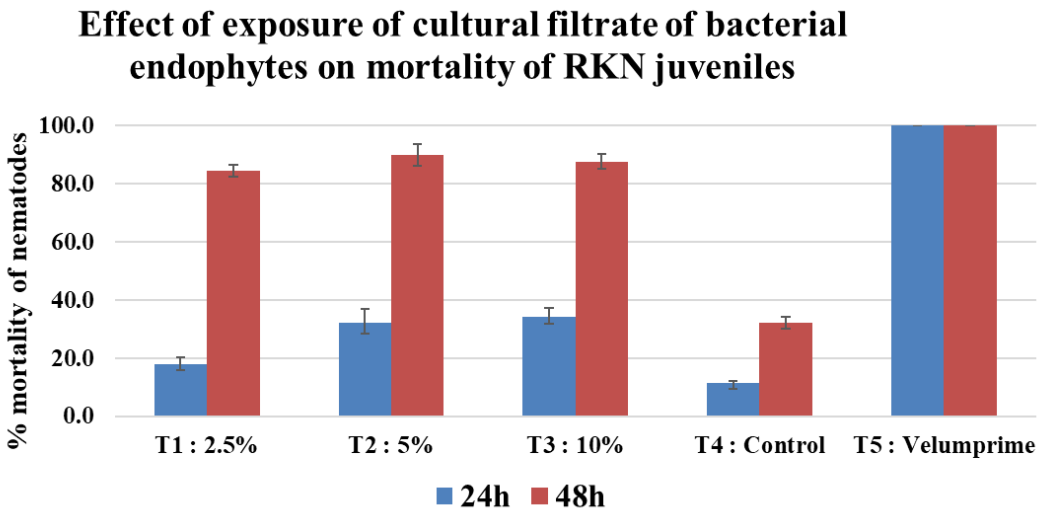


Fig 4.26: Effect of exposure of cultural filtrate of bacterial endophytes on mortality of J2s root knot nematode, *Meloidogyne incognita*.

Results: We observed that root knot nematode mortality increases as concentration of cultural filtrate / exposure duration increases. At 2.5% concentration, 18% mortality observed, which increased to 84% when exposure duration is increased from 24 hrs. to 48 hrs. Exposure to Fluopyrum 34.48% SC cause 100% morality within 24 hrs. of J2 exposure. We have tested previously that the individual bacterial endophytes were effective against the nematode. We confirmed that bacterial endophytes as well as its cultural filtrate can be used for the RKN management.

4.3.6 Mass multiplication of Bio-agents

Experiment was planned to test suitability of different carrier materials for the mass multiplication of consortia of 3 different *Trichoderma* species (*T. erinaceum; T. harzianum & T. asperellum*). The different carriers like Neem cake, Saw dust, Sorghum grains, Wheat bran, Coco-peat, Press-mud, Bajra and well decomposed FYM were evaluated.

Fig 4.27: Mass multiplication of *Trichoderma harzianum*

Among the carriers tested, well decomposed FYM and Neem cake mixture was found the best. Material is being evaluated for multiplication and survival using CFU count every month.

The bio-agents were surviving well up to 6 months' post inoculation with minimum required CFU count ($1X10^8$) at 24±2°C.

Making the Solid powder formulation Wettable Powder (WP) of Trichoderma species consortia:

Fig 4.28: Trichoderma solid formulation packed in plastic bag and liquid formulation in bottles.

5. Post-harvest Management and value Addition

5.1 PROJECT: POST-HARVEST MANAGEMENT AND VALUE ADDITION IN POMEGRANATE FOR ENTREPRENEURSHIP DEVELOPMENT

5.1.1 Microencapsulation of pomegranate peel extracts using ion gelation method

Pomegranate peel extract (PPE) is rich in interesting bioactive chemicals, principally phenolic compounds, which have shown anti-inflammatory, antimutagenic, antimicrobial and antioxidative properties. PPE can be used as food additives in a variety of food products as they can provide oxidative stability in the food and also suppresses microbial growth. Microencapsulation is a technique by which one can pack all the active ingredients within a second material in order to shield the active ingredient from the surrounding environment. Ionic gelation is based on the ability of polyelectrolytes (sodium alginate) to cross link in the presence of crosslinking ions (calcium chloride) to form hydrogel beads also called as gelispheres. The experiments were conducted to optimize the microencapsulate pomegranate peel extract process by using ionic gelation technique with calcium alginate as wall material.

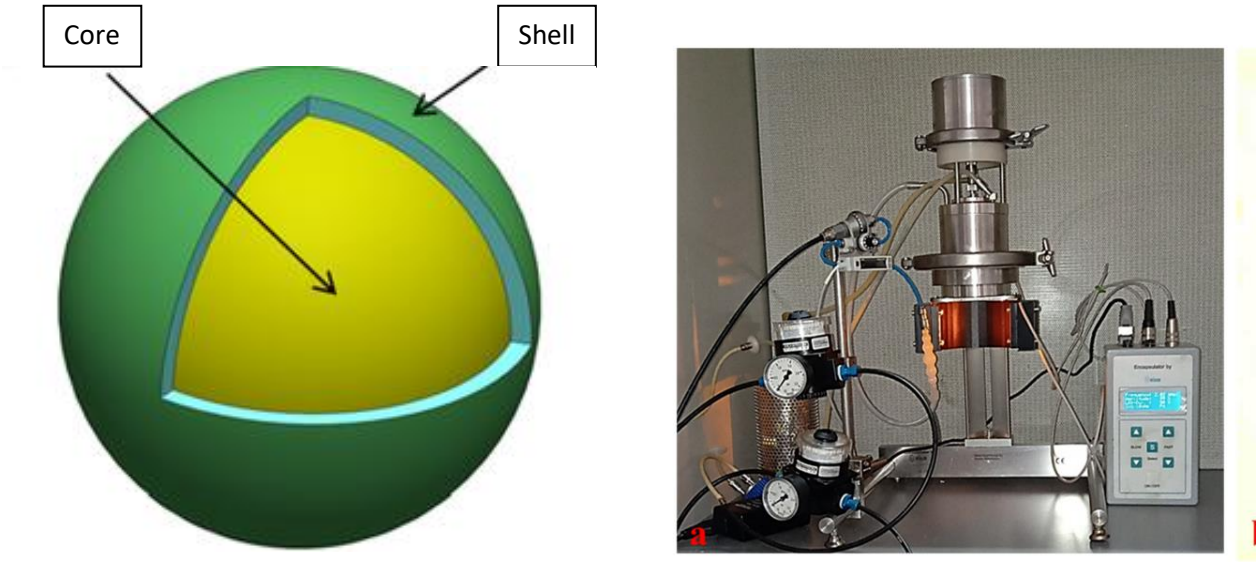


Fig. 5.1 (a) Microcapsule with core and shell (b) Microencapsulator

The pomegranate peel was extracted by the method as depicted below in flow chart

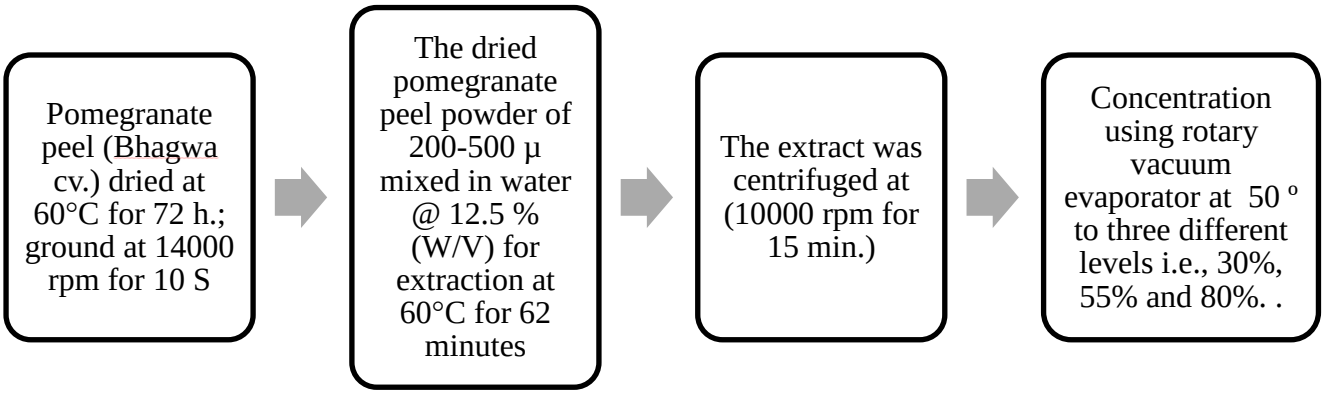


Fig. 5.2 Flow chart for pomegranate peel extraction

Microencapsulation method

Microencapsulation was carried out by using ionic gelation method in encapsulator with vibrating-jet technique or prilling for the production of microspheres. A mixture of sodium alginate and PPE emulsion was prepared at desired concentration using magnetic stirrer (500 rpm for 1 hr.) and sprayed in CaCl2 solution (500 mM) using encapsulator with a fixed nozzle diameter of 350 µm. Encapsulated beads thus obtained were allowed to harden in 500 mM $CaCl_2$ solution for about 45 minutes. The peel extract loaded alginate beads were finally collected from the cross-linking solution using a sieve and were rinsed (3-4 times) with distilled water for further analysis.

Experimental design

RSM was used to optimize the percentage reduced to concentration (*A*), peel extract level (*B*) and alginate concentration (*C*). Based on preliminary trials, upper and lower limits of the independent variables were established. A Box–Behnken experimental design with three factors and three levels was followed to study the response pattern and to determine the optimum combination of variables. The levels reduced concentration (30%, 55% & 80%), peel extract level (40%, 50% & 60%) and alginate concentration (1 %, 1.5%, and 2%) were used for experiment. A total of 17 experiments were conducted separately for getting the experimental response for encapsulation efficiency (EE) (%), encapsulation yield (EY), antioxidant activity (DPPH) (%), antioxidant activity (FRAP) (%), sphericity factor (SF), roundness (Rn), equivalent diameter (ED).

Parameters studied

Encapsulation efficiency:

It is a very crucial parameter, which refers to the amount of pomegranate peel extract encapsulated within the microsphere to the total peel extract used in emulsion. It is expressed by the equation,

Encapsulation Efficiency (%) = $\frac{TPC - SPC}{TPC} \times 100$

(where, TPC = Total phenol content in the beads; SPC = Surface phenol content on the beads)

A total of 100 mg of microcapsules were dissolved in 3 mL of ethanol: acetic acid: water mixture (50:8:42, v/v/v) and its further analysis was done to calculate its TPC. Similarly, for calculating the SPC 100 mg of microcapsules were dissolved in 3 ml of solution containing ethanol and methanol (1:1). Optical densities were calculated using these two methods and then standard curve was used to deduce the total phenol and surface phenol content of the extract.

Encapsulation yield (EY):

It is the measure of the efficiency of the encapsulator in producing microspheres. It is the ratio of weight of microspheres obtained to the weight of emulsion used in the microencapsulation process.

Encapsulation Yield (%) = $\frac{\mathrm{WMS}}{\mathrm{WEM}} \times 100$

where WMS = Weight of microspheres obtained; WEM =Weight of emulsion used

Antioxidant Activity (DPPH & FRAP):

The antioxidant activity was calculated using in vitro DPPH assay and FRAP method (Tolun, A et al. 2016).

Viscosity

The viscosity of the peel extract was measured using a rotational viscometer (Anton Par ViscoQC100). For this, RH2 spindle size was selected. Peel extract of different concentration levels i.e., 55%, 30% & 80% were taken for viscosity measurement. From each sample, around 500 ml of extract was taken into a beaker. The spindle attached to the viscometer was dipped into the beaker & then allowed to rotate. For each sample, the speed of spindle was fixed at 200 rpm and the torque ranges between 10-100%. The dynamic viscosity which showed at the set speed and torque range was finally selected as its viscosity (Anton Par., Rotational Viscosity testing of Fruit Juice with Visco QC, www.anton-paar.com).

Colour

Colour of the peel extract was measured using a colour diffraction meter (Hunter Labscan XE). 3 different concentration levels of the peel extract (30%, 55% & 80%) and an unconcentrated crude centrifuged peel extract were taken for colour measurement. The colour of the peel extract was analysed using Hunter L, a, b colour space.

Characterization of beads

The beads were characterized using Nikon (Eclipse 90i, Japan) light microscope equipped with a Nikon (DS-Ri1, Japan) photographic camera to view and data acquisition for representative images. Finally, all the images were analysed using software NIS Elements BR version 3.22.00. To analyse the microscopic parameters of the beads, a total of 15 random beads were taken from each run and then their different parameters such as perimeter, area, roundness, sphericity factor, maximum and minimum diameter of those were studied. Out of the total data obtained, the mean value of each parameter was chosen as the desired output.

Sphericity factor

The sphericity in general, is defined as how close the bead is to a perfectly spherical shape. It was determined for each microsphere by observing and selecting five points around the periphery of the microsphere using a microscope. Then, the maximum diameter (*D*max) and the minimum diameter (*D*min) to each of the microsphere are measured to determine their Eds. From each experiment, 15 random beads were taken and analysed. Finally, sphericity factor was determined using the following equation (Lee, B.B et al., 2013).

$$\text{Sphericity factor (SF)} = \frac{\text{Dmax}-\text{Dmin}}{\text{Dmax}+\text{Dmin}}$$

Roundness

Roundness (Rn) values of the microspheres were measured by calculating their perimeter and area in the similar fashion, by selecting five random points around the periphery of the beads with the help of microscope. The Rn value of the beads were calculated using the following equation (Lee, B.B et al., 2013):

$$\text{Roundness (Rn)} = \frac{P^2}{4\pi A}$$

Where, P = Perimeter of the bead, A = Area of the bead

Statistical Analysis

Design Expert Software Evaluation *V.12* (Stat-Ease, Inc., Minnesota) was used for the regression and graphical analysis of the data. Further, Myers and Montgomery's desirability function was employed for the optimization process. Finally, the factors, namely, percentage reduced to concentration, peel extract level and alginate concentration were set within the range. The response variables i.e., EE, EY, AA (FRAP & DPPH) were set for maximization, response variables i.e., SF was set for minimization and response variable Rn & ED were set for in range in this experiment. The ANOVA for each suitable model was also discussed.

Results

The results of the encapsulation experiments were tabulated in table 1.

Table 5.1: Effect of independent variables on the responses for PPE microencapsulation

A: PRC	B: PEL	C:AC	EE	EY	AA (DPPH)	AA (FRAP)	SF	Rn	ED
%	%	%	%	%	%	%	none	none	µm
55	**60**	**1**	75.12	66.07	8.91	4.8	0.11	1.01	958.95
55	**50**	**1.5**	74.98	70.93	7.92	4.65	0.10	1.09	756.12
80	**40**	**1.5**	62.95	62.8	1.98	3.27	0.13	1.01	950.93
80	**60**	**1.5**	67.97	65.13	3.96	4.19	0.07	1.01	1193.76
55	**40**	**1**	74.58	64.13	5.94	4.80	0.10	1.03	1015.12
30	**50**	**1**	77.65	68.67	14.85	5.87	0.15	1.02	856.47
55	**50**	**1.5**	76.62	69.67	7.92	4.57	0.14	1.01	941.70
55	**60**	**2**	77.29	75.33	10.89	5.11	0.06	1.02	1447.22
55	**50**	**1.5**	76.05	71.33	6.93	4.65	0.09	1.01	962.63
80	**50**	**1**	65.17	60.6	2.97	3.73	0.11	1.03	1068.81
30	**60**	**1.5**	78.78	72.6	18.81	6.18	0.07	1.61	777.95
30	**40**	**1.5**	76.48	71.53	10.89	5.11	0.12	0.99	547.64
55	**50**	**1.5**	76.30	70.2	7.92	4.49	0.13	1.06	765.32
55	**40**	**2**	75.22	76.47	4.95	4.34	0.06	1.01	782.22
55	**50**	**1.5**	77.13	71.00	6.93	4.72	0.13	1.01	1127.14
80	**50**	**2**	66.78	73.40	2.97	3.81	0.13	0.99	653.71
30	**50**	**2**	78.22	77.2	13.86	5.72	0.14	1.00	1005.20

Encapsulation Efficiency (EE)

EE varied from 62.95% -78.78%. The highest EE observed at low PRC ie. High concentration of extract and higher PEL due to the higher entrapped total phenols as compared to surface phenols. The higher increase in the EE (2.5%) with increase in alginate concentration from 1 to 2 % at 60% PEL observed as higher AC leads to tight crosslinking of the network structure and increased free volume and pore size.

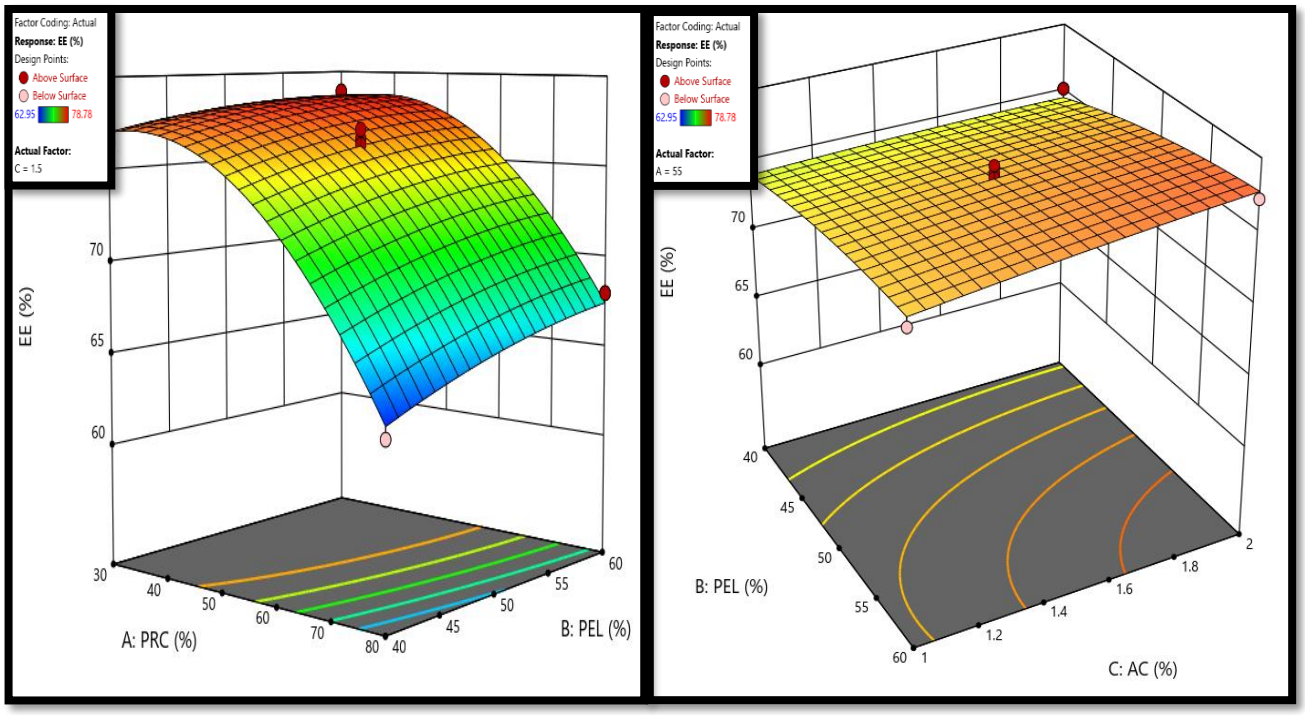


Fig. 5.3 (a) Effect of percentage reduction in conc. & peel extract level on EE (b) Effect of alginate concentration & peel extract level on EE

Encapsulation Yield (EY)

EY values that ranged from 60% to 77%. Low PRC has higher concentration of PPE and corresponding higher viscosity and the beads become heavier resulting in higher EY and vice versa. EY value increases significantly in the range of 10-12% when the alginate concentration increases from 1-2%. The higher polymer (sodium alginate) concentration forms the viscous emulsion and consequent larger microspheres. Low EY could be explained by emulsion loss throughout the encapsulation process in the transfer tubes, syringes, and emulsion bottle.

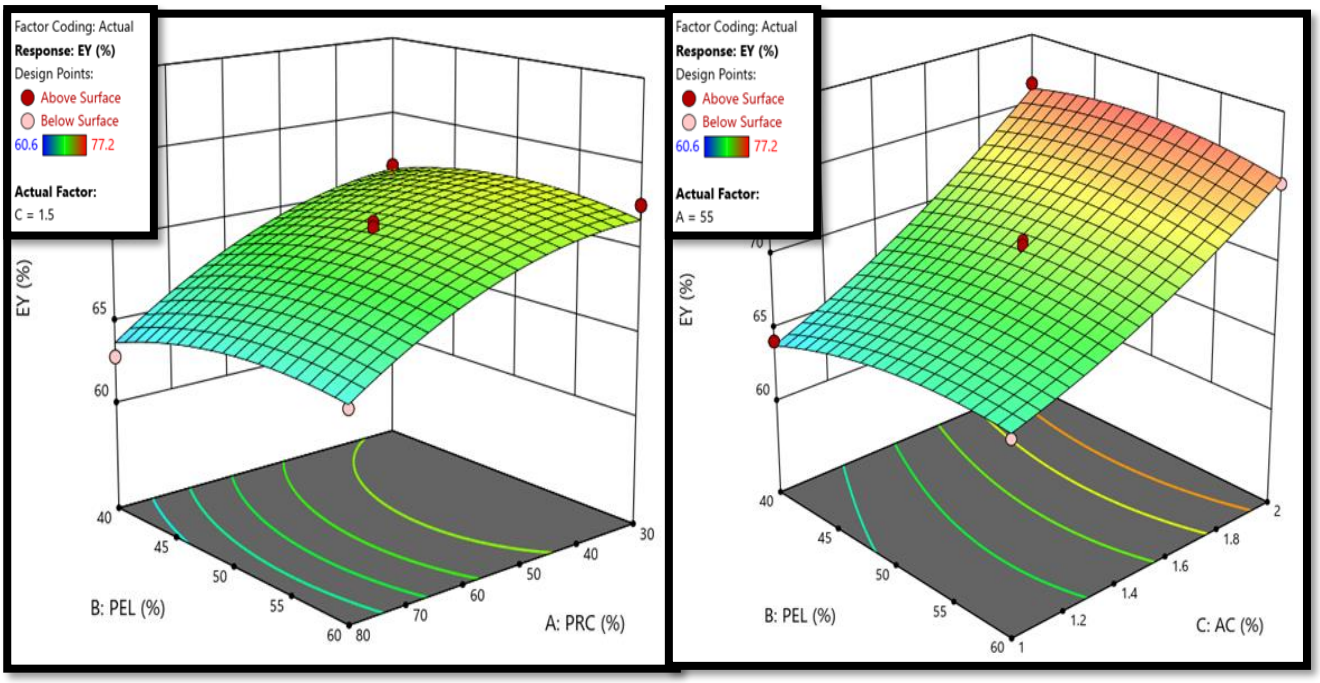


Fig. 5.4. (a)Effect of percentage reduction in conc. & peel extract level on EY (b) Effect of alginate concentration & peel extract level on EY

Antioxidant Activity (AA) DPPH

Antioxidant activity is also a very important parameter to understand the characteristic of the peel extract which is trapped in the form of beads upon encapsulation. The antioxidant activity of the encapsulated beads is highest when the peel extract is in its most concentrated form (30%) and the peel extract level is highest (60%) as total phenol content of the emulsion is highest which increases the antioxidant activity of the beads (Fig. 5). Alginate concentration does not significantly affect the antioxidant activity.

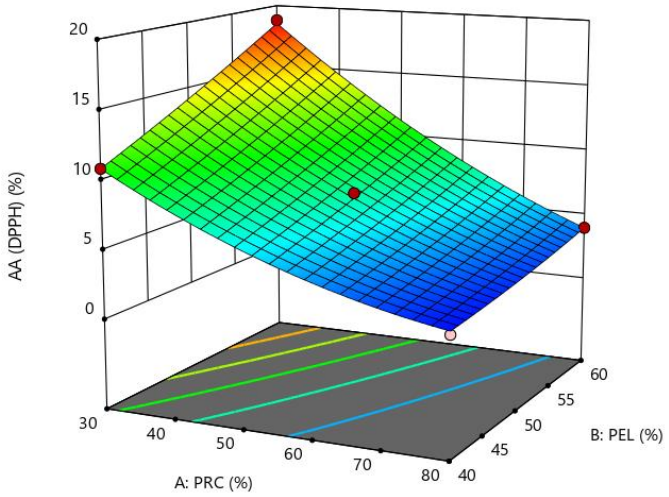


Fig. 5.5: Effect of PRC & PEL on antioxidant activity

Equivalent Diameter (ED)

The ED of the beads is important parameter. As per cent peel extract level increases the size of the beads increases while increase in PRC (ie. reduction in PPE concentration) the bead size has been seen to be increased.

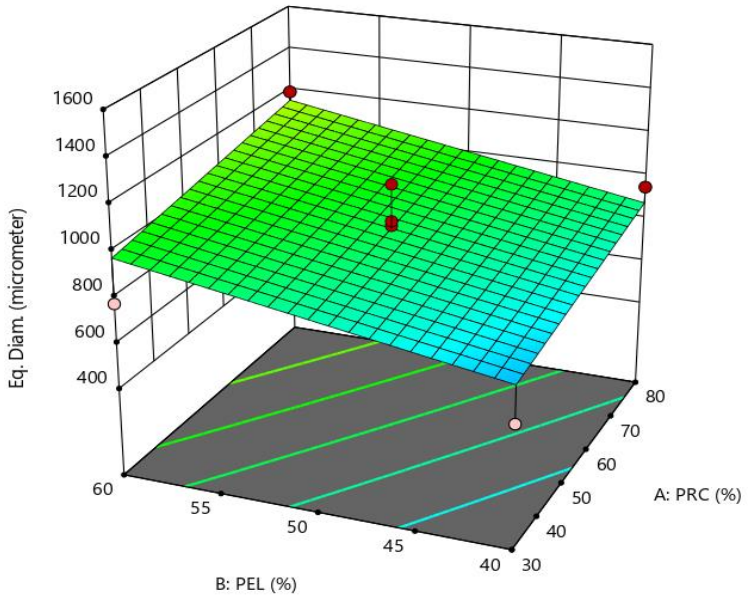


Fig. 5.6: Effect of PRC & PEL on ED

Viscosity of the PPE

This is a very important parameter which tells us about the flowability of the liquid. The spindle speed as mentioned was kept constant at 200 rpm. The mean dynamic viscosity and mean torque has been increased significantly with increase in the concentration of PPE (reduction in PRC). The dynamic viscosity certainly affects the encapsulation process. Torque ranged between 18.46-22.16 %.

Table 5.2: Final Viscosity Data of all three PRC's

PRC	Mean Dynamic Viscosity (mPa.s)	Mean Torque
30%	43.38	22.16
55%	37.08	19.03
80%	28.27	18.46

Colour of the PPE

L* values shows color in terms of light to dark, a* values shows color from red to green whereas the b* values refers to the color from yellow to blue. The value of L*, a* & b* for the 30%, 55% and 80% PRC and PPE used for concentration were depicted in table. Higher the concentration of the PPE ie. at 30% PRC shows higher L* depicting increase in the darkness of the extract. The a* values decreases with increase in the concentration of PPE and thus showing lowest value and corresponding decrease in redness at the 30% PRC. The b* values decreases with increase in the concentration of PPE and thus showing lowest value and corresponding decrease in yellowness

Table 5.3: L*, a*, b* colour scale values of the PPE samples (Data given are the arithmetic mean of the three replicates)

Sample	L*	a*	b*
30% PPE	4.16	23.68	7.18
55% PPE	10.66	32.89	18.38
80% PPE	13.82	34.16	23.82
PPE before Concentration	22.87	34.71	38.34

Optimization of process parameters

The final predicted optimized process conditions were 37.134 % PRC, 60% peel extract level, 2% alginate concentration. The predicted value of responses at optimized process conditions were encapsulation efficiency (79.33%), encapsulation yield (76.34 %), antioxidant activity DPPH method (16.41%), sphericity factor (0.063), and equivalent diameter (1281.97μm). The average of three replications for observed responses were encapsulation efficiency (78.11%), encapsulation yield (76.90%), antioxidant activity via DPPH (17.11%), sphericity factor (0.08), and equivalent diameter (1279.71 μm). This shows that observed responses were very close to predicted one thereby highlighting the accuracy of the models for prediction.

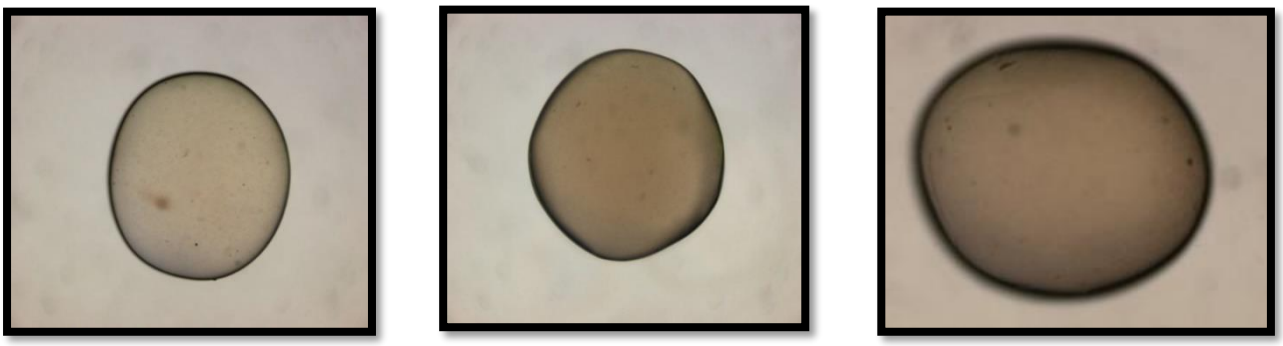


Fig. 5.7. The beads prepared from 80% PRC, 55% PRC and 30 % PRC respectively

The study on microencapsulation of PPE revealed that the AC, PRC & PEL significantly affected the encapsulation efficiency as well as the encapsulation yield. The PRC, PEL and AC significantly affected the shape size and roundness of the microsphere. The optimum process conditions for microencapsulation of PPE were 37.13 % PRC, 60% PEL and 2 % alginate concentration. The study of viscosity of the PPE revealed that the % PRC significantly affects the viscosity and with increase in concentration of PPE the dynamic viscosity of the peel extract increases. The colour values of the PPE significantly affected by the PRC and with increase in concentration of PPE the darkness increases, decreases lightness, redness, and yellowness.

5.1.2 Storage of osmotic assisted tray dried (OATD) pomegranate arils

The OATD pomegranate arils dried at the optimized condition with an approximate final moisture content of 10% wb were used for the storage studies. The dried arils were packaged in a packet of laminated aluminum foil. The packets were filled with air (control) and modified atmosphere (30% CO2+70% N2) and stored at 30 °C (room temperature) and 5°C (refrigerated temperature) for six months. The samples were drawn at intervals of one month for total phenol content (TAC), antioxidant capacity (AC), anthocyanin (AA), delta E and microbial quality analysis. The total aerobic plate count and total yeast and mold count were determined and expressed as log cfu/g (Gaikwad et al. 2017).

Total Phenol Content (TPC)

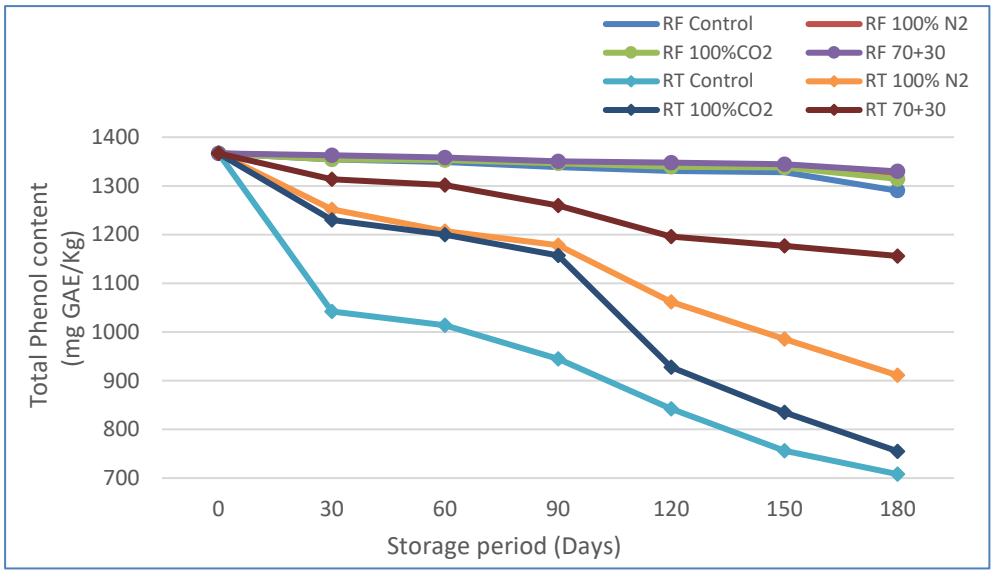


Fig. 5.8: Effect of storage period on total phenol content

The total phenol content decreased during storage in all treatments. However, samples stored in refrigerated temperature had higher TPC than room temperature samples. Arils packed with 100% N_2 and 70% N_2 + 30% CO_2 and stored at RF had retained higher TPC than other samples. The % reduction in TPC of RF control sample was 5.61%, whereas in RF (70% N_2 + 30% CO_2) loss was only 2.71%.

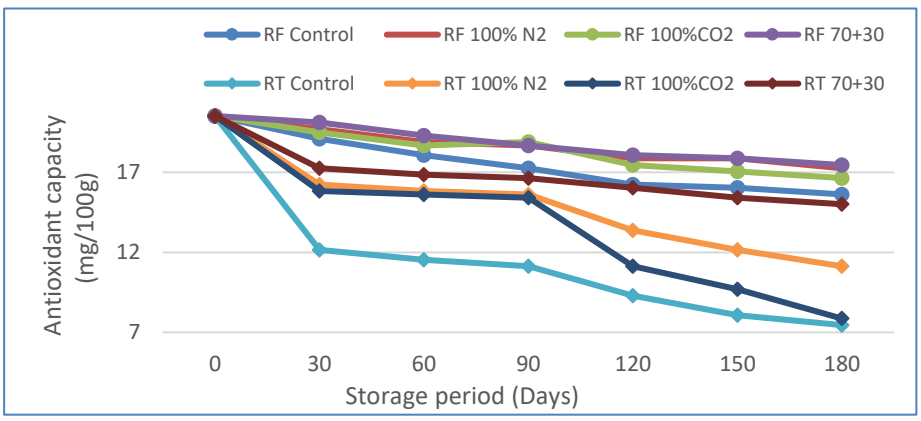


Fig. 5.9: Effect of storage period on antioxidant activity

Antioxidant Capacity (AC)

The AC decreased in all the treatments in both storage condition. However, deterioration was higher in treatments stored at room temperature (RT) when compared to refrigerated temperature (RF). Arils packed with 100% N_2 and 70% N_2 + 30% CO_2 and stored at RF had

retained higher AC than other samples. The % reduction in AC of RF control sample was 23.88%, whereas in RF (70% N_2 + 30% CO_2) loss was only 14.93%.

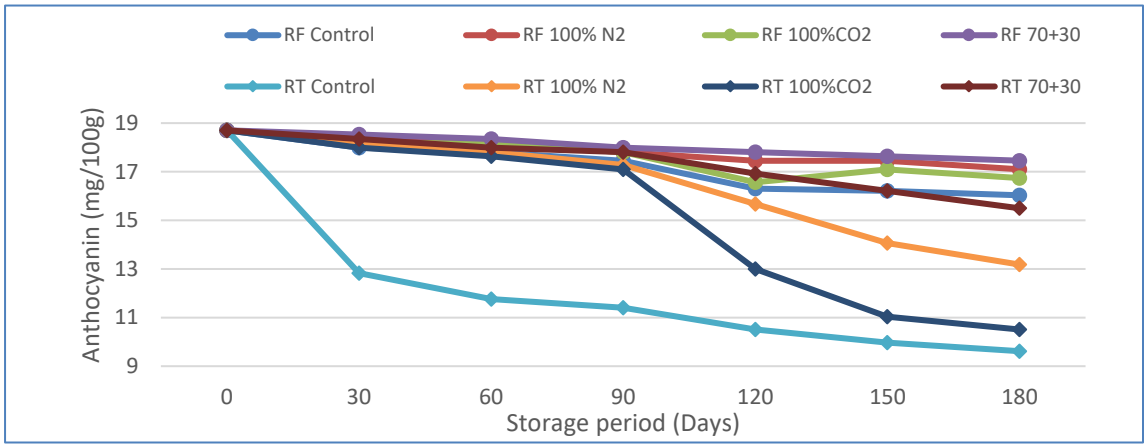


Fig. 5.10: Effect of storage period on anthocyanin content

The anthocyanin content decreased in all the treatments irrespective of their storage condition. However, deterioration was higher in treatments stored at room temperature (RT) when compared to refrigerated temperature (RF). Arils packed with 70% N_2 + 30% CO_2 and stored at RF had retained higher anthocyanin followed by 100% N_2. The % reduction in anthocyanin of RF control sample was 14.29%, whereas in RF (70% N_2 + 30% CO_2) loss was only 6.67%.

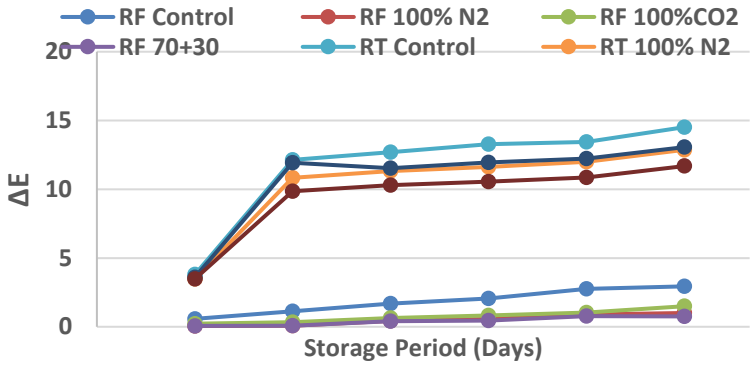


Fig. 5.11: Effect of storage period on delta E

Delta E represents the difference between a given color and a different color. ΔE is measured on a scale from 0 to 100, where 0 is less color difference, and 100 indicates complete distortion. ΔE value increased with increase in storage duration. The difference in color (ΔE) was higher for samples stored at RT when compared to RF. Arils packed with 70% N_2 + 30% CO_2 and stored at RF had lowest ΔE value followed by 100% N_2.

Table 5.4: Effect of storage period and condition on total aerobic plate count

	Total Aerobic Plate Count							
Storage Period (Days)	**RF Control**	**RF 100% N2**	**RF 100%CO2**	**RF 70%N_2 +30%CO_2**	**RT Control**	**RT 100% N2**	**RT 100%CO2**	**RT 70%N_2 +30%CO_2**
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	0.00	0.00	0.00	0.00	5.43	0.00	1.67	0.00
150	6.37	0.00	1.67	0.00	6.73	0.00	6.03	0.00
180	6.72	0.00	0.00	0.00	7.80	2.20	7.45	0.00

Table 5.5: Effect of storage period and condition on total yeast and mold count

	Total Yeast and Mold Count							
Storage Period (Days)	**RF Control**	**RF 100% N2**	**RF 100%CO2**	**RF 70%N_2 +30%CO_2**	**RT Control**	**RT 100% N2**	**RT 100%CO2**	**RT 70%N_2 +30%CO_2**
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00
150	5.92	0.00	5.00	0.00	0.27	0.00	0.08	0.00
180	6.40	0.00	3.33	0.00	0.15	3.46	0.25	0.00

The results of the storage studies revealed that there was no microbial growth up to 3 months in dried arils stored at both storage temperatures. The total aerobic plate count has exceeded the acceptable limits (5 log cfu/g) and the total yeast and mold count was within acceptable limits (4 log cfu/g) for dried products as per FSSAI guidelines. However, the control samples at room temperature (30°C) had shown a total aerobic plate count of 5.43 log cfu/g and a total yeast and mold count of 0.17 log cfu/g at the end of 4th month while RF-Control has shown total aerobic plate count of 6.37 log cfu/g and total yeast and mold count of 5.92 log cfu/g at the end of 5th month. Whereas the 70% N_2+30% CO_2 and 100% N_2 samples had no microbial growth of either type even at the end of a six-month storage period in both storage condition.
The results of the storage studies based on the quality in terms of bioactive compounds, color change and microbial quality reveals that the storage of OATD arils at refrigerated condition

with 70% N2+30% CO2 and 100% N2 in laminated aluminium foil was found to be best for storage upto 6 months.

5.1.3 Storage studies on foam mat dried pomegranate juice powder

The foam mat drying of pomegranate juice has been standardized in the previous experiment were used for the storage studies. The foam mat dried pomegranate juice powder (FPJP) was vacuum packaged in laminated aluminium pouch and stored at two different temperatures i.e. room temperature (RT: 25°C) and refrigeration temperature (RF: 5°C) for 8 months. The stored samples were withdrawn at the interval of 2 months and were evaluated for ascorbic acid (AA), antioxidant capacity (AC), total anthocyanin content (TAC) and total phenol content (TPC) and microbial quality in terms of total aerobic plate count, total yeast and mold count.

Results

The changes in ascorbic acid (AA), antioxidant capacity (AC), total anthocyanin content (TAC) and total phenol content (TPC) during storage were depicted (fig.1). All the bioactive compounds in FPJP have shown the decreasing trend with higher retention in FPJP sample stored at 5°C than that stored at 25°C during storage. Storage temperature has been known to be a critical factor for protecting phytochemicals in food.

The AA at the end of 8th month of storage has higher retention of (86.67%) at 5°C when compared to (80%) at 25°C. The similar results were also observed by Caparino et al, (2016) during storage of refractance window dried mango powder and Suhag and Nanda (2016). The decrease in AC with storage duration has been observed with higher retention (85.91%) at 5°C when compared to (53.53%) at room temperature (25°C). A two fold decrease in AC was observed for freeze dried pomegranate powder over a storage period of 3 months at room temperature (Adetoro, 2020). Zorin et al, (2017) reported significant influence of storage period and storage temperature on AC in marasca sour cherry. The decrease of the AC during storage may be due to decrease of phenolic compounds, ascorbic acid and anthocyanins which contributes to AC of the FPJP. The TAC at the end of 8th month of storage has higher retention of (85.93%) at 5°C when compared to (53.53%) at 25°C. Previous studies on bayberry (Cheng et al, 2017) and jambolan juice powder (de Carvalho Tavares et al, 2020) had shown the similar results for TAC retention. The retention of the TPC after 8 months

storage in FPJP was 88.25% and 72.85% at 5°C and 25°C respectively (Fig.5). The similar behaviour was observed in spray dried hog plum juice powder (Mishra et al, 2017).

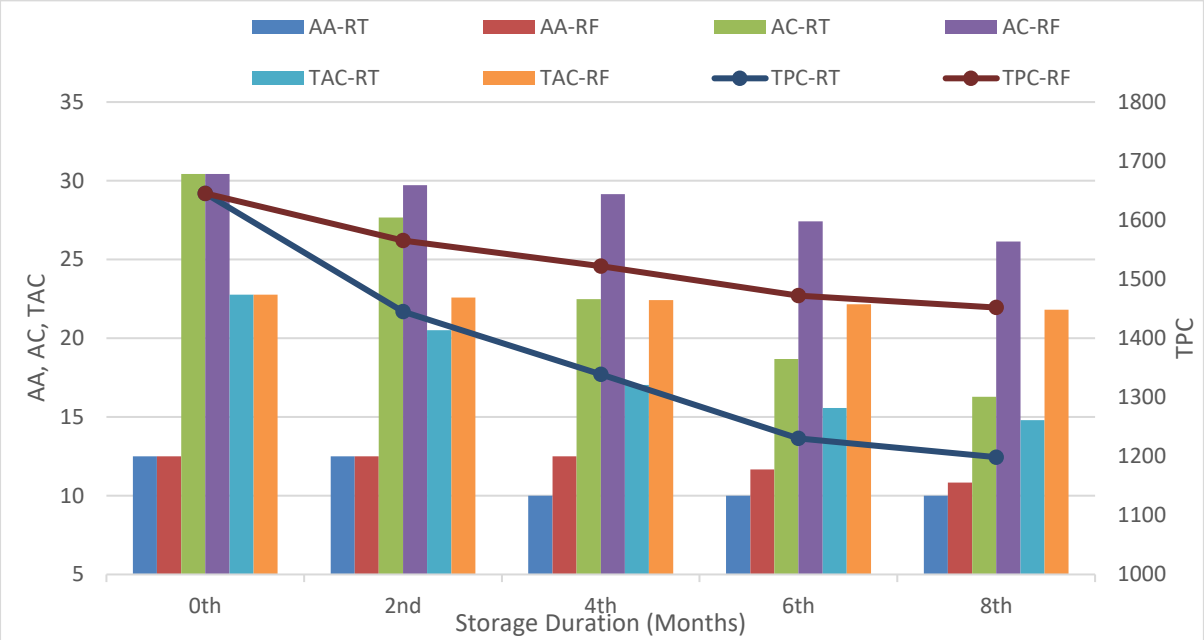


Fig 5.12 : Effect of storage study of pomegranate juice powder on AA (ascorbic acid (mg/100g)), AC (antioxidant capacity (mg/100ml)), TAC (total anthocyanin content (mg/100g)) and TPC (total phenol content (mg/ml)) under RT (room temperature) and RF (refrigerated temperature) condition

The carrier material protects the active ingredients present in juice powders better during storage at a lower temperature. At higher temperatures there seems to be degradation of the carrier material thus affecting retention of the active ingredients (anthocyanin, polyphenols and phenols) which may be exposed to oxidation (Bednarska et al 2020; Adetoro, 2020).

Further, it has been observed that there was no microbial growth in terms of total aerobic plate count, total yeast and mold count at the end of storage period of 8 months at both the storage conditions.

The FPJP can be stored at refrigerated temperature for eight months with minimum deterioration in bioactive compounds and no microbial growth.

Determination of Anardana recovery:

Anardana is the dried form of arils and arils are the edible parts of pomegranate. It is obtained by drying the arils of pomegranate in the hot air oven with air circulation facility. It is useful as souring agent. Assessment of anardana recovery from ten sour type pomegranate hybrids was undertaken. The results revealed that anardana recovery ranged from 17.2-21.4°B. Anardana recovery

was highest in Solapur Anardana (21.4%) closely followed by NRCP H-4 (20.6%). The recovery was lowest in Amlidana (17.2%).

STEPS IN ANARDANA PREPARATION:

SELECTION OF GOOD QUALITY FRUITS

WASHING AND CLEANING

PEELING

(Incision around crown, Crown removal, Incision along fruit, Splitting of fruits, Splitting into quarters)

SEPARATION OF ARILS

(Tap the fruits, Extraction of arils, pre-treatment 1%KMS for 3 minutes)

DRYING OF ARILS

(Loading of arils in dryer; Setting the Temperature 60^{o}C, Drying for 8-10 hrs)

COLLECTION OF DRIED ARILS (After 8-10 hrs time period)

PACKING OF ANARDANA

(Polythene Bag, Aluminium Laminated Pouch)

STORAGE OF PACKED ARILS (3, 6 months, etc.)

Table 5.6 Anardana recovery from pomegranate hybrids

S.No.	Variety/ Hybrid	Anardana recovery from arils (%)
1	NRCP H-1	19.2
3	NRCP H-3	18.8
4	NRCP H-4	20.6
5	NRCP H-11	20.2
6	NRCP H-12 (Solapur Anardana)	21.4
7	NRCP H-15	20.4
8	6/4	19.2
9	6/5	18.4
10	Hybrid A	20.2
11	Amlidana	17.2

5.2. PROJECT: DEVELOPMENT OF FUNCTIONAL FOOD PRODUCTS AND WASTE UTILIZATION FROM POMEGRANATE

5.2.1 Comparative Study on Effect of Pomegranate Peel Powder as Natural Preservative and Chemical Preservatives on Quality and Shelf Life of Muffins

This research aims to investigate the potential of utilizing pomegranate peel powder as a natural preservative in muffin preparation (Fig.1). The *In-Vitro* antifungal activity of pomegranate peel powder (8% PPP), potassium sorbate (0.1% PS) and calcium propionate (0.5% CP) was assessed against *Penicillium* sp. and *Aspergillus* sp. using poison food technique. The PPP showed the anti-fungal activity by delaying the growth of microorganism on media plate similar to the PS and CP.

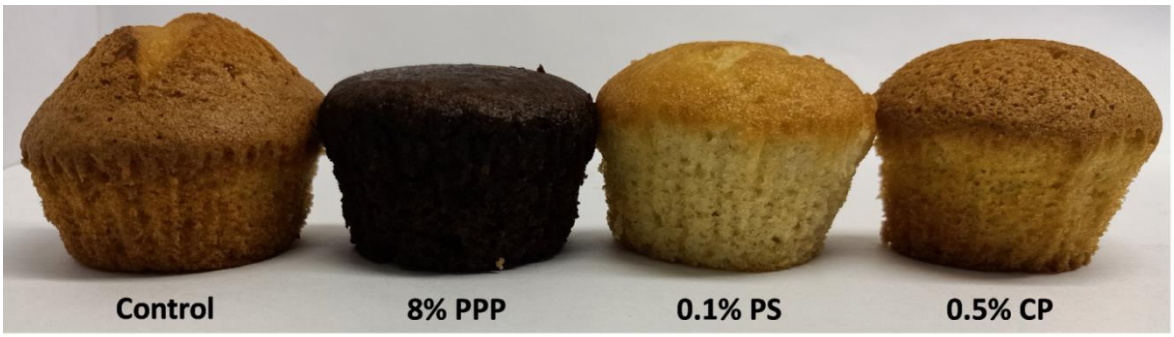


Fig 5.13 Muffins with pomegranate peel powder and chemical preservatives

The viscosity and specific gravity of batter significantly increased from 7.98 to 11.87 Pa.s and 1.089 to 1.398 respectively on addition of 8% PPP. The optical microscopic structure of batter revealed that there was decrease in the number of air cells from 24 to 12 with radius range of 6.42 to 72.72 μm and area range of 511.03 to 15383.17 μm^2 due to incorporation of PPP (Fig.2).

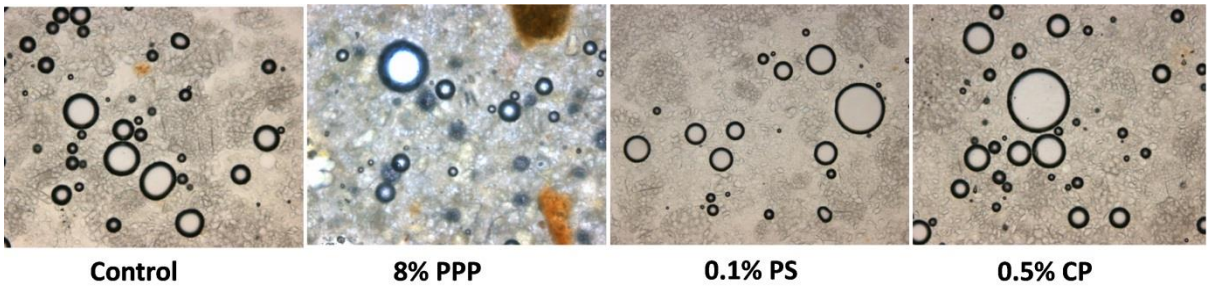


Fig 5.14 Optical microscopy images for batter samples of control (without preservatives), batter with 8% PPP, 0.1% PS and 0.5% CP.

The 418.36% increase in fibre content, 14.46% and 18.46% decrease in carbohydrates and energy value was observed in muffin with 8% PPP as compared to control respectively. The total phenols was increased from 0.92 to 12.5 mg GAE/100g, total tannin from 0.2 to 8.27 mg GAE/100g, *In-vitro* antioxidant activity by DPPH from 6.97 to 29.34% and *In-vitro* antioxidant activity by FRAP from 0.497 to 2.934 mg AAE/100g in muffins added with 8% PPP.

The addition of the PPP in the muffins controlled the growth of microorganisms responsible for the spoilage of muffins as similar to the chemical preservatives. The results suggest that pomegranate peel powder can be successfully used as a natural preservative in muffins, enhancing their shelf life while maintaining their quality (17 days) (Fig.3).

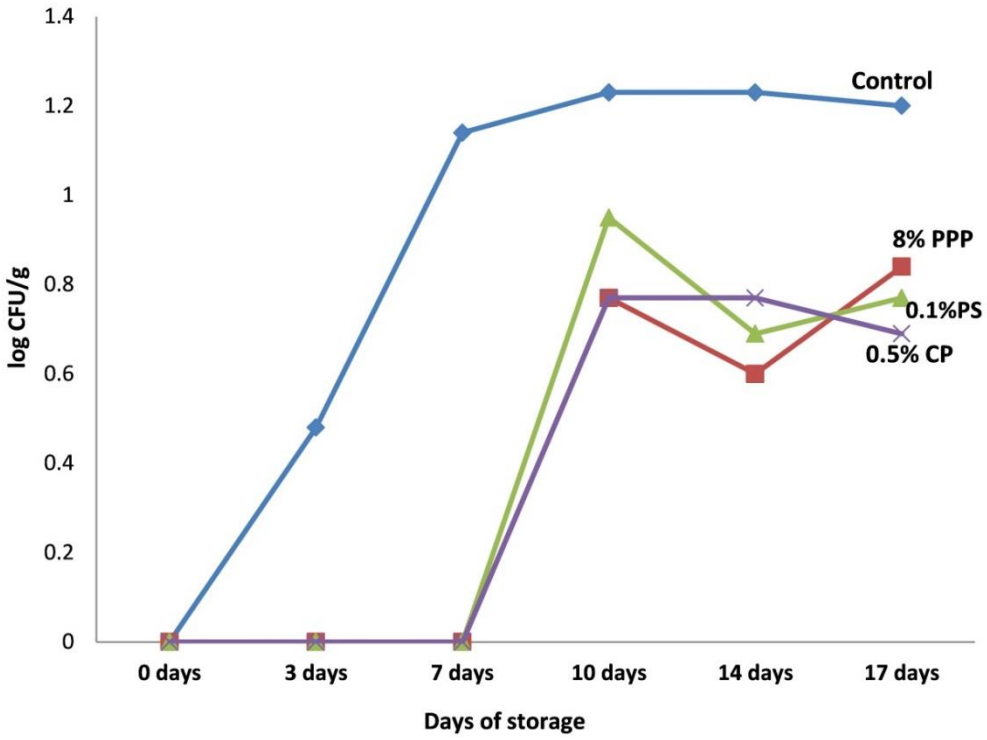


Fig 5.15 Total microbial count of muffins during storage at room temperature

5.2.2 Development and evaluation of Pomegranate based Iron rich RTS drinks

The D-optimal mixture design of Response Surface Methodology was used with levels of factors such as Pomegranate Juice: 40 to 65%, Karonda Juice: 20 to 35% and Aonla Juice: 15 to 25%. The responses were considered as iron content (mg/100ml), ascorbic acid content (mg/100ml), total phenols (mg GAE/ 100ml), in-vitro antioxidant activity (%) and overall acceptability. The nutritional composition of pomegranate, karonda and aonla juice were evaluated and karonda juice was found rich in iron (20.87mg/L) as compared to pomegranate and aonla juice. However, ascorbic acid content was found highest in aonla juice (185 mg/100ml).

Table 5.7 Nutritional composition of the pomegranate juice, karonda juice and aonla juice

Sample	Iron (mg/L)	Copper (mg/L)	Calcium (%)	Magnesium (%)	Ascorbic acid (mg/100ml)
Pomegranate Juice	9.83	0.73	0.15	0.14	10
Karonda Juice	20.87	0.70	0.14	0.15	7.5
Aonla Juice	18.58	0.42	0.14	0.13	185

Total 16 formulations with different combinations of pomegranate, karonda and aonla juice for preparation of iron rich drink were prepared as per the D-optimal mixture design. The response surface graph for the combined effect of pomegranate, karonda and aonla juice on iron content (mg/100ml), ascorbic acid content (mg/100ml), total phenols (mg GAE/100ml), in-vitro antioxidant activity (%) and overall acceptability of pomegranate based iron rich drink is shown in Fig.4. The increase in the level of karonda juice in the formulation resulted to increase in the iron content of drink.

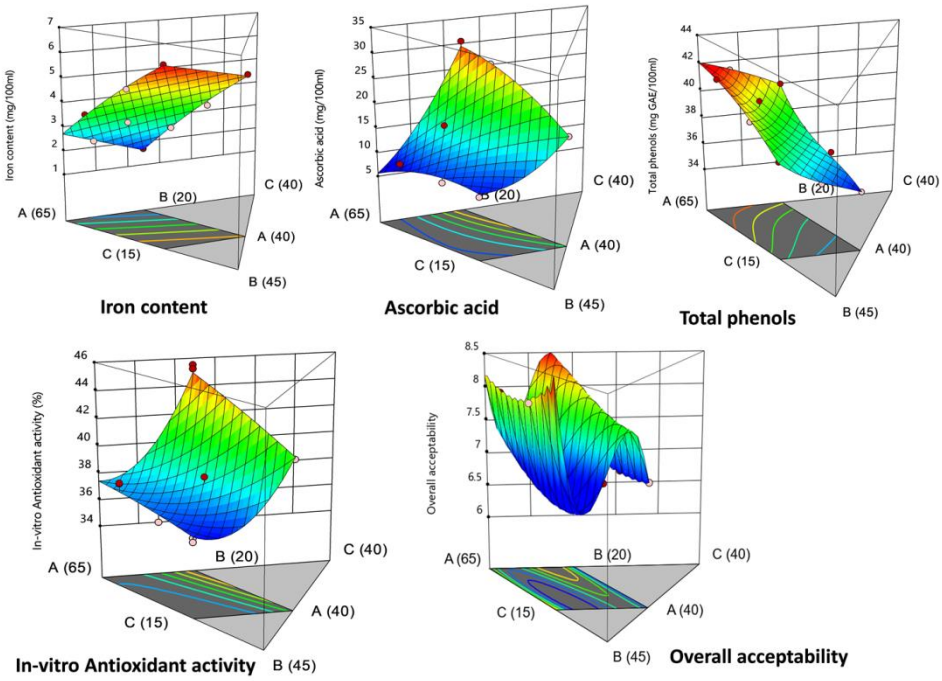


Fig 5.16 Response surface graph for combined effect of pomegranate, karonda and aonla juice on iron content (mg/100ml), ascorbic acid content (mg/100ml), total phenols (mg GAE/100ml), in-vitro antioxidant activity (%) and overall acceptability of pomegranate-based iron rich drink

The fitted model equations, R^2 value, F-value and p-value for the different responses of the pomegranate-based iron rich drink. The quadratic model with F- value of 416.79, 70.43 and 79.86 was significant for the iron content, ascorbic acid and in-vitro antioxidant activity of drink respectively. Whereas, special quadratic model with F-value of 130.18 was significant for total phenol content of the drink.

Table 5.8 Analysis of the fitted model equations for the nutritional quality and overall acceptability of Pomegranate based iron rich drink

Responses	Model	Mean ±SD	R^2	F-value	p-value	Polynomial equation
Iron content (mg /100ml)	Quadratic	4.01±0.13	0.9952	416.79	<0.0001	=+2.70 A+7.76 B+0.0844 C+1.85 AB-0.0502 AC+3.30 BC
Ascorbic acid (mg/100ml)	Quadratic	15.88±1.61	0.9724	70.43	<0.0001	= +5.63 A+2.12 B+102.02 C+21.38 AB-60.93 AC-102.28 BC
Total phenols (mg GAE/100ml)	Special Quadratic	38.74± 0.26	0.9933	130.18	<0.0001	= +42.04 A +32.52 B +34.78 C+6.63 AB+3.50 AC+7.49 BC-73.65 A^2BC+2.91 AB^2C-32.92 ABC^2
In-vitro Antioxidant activity (%)	Quadratic	39.44±0.62	0.9756	79.86	<0.0001	= +37.40 A+34.25 B+86.82 C+1.58 AB-50.75 AC-59.53 BC
Overall acceptability	Cubic	7.50±0.02	0.9995	1219.47	<0.0001	= +8.15 A+11.33 B-148.64 C-6.18 AB+287.34 AC+285.73 BC-324.61 ABC+1.66 AB(A-B) -154.25 AC(A-C) -185.82 BC(B-C)

Where, A: Pomegranate juice; B: Karonda juice; C: Aonla juice

The nutritional evaluation of the optimized pomegranate iron rich drink showed that, the iron content was increased by 31.91% and ascorbic acid content by 10.66% as compared to control (pomegranate RTS drink without blend of karonda and aonla juice). The prepared drink may fulfill the iron requirement of 32.63% (Men), 21.37% (women) & 22.96% (pregnant women) when consumed 100ml per day according to RDA.

5.2.3 Pomegranate based Spiced beverages

Pomegranate RTS are refreshing and thirst quenching but lacks in pleasant aroma or flavor. The flavor of RTS drink and its nutritional value was enhanced with the addition of spices extract. The spice extract of cinnamon, cumin and cardamom were used along with pomegranate juice. The spice extract were used in the range of 0-15%. The spiced pomegranate RTS were prepared with different combinations of pomegranate juice and spices extract.

The nutritional composition of different formulations were evaluated with respect to total phenols, antioxidant activity, antioxidant capacity and anthocyanin content. Sample with 100% pomegranate juice was considered as control. RTS specification: Juice: 20%; TSS: 15Bx; Acidity: 0.375%; Sodium benzoate: 200ppm.

Table 5.9 Bioactive composition of Pomegranate based Spiced beverages

Treatments	Total phenols (mg GAE/100ml)	Antioxidant activity (%)	Antioxidant capacity (mg/100ml)	Anthocyanin content (mg/100ml)
Control (Pome)	36.93±0.05e	61.07±0.03d	28.98±0.06e	3.28±0.05a
Cinnamon extract + Pome	45.54±0.07a	68.67±0.05a	34.83±0.05a	3.07±0.06c
Cardamom extract + Pome	41.37±0.05d	63.29±0.02c	29.22±0.05d	3.07±0.05c
Cumin extract + Pome	42.90±0.03c	66.13±0.05b	30.59±0.03b	3.03±0.06c
Cinnamon+Cumin+ Cardamom+Pome	44.29±0.06b	66.77±0.05b	31.51±0.05c	3.15±0.05b

The pomegranate juice based RTS added with cinnamon extract showed the improved nutritional value in terms of the total phenols (45.54 mg GAE/100ml), antioxidant activity (68.67%) and antioxidant capacity (34.83mg/100ml) as compared to control and sample with other spice extract.

6. Externally Funded / Collaborative Projects

6.1 PROJECT: INDUCED MUTAGENESIS IN POMEGRANATE FOR BIOTIC STRESS RESISTANCE:

During this period the following work has been carried out

Development of mutation population through cuttings

- The pomegranate cultivar 'Bhagwa' and 'Solapur lal' were selected during the stress period at field of ICAR-NRC on Pomegranate, Solapur for inducing desirable mutation through gamma rays mutagenesis (Fig 1 and 2). Twig cuttings of size 12-13 cm length and 2- 3 cm width of 'Bhagawa' and 'Solapurlal' were used for gamma rays treatment with GC 5000 at FIPLY, BARC, Mumbai.

Fig 6.1 Plants under stress were selected for cuttings Fig 2 Pencil sized cuttings (12cm)

Pre-treatment

The cuttings were given chemical treatment to avoid the contamination from fungus, bacteria and other contaminants.The cuttings immersed in water (45°C) and treated fungicide (Bavistin 2gm/litre), bactericide Bacterinol (0.5gm/litre for 20min.), and placed in a solution containing 5ml/litre of Sodium hypochlorite for surface sterilization for 10 min.

Irridation treatment

The cuttings and seeds were placed in the gamma irridation chamber (GC-5000) to induce mutation at different concentrations in Table 1.

Table:6.1. Details of the concentration of gamma irradiation for different cultivars for cuttings and seeds

Cuttings Dosage				Seeds Dosage	
Treatment	Gamma radiation (in Gy)	Cultivar name		Gamma radiation (in Gy)	Cultivar name
1	10	Bhagawa	Solapur Lal	100	Bhagawa
2	15	Bhagawa	Solapur Lal	200	Bhagawa
3	20	Bhagawa	Solapur Lal	300	Bhagawa
4	25	Bhagawa	Solapur Lal	400	Bhagawa
5	30	Bhagawa	Solapur Lal	500	Bhagawa
6	40	Bhagawa	Solapur Lal	600	Bhagawa
7	50	Bhagawa	Solapur Lal	Control	Bhagawa
8	60	Bhagawa	Solapur Lal		Bhagawa
9	Control	Bhagawa	Solapur Lal		Bhagawa

Bed preparation for planting the cuttings

Two retangular brick beds were prepared for sowing the cuttings with small pebble rocks for percolation of water as bottom layer followed by small rocks to avoid excess holding of material and cocopeat for holding moisture and to supply the water requirement for plant growth (Fig 2 & 3)

Fig 6. 2. Bed prepartion and irradiated cuttings treated with IBA

Planting of the cuttings

Fig 6.3. Planting of different varieties of cuttings treatment wise in coco peat and maintained at shade net structure

Results

Validation of LD_{50} and sprouting percentage:

The cuttings of Bhagwa and Solapur Lal has been irradiated at different doses and below observations has been recorded

Bhagwa

The observations were recorded on sprouting percentage of the irradiated cuttings on the 5th day after plantation and the sprouting percentage ranged from 1.9 % - 38.29 % and observations were recorded on every week till 9th March 2023 where sprouting has been continued.

The highest sprouting percentage was observed in Bhagwa @ 20gy was 91.74%. The lowest sprouting percentage was observed in 50Gy was 20%. Previous studies LD_{50} was at 45gy. In this study we got LD_{50} of Bhagwa cultivar at 48.774 Gy

.

Solapur lal

The observations were recorded on sprouting percentage of the irradiated cuttings on the 5th day after plantation and the sprouting percentage ranged from 0-52 % and observations were recorded on every week till 9th March 2023 where sprouting has been continued. The highest sprouting percentage was @ 15Gy was 97.97%. The lowest sprouting percentage was observed in 50gy was 24%. In this study we are able to determine LD_{50} of Solapur lal at 52.541 Gy.

Table **6.2**: Estimation of Probit Line, LC_{50}/LD_{50} and Fit statistics

Name of the Cultivar	Bhagwa	Solapur lal
Component	**Estimate**	**Estimate**
Mean X	27.875	28.794
Mean Y	-0.809	-0.915
Intercept	-5.620	-6.030
Beta	3.329	3.505
LC_{50}	**48.774**	**52.541**
LL	**43.164**	**44.024**
UL	**55.114**	**62.706**
$Log(LC_{50})$	1.688	1.720
Log LL	1.635	1.644
Log UL	1.741	1.797
Chi-Square ML	61.926	42.444
Sign (Chi-Square)	0.000	0.000

6.2 Genome Wide Association Mapping in Pomegranate to Identify Novel Genes

Raising of germplasm lines:

The pomegranate germplasm lines including wild and cultivated accessions are raised in nursery by using hardwood cuttings at ICAR-NRCP, Solapur.

Phenotyping of germplasm lines:

Fresh ripe fruits of all pomegranate germplasm (planted in the Field Gene Bank of ICAR-NRCP) were harvested for 2023 season. Five fruits were randomly selected for each variety per replicate with three replicates per variety. In total, 15 fruits of each variety/accession were individually analyzed for fruit quality traits like seed softness, fruit color, fruit length, fruit weight, 100-aril weight, fruit yield, acidity and Total Soluble Solids (TSSs).

Genotyping by sequencing analysis germplasm lines:

Genomic DNA was extracted from plant tissue samples of 99 pomegranate accessions using C-TAB and Phenol: chloroform extraction method with some minor modifications followed by column purification. The quality and quantity of the extracted gDNA sample was checked on NanoDrop followed by 0.8% Agarose gel. The isolated DNA were found to be of good quality for sequencing, hence subjected for library preparation for GBS (Genotyping By Sequencing).

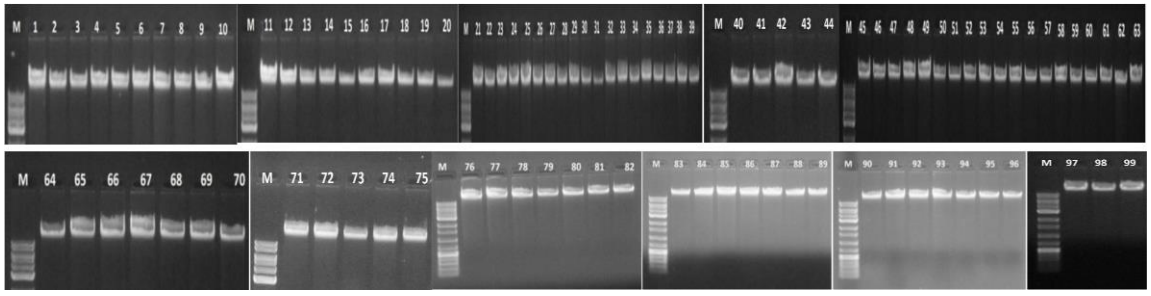


Fig 6.4. Genomic DNA isolation from 99 pomegranate germplasm accessions

Sequencing of selected pomegranate lines completed using Illumina platform at Eurofins Genomics India Pvt. Ltd. Bengaluru. The sequenced raw data was processed to obtain high quality clean reads to remove adaptor sequences, ambiguous reads and low quality sequences using Trimmomatic v.038. The reads of the sample were aligned to the reference pomegranate genome using Burrows-Wheeler Aligner v0.7.17 and the read group information was added to the alignment files using Picard v2.27.5 and the duplicate read groups were marked.

A total of 626.7 million raw reads were generated covering 173.8 GB of sequence data with an average of 6.5 million reads per sample, the raw reads were trimmed to obtain 525.4 million clean high quality reads with an average of 5.5 million reads per sample. Subsequently, the clean reads of each sample that have been trimmed were mapped to the pomegranate reference genome (Genome length = 320.30Mb). Mapping percentage of above 99% have been acquired in the study with the total number of mapped tags ranged from 1,44,298 to 1,85,10,279 across all samples.

SNPs were identified from the sorted BAM file of the samples using FreeBayes (v1.0.2) and filtered based on minimum read depth of 10 and mapping quality threshold of 25 using. The SNPs were further filtered with VCFtools (v0.1.016) to retain sites with genotypes present in 80% of the sample which revealed 36,471 polymorphic SNP sites out of 9,56,531 total filtered SNPs across 95 genotypes (10,069 SNPs/sample).

Table 6.2 : Summary of GBS data

Sr. No.	**SNP details**	**Number/bp**
High Quality Data Statistics		
1	Average number of raw reads	6696656.116
2	Average number of clean reads	5531332.589
Mapping Statistics		
1	Overall mapping %	>99%
2	Range of mapped tags	1,44,298 - 1,85,10,279
3	Total number of mapped tags	52,47,90,873
Filtered SNPs		
1	Total filtered SNP loci	9,56,531
2	Avg. No. of filtered SNPs per sample	10,069
3	Number of informative SNPs (min. depth = 10)	36,471

6.2 PROJECT: ESTABLISHMENT OF DUS CENTRE ON POMEGRANATE AT ICAR- NRCP, SOLAPUR

- In 2023, visited the orchards of Mr. Ram Prakash Kesharwani (Village Lakhuri) and Mr. Deendayal Yadav (Village Behradih) at Janjgir-Champa (D), Chattisgarh who have submitted application for registration of pomegranate varieties (Lakhuri anar; Anaar) under PPV&FRA, New Delhi and recorded the stage specific 15 DUS characteristics of the candidate varieties (Lakhuri anar and Anar) (Fig. 1).
- Revised DUS guidelines for Pomegranate has been prepared and submitted to PPV&FRA, New Delhi

(A) **(B)**

Fig. 6.5: (A) "Lakhuri Anar" candidate variety at Lakhuri village, Bimhanidh block, Janjgir-Champa, Chattisgarh; (B) "Anaar" candidate variety at Behradih village, Champa Tehsil, Janjgir-Champa, Chattisgarh**.**

Visited the pomegranate orchards of cv. Sharad King to observe and record the performance of the new variety at Dasur (V), Pandharpur (T) (Fig. 2). The variety has showed good performance in flowering, fruit set and production under climatic conditions of Pandharpur taluk. In the orchards higher incidence of wilt, bacterial blight, mealy bugs were recorded and at lower percentage incidence of scab, thrips and sunscald were also observed

Fig.6.6: Pomegranate orchard visited at Dasur, Pandhrapur

6.3 PROJECT: ALL INDIA COORDINATED RESEARCH PROJECT ON ARID ZONE FRUITS

3.i. MLT on Evaluation of sweet type pomegranate variety 'Solapur Lal':

Multi-locational trial on pomegranate variety Solapur Lal was conducted in Lead Centre, Solapur besides four other coordinating centres under All India Coordinated Research Project on Arid Zone Fruits during 2023-24. The planting material distributed to other centres for MLT include, HRS – APHU, Ananthapuram; ICAR-CIAH, Bikaner, ICAR-IIHR, Bengaluru and MPKV, Rahuri.

At ICAR-NRC on Pomegranate, Solapur the trial was initiated by planting the air-layer progenies in C2 block, Kegaon Experimental Farm, during Nov 2018.

Planting : Nov 2018
Design : Randomized Block Design
Treatments: Ganesh, Solapur Lal, Phule Bhagawa Super, Bhagawa (04)
Replications : Seven (07)
Unit : Two (02)

The data on vegetative growth parameters viz., plant height (cm), plant spread (East West), plant spread (North South), and stem girth were recorded at five years after planting (Table).

The growth performance revealed that sweet type varieties differed significantly with respect to different growth parameters. Among four varieties, Solapur Lal recorded the highest value for plant height (225.0 cm), E-W spread (250.6 cm), N-S spread (240.5cm). This was followed by Ganesh whereas Bhagawa had the lowest value. For stem girth (14.4cm), Ganesh recorded second highest value followed by Solapur Lal (13.8cm), due to its hybrid vigour. The check variety, Bhagawa recorded the lowest value for stem diameter and girth (11.4cm).

Table 6.3 . Growth performance of pomegranate varieties during fifth year under Solapur condition

Variety	Plant height (cm)	Canopy spread East-West (cm)	Canopy spread North-South (cm)	Stem diameter (cm)	Stem girth (cm)
Ganesh	202.5	215.2	210.4	4.70	14.4
Solapur Lal	225.0	250.6	240.5	4.50	13.8
Phule Bhagawa Super	182.5	205.4	195.0	3.90	11.9
Bhagawa (Check var.)	165.5	185.2	175.6	3.70	11.4
SEm±	4.9	5.5	5.6	0.12	0.4
CD (5%)	15.2	16.8	17.2	0.40	1.3

Flowering and fruitset was recorded from all four varieties during 2023-24 due to crop regulation during mrig bahar. Fruitset was highest in Solapur Lal (59.90%), whereas it was lowest in Bhagawa (50.32%).

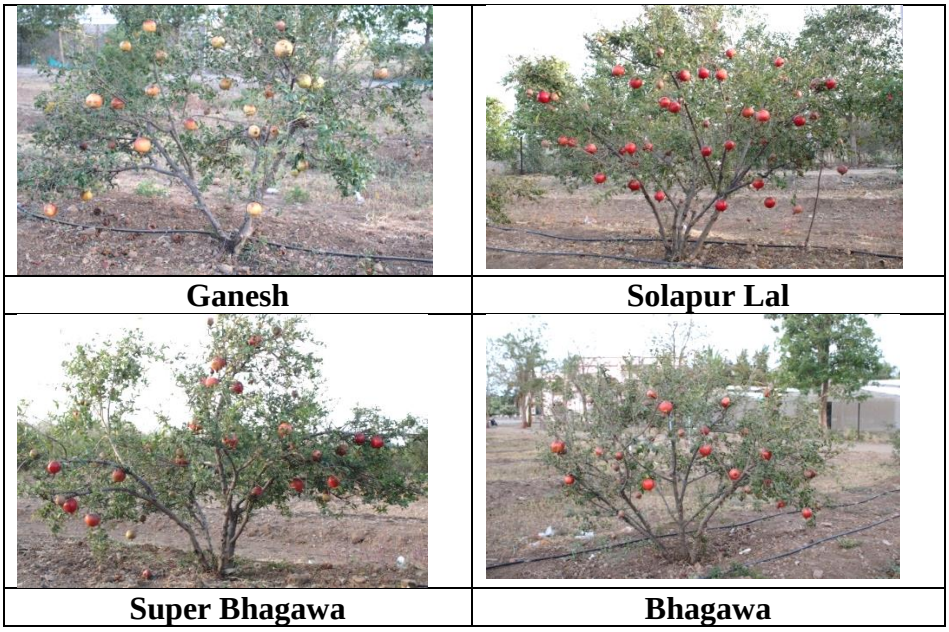
Table 6.4. Flowering and fruit set of pomegranate varieties during fifth year under Solapur condition

Variety	No. of bisexual Flowers / tree	No. of fruits / tree	Fruit set (%)
Ganesh	165.3	93.28	56.53
Solapur Lal	202.4	121.0	59.90
Phule Bhagawa Super	186.0	95.42	51.30
Bhagawa (Check var.)	176.6	88.56	50.32
SEm±	3.1	1.9	1.0
CD (5%)	9.6	5.8	3.2

Fruit yield / tree ranged from 23.96 to to 32.11 kg/tree. Total soluble solids content ranged from 15.5 to 17.7 º Brix, whereas the titrable acidity ranged from 0.38 to 0.46%. Brix – acid ratio ranged from 33.80 to 44.25. Solapur Lal recorded the highest yield (32.11kg/tree) besides TSS (17.7ºBrix) and Brix- acid ratio (44.25).

Table 6. 5. Yield and quality of pomegranate varieties during fifth year under Solapur condition

Variety	No. of fruits /tree	Fruit weight (g)	Yield (kg / tree)	TSS (^{0}Brix)	Titrable Acidity (%)	Brix – Acid ratio
Ganesh	93.3	280.2	26.14	16.05	0.38	42.23
Solapur Lal	121.0	265.4	32.11	17.70	0.40	44.25
Phule Bhagawa Super	95.4	272.2	25.97	15.65	0.44	35.56
Bhagawa (Check var.)	88.6	270.6	23.96	15.55	0.46	33.80
SEm±	1.5	1.6	0.64	0.27	0.02	0.6
CD (5%)	4.8	5.1	1.96	0.84	0.08	2.1



6

Fig 6.7. MLT on pomegranate var. Solapur Lal

3.ii. MLT on Evaluation of sour type pomegranate variety "Solapur Anardana':

Multi-locational trial on pomegranate variety Solapur Anardana was conducted in Lead Centre Solapur besides four other coordinating centres under All India Coordinated Research Project on Arid Zone Fruits during 2023-24. The planting material distributed to other centres for MLT include, HRS, Ananthapuram; ICAR-CIAH, Bikaner, ICAR-IIHR, Bengaluru & MPKV, Rahuri.

The data on vegetative growth parameters viz., plant height (cm), plant spread (East West), plant spread (North South), and stem girth were recorded at four years after planting (Table).

The results revealed that sour type varieties differed significantly with respect to different growth parameters. Among three varieties, Solapur Anardana recorded the highest value for plant height (255.6cm), E-W spread (275.7 cm), N-S spread (270.3cm), stem diameter (4.9 cm) and stem girth (15.1 cm) due to its hybrid vigour. This was followed by IC-1181. The check variety, Amlidana recorded the lowest value for different growth parameters.

Table 6. 6. Growth performance of pomegranate varieties during fourth year under Solapur condition

Variety	Plant height (cm)	Plant spread East-West (cm)	Plant spread North-South (cm)	Stem diameter (cm)	Stem girth (cm)
IC-1181	225.4	255.3	245.1	4.4	13.6
Solapur Anardana	255.6	275.7	270.3	4.9	15.1
Amlidana	150.7	165.1	160.4	3.1	9.6
SEm±	5.3	5.7	6.1	0.13	0.6
CD (5%)	16.5	17.4	18.6	0.40	1.8

Flowering and fruitset was recorded from all three varieties during 2023-24 due to crop regulation during mrig bahar. Fruitset was highest in Solapur Anardana (63.81%), whereas it was lowest in Amlidana (51.53 %).

Table 6.7. Flowering and fruitset of pomegranate varieties during fourth year under Solapur condition

Variety	No. of bisexual Flowers	No. of Fruits / tree	Fruitset (%)
IC-1181	76.3	36.1	47.55
Solapur Anardana	165.1	105.3	63.81
Amlidana	140.4	72.4	51.53
SEm±	3.3	2.0	1.2
CD (5%)	10.2	6.3	3.9

Fruit yield / tree ranged from 7.27 kg to 28.69 kg/tree. Total soluble solids content ranged from 15.1 to 16.8^{o} Brix. Solapur Anardana recorded the highest yield (28.69 kg/tree) besides titrable acidity (4.83%).

Table 6.8 . Yield and quality of pomegranate varieties during fourth year under Solapur condition

Variety	No. of fruits / tree	Fruit weight (g)	Yield (kg/tree)	TSS (^{0}Brix)	Titrable acidity (%)
IC-1181	36.1	201.2	7.27	15.1	3.15
Solapur Anardana	105.3	272.5	28.69	16.8	4.85
Amlidana	72.4	225.2	16.31	16.3	4.15
SEm±	1.5	2.6	0.68	0.30	0.26
CD (5%)	6.6	8.1	2.10	0.93	0.84

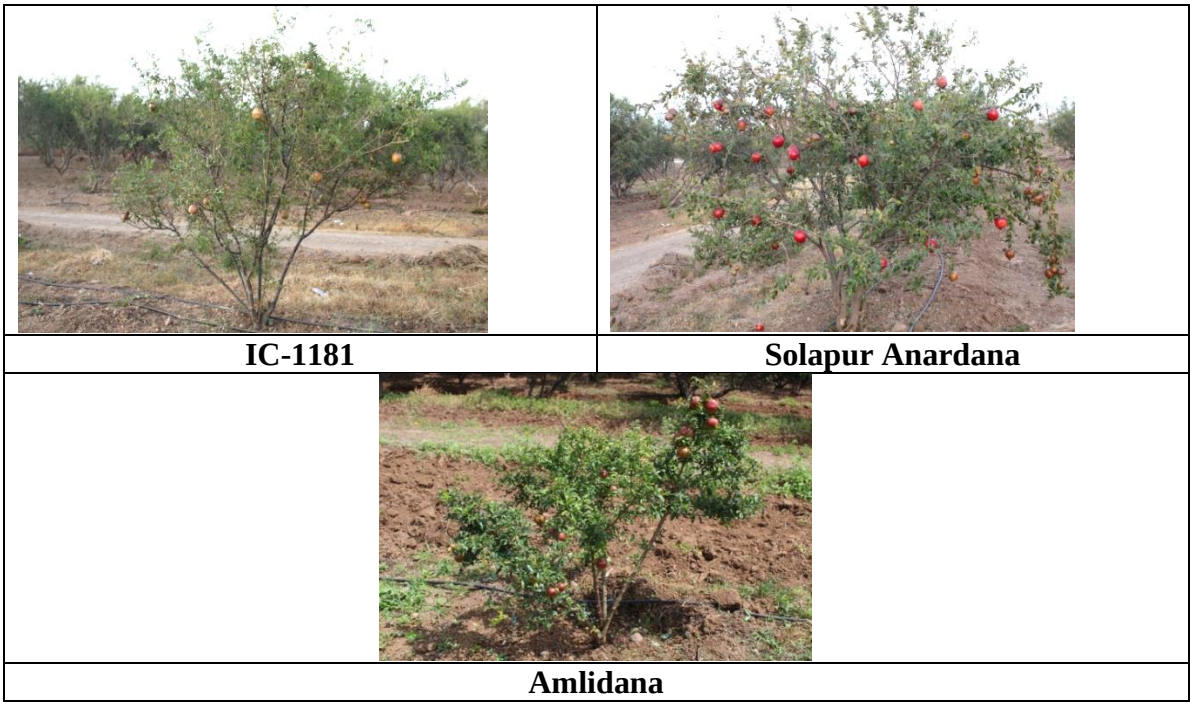


Fig 6.8.MLT on pomegranate var. Solapur Anardana

6.4 PROJECT: HORTICULTURE PEST SURVEILLANCE ADVISORY PROJECT (CROP SAP-HORTSAP)

1. Survey of Insect Pests Affecting Pomegranate Orchards in Solapur District, Maharashtra.

A survey was conducted in Maharashtra to assess insect pests affecting the pomegranate crop. The study covered an area of 91.25 acres, including 4 districts of Maharashtra. The primary pests identified were the shot hole borer (SHB), Thrips, stem borer and fruit-sucking moth. Among these, the SHB has been recorded as a major threat to pomegranate orchards in the Sangli, Nasik and Ahmednagar districts of Maharashtra. The details of the treatment and results and given in Fig.1.

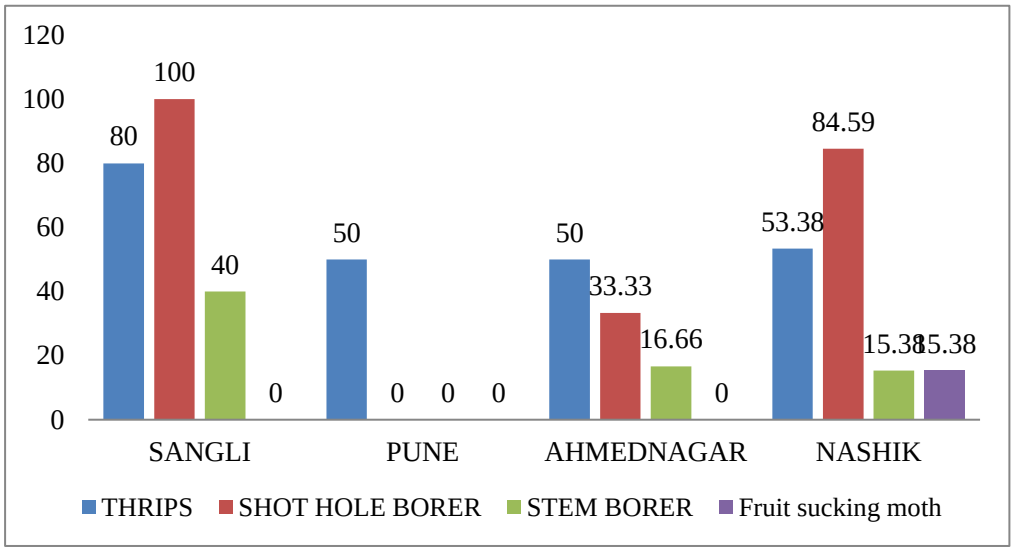


Fig. 6.9. Survey of Insect Pests of pomegranate in four Districts of Maharashtra

Activities under Tribal Sub-plan / STC

Table 1: Training programme/workshop organized for tribal farmers

S. No.	Name of the training programme	Place	Date	Farmers benefited (Nos.)
1	One-day awareness-cum-training programme on “Good Agricultural Practices for Sustainable Crop Production”	KVK, Sonapur, Gadchiroli.	11.01.2023	74
2	One-day training cum demonstration programme under Scheduled Tribe Component STC–TSP Scheme	KVK, Sonapur, Gadchiroli	27.03. 2023	79
3	One-day training and demonstration program on "Good Agricultural Practices for Quality Pomegranate Production"	Pomegranate Research and Technology Transfer Center (PRTTC) Lakhmapur Maharashtra,	23.11.2023	53

Brief description of activities

Activity 1. A team of scientists from ICAR-NRC on Pomegranate, Solapur, consisting of Dr. Mallikarjun Harsur, Dr. Shilpa Parashuram and Mr. Rahul Devidas Damale in collaboration with KVK, Sonapur, Gadchiroli has organized one-day awareness-cum-training programme on “Good Agricultural Practices for Sustainable Crop Production” for tribal farmers of Gadchiroli under the TSP scheme on January 11, 2023. During this one-day training programme, various lectures were delivered, demonstrations were conducted and agricultural inputs like two insecticides and Knapsack sprayers were distributed to the 74 STC-TSP farmer-beneficiaries.

Address and lecture delivered by Dr. Mallikarjun M.H. and Dr. Shilpa Parashuram

लोकमत

आदिवासी उपयोजनेअंतर्गत कृषी विज्ञान केंद्रात शेतकरी प्रशिक्षण

स्प्रेअर पंपाद्वारे कीटकनाशकांनी भेदा पिकांवरील रोग

लोकमत न्यूज नेटवर्क

गडचिरोली : आदिवासी उपयोजनेंतर्गत राष्ट्रीय डाळिंब संशोधन केंद्र सोलापूर आणि कृषी विज्ञान केंद्र, सोनापूर-गडचिरोली यांच्या संयुक्त विद्यमाने शेतकरी प्रशिक्षण ११ जानेवारी रोजी शेतकऱ्यांना देण्यात आले. याअंतर्गत शेतकऱ्यांना स्प्रेअर पंपांचे वितरण करून त्यांना पिकांवरील कीड व रोगांच्या नायनाटासाठी योग्य कीटकनाशकांची फवारणी करण्याचा सल्ला देण्यात आला. सोबतच विविध विषयांवर मार्गदर्शन केले.

प्रशिक्षण कार्यक्रमास राष्ट्रीय डाळिंब संशोधन केंद्र सोलापूर येथील प्रमुख शास्त्रज्ञ डॉ. पी. शिल्पा, शास्त्रज्ञ डॉ. मल्लिकार्जुन, डॉ. राहुल डमाळे, गृहविज्ञान विभागाच्या विषय विशेषज्ञ प्रा. नीलिमा पाटील, विषय विशेषज्ञ डॉ. व्ही. एस. कदम, पी. ए. बोथीकर, डी. व्ही. ताथोड, एस. के. लाकडे, डॉ. पी. एन. चिरडे, डॉ. देवाजी तोफा, मंगेश भानारकर तसेच शेतकरी उपस्थित होते. शेतकरी प्रशिक्षण कार्यक्रमात आदिवासी उपयोजने अंतर्गत आदिवासी शेतकऱ्यांना नॅपसॅक स्प्रेअर कृषीनिविष्ठा स्वरूपात देण्यात आल्या. डॉ. राहुल डमाळे यांनी केंद्र शासनांतर्गत राबविण्यात येणाऱ्या आदिवासी उपयोजनेविषयी सखोल मार्गदर्शन केले.

डॉ. देवाजी तोफा यांनी शास्त्रशुद्ध पद्धतीने शेती करण्याचे फायदे उपस्थित शेतकऱ्यांना समजावून सांगितले. त्याचप्रमाणे शेती पद्धतीत सुधारणा करून शेतकऱ्यांनी जास्त उत्पादन देणाऱ्या वाणांची निवड करावी, असे आवाहन केले. डॉ. पी. एन. चिरडे यांनी पीक लागवड तंत्रज्ञानाविषयी विशेष मार्गदर्शन केले.

स्प्रेअर पंपाचा लाभ मिळालेले शेतकरी तसेच कृषी विज्ञान केंद्र सोनापूरचे अधिकारी.

शेतकऱ्यांनो, फळबाग लागवडीतून भरघोस आर्थिक नफा मिळवा

डॉ. पी. शिल्पा यांनी डाळिंब पिकाची लागवड करून शेतकऱ्यांना अधिक आर्थिक नफा कमावता येऊ शकतो, असे सांगत आंबा, सीताफळ, चिकू, फळबाग लागवडीबाबत माहिती दिली. डॉ. मल्लिकार्जुन यांनी रब्बी पीक लागवड तंत्रज्ञान व पिकांची घ्यावयाची काळजीविषयक सखोल मार्गदर्शन केले. त्याचप्रमाणे जमिनीची उत्पादकता टिकविण्यासाठी व शाश्वत उत्पादन मिळण्यासाठी रब्बी पिकासोबतच फळ पिके घेणे गरजेचे आहे. व्यावसायिक पिकाकडे शेतकऱ्यांनी वळावे, जेणेकरून याचा फायदा जमिनीची सुपिकता वाढविण्यास होईल व शाश्वत उत्पादन मिळेल, असे प्रतिपादन केले. फळबागाची लागवड करून उत्पादनात भर पाडावी असे मार्गदर्शनात म्हटले. तसेच फवारणी करताना घ्यावयाची काळजीविषयी सविस्तर मार्गदर्शन केले.

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Distribution of agriculture inputs and equipment, the media coverage of training programme

Activity 2. A team of scientists from ICAR-NRC on Pomegranate, Solapur, consisting of Dr. Mallikarjun Harsur, Dr. Shilpa Parashuram and Mr. Rahul Devidas Damal in collaboration with KVK, Sonapur, Gadchiroli has organized the one-day training-cum-demonstration program for tribal farmers of Gadchiroli under the STC-TSP Scheme on March 27, 2023. During this training programme, various lectures were delivered, demonstrations were conducted and agricultural inputs like green gram seeds and Knapsack sprayers were distributed to the 79 STC- TSP farmer-beneficiaries.

Address and lecture delivered by Dr. Mallikarjun M. H and method demonstration on seed treatment

पुण्य नगरी

City Pulse

आदिवासी उपयोजनेंतर्गत शेतकरी प्रशिक्षण

गडचिरोली : स्वातंत्र्याच्या अमृत महोत्सवानिमित्त आदिवासी उपयोजनेतर्गत राष्ट्रीय डाळींब संशोधन केंद्र सोलापूर आणि कृषी विज्ञान केंद्र सोनापूर-गडचिरोलीच्या संयुक्त विद्यमाने शेतकरी प्रशिक्षण कार्यक्रमाचे आयोजन २७ मार्च रोजी कृषी विज्ञान केंद्र सोनापूर-गडचिरोली येथे करण्यात आले. या प्रशिक्षण कार्यक्रमाला राष्ट्रीय डाळींब संशोधन केंद्र सोलापूरचे डॉ. पी. शिल्पा, डॉ. मल्लिका अर्जून, डॉ. राहूल उमाळे, डॉ. चंद्रकांत अवचार, डॉ. संदीप कऱ्हाळे, डी. व्ही. ताथोड, डॉ. पी. एन. चिरडे, बारीकराव मडावी, परशराम पदा आदी उपस्थित होते. या शेतकरी प्रशिक्षण कार्यक्रमात आदिवासी उपयोजनेतर्गत आदिवासी शेतकऱ्यांना नॅपसॅक स्प्रेअर व मूग बियाणे कृषी निविष्ठा स्वरूपात देण्यात आल्या. याप्रसंगी डॉ. पी. शिल्पा यांनी डाळींब पिकाची लागवड करून शेतकऱ्यांना आर्थिक नफा कमविता येऊ शकतो, असे सांगून मूग लागवडविषयी तसेच आंबा, सीताफळ, चिकू, फळबाग लागवडबद्दल माहिती दिली. सोबतच आदिवासी उपयोजनेअंतर्गत विशेष मार्गदर्शन केले. याप्रसंगी उपस्थित मान्यवरांनीसुद्धा शेतकऱ्यांना मार्गदर्शन केले. संचालन ज्ञानेश्वर ताथोड यांनी केले.

Distribution of agriculture inputs and equipment, the media coverage of training programme

Activity 3. A team of scientists from ICAR-NRC on Pomegranate, Solapur, consisting of Dr. Mallikarjun Harsur, Dr. Shilpa Parashuram and Mr. Rahul Devidas Damale in collaboration with Pomegranate Research and Technology Transfer Center (PRTTC) Lakhmapur and State Department of Agriculture, Government of Maharashtra has organized the one-day training-cum-demonstration program on “Good Agricultural Practices for Quality Pomegranate Production" for tribal farmers of Nasik, Maharashtra under the STC-TSP Scheme on November 23, 2023. During this training programme, various lectures were delivered and demonstrations were conducted agriculture inputs and equipment like sprayers, spades, LED torches, axes, secateurs, and two types of insecticides were distributed to the 53 STC farmer-beneficiaries.

Farmers registration for One-day training-cum-demonstration programme at PRTTC Lakhamapur

	
Inaugaral ceremony of TSP training at PRTTC Lakhamapur Ta. Satana Dist. Nashik.	**Introduction of TSP scheme and training**

लखमापूर : आदिवासी शेतकऱ्यांना डाळिंब प्रशिक्षणावेळी करण्यात आलेल्या साहित्य वाटपावेळी उपस्थित कृषी विभागाचे अधिकारी व शेतकरी.

सकाळ

आदिवासी शेतकऱ्यांसाठी डाळिंब लागवडीचे प्रशिक्षण

लखमापूर : येथील डाळिंब संशोधन व तंत्रज्ञान प्रसार केंद्रात सोलापूरचे राष्ट्रीय डाळिंब संशोधन केंद्र, कृषी विभाग आणि राहुरीच्या महात्मा फुले कृषी विद्यापीठातर्फे आदिवासी शेतकऱ्यांसाठी डाळिंब लागवडीचे प्रशिक्षण झाले. आदिवासी शेतकऱ्यांचे आर्थिक उत्पन्न वाढावे म्हणून डाळिंबाची लागवड करत शास्त्रशुद्ध पद्धतीने उत्पादन घेता यावे यासंबंधीचे मार्गदर्शन राष्ट्रीय डाळिंब संशोधन केंद्राच्या शास्त्रज्ञांनी केले. मालेगावचे उपविभागीय कृषी अधिकारी गोकुळ आहिरे, तालुका कृषी अधिकारी भगवान गोरडे, प्रमुख शास्त्रज्ञ डॉ. मल्लिकार्जुन हरसूरे, वरिष्ठ शास्त्रज्ञ डॉ. शिल्पा परशुराम, कनिष्ठ शास्त्रज्ञ डॉ. राहुल डमाळे, दाभाडीचे मंडल कृषी अधिकारी संदीप पवार आदी उपस्थित होते. लखमापूर केंद्राचे प्रमुख डॉ संजय हिरे यांनी प्रास्ताविक केले. डॉ. हरसूरे यांनी डाळिंब कीड व रोगाविषयी मार्गदर्शन केले. डॉ. परशुराम यांनी डाळिंबाच्या विविध वाणांविषयी सविस्तर माहिती दिली. श्री. आहिरे यांनी पीएम किसान, कृषी ॲप विषयी माहिती दिली. श्री. गोरडे यांनी पीक विमा, फळबाग लागवड, क्रॉप कव्हर आणि महाडीबीटीतर्गतच्या विविध कृषी योजनांची माहिती सांगितली. प्रशिक्षणात सहभागी झालेल्या मालेगाव व बागलाण तालुक्यातील आदिवासी शेतकऱ्यांना नॅपसॅक बॅटरी फवारणी पंप, छाटणी कात्री, कीटकनाशके, पावडा आदी साहित्य कीटचे सोलापूरच्या केंद्रातर्फे मोफत वाटप करण्यात आले.

Distribution of agriculture inputs and equipment, the media coverage of training programme

SCSP: Brief description of activities

SC farmers adopted by NRCP							
S.No.	State	District	Taluk	Village	SC Population Benefited	Year of adoption	Status as on 31.12.2021
1	Karnataka	Kalaburagi		Kadganchi, Suntunoor, Narona, Vaijapur Belamagi Tandaa	108	2022	Ongoing

Training programme/workshop organized for tribal/SCSP farmers

Sl.No.	Name of the training programme	Place	Date	Farmers benefited (Nos.)
1	Farmer scientist interaction and farm input distribution programme	Kalaburagi	27.02.2023	58
2	Training on Pomegranate cultivation cum farm input distribution programme	Kalaburagi	27.06.2023	50

Activity 1: Team of scientists of ICAR-NRC on Pomegranate including Dr. Pinky Raigond, Dr. Shilpa Parashuram, Dr. Mallikarjun H, Dr. Chandrakant Awachare and Mr. Mahadev Gogaon organized a one day 'Farmer scientist interaction and farm input distribution programme' in collaboration with KVK, Kalaburagi, Karnataka on 27.02.2023. During the farmers-scientist interaction, 58 farmers from Kadganchi, Suntunoor, Narona and Vaijapur village of Kalaburagi participated in the programme. During the programme, lectures were delivered on various aspects of pomegranate cultivation. During interaction, farmers showed their interest and need for seeds of vegetables and pulses for kharif season. Total 27 SC farmers from Kadganchi village were provided with the farm inputs such as Secateur, Vermicompost, Neem Powder, Single Super Phosphate, Trichoderma, Vegetable Kit, Verticillium, Pulse magic, Chickpea magic, Spade and bicycles purchased under SCSP scheme.

Scientist-farmer interaction and Agri-input distribution for SC farmers of Kalaburagi

Activity 2: Team of scientists of ICAR-NRC on Pomegranate including Dr. Pinky Raigond, Dr. Shilpa Parashuram, Dr. Mallikarjun H, Dr. Chandrakant Awachare and Mr. Mahadev Gogaon organized a one day 'Training on Pomegranate cultivation cum farm input distribution programme' in collaboration with KVK, Kalaburagi, Karnataka on 27.06.2023. A group of 50 farmers from Belamagi village and Tandaa in Kalaburagi actively participated in the training and gets benefitted with the farm inputs. During the training lectures were delivered on orchard establishment, commercial pomegranate varieties and management of disease, insects and pests. During the programme 50 farmers were provided with farm inputs such as vegetable seeds, sprayers, secateurs, biofertilizers and biopesticides.

One-day training programme on pomegranate cultivation cum farm inputs distribution programme for SC farmers of Kalaburagi

ರೈತರಿಗೆ ದಾಳಿಂಬೆ ಕೃಷಿ ವೈಜ್ಞಾನಿಕ ತರಬೇತಿ

ಕಲಬುರಗಿ: ಸೊಲ್ಲಾಪುರ ರಾಷ್ಟ್ರೀಯ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರ ಹಾಗೂ ಕಲಬುರಗಿ ಐಸಿಎಆರ್-ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರದ ಸಹಯೋಗದಡಿ ರೈತರಿಗೆ ಎಸ್‌ಸಿಎಸ್‌ಪಿ ಯೋಜನೆಯಡಿ ವೈಜ್ಞಾನಿಕ ಕೃಷಿ ತರಬೇತಿಯನ್ನು ಇಲ್ಲಿನ ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರದಲ್ಲಿ ಮಂಗಳವಾರ ನಡೆಯಿತು. ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದ ವಿಜ್ಞಾನಿಗಳಾದ ಡಾ.ಪಿಂಕಿ ರಾಯಗೊಂಡ, ಡಾ.ಮಲ್ಲಿಕಾರ್ಜುನ ಹರಸೂರ, ಡಾ.ಶಿಲ್ಪಾ ಪಿ., ಡಾ.ಚಂದ್ರಕಾಂತ, ತಾಂತ್ರಿಕ ಅಧಿಕಾರಿ ಮಹಾದೇವ, ಕೆವಿಕೆಯ ವಿಜ್ಞಾನಿಗಳಾದ ಡಾ.ಯುಸೂಫ್ ಅಲಿ ನಿಂಬರಗಿ, ಡಾ.ಜಹೀರ್ ಅಹ್ಮದ್, ಡಾ.ಮಂಜುನಾಥ ಪಾಟೀಲ್ ಅವರು ದಾಳಿಂಬೆ ಕೃಷಿಗೆ ಸೂಕ್ತ ಮಣ್ಣು, ಸಾವಯವ ಗೊಬ್ಬರ, ರಸಗೊಬ್ಬರ, ನೀರಾವರಿ ವಿಧಾನ ಮತ್ತು ಕೀಟರೋಗದ ಕುರಿತು ರೈತರಿಗೆ ತಿಳಿವಳಿಕೆ ನೀಡಿದರು. ಕೇಂದ್ರದ ಮುಖ್ಯಸ್ಥ ಡಾ.ರಾಜು ತೆಗ್ಗಳ್ಳಿ ಅಧ್ಯಕ್ಷತೆ ವಹಿಸಿದ್ದರು.

ದಾಳಿಂಬೆ ಕೃಷಿ ಕುರಿತು ರೈತರಿಗೆ ತರಬೇತಿ

ಕಲಬುರಗಿ: ಸೋಲಾಪೂರ ರಾಷ್ಟ್ರೀಯ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರ ಹಾಗೂ ಕಲಬುರಗಿ ಐಸಿಎಆರ್-ಕೃಷಿ ವಿಜ್ಞಾನಕೇಂದ್ರದ ಸಂಯುಕ್ತಾಶ್ರಯದಲ್ಲಿ ರೈತರಿಗೆ ಎಸ್‌ಸಿ ಎಸ್‌ಪಿ ಯೋಜನೆಯಡಿ ದಾಳಿಂಬೆ ವೈಜ್ಞಾನಿಕ ಕೃಷಿ ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮ ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರದಲ್ಲಿ ಆಯೋಜಿಸಲಾಯಿತು. ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದ ವಿಜ್ಞಾನಿಗಳಾದ ಡಾ.ಪಿಂಕೆ ರಾಯಗೊಂಡ್, ಡಾ.ಮಲ್ಲಿಕಾರ್ಜುನ ಹರಸೂರ್, ಡಾ.ಶಿಲ್ಪಾ ಪಿ., ಡಾ.ಚಂದ್ರಕಾಂತ, ತಾಂತ್ರಿಕ ಅಧಿಕಾರಿ ಮಹಾದೇವ ಕೆವಿಕೆಯ ವಿಜ್ಞಾನಿಯಾದ ಡಾ.ಯುಸುಫ್‌ಅಲಿ ನಿಂಬರಿಗಿ, ಡಾ.ಜಹೀರ್‌ಅಹೆಮದ್, ಡಾ. ಮಂಜುನಾಥ ಪಾಟೀಲ್ ರೈತರಿಗೆ ದಾಳಿಂಬೆ ಕೃಷಿಗೆ ಸೂಕ್ತ ಮಣ್ಣು, ಸಾವಯವಗೊಬ್ಬರ, ರಸಗೊಬ್ಬರ, ನೀರಾವರಿ ವಿಧಾನ ಮತ್ತುಕೀಟರೋಗದ ಕುರಿತು ಮಾಹಿತಿ ನೀಡಿದರು. ಕೇಂದ್ರದ ಮುಖ್ಯಸ್ಥರಾದ ಡಾ.ರಾಜು. ಜಿ. ತೆಗ್ಗಳ್ಳಿ ಅವರು ಕಾರ್ಯಕ್ರಮದ ಅಧ್ಯಕ್ಷತೆ ವಹಿಸಿದರು.

ನೆಮ್ಮದಿಯ ಜೀವನ ನಮ್ಮದಾಗಲಿ

ದಾಳಿಂಬೆ ಕೃಷಿ ವೈಜ್ಞಾನಿಕ ತರಬೇತಿ

emedialine - June 28, 2023

ಕಲಬುರಗಿ; ಐಸಿಎಆರ್ ರಾಷ್ಟ್ರೀಯ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರ, ಸೋಲಾಪೂರ ಕಲಬುರಗಿ ಮತ್ತು ಐಸಿಎಆರ್-ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರ ಇವರ ಸಂಯುಕ್ತ ಆಶ್ರಯದಲ್ಲಿ, ರೈತರಿಗೆ ಎಸ್.ಸಿ.ಎಸ್.ಪಿ ಯೋಜನೆಯಲ್ಲಿ ದಾಳಿಂಬೆ ವೈಜ್ಞಾನಿಕ ಕೃಷಿ ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮವನ್ನು ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರ, ಕಲಬುರಗಿಯಲ್ಲಿ ಆಯೋಜಿಸಲಾಗಿತ್ತು.

ಕೇಂದ್ರದ ಮುಖ್ಯಸ್ಥರಾದ ಡಾ.ರಾಜು. ಜಿ. ತೆಗ್ಗಳ್ಳಿ ರವರು ಅಧ್ಯಕ್ಷತೆ ವಹಿಸಿದರು. ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದ ವಿಜ್ಞಾನಿಗಳಾದ ಡಾ.ಪಿಂಕಿ ರಾಯಗೊಂಡ್, ಡಾ.ಮಲ್ಲಿಕಾರ್ಜುನ ಹರಸೂರ್, ಡಾ.ಶಿಲ್ಪಾ ಪಿ., ಡಾ.ಚಂದ್ರಕಾಂತ, ತಾಂತ್ರಿಕ ಅಧಿಕಾರಿ ಮಹಾದೇವ ಕೆವಿಕೆಯ ವಿಜ್ಞಾನಿಯಾದ ಡಾ.ಯುಸುಫ್ ಅಲಿ ನಿಂಬರಗಿ, ಡಾ.ಜಹೀರ್ ಅಹಮದ್, ಡಾ. ಮಂಜುನಾಥ ಪಾಟೀಲ್ ರೈತರಿಗೆ ದಾಳಿಂಬೆ ಕೃಷಿಗೆ ಸೂಕ್ತ ಮಣ್ಣು, ಸಾವಯವ ಗೊಬ್ಬರ, ರಸ ಗೊಬ್ಬರ, ನೀರಾವರಿ ವಿಧಾನ ಮತ್ತು ಕೀಟ ರೋಗದ ಬಗ್ಗೆ ಮಾಹಿತಿ ನೀಡಲಾಯಿತು.

Media coverage of training programme on pomegranate cultivation cum farm inputs distribution programme

Outreach Activities

TRAININGS/ WORKSHOPS/ FARMERS FAIR/ FIELD DAY

Several trainings, workshops and interactive meets were organized by different organizations in collaboration with ICAR-NRCP Solapur, where different scientists/ technical staffs of ICAR-NRCP participated as resource persons to disseminate the technologies developed to different stake holders. These outreach activities are given below.

Table 1: Trainings/ Workshops/ Farmers' Fair/ Field Day

S. No.	Name of Trainings/ Workshops/ Farmers Fair/ Field Day/ FLD	Venue	Date	No. of participants
	Training:			
1.	One day training on "Diagnosis and management of shot hole borer in a pomegranate"	ICAR-NRCP, Solapur	03.02.2023	73
2.	One day training on "Good agricultural practices for quality pomegranate production" and distribution of Agri inputs for tribal farmers of Nashik District under the STC Scheme on 23rd November, 2023 in collaboration with Pomegranate Research and Technology Transfer, Centre, Lakhmapur; KVK, Malegaon, and State Department of Agriculture, Ta. Satana District, Nashik	Pomegranate Research and Technology Transfer, Centre, Lakhmapur, Ta. Satana District, Nashik	23.11.2023	53
3.	Technical meet on **"**Pomegranate cultivation" organized by South Region Pomegranate Growers Association (SRPGA), FPO, Banavara, Hassan District and NRCP, Solapur	Chikkamagaluru, Karnataka	13.12.2023	300
	Workshop:			
4.	Igniting Young Minds for scientific innovations	ICAR – NRCP, Solapur	27.03.2023	43
5.	Pomegranate strategy workshop organized by GT and sponsored by Maharashtra Agribusiness Network (MAGNET) Project	Shiv Chhatrapati Rangbhavan Sabhagruha, Solapur	21.04.2023	250
6.	One-day workshop on "Residue free pomegranate production" at KVK, Baramati jointly organized by KVK, Baramati; ADT, Baramati; Pomegranate grower's association, Mandeshi Foundation	KVK, Baramati	07.10. 2023	128

	and NRCP, Solapur			
	Farmers Fair:			
7.	Pomegranate farmer's seminar on "Improved cultivation practices of pomegranate" in collaboration with KVK, Mundra, Kutch-I	Durgapur Village, Kutch, Gujarat	16.02.2023	300
	Field Day:			
8.	"Pest and disease management in pomegranate" with special emphasis on shot hole borer and wilt disease	Sankh, Jat District, Sangli	17.08.2023	180
9.	"Pest and disease management in pomegranate" jointly organized by Agri. Dept. Govt. of Maharashtra and ATMA, Solapur	Karandewadi (Budheyhal), Sangola	16.10.2023	80
	Farmer-Scientist Interface meet:			
10.	Scientist-farmers interface meeting on "Good horticultural practices for pomegranate production" in collaboration with Valagro Biosciences Private Limited	Kothda Chakar village of Anjar Tahsil, Kutch, Gujarat	19.02.2023	120
11.	Training cum interaction meet on "Pomegranate cultivation in hot arid zone" in association with CIAH, Bikaner	CIAH, Bikaner	20.07.2023	55
12.	Farmer scientist meeting on "Residue free export quality pomegranate production" in collaboration with Mandeshi foundation, Mhaswad	Mhaswad, Satara	21.11.2023	136
13.	Pomegranate technical meet jointly organized by South Region Pomegranate Growers Association (SRPGA), FPO, Banavara, Hassan District and NRCP, Solapur	Chikkamagaluru, Karnataka	13.12.2023	300
	Special Events			
14.	One day stakeholders meet on "Pomegranate production: Problems, Solutions, Challenges and Opportunities"	ICAR- NRCP, Solapur	25.08.2023	80
	Webinar			
15.	National webinar on "Recent advances and opportunities in post-harvest technology" organized by Kirti M. Doongursee College, Dadar and Mula	Kirti M. Doongursee College, Dadar, Mumbai	21.01.2023	125

	Eduacation Societies, Sonai college			
16.	NRCP-Stakeholders-Industry Interface Meet on the occasion of 19th foundation day of the institute.	ICAR-NRCP, Solapur	25.09.2023	130
17.	Workshop on "Export of pomegranate" in the year 2024	APEDA, New Delhi.	14.12.2023	50
18.	One District One Product (ODOP) webinar on "Pomegranate processing and value addition" under Prime Minister - Formalization of Micro food processing Enterprises (PMFME) Scheme.	National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) - Thanjavur	15.12.2023	220
	TV Programme			
19.	Dr. Nilesh Gaikwad participated in phone in live programme Krishidarshan of DD Sahyadri entitled "Opportunities in Pomegranate Processing".	-	23.02.2023	DD Sahyadri viewers from Maharashtra

Workshop on Igniting Young Minds for scientific innovations at ICAR –NRCP, Solapur

ಜನಮಿತ್ರ

ರೈತರ ಅಭಿವೃದ್ಧಿಯೇ ನಮ್ಮ ಉದ್ದೇಶ

ದಾಳಿಂಬೆ ಬೆಳೆಗಾರರಿಗೆ ತಾಂತ್ರಿಕ ಕಾರ್ಯಾಗಾರ | ಬೈನರಿ ಎಕ್ಲೋಟಿಕ ರೆಸಾರ್ಟ್‌ನಲ್ಲಿ ನಡೆದ ಕಾರ್ಯಕ್ರಮ

ಚಿಕ್ಕಮಗಳೂರು: ಮನುಷ್ಯರಲ್ಲಿ ಕೆಲವರಲ್ಲಿ ಒಳ್ಳೆಯತನವಿರುತ್ತದೆ. ಇನ್ನು ಕೆಲವರಲ್ಲಿ ಕೆಟ್ಟತನವಿರುತ್ತದೆ. ಹಿಗೆಯಾವಾಗ ಯಾರಿಗಾದರೂ ಒಳ್ಳೆಯದನ್ನು ಮಾಡಲು ಹೋದಾಗ ಟೀಕೆ ಮಾತನಾಡುವವರು ಇರುತ್ತದೆ. ಅಂಥವರನ್ನು ನಿರ್ಲಕ್ಷ್ಯ ಮಾಡಬೇಕು. ಸ್ವಾತಂತ್ರವನ್ನು ಬಿಟ್ಟು ಅಭಿವೃದ್ಧಿ ಸಾಧ್ಯವಿಲ್ಲ. ಎಲ್ಲರೂ ಒಂದಾಗಬೇಕು ಎಂದು ಬೆಂಗಳೂರಿನ ತೋಟಗಾರಿಕೆ ಇಲಾಖೆಯ ಜಂಟಿ ನಿರ್ದೇಶಕ ಜಿ.ಎನ್. ಪ್ರಸಾದ್ ಹೇಳಿದರು.

ನಗರದ ಹೊರವಲಯದ ಬೈನರಿ ಎಕ್ಲೋಟಿಕ ರೆಸಾರ್ಟ್‌ನಲ್ಲಿ ದಕ್ಷಿಣ ಭಾಗದ ದಾಳಿಂಬೆ ಬೆಳೆಗಾರರ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆ ಹಾಗೂ ಸೊಲ್ಲಾಪುರದ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದಿಂದ ಬುಧವಾರ ಆಯೋಜಿಸಲಾಗಿದ್ದ ದಾಳಿಂಬೆ ತಾಂತ್ರಿಕ ಕಾರ್ಯಾಗಾರದಲ್ಲಿ ಮುಖ್ಯ ಅತಿಥಿಯಾಗಿ ಪಾಲ್ಗೊಂಡು ಮಾತನಾಡಿ. ರೈತರನ್ನು ಸಬ್ಸಿಡಿಗೋಸ್ಕರವೇ ಕೃಷಿ ಮತ್ತು ತೋಟಗಾರಿಕೆ ಇಲಾಖೆಯ ಕೆಲಸ. ಆದರೆ, ಕೆಲವೊಮ್ಮೆ ಇದು ಇಲಾಖೆಗಿಂತ ಸಾಧ್ಯವಾಗದಾಗ ರೈತರ ಪರವಾಗಿರುವ ಬೆಳೆಗಾರರ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆಗಳಿಗೆ

ದಾಳಿಂಬೆ ಬೆಳೆ ಮಂಜಾಗು ಅಂಗಮಾರಿ ರೋಗ ಹಾಗೂ ಸೊಣಗ ರೋಗದಿಂದ ಬಳಲುತ್ತಿದೆ. ಈ ರೋಗಗಳ ನಿರ್ವಹಣೆ ರೈತರಿಗೆ ಕಷ್ಟವಾಗುತ್ತಿದೆ. ಹೀಗಾಗಿಯೇ ರೈತರಿಗೆ ರೋಗ ನಿರ್ವಹಣೆ ಬಗ್ಗೆ ತಾಂತ್ರಿಕ ಮಾಹಿತಿ ನೀಡಲಾಗುತ್ತಿದೆ. ಸಂಬಂಧಿಸಿದ ವಿಜ್ಞಾನಿಗಳೇ ರೈತರಿಗೆ ಅನ್ವಯ ಮಾಹಿತಿ ನೀಡಲಿದ್ದಾರೆ.
– ಡಾ.ಎಚ್.ಆರ್.ಯೋಗೀಶ್ವರ್, ಎಸ್‌ಆರ್‌ಪಿಜಿ ಅಧ್ಯಕ್ಷ

ರೈತರು ಎಂದೆಂದಿಗೂ ಒಗ್ಗಟ್ಟಾಗಿರಿ ರಾಜಕೀಯ ಭಿನ್ನಾಭಿಪ್ರಾಯ ಬಂದಾಗ ಸೇವಾಮನೋಭಾವನೆ ಮಾತನಾಡಬೇಕು. ಆಗ ಮಾತ್ರ ಸಮಸ್ಯೆಗಳು ಬಗೆಹರಿಯಲು ಸಾಧ್ಯ. ಇಲ್ಲವಾದಲ್ಲಿ ರೈತರು ಒಗ್ಗಟ್ಟು ಮುರಿದು ಹೋಗುತ್ತದೆ.
– ಎಚ್.ಎಲ್.ಸುಜಾತಾ, ಜಂಟಿ ಕೃಷಿ ನಿರ್ದೇಶಕರು ಚಿಕ್ಕಮಗಳೂರು

ದಕ್ಷಿಣ ಭಾಗದ ದಾಳಿಂಬೆ ಬೆಳೆಗಾರರ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆ ಸೊಲ್ಲಾಪುರದ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದಿಂದ ಆಯೋಜನೆ

ಯಾವುದೇ ಸಂಸ್ಥೆಗಳಾದರೂ ಮೊದಲು ರೈತರಿಗೆ ಲಾಭ ತಂದುಕೊಡುವ ಕೆಲಸ ಮಾಡಬೇಕು. ಆಗ ರೈತ ಉದ್ಧಾರ ಹಾಗೂ ಜೊತೆಗೆ ಸಂಸ್ಥೆಗೂ ಬೆಳವಣಿಗೆ ಯಾಗುತ್ತದೆ. ಯಾವುದೇ ಬೆಳೆಯಾಗಲಿ ರೈತರು ಆ ಬೆಳೆಗಳಿಗೆ ಬರುವ ರೋಗಗಳ ನಿರ್ವಹಣೆ ಮಾಡುವ ಕಲೆ ತಿಳಿದುಕೊಂಡಿರಬೇಕು.

ತೋಟಗಾರಿಕೆ ಇಲಾಖೆಯಿಂದ ಹಲವು ಸೌಲಭ್ಯಗಳಿಗೆ ಸಹಾಯಧನ ನೀಡುತ್ತೇವೆ. ರೈತರು ಈ ಸವಲತ್ತಿನ ಸದ್ಬಳಕೆ ಮಾಡಿಕೊಳ್ಳಬೇಕು. ಹನಿ ನೀರಾವರಿ ಪದ್ಧತಿಯಲ್ಲಿ ಬೆಳೆಗಳನ್ನು ಬೆಳೆದಾಗ ಕಡಿಮೆ ನೀರಿನಲ್ಲಿ ಆಧಿಕ ಇಳುವರಿ ಪಡೆಯಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಬರದ ಸಂದರ್ಭದಲ್ಲಿ ರೈತರಿಗೆ ಹನಿ ನೀರಾವರಿ ಪದ್ಧತಿಯೇ ಜೀವನಾಡಿ ಸಹಕಾರವನ್ನು ನೀಡುತ್ತೇವೆ. ಒಬ್ಬರಿಂದ ರೈತರು ಅಭಿವೃದ್ಧಿಯಾಗಬೇಕು ಎಂಬುದೇ ನಮ್ಮ ಉದ್ದೇಶ ಎಂದು ತಿಳಿಸಿದರು.
– ಬಿ.ಎಸ್.ಪ್ರಸಾದ್, ಜಂಟಿ ತೋಟಗಾರಿಕೆ ನಿರ್ದೇಶಕರು ಬೆಂಗಳೂರು

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ಜನಮಿತ್ರ

ರೈತರ ಅಭಿವೃದ್ಧಿಯೇ ನಮ್ಮ ಉದ್ದೇಶ

» ಮೊದಲ ಪುಟದಿಂದ

ಆಗ ಮಾತ್ರ ಉತ್ತಮ ಫಸಲು ಪಡೆದು ಲಾಭ ಗಳಿಸಲು ಎಂದು ಸಾಧ್ಯ ಸಲಹೆ ನೀಡಿದರು.

ಕಾರ್ಯಕ್ರಮ ಉದ್ಘಾಟಿಸಿದ ಎಸ್‌ಆರ್‌ಪಿಜಿ ಅಧ್ಯಕ್ಷ ಡಾ.ಎಚ್.ಆರ್.ಯೋಗೀಶ್ವರ್ ಮಾತನಾಡಿ, ನಮ್ಮ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆಯ ಉದ್ದೇಶ ರೈತರಿಗೆ ಕಡಿಮೆ ದರದಲ್ಲಿ ಕೃಷಿ ಪರಿಕರ ಸಿಗಬೇಕು, ಮಾರುಕಟ್ಟೆ ಸಿಗಬೇಕು ಹಾಗೂ ತಾಂತ್ರಿಕ ಸಲಹೆ ಸಿಗಬೇಕು ಎನ್ನುವುದಾಗಿದೆ. ಈಗಾಗಲೇ ರೈತರಿಗೆ ಎಲ್ಲ ರೀತಿಯ ಸಲಹೆ ನೀಡಿ ಅವರ ಅಭ್ಯುದಯಕ್ಕೆ ಕ್ರಮ ಕೈಗೊಳ್ಳಲಾಗಿದೆ ಎಂದರು.

ಸಂಸ್ಥೆ ಆರಂಭಗೊಂಡ ಎರಡೂವರೆ ವರ್ಷದಲ್ಲಿಯೇ ದಾಳಿಂಬೆ ಬೆಳೆಗಾ ರರಿಗೆ ತಾಂತ್ರಿಕ ಸಲಹೆ ನೀಡುವ ಮೂಲಕ ಅವರ ಬೆಳೆಗಳಲ್ಲಿ ಅದನ್ನು ಅಳವಡಿ ಸಿಕೊಳ್ಳಲು ಕ್ರಮಗೊಳ್ಳಲಾಗಿದೆ. ಸಂಸ್ಥೆ ರೈತರ ಸಹಕಾರದಿಂದ ಉತ್ತಮವಾಗಿ ನಡೆಯುತ್ತಿದ್ದು, ಮುಂದಿನ ವರ್ಷದಿಂದ ಸದಸ್ಯರಿಗೆ ಡಿವಿಡೆಂಟ್ ನೀಡಲು ತೀರ್ಮಾನಿಸಿದ್ದೇವೆ. ರೈತರ ಬೆಳೆಗಳನ್ನು ಸಂಗ್ರಹಿಸಲು ಸಂಸ್ಕರಣಾ ಘಟಕವನ್ನೂ ಮುಂದಿನ ದಿನಗಳಲ್ಲಿ ಆರಂಭಿಸಲಾಗುವುದು ಎಂದು ಹೇಳಿದರು.

ಹಾಸನದ ಜಂಟಿ ಕೃಷಿ ನಿರ್ದೇಶಕಿ ರಾಜು ಸುಲೋಚನಾ ಮಾತನಾಡಿ, ಸರ್ಕಾರದ ಯಾವುದೇ ಅನುದಾನವಿಲ್ಲದೇ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆ ದೊಡ್ಡ ಮಟ್ಟಕ್ಕೆ ಬೆಳೆದಿರುವುದು ಸಂತಸದ ಸಂಗತಿ. ರೈತರಿಗೆ ತರಬೇತಿ, ಭೇಟಿಯಿಂದ ಅನುಭವ ಹಾಗೂ ಹೊಸ ಆವಿಷ್ಕಾರ ಹುಟ್ಟಲು ಸಾಧ್ಯ. ಈ ನಿಟ್ಟಿನಲ್ಲಿ ಸಂಸ್ಥೆ ಕೆಲಸ ಮಾಡುತ್ತಿರುವುದು ಶ್ಲಾಘನೀಯ ಎಂದರು.

ಚಿಕ್ಕಮಗಳೂರಿನ ಜಂಟಿ ಕೃಷಿ ನಿರ್ದೇಶಕಿ ಎಚ್.ಎಲ್.ಸುಜಾತಾ ಮಾತನಾಡಿ, ರೈತರು ಸಂಘಟಿತರಾದಾಗ ಮಾತ್ರ ಬೆಳೆಯಲು ಸಾಧ್ಯ. ಹೀಗಾಗಿಯೇ ಸರ್ಕಾರ ರೈತೋತ್ಪಾದಕ ಸಂಸ್ಥೆಗಳ ಸ್ಥಾಪನೆಗೆ ಒತ್ತು ನೀಡುತ್ತಿದೆ. ಹೀಗೆ ಆರಂಭಗೊಂಡ ಸಂಸ್ಥೆಗಳಿಗೆ ಸರ್ಕಾರದಿಂದ ಅನುದಾನ ಪಡೆಯಲು ಕೆಲವು ಮಾನದಂಡಗಳಿವೆ. ಆದರೆ ಈ ಸಂಸ್ಥೆ ಸರ್ಕಾರದ ಅನುದಾನ ಪಡೆಯದೆ ಈ ಮಟ್ಟಕ್ಕೆ ಬೆಳೆದಿದೆ ಎಂದು ಸಂತಸ ವ್ಯಕ್ತಪಡಿಸಿದರು.

ಚಿಕ್ಕಮಗಳೂರಿನ ತೋಟಗಾರಿಕೆ ಇಲಾಖೆ ಉಪನಿರ್ದೇಶಕಿ ಜಿ.ಪೂರ್ಣಿಮಾ ಮಾತನಾಡಿ, ರೈತರು ಸಂಘಟಿತರಾದರೆ ಸದೃಢತೆ ತಾನಾಗಿಯೇ ಬರುತ್ತದೆ. ಬೆಳೆ ಬೆಳೆಯುವುದಾಗ ಆತಿಯಾದ ಕೀಟ ನಾಶಕ ಬಳಕೆ ಬೇಡ. ಅವಶ್ಯಕತೆ ಎಷ್ಟಿದೆಯೋ ಅಷ್ಟು ಬಳಕೆ ಮಾಡಿ. ಈ ಮೂಲಕ ಮಣ್ಣಿನ ಆರೋಗ್ಯ ಕಾಪಾಡಿಕೊಳ್ಳಿ, ಒಂದೇ ಬೆಳೆಯನ್ನು ನಿರಂತರವಾಗಿ ಬೆಳೆಯದೆ ಬೆಳೆಗಳನ್ನು ಬದಲಾವಣೆ ಮಾಡಿ. ಜೊತೆಗೆ ತಾವು ಬೆಳೆದ ಬೆಳೆಗಳನ್ನು ನೀವೇ ಮೌಲ್ಯವರ್ಧನೆ ಮಾಡುವತ್ತ ಗಮನ ಕೊಟ್ಟಾಗ ರೈತರು ಹೆಚ್ಚು ಲಾಭಗಳಿಸಲು ಸಾಧ್ಯ ಎಂದು ಹೇಳಿದರು.

ಕಾರ್ಯಕ್ರಮದಲ್ಲಿ ಸೊಲ್ಲಾಪುರ ದಾಳಿಂಬೆ ಸಂಶೋಧನಾ ಕೇಂದ್ರದ ಸಸ್ಯರೋಗ ಶಾಸ್ತ್ರದ ಹಿರಿಯ ವಿಜ್ಞಾನಿ ಡಾ.ಎನ್.ಮಂಜುನಾಥ್, ತಳಿಶಾಸ್ತ್ರ ಮತ್ತು ಸಸ್ಯ ಸಂತಾನೋತ್ಪತ್ತಿ ವಿಭಾಗದ ವಿಜ್ಞಾನಿ ಡಾ.ಶಿಲ್ಪಾ ಪರಶುರಾಮ್, ಹಿರಿಯ ವಿಜ್ಞಾನಿ ಡಾ.ಸೋಮನಾಥ್ ಸುರೇಶ್ ಪೊಕರೆ ನಿರ್ದೇಶಕರುಗಳಾದ ಮಂಜುನಾಥ್, ಮಹಾಬಲೇಶ್, ಯತೀಶ್, ದಿನೇಶ್ ಟಿ.ಬಿ ಕಾವಲು, ಯತೀಶ್ ಎಸ್ ಸೇರಿದಂತೆ ದಾಳಿಂಬೆ ಬೆಳೆಗಾರರು ಪಾಲ್ಗೊಂಡಿದ್ದರು

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Technical Meet on "Pomegranate cultivation" organized by South Region

Stakeholders meeting 25th Aug 2023

SCIENTIFIC AGRO ADVISORIES

In response to the various queries of farmers, information on pomegranates was provided to the farmers through e-mail and phone. Scientific agro-advisories were sent to more than 1200 pomegranate growers through the "m-Kisan portal" social media platform during the period under the report. The electronic media like WhatsApp and phone calls were used to disseminate NRCP technologies through sharing advisories to more than 50 farmers across the year on NRCP Website (https://nrcpomegranate.icar.gov.in/Advisory) & Dalimbmitra (https://dalimbmitra.com/).

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Transfer of Technology and Entrepreneurship Development

ICAR-NRCP, Solapur organized the following trainings, workshops/ field day/ FLD, technology transfer agreement for entrepreneurs and MoU for students. In addition, ICAR-NRCP actively participated in several exhibitions besides facilitating the visit of farmers/ stakeholders to the Institute to provide information on pomegranate.

Table 1: Trainings conducted by ICAR-NRCP, Solapur

S. No.	Name of Training Programmes (Duration: 3 or more days)	No. of participants	Period	
	Duration: 3 days or more		From	To
1.	Training programme on "Good Horticultural Practices for Quality Pomegranate Production and Value Addition" for farmers of Rajasthan.	20	07.06.2023	09.06.2023
2.	Training programme on "Diagnosis of pomegranate pest and diseases and their integrated management" under Plant Health Clinic project sponsored by RKVY.	25	19.10.2023	21.10.2023
3.	Training programme on "Diagnosis of pomegranate pest and diseases and their integrated management" under Plant Health Clinic project sponsored by RKVY.	28	20.12.2023	22.12.2023
	Duration: < 3 days			
4.	One-day training programme on "Diagnosis and management of shot hole borer in a pomegranate" organized by ICAR-NRCP, Solapur, Maharashtra sponsored by the Department of Agriculture, Govt. Maharashtra	73	03.02.2023.	03.02.2023.
5.	Training program on "Export quality pomegranate production" in association with Shiv Kisan Farmer Producer Company, Budiwada and KVK, Gudamalani, Rajasthan	180	19.03.2023	19.03.2023
6.	Strategy workshop cum training programme on "Pomegranate production, post-harvest handling and processing".	200	05.04.2023	05.04.2023
7.	State level training program and exhibition on "Use of Geographical Indication of 'Solapur Pomegranate' for domestic market, export and value	250	11.04.2023	11.04.2023

	addition".			
8.	One day stakeholders meet on "Pomegranate production: problems, solutions, challenges and opportunities".	80	25.08.2023	25.08.2023
9.	Training program for pomegranate pruning labors organized by Agri. Dept. Govt. of Maharashtra (TAO, Sangola) and ATMA, Solapur	80	16.10.2023	16.10.2023

	
Inauguration of the one-day training programme	**Address by Mr. Rafiq Naikwadi, Divisional Joint Director, Pune**
	
Lecture delivered by Dr. Mallikarjun M. Harsur	**Group photo of the one-day training programme**

Diagnosis and management of shot hole borer in a pomegranate organized on 03.02.2023.

RKVY sponsored training program conducted on "Diagnosis of pomegranate pest and diseases and their integrated management" from 19-21 October 2023 at ICAR-NRCP, Solapur

Three days training to pomegranate farmers of Rajasthan 07 to 09 June 2023

Table 2: Workshop/ Field day/FLD conducted

S. No.	Name of Training Programme	No of Participants	Date
1.	One day workshop on "Women and IP: Accelerating innovation and creativity" on the occasion of World IP day	40	26.04.2023
2.	Seminar on "Improved cultivation practices of pomegranate" at Durgapur village, Mandavi Tahsil of Kutch in collaboration with KVK Kutch I, Mundra	300	16.02.2023
3.	Organized "Scientist farmers interface meeting" at Kothda Chakar village of Anjar Tahsil, Kutch in collaboration with Valagro Bioscience.	120	19.02.2023
4.	"National Pomegranate Buyer Seller Conclave-2023" was organized at Sindhoor Convention Hall, Devanahalli, Bangaluru in collaboration with Karnataka Pomegranate Growers Association, Bengaluru and Karnataka State Agricultural Produce Processing & Export Corporation Limited (KAPPEC)	550	19.10.2023
5.	Filed day on "Pest and disease management in pomegranate" with special emphasis on shot hole borer and wilt disease.	----------	17.8.2023

One day workshop on "Women and IP: Accelerating innovation and creativity" on the occasion of World IP Day on 26th Apr 2023

TECHNOLOGY TRANSFER AGREEMENT WITH VARIOUS STAKEHOLDERS

For Entrepreneurs

ICAR-NRCP technologies were transferred to the following entrepreneurs through signing of Memorandum of Understanding (MoU).

Table 3: MoU with entrepreneurs

S. No.	Technology transferred	Address of beneficiary	Date of signing MoU	Revenue received (Rs.)
1.	"Standardized mass production protocol of pomegranate fruit piercing moths *Eudocima maternal* "	M/s. UPL Limited, Mumbai	04.05.2023	1.0 Lakh plus GST @18%
2.	"*In-vitro* propagation of pomegranate cultivar Bhagawa including bio-hardening"	Department of Horticulture, Government of Karnataka, Biocentre, Hulimavu, Bengaluru	24.05.2023	Rs. 3.54 Lakh.

Transfer of technology on "Standardized mass production protocol of pomegranate fruit piercing moths *Eudocima maternal* " on 04.05.2023 with UPL. Pvt. Ltd.

Dr. R. A. Marathe, Director, ICAR-NRCP, Solapur signed an MoU agreement with officials of the Government of Karnataka on 24.05.2023

Others MoU:

- MoU with Maharashtra Agribusiness Network (MAGNET) Project is made on 28.3.2023.
- MoU is signed between Deepak fertilizers & petrochemicals corporation Ltd./ Smartchem technology Ltd. regarding Contract Research Project "Response of Customized Water Soluble Fertilizers (WSF) grades on growth, yield, quality of pomegranate".
- MoU with Willowood Chemical Limited, New Delhi regarding Contract Research Project "Evaluation of bio-efficacy and phyto-toxicity of β-Sitosterol & Stigmasterol 0.05% DF (Brand Name: WILBOND) on pomegranate crop"
- MoU is signed between ICAR-NRCP, Solapur & M/s. Bayer Crop Science Limited regarding collaborative project for "Evaluation of IDIPM schedules using new molecules for export quality pomegranate production" on 18.05.2023.

For Students

Table 4: MoU with Academic Institutions

S. No.	Programme	Address of beneficiary	Date	Revenue generated (Rs.)
1	For facilitating students for Training and Research	Walchand College of Arts and Science, Ashok Chowk, Solapur	14.3.2023	Nil
2				

Table 5: Exhibitions

S. No.	Name of the exhibition	Organizer	Venue	No. of participants	Date
1.	Siddheshwar Krishi Pradarshan	Displayed the NRCP technologies	Home ground, Solapur	1500	29.12.2022 to 02.01.2023
2.	Solapur District Agricultural Exhibition	Displayed the NRCP technologies	Laxmi Vishnu Mill, Exhibition Centre, Solapur	1000	05.03.2023 to 09.03.2023
3.	Krushi Pandhari Agricultural Exhibition and Millet Mohatsav	Displayed the NRCP technologies	Pandharpur	750	28.06.2023 to 30.06.2023
4.	108th Indian Science Congress - Pride of India Expo	Displayed the NRCP technologies	RTMNU, Nagpur University	1000	03.01.2023 to 07.01.2023
5.	Samruddha Maharashtra- "A step towards growth and development" exhibition	Displayed the NRCP technologies	Sangola, Maharashtra	750	23.08.2023-25.08.2023
6.	ICAR-Foundation day cum technology day and concurrent Industry-Institute Interaction for SMD (Horticultural Sciences)	NAAS Complex, New Delhi	Indian Council of Agricultural Research	2000	16.07.2023 18.07.2023

Siddheshwar Exhibition, Solapur

Samruddha Maharashtra-A Sangola Exhibition

POMEGRANATE GROWERS/ VISITORS TO ICAR-NRCP, SOLAPUR

Following beneficiaries/ visitors visited this Centre during 2023 and the details are given below

Table 6: Visitors to ICAR-NRCP, Solapur

S. No.	Date	Organization/ Place of beneficiaries	Category	No. of beneficiaries
1.	22.02.2023	Barwani district of Madhya Pradesh	Farmers	17
2.	21.02.2023	FPC under Magnet project from DIPD, Dist- Latur	Farmers	19
3.	21.03.2023	Gadchiroli district	Farmers	50
4.	23.03.2023	Atpadi, Dist-Sangli	Farmers	25
5.	08.04.2023	Tiwasa, Dist- Amravati	Farmers	15
6.	13.04.2023	KVK Tuljapur	Farm women's	15
7.	16.05.2023	Indapur, Dist- Pune	Farmers	35
8.	07.07.2023	DAESI (Diploma in Agriculture Extension services for Input Dealers) from SGSVVP, Wadala Solapur	Agri. Input dealers	40
9.	26.10.2023	Grower's producer company Limited, Banavara, Haasan, Karnataka.	Farmers	40
10.	Jan-Dec 2023	Individual farmers visited institute in 2023	Individual farmers	134
11.	----------	Gadchiroli District, Atpadi and Indapur of Maharashtra	farmers	110
			Total	**350**

Farmer visited from Hassan, Karnataka

	
Farmer visit of Barwani (Madhya Pradesh)	----------

Distinguished Visitors to ICAR-NRCP, Solapur

Hon. Sh. Anup Kumar, IAS, Add. Chief Secretary, MSAMB, GoM and Sh. Deepak Shinde, Project Director, MAGNET Society, MSAMB, GoM visited ICAR-NRC on Pomegranate, Solapur on 21st April 2023. They visited the demonstration block of pomegranate processing pilot plant and appreciated the research work undertaken at ICAR-NRC on Pomegranate, Solapur.

Visit of Hon. Sh. Anup Kumar, IAS, Add. Chief Secretary, MSAMB, GoM and Sh. Deepak Shinde, Project Director, MAGNET Society, MSAMB, GoM to ICAR NRC on Pomegranate

Students

S. No.	Date	Organization/Place	Category	No. Beneficiaries
1	23.02.2023	Lokmangal College of Agricultural Biotechnology, Wadala, Solapur	Students	33
2	04.05.2023	Vasundhara kala Mahavidyalaya Jule Solapur	Students	40
3	09.05.2023	DBF Dayanand College of Arts and Sciences, Solapur	Students	56
4	02.06.2023	Lokmangal Agriculture college, Solapur	Students	33
5	08.06.2023	College of Agriculture Udgir, affiliated to VNMKV, Parbhani	Students	85
6	08.06.2023	College of Agriculture, Dongarshelki, Udgir (VNMKV, Parbhani)	Students	85
7	27.6.2023	KAKU College of Agriculture, Beed	Students	41
8	07.09.2023	Lokmangal College of Agril. Biotechnology, Wadala	Students	15
9	06.10.2023	College of Agriculture, Osmanabad	Students	60
10	10.10.2023	College of Agri. Karekere Hassan Karanataka	Students	65
11	20.10.2023	Shri. Siddeshwar Womens Polytectnic, Solapur	Students	110
12	30.11.2023	Aditya Agricultural Biotechnology college, Beed	Students	40
13	11.12.2023	PM Shri Kendriya Vidyalaya, Solapur	Students	224
14	28.12.2023	Rise and Shine School, Solapur	Students	15
			Total	**718**

Visit of college students to ICAR-NRCP, Solapur

Institutional Activities

COMMITTEE MEETINGS (RAC, IRC, IMC, IJSC)

Research Advisory Committee (RAC) Meeting

The 16th Research Advisory Committee (RAC) meeting of ICAR–National Research Centre on Pomegranate (NRCP) was held on August 11, 2023 at ICAR–NRCP, Solapur under the Chairmanship of Dr. CD Mayee, Former ASRB Chairman, New Delhi. The list of RAC members who participated in the meeting are given below.

	Chairman		
1.	Dr. CD Mayee, Ex-Chairman, ASRB	**5.**	Dr. KK Pandey, PS, IIVR, Varanasi
	Members		
2.	Dr. VB Patel, ADG (HS-II), ICAR	6.	Mr. Ramdas Patil, Pomegranate Grower, Nashik
3.	Dr. SH Jalikop, EX-PS, IIHR	**7.**	Mr. Shankar Waghmare, Pomegranate Grower, Mohol
			Member Secretary
4.	Dr. Sunil Pareek,Head, (Ag & Envt. Sc.), NIFTEM, Sonipat	**8.**	Dr. K. Dhinesh Babu, ICAR –NRCP, Solapur (M.S.)

The RAC members interacted with the scientists on each project. After thorough deliberations and interactions, they gave valuable suggestions and recommendations to improve the experimental output. They also visited the block at Hiraj. The RAC members were briefed on the development at Centre during last one year by Dr. R A Marathe, Director. The committee appreciated the infrastructure development and research efforts made by the Centre under the dynamic leadership of Dr. R.A. Marathe during 2021-2024.

Recommendations of 16th RAC held during August 11, 2023

Recommendations of 16th RAC held during August 11, 2023

- Grouping of field germplasm for important traits like tree vigour, seed mellowness, aril colour and fruit colour to select parents for hybridization; Hybridization involving new parents to identify superior genotypes by raising large hybrid population; application of molecular breeding including genomics and marker assisted selection in practical pomegranate breeding programme.
- Development of standard fertigation schedule for integrated nutrient management in pomegranate.
- Screening of large number of rootstocks may be undertaken to identify resistant ones to wilt and nematodes; Demonstration of technologies developed for insect-pest management of pomegranate under farmers' field conditions.
- Scientific recommendation involving soil application of microbial slurry based formulations having bio-fertilizers, plant growth promoting microbes & bio-agents for control of bacterial blight disease (BBD); Popularization of stem solarization technique for control of BBD in different pomegranate growing regions of Maharashtra.
- Commercialization of the post-harvest technologies developed by NRCP for entrepreneurship development on priority for better visibility of the Institute.

16th RAC Meeting, August 11, 2023

Institute Management Committee (IMC) Meeting

The Institute Management Committee (IMC) meeting of ICAR-NRCP, Solapur was held on 07.11.2022. The members of the IMC team interacted and discussed on several issues concerned with development of institute management aspect.

Table 3. Institute Management Committee of ICAR-NRCP, Solapur

1.	Dr. R. A. Marathe	Director, ICAR-NRCP, Solapur	Chairperson
2.	Dr. V. K. Pandey	ADG, HS-I, ICAR, New Delhi	Member
3.	Dr. P. G. Patil	Vice Canceller, MPKV, Rahuri	Member
4.	Dr. K. P. Mote	Director of Horticulture, Maharashtra State, Pune	Member
5.	Dr. Rohita Lenka	Director of Horticulture, Odisha State, Bhubaneswar	Member
6.	Dr. Ashutosh Murkute	Pr. Scientist, ICAR-CCRI, Nagpur	Member
7.	Dr. D. V. Sudhakar Rao	Pr. Scientist, ICAR-IIHR, Bangalore	Member
8.	Dr. (Mrs.)Jyotsana Sharma	Pr. Scientist, ICAR-NRCP, Solapur	Member
9.	Sh. Srinivas Rao	F&AO, ICAR-IIRR, Hyderabad	Member
10.	Sh. V. A. Shinde	F&O, ICAR-NRCP, Solapur	Invitee
11.	Sh. R. B. Rai	AO, ICAR-NRC on Pomegranate, Solapur	Member Secretary

Institute Joint Staff Council

The Institute Joint Staff Council (IJSC) of ICAR-NRCP, Solapur consists of following members.

Table 4. Institute Joint Staff Council of ICAR-NRCP

	Chairperson		
1.	Director, ICAR-NRCP, Solapur		
	Member (Official side)		**Member (Staff side)**
2.	Dr. K. Dhinesh Babu, Pr. Scientist	7.	Sh. B.V. Naikwadi, Sr. Tech. Asst. Member (CJSC)
3.	Dr. P.G. Patil, Sr. Scientist	8.	Sh. D.T. Chaudhari, Tech. Officer Secretary (IJSC)
4.	Dr.Roopa Sowjanya, Scientist	9.	Sh. Aabasaheb Babar LDC, ICAR-NRCP
5.	Officer-in-Charge of Accounts	10.	Sh. V.S. Gangane SSS, ICAR-NRCP
6.	Officer-in-Charge of Administration		

OTHER ACTIVITIES

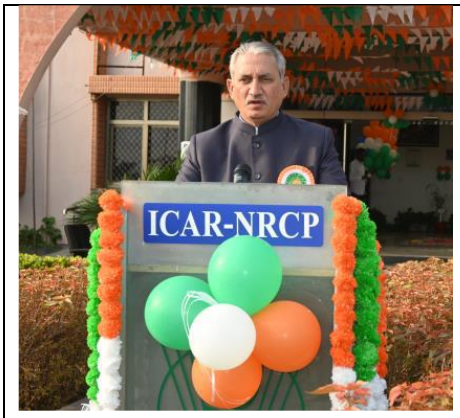
INTERNATIONAL WOMEN'S DAY

International women's day was celebrated at ICAR-NRCP, Solapur on 8th March, 2023. The programme was inaugurated by the Dr. R. A. Marathe, Director, ICAR-NRCP and addressed to the gathering about the achievement made by the lady scientists and NRCP staff. A lecture on the "Role of Women's in Agriculture" was delivered by Dr. Jyotsana Sharma, Principal Scientist, ICAR-NRCP. On this occasion, the women staff of this centre who have made significant contribution in research and administration work was identified and felicitated by the Director, ICAR-NRCP. This event was co-ordinated by Dr. Namrata Giri, Scientist, ICAR-NRCP, Solapur.

Celebration of International Women's day at ICAR-NRCP, Solapur

Republic day celebration

ICAR-NRCP celebrated a 74th Republic Day on 26th January, 2023 by unfurling of the Indian National flag by Dr. R. A. Marathe, Director, ICAR-NRCP in presence of all the scientific, technical, administrative & contractual etc. staff of this Centre. The gathering was addressed by speech of Director followed by felicitation of the farm labour and children of the staff who scored highest in academics. Different event and competition such as musical chair, lemon-spoon etc. was conducted on this occasion and prize were distributed to the winners.



74th Republic Day celebrated at ICAR-NRCP, Solapur

18th Parthenium Awareness Week

ICAR-NRCP has celebrated 18th Parthenium Awareness Week during 16-22 August, 2023. During the week the different programmes were conducted under the guidance of Director, ICAR-NRCP. The all staff was involved in different drive conducted i.e swachhta awareness among the MIT Gurukul school students, uprooting of parthenium weed by NRCP Staff, cleaning and uprooting of weeds by school students, students rally by Kegaon school students & the event were organized by Rahul Damale and NA Giri Scientist of NRCP, Solapur.

Uprooting of parthenium weed by ICAR-NRCP Staff

Students rally by Kegaon School Students

	
Cleaning and Uprooting of Weeds at Kegaon C-1 Block ICAR-NRCP by Kegaon School Students	**Swachhta Awareness among the MIT Gurukul School Students**

Mera Gaon Mera Gaurav: MGMG

Mera Gaon Mera Gaurav scheme has been implemented by ICAR-NRCP at six villages. In total 13 number of scientists were in volved in implementation of MGMG programme through 4 groups. ICAR-NRC on pomegranate has conducted six visits during the period reported upon and organized 6 demonstrations and interface meetings six scientists were involved in the collection of the soil samples from adopted villages, soil health cards were prepared and distributed among the farmers. Integrated disease and insect, pest management and integrated nutrient management schedule was extended to the farmers of the adopted villages. Awareness regarding pomegranate processing and value addition was created amongst the pomegranate farmers.

Stakeholder's Meet on Clean Plant Programme

Experts and Stakeholders- Clean Plant Programme on Pomegranate at ICAR-NRCP, Solapur

A team of international and national experts on Clean Plant Programme (CPP) from Asian Development Bank, Ministry of Agriculture and Farmers' Welfare and National Horticulture Board have visited the laboratory and farm-field facilities of ICAR-NRC on Pomegranate, Solapur on 24th Jan, 2023. On this occasion, the ICAR-NRCP has organized a Stakeholder's

Meet to facilitate interaction between the team of experts on CPP and stakeholders of pomegranate propagation industry to incorporate critical inputs and suggestions while formulating policy framework on clean plant programme for fruit crops in India.

The expert committee along with the stakeholders from reputed private tissue culture laboratories, registered nurseries and progressive farmers have visited the laboratory facilities of ICAR-NRCP including tissue culture, biotechnology and plant pathology laboratories. The committee had also visited the propagation units and polyhouse facilities of ICAR-NRCP before visiting the location to be assigned for establishing the Clean Plant Centre at ICAR-NRCP, Solapur.

Rashtriya Kisan Divas

Kisan Day Celebration at ICAR-NRCP Solapur

- ICAR-NRCP has celebrated Rastriya Kisan Day with pomegranate trainee farmers at ICAR-NRCP Solapur on 23.12.2023. Kisan Diwas celebrated to create awareness among the trainees farmers and total 87 participants participated on the occasion of Kisan Diwas.

Stakeholders meeting

ICAR-NRCP, Maharashtra Pomegranate Association, Pune, Agriculture State Government of Maharashtra and MPKV, Rahuri jointly organized the one-day Stakeholders meeting on "Pomegranate production : problems, solutions, challenges and opportunities" on 25 Aug 2023 at ICAR-NRCP Solapur for pomegranate growers and stakeholders.

Stakeholders meeting 25 Aug 2023 at ICAR-NRCP Solapur

Foundation Day cum NRCP – Industry Interface Meet:

ICAR-NRCP organized 19th Foundation Day cum Industry-Interface Meet on 25.09.2023. Dr. Kailash Mote, Director of Horticulture acted as the chief guest and Dr. K. Sammi Reddy was invited as Guest of Honour. On this occasion, more than 20 industry persons have participated and shared their experience to about 150 farmers.

Inauguration of 19th Foundation Day of ICAR-NRCP, Solapur by chief guest Dr. Kailas Mote, Director Horticulture, MSH&MPB, Pune

Release of ICAR-NRCP publication on the occasion of 19th Foundation day of ICAR-NRCP.

Swachhta Pakhwada

ICAR-NRCP has celebrated Swachhata Pakhwada week and conducted several activities under this programme during 16-31 December, 2023. The all staff was involved in different cleaning drive and different programme and activities were carried out as per the

schedule provided by the ICAR and the various activities of NRCP viz. taking swachhata pledge, plantation of Mango, Rose, Red Rib, Essay and drawing competition for childrens of Shree Sharadchandra School Solapur, Mahatma Gandhi 154th Jayanthi celebration, cleaning of institute roads and premises, waste to wealth and making compost demo to the farmers. The events were coordinated by Rahul Damale and NA Giri, Scientists of NRCP, Solapur.

	
Taking of Swachhta Pledge by ICAR-NRCP Staff	**Rose and Red Rib Plantation**

	
Mahatma Gandhi 154th Jayanti celebration	**swachhata awareness among ICAR-NRCP Staff**

	
Swchhta awareness among ICAR-NRCP Staff	**Cleaning of ICAR-NRCP Roads and Premises**

Kisan day celebration on 23rd December 2023

Plantation of Mango plants at ICAR-NRCP Field

Debate competition for Sharadchandra School Students

Waste to wealth and making compost demo to the farmers

Flag off of trial air shipment of irradiated pomegranate fruits to USA

ICAR-NRC on Pomegranate, Solapur; APEDA, New Delhi; National Plant Protection Organization (NPPO), New Delhi; Maharashtra State Agriculture Marketing Board (MSAMB), Government of Maharashtra and INI Farms Pvt. Ltd. joined hands for the successful trial shipment of irradiated pomegranate fruits by Air from India to USA. The virtual flag off ceremony was conducted on 27.07.2023 by the Sh. Abhishek Dev, Chairman APEDA, Dr. Rajiv A. Marathe, Director, ICAR-NRC on Pomegranate, Dr. J. P. Singh National Plant Protection Advisor, and by other dignitaries. Dr. Nilesh Gaikwad (Sr. Scientist) & Dr. Namrata Giri (Scientist) ICAR-NRCP were also present on the occasion.

After the ban of pomegranate fruit export to the USA in 2018, the pomegranate fruit export from India to the USA was halted. The USDA-APHIS has prescribed a new operational work plan for the pomegranate export to the USA including surfactant wash, surface disinfection, irradiation and packaging, etc. The operational work plan has been meticulously followed in the presence of the USDA-APHIS observer and a trial shipment of 150 Kg irradiated pomegranate fruits in 45 boxes was shipped by air to New York, USA.

Flag off of trial air shipment of irradiated pomegranate fruits from India by Air to USA

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HUMAN RESOURCE DEVELOPMENT

TRAINING ATTENDED

During the year under report, scientists, technical staff, administrative and finance staff have undergone the following need based training as part of the capacity building. The details of trainings undergone by different categories of staff are given below.

Table 1: TRAINING ATTENDED BY THE STAFF OF ICAR-NRCP, SOLAPUR

S. No.	Name of training	Date	Venue	Name of participant
a.	**Scientific staff**			
1.	ICAR sponsored CAFT training programme on "Artificial Intelligence and Advances in ICT for Smart Agriculture and Food Processing"	23.2.2023-04.03.2023	ICAR-CIAE, Bhopal	Dr. Namrata Giri
2.	Enhancing pedagogical competencies for agricultural education	31.07.2023-05.08.2023	NAAS New Delhi	Awachare Chandrakant Madhav
3.	NAHEP online training programme on "Agriculture in Future & Future in Agriculture"	20.11.2023-10.12.2023	RVSKVV, Jabalpur (Virtual)	Dr. K.Dhinesh Babu
b.	**Technical staff**			
1.	Attended the one day regional training cum-awareness workshop for western region of J-Gate@CeRA	21.12.2023	AAU Anand, Gujrat	Mr. G A Salunke
c.	**Administrative staff**			

CONFERENCES, WORKSHOPS AND MEETINGS ATTENDED

The scientists of the Centre participated in conferences/workshops and meetings conducted by various organizations in India besides the meetings mentioned in the chapter on institutional activities. Conferences, seminars, symposia, workshops and important meetings attended by the scientists are enlisted below.

Table 2. Conference/ Seminar/ Symposia

S. No.	Title of Conference/ Seminar/ Symposia	Date	Venue	Name of the participant(s)
1.	National Conference on "Plant-parasitic Nematodes"	16.01.2023-18.01.2023	Hotel Leela Bhartiya City, Bengaluru	Dr. Mallikarjun
2.	Platinum Jubilee Conference of the Indian Phytopathological Society, New Delhi	02.02.2023-04.02.2023	University of Mysore, Karnataka	Dr. Somnath Suresh Pokhare
3.	International millets (Shree Anna) conference on enhancing productivity and value addition in Millets-	18.03.2023	NRCP, Solapur, (Online)	Dr. Mallikarjun
4.	5th International Conference on "Climate Change and Its Impact (CCI-2023)"	09.06.2023-11.06.2023	Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar, J&K., India-(Online)	Dr. Mallikarjun
5.	4th International Conference, ITAHAS-2023 "Innovations to Transform Agriculture, Horticulture and Allied Sectors"	21.06.2023-23.06.2023	On-line Malla Reddy University, Hyderabad in collaboration with ISAHRD, Chandigarh, JUST AGRICULTURE Education Group	Dr. Shilpa Parashuram & P.G. Patil
6.	ICAR-Foundation Day cum Technology Day and concurrent Industry-Institute Interaction for SMD (Horticultural Sciences).	16.07.2023-18-07.2023	NAAS Complex, New Delhi	Dr. R. A. Marathe, Dr. Nilesh N. Gaikwad, Dr. Somnath Pokhare
7.	Global Symposium on Farmers Rights organizing	12.09.2023-15.09.2023	ICAR, Convention Centre, PPV&FRA, New Delhi.	Dr. Shilpa Parashuram
8.	International Seminar on Exotic and Underutilized Horticultural crops: Priorities & Emerging Trends	17.10.2023-19.10.2023	ICAR-IIHR, Bengaluru (Physical)	Dr.K.Dhinesh Babu

9.	"International Conference on PHM 2023 - Innovation & Sustainability"	15.11.2023-18.11.2023	Hyderabad	Dr.Namrata Ankush Giri
10.	"International Conference on Plant Health Management- 2023 - Innovation & Sustainability" from at Hyderabad	15.11.2023-18.11.2023	Hyderabad	Dr. Somnath Suresh Pokhare
11.	DUS & PVP Data Management (Webinar)	17.11.2023	PPV& FRA, New Delhi	Dr. P. Roopa Sowjanya & Dr. Shilpa Parashuram
12.	National Conference of Plant Physiology – 2023 on "Physiological and Molecular Approaches For Climate Smart Agriculture"	9.12.2023-11.12.2023	ICAR-IARI, New Delhi	Dr.Pinky Raigond & Dr. P. Roopa Sowjanya

Table 3. Workshops

S. No.	Title of Workshop	Date	Venue	Name of Participant(S)
1.	Use of Geographical indication of Solapur Pomegranate for domestic market, export and value addition. Organized by ICAR-National Research Centre on Pomegranate, Solapur, Akhil Maharashtra Dalimb Utpadak Sanshodhan Sangh, Pune, in collaboration with APEDA, Delhi, NABARD, Pune, MSAMB and State Agriculture Marketing Board, Pune.	11.04.2023	Pandharpur, District Solapur	Dr. Namrata Giri Dr. Somnath Pokhare Dr. Nilesh Gaikwad

Table 4. Meetings

S. No.	Title of meeting	Date	Venue	Name of participant(s)
1.	Farmer-Scientist-interaction meeting	06.01.2023	Modnimb Madha, Solapur	Dr. Mallikarjun Dr. Somnath S. Pokhare
2.	Scientific Advisory Committee (SAC) meeting of KVK Kalaburagi	19.01.2023	KVK Kalaburagi	Dr. Mallikarjun
3.	Stakeholders meet on clean plant	24.01.2023	NRCP, Solapur	Dr. Mallikarjun

4.	BOS subcommittee meeting as member for finalization of the syllabus of M.Tech. integrated in cosmetic technology of PAHSUS, Solapur.	10.01.2023	PAHSUS, Solapur	Dr. Nilesh Gaikwad
5.	Meeting of the cluster development cell of National Horticulture Board	12.01.2023	(online mode)	Dr. Nilesh Gaikwad
6.	15th State level executive committee meeting of MIDH, Govt. of Maharashtra	30.1.2023	(online mode)	Dr. Nilesh Gaikwad
7.	Hortsap meeting	10.02.2023	NRCP. Solapur Online	Dr. Mallikarjun
8.	Farmer-Scientist-interaction meeting	15.02.2023	Uplai-Madha	Dr. Mallikarjun
9.	Pre-PRC meeting of variety release proposal of Solapur Anardana	16.02.2023	MPKV Rahuri	Dr. K.Dhinesh Babu
10.	RKVY meeting on cost verification of sanctioned project on Biocontrol Lab an PHC at Pune	17.02.2023	Sakhar Sankul Shivajinagar Pune, Maharashtra	Dr. Mallikarjun
11.	Meeting on implementation of eHRMS software	24.02.2023	NRCP, Solapur-(Online)	Dr. Mallikarjun and all staff
12.	Annual Review Meeting of AICRP on Arid Zone Fruits	24.02.2023	NRCP, Solapur (online)	Dr. Mallikarjun, Dr. K. Dhinesh babu Dr.Chandrakant Awachare
13.	Farmer scientist interaction and farm input distribution programme	27.02.2023	KVK, Kalaburagi	Dr. Mallikarjun
14.	Farmer-Scientist-interaction meeting	17.03.2023	Barmer Rajasthan	Dr. Mallikarjun, Dr. J Sharma Dr. Somnath S. Pokhare
15.	RRC meeting of variety release proposal of pomegranate var. 'Solapur Anardana'	19.03.2023	MPKV, Rahuri	Dr. K.Dhinesh Babu
16.	Review of eHRMS implementation	31.03.2023	NRCP, Solapur (online)	Dr. Mallikarjun
17.	Scrutiny meeting of variety release proposal of pomegranate var. 'Solapur Anardana'	05.04.2023'	MPKV, Rahuri	Dr. K.Dhinesh Babu
18.	Pre-RFRC meeting for variety release proposal of pomegranate	13.04.2023	MPKV, Rahuri	Dr. K.Dhinesh Babu

	var. ‘Solapur Anardana’			
19.	Pre QRT Meeting of AICRP AZF	19.04.2023	NRCP, Solapur (online)	Dr. K. Dhinesh babu Dr. Mallikarjun, Dr.Chandrakant Awachare
20.	eHRMS Review meeting	21.04.2023	NRCP, Solapur (online)	Dr. Mallikarjun,
21.	An Interactive Session of Young Scientists with FOCARS Trainees (112th FOCARS)	22.04.2023	NAARM, Hyderabad	Dr.Pinky Raigond
22.	AICRP-AZF QRT Meeting	25.04.2023	NRCP, Solapur online	Dr. K. Dhinesh babu Dr. Mallikarjun, Dr.Chandrakant Awachare
23.	खरिप हंगामपुर्व नियोजन प्रशिक्षण व आढावा बैठक	26.04.2023	Pandharpur	Dr. Mallikarjun
24.	खरीप हंगाम नियोजन प्रशिक्षण	27.04.2023	Krushak Bhavan, Solapur	Dr. Mallikarjun
25.	Farmer-Scientist interaction meet	28.04.2023	Kurduvadi	Dr. Mallikarjun
26.	RFRC meeting of variety release proposal of Pomegranate var. ‘Solapur Anardana’	29.04.2023	MPKV, Rahuri	Dr. K.Dhinesh Babu
27.	QRT meeting of AICRP-AZF & presented achievements of Solapur Centre Pomegranate Crop	08.05.2023	Through (Online mode)	Dr. K.Dhinesh Babu
28.	A meeting for signing of MoU with Bayer Crop science Ltd. for research collaboration	12.05.2023	NRCP, Solapur	Dr. Mallikarjun
29.	Review Meeting of eHRMS under the Chairmanship of Additional Secretary, DARE & Secretary, ICAR	12.05.2023	NRCP, Solapur,, (Online)	Dr. Mallikarjun
30.	51st Joint Agresco meeting of SAUs, MCAER for recommendation of pomegranate var. Solapur Anardana for anardana purpose in Maharashtra State.	25.05.2023-27.5.2023	MPKV Rahuri	Dr. K.Dhinesh Babu
31.	SLEC 16th Meeting	09.06.2023	NRCP, Solapur,, (Online)	Dr. Mallikarjun, Dr. Jyotsana Sharma
32.	1st Steering Committee meeting of “Crop Pest Surveillance and Advisory Project (CROPSAP) 2023-24	13.06.2023	NRCP, Solapur, (Online)	Dr. Mallikarjun, Dr. Jyotsana Sharma

33.	राष्ट्रीय कृषि विकास योजना – कॅफेटेरिया अंतर्गत प्रकल्पातील विहित बाबींचे दर मुल्य निर्धारणासाठी ॲनलाईन बैठकी	20.06.2023	NRCP, Solapur, (Online)	Dr. Mallikarjun, Dr. Jyotsana Sharma
34.	An Interactive Session of Young Scientists with FOCARS Trainees (113th FOCARS)	18.7.2023-29.7.2023	NAARM, Hyderabad	Dr.Pinky Raigond
35.	Meeting to discuss about RAC	25.07.2023	NRCP, Solapur	Dr. Mallikarjun
36.	Research Advisory Committee	11.08.2023	NRCP, Solapur	All Scientific staff
37.	18th "Parthenium Awareness Week	16.08.2023	NRCP, Solapur	Dr. Mallikarjun
38.	Farmer-Scientist-interaction meeting	17.08.2023	Sonyal, Tah-Jat, Sangli	Dr. Mallikarjun, Dr. Jyotsana Sharma. Dr. Somnath Pokhare
39.	Stakeholders meet	25.08.2023	NRCP, Solapur	Dr. Mallikarjun
40.	ICAR-IIHR Foundation Day Lecture	05.09.2023	NRCP, Solapur	Dr. Mallikarjun
41.	Attend the visit to farmer's field of Mr. Vishnu Laxman Sule as an expert of ICAR-NRCP, Solapur along with official of National Horticultural Board (NHB) acts as an expert for identification of Age of the plants	31.08.2023.	Pandharpur	Dr. K.Dhinesh Babu
42.	BOS committee meeting as member for finalization of the syllabus of MSc.Part 1. PAHSUS, Solapur.	09.08.2023	PAHSUS Solapur	Dr. Pinky Raigond
43.	Farmer- Scientist- interaction meet on "Diagnosis and management of shot hole borer in pomegranate"	27.09.203	Modnimb - Madha Solapur	Dr. Mallikarjun, Dr. Jyotsana Sharma. Dr. Somnath Pokhare
44.	Visitied farmer's field training session on single stem technology of pomegranate at Bibi Darfhal village for interacted with more than 300 farmers	27.09.2023	Bibi darfhal village	Dr. K.Dhinesh Babu
45.	BOS committee meeting as member for finalization of the syllabus of BSc.Part 1. PAHSUS, Solapur.	04.10.2023	PAHSUS Solapur	Dr. Pinky Raigond
46.	RKVY-SLPSC meeting	06.11.2023	Central Building	Dr. Mallikarjun, Dr. Manjunatha

			Mumbai	N.
47.	Farmer- Scientist- interaction meet on “Diagnosis and management of Insect pests and Diseases in pomegranate”	09.11.2023	Atharga, Vijayapura	Dr. Mallikarjun, Dr. Manjunatha, N. Dr. Somnath Pokhare
48.	2nd Steering Committee meeting of “Crop Pest Surveillance and Advisory Project (CROPSAP) 2023-24	28.11.2023	NRCP, Solapur, (online)	Dr. Mallikarjun, Dr. Manjunatha, N.
49.	Swachhta Pakhwada celebration	15.12.2023	NRCP, Solapur, (online)	Dr. Mallikarjun
50.	25th SAC meeting of ICAR KVK Vijayapura-II (Indi)	19.12.2023	NRCP, Solapur, online	Dr. Mallikarjun
48.	Pre-season, Pre-cleared Pomegranate Export from India to the meeting with APHIS, APEDA	20.12.2024	(online mode)	Dr. Nilesh Gaikwad

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Publications

Table 1: Research articles

S. No.	Research paper	NAAS Rating
1.	Giri, N. A., Gaikwad, N. N., Raigond, P., Damale, R., & Marathe, R. A. 2023. Exploring the Potential of Pomegranate Peel Extract as a Natural Food Additive: A Review. *Current Nutrition Reports*, 12(2):270-289. (IF:5.53)	11.53
2.	Singh, N. V., Sharma, J., Dongare, M. D., Gharate, R., Chinchure, S., Manjunatha N., Shilpa P., Patil, P. G., Babu, K. D., Mundewadikar, D. M., Salutgi, U., Tatiya, M., Kumar, A. and Marathe, R. A. 2023. In Vitro and In Planta antagonistic effect of endophytic bacteria on blight causing *Xanthomonas axonopodis* pv. punicae: A destructive pathogen of pomegranate. *Microorganisms.* 11: 5 Doi:10.3390/microorganisms 11010005	10.93
3	Sharma J., Manjunatha N., Somnath Pokhare S., P.G. Patil, Agarrwal R, Mansi G. Chakranarayan, Sirsat J, Patil J and Marathe RA. 2023. First report of *Lasiodiplodia theobromae* causing stem canker of pomegranate (*Punica granatum* L.) in India. Plant Disease Doi:10.1094/PDIS-09-22-2025-PDN.	10.50
4	Giri, N. A., Gaikwad, P., Gaikwad, N. N., N, M., Krishnakumar, T., Kad, V., Manjunatha N., Raigond P.& Marathe, R. A. 2023. Development of fiber-enriched muffins using pomegranate peel powder and its effect on physico-chemical properties and shelf life of the muffins. *Journal of the Science of Food and Agriculture*. doi: 10.1002/jsfa.13138.	10.13
5	Manjunatha N., Sharma **J**, Pokhare **S**, Mansi G., Chakranarayan, Agarrwal R, Gavande B**.**S, Raigond B, Mallikarjun M. H., &. Marathe R A **.**2023. Development of simple and quick DNA release protocol for conventional PCR-based detection of *Xanthomonas axonopodis* pv. punicae causing bacterial blight in pomegranate. *Archives of Phytopathology and Plant Protection*, Doi:10.1080/03235408.2023.2228004.	7.0
6	Sawant, C.P., Jyoti, B., Gaikwad, B.B., Gaikwad, N., Kemar N., and Kumar, M. 2023 Optimization of Operational Parameters of site-specific pesticide spray module for young pomegranate orchards using RSM and RBFNN-PSO, Techniques. *Journal of Biosystems* Engineering. Doi:10.1007/s42853-023-00185-x`	7.98
7.	Watpade, S, Naga, K. C., Pramanick, K. K. Tiwari, R. K., Kumar, R., Shukla, A K., Mhatre, P. H., Lal, M K., Pal, D., and Manjunatha, N 2023. First report of powdery mildew of pomegranate (Punica granatum) caused by Erysiphe punicae in India. Journal of Plant Disease and Protection. Doi:10.1007/s41348-023-00718-8.	7.85
8.	Manjunatha, N., Pokhare S. S., Sharma J., Patil P. G., Agarrwal R., Chakranarayan M. G., Sirsat J. D, Patil J and R. A. Marathe 2023. Collar rot caused by Calonectria hawksworthii, a new record for pomegranate (Punica granatum). Journal of Plant Pathology. Doi: 10.1007/s42161-023-01391-4.	8.64

S.No.	BOOK CHAPTERS
1.	Giri N.A,. Sakhale B. K. and. Nirmal N. P. 2023. Functional beverages: an emerging trend in beverage world. In. *Recent Frontiers of Phytochemicals* (Applications in Food, Pharmacy, Cosmetics, and Biotechnology). (Eds. Pati Siddhartha et al.). Elsevier, 123-138.
2.	Visalakshi Chandra C., Sheela M. N., Suresh Kumar J., Giri N.A, and Sankar S.A. 2023. Cassava In:Production technology of underutilized vegetable crops. Dubey R.K., Singh J Eds. Kalyani Publisher, New Delhi, PP.531-552.
3.	Shilpa P., Roopa Sowjanya P., Babu K. D., Singh N. V., Patil P. G., Sharma J., and Marathe R. A. 2023. pomegranate genetic resources: conservation and utilization. In: Rajasekharan, P.E., Rao, V.R. (eds) Fruit and Nut Crops. *Handbooks of Crop Diversity: Conservation and Use of Plant Genetic Resources.* Doi:10.1007/978-981-99-1586-6_18-1 published in Springer, Singapore.
S.No.	**POPULAR ARTICLES**
1.	Damale R.D., Patil P.G., Raigond P, Gaikwad, N.N., Awachare, C, Mallikarjun H, Giri, N.A. and. Marathe, RA .2023. Pomegranate Phytochemicals and their Health Benefits. *The Agriculture Magazine.* 2(7) 2023. E-ISSN: 2583-1755.
2.	राहुल डमाळे, पी.जी.पाटील, नीलेश गायकवाड, नम्रता गिरी, पिंकी राइगोंड्, आर .ए. मराठे . दैनिक कृषि सहकार .डाळिंब एक प्राचीन आयुर्वेदिक आणि औषधी वनस्पति .2023,वे 8, .316 पान नंबर.2 .
3.	Raigond, P, More, A, Singh, NV, Parashuram, S, Babu, KD, Giri, NA, Gaikwad, NN, Awachare, C, Patil, PG and Marathe, RA. 2023 Enhancing flower induction and nutritional quality of pomegranate: Role of plant growth regulators and chemicals. *ICAR-NRCP newsletter* (January-June). PP. 2-3
4.	Patil, PG, Jamma, SM, Manjunatha, N, Babu KD, Gaikwad, NN, Raigond, P, Parashuram, S and Marathe, RA. 2023. Development of InDel markers specific to gene families involved in pomegranate growth and development. *ICAR-NRCP newsletter* (January-June). PP. 3
5.	Roopa Sowjanya P., Shilpa, P. and Marathe, R.A. 2023. Standardization of LD_{50} & GR_{50} of gamma rays for the Pomegranate Cultivars Bhagawa and Solapur Lal, – *Newsletter, NRCP, Solapur*.
6.	Patil, P.G., Shilpa, P, Singh, N.V., Roopa Sowjanya P and Marathe, RA. 2023. pomegranate genome and its prospects for breeding elite pomegranate varieties. *Just Agriculture* 3(9): 200-208.
7.	Patil,P.G., Shilpa P, Babu KD and Marathe, RA. 2023. Novel genic markers for genetic improvement of pomegranate. *Just Agriculture* 5(3): 173-179.
8.	Damale, RD, Roopa Sowjanya P, Babu K.D, Singh, N.V., Marathe, RA and Shilpa, P. 2023. डाळिंबाच्या व्यावसायिक जाती आणि त्यांची वैशिष्ट्ये) Pomegranate commercial varieties and their features in Marathi). *Krishi Sahakaar*.
9.	Mallikarjun H and Damale R D.2023. आदिवासी शेत्कार्याना दिले सुधारित शेती तंत्रग्न्नाचेघड़े .Local newspaper Gadchiroli: देशोंन्नती, NA:1.
10.	Mallikarjun, H, Marathe, RA, Damale, R.D, Shilpa P. 2023. स्प्रे पम्पाद्वारे कीतानाशाकांची भे द पिकावरील रोग . *लोकमत.*
11.	Mallikarjun, H, Shilpa P, Damale, R.D and Marathe R.A, 2023. आदिवासी उपयोज्ञान्तार्गत शेतकारी प्रशिक्षण City pulse Local newspaper Gadchiroli, Maharashtra, NA:1.

12.	Shilpa P., Roopa Sowjanya, P., Babu, K.D., and Marathe, R. A. 2023. Shetakane vikasith 'Sharad King' daalimb vaanala swamithv hak. Agrowon. Published on 17 July 2023.
13.	Roopa Sowjanya, P., Shilpa P., Singh, N. V., Patil, P. G. and Marathe, R. A. 2023. Pomegranate Genome Sequence Application and usage. Terragreen, vol 15(10): 50-52.

PRESENTATIONS IN CONFERENCES/ SYMPOSIA/ SEMINAR/ OTHER FORA

S.No.	ORAL
1.	Mallikarjun, M. H., Marathe, R. A., Manjunatha, N., Pokhare, S. Fand D. N., Sagar Y.K. 2023. Relative susceptibility of pomegranate verities to of invasive shor hole borer (*Euwallacea fornicatus*) and its management. 5th International Conference on "Climate Change and Its Impact (CCI 2023)" June 9-11, 2023. Souvenir cum Abstract book.pp. 115. ISBN 978-93-5396-006-3.
2.	Mallikarjun, M. H., Pokhare, S., Manjunatha N. and Marathe, R. A.2023. Root knot nematode of pomegranate and its integrated management. National Conference on Plant-parasitic Nematodes. Organized by Bayer Crop Sciences at Hotel Leela Bhartiya City, Bengaluru from January 16-18, 2023. Souvenir abstracts of guest lectures poster presentations. p.16.
3.	Gaikwad, N.N. 2023. Processing and value addition in pomegranate. In: NRCP-Stakeholders-Industry Interface Meet on the occasion of 19th Foundation Day of the institute on 25th Sep. 2024.
4.	Giri, NA *, Gaikwad,NN., Manjunatha N. and Marathe, R.A.. 2023. Oral presentation on "Post-harvest application of pomegranate peel powder as an antimicrobial agent in extension of shelf life of Muffins". In "International Conference on PHM 2023 - Innovation & Sustainability" from 15-18th November, 2023 at Hyderabad.
5.	Raigond, P, Singh N.V., More Amarja. Damale RD, Shilpa P, Giri NA., Awachare C, Patil PG., Roopa S, K Dhinesh Babu and Marathe R.A. 2023. "Unlocking the Secrets of Pomegranate Fruit Cracking: A Comprehensive Study of Irrigation Levels and Chemical treatments" by at National Conference of Plant Physiology – 2023 on Physiological and Molecular Approaches For Climate Smart Agriculture**"** from December 9-11, 2023 at ICAR-Indian Agricultural Research Institute, New Delhi.
6.	Roopa Sowjanya P., Sangnure Vipul, Shilpa P, Ajinkya Madave, Amar K, Dhinesh Babu, K. Pinky R and Marathe, RA. 2023, Exploring Mutations to unravel LD_{50} & GR_{50} of gamma rays in Pomegranate improvement, In Proc: National Conference of Plant Physiology-2023, IAR, New Delhi.
7.	Roopa Sowjanya P., Sangnure Vipul, Shilpa P, Madave Ajinkya, Amar K, Dhinesh Babu, K. Pinky R and Marathe, RA. 2023. Mutation Breeding: Standardization of LD50 & GR50 of gamma rays for the pomegranate cultivars, In Proc:10th Indian Horticultural Congress 2023, Guwahati.
8.	Shilpa, P., Aldar, K. S., Raigond, P., Singh, N. V., Patil P. G., Roopa Sowjanya, P., Babu, K. D., Girme, A. R. and Marathe, R. A. 2023. Combined evaluation of morphological, physiological and microsatellite markers in relation to fruit cracking resistance in pomegranate. In: 4th International Conference, ITAHAS-2023 "Innovations to Transform Agriculture, Horticulture and Allied Sectors" Malla Reddy University, Hyderabad.
9.	Patil P.G Jamma SM, Manjunatha N, Babu KD, Gaikwad N, Raigond P, Shilpa,P,

	and Marathe, RA. 2023. Development of gene family derived InDel markers for genetic improvement of pomegranate. In: 4th International Conference, ITAHAS-2023 "Innovations to Transform Agriculture, Horticulture and Allied Sectors" Malla
10.	Shilpa Parashuram, Roopa Sowjanya P., Patil Prakash, Singh N. V., Babu K. D. and Marathe, R. A. 2023. Application of molecular markers in assessment of pomegranate diversity. In: Workshop programme on "Igniting young minds for scientific innovations" held on 27th March, 2023 at ICAR-NRCP, Solapur. Workshop/NRCP/SERB/ 2023/01. pp. 23-26.
11.	Patil P.G. 2023. Invited lecture Genome editing. In: Workshop programme on "Igniting young minds for scientific innovations" held on 27th March, 2023 at ICAR-NRCP, Solapur. Workshop/NRCP/SERB/ 2023/01. pp. 23-26.
12.	Bhosale S. R., Shilpa, P., Jagtap, M. N., Girme, A. R., Daphale T. and Marathe, R. A. 2023. Effect of Sodium Azide treatment on seed germination, seedling survival and seedling growth parameters in Pomegranate (*Punica granatum* L.). In: National Seminar on "Challenges, opportunities and strategies of plant science for crop improvement" organized by Indian Society of Genetics & Plant Breeding, New Delhi from 08-09 November, 2023.
S.No.	**POSTERS**
1.	Shirgure P. S., Marathe R. A., K. Dhinesh Babu, Manjunatha N., Mallikarjun H. and Wadne S.S. 2023. "Scheduling of N, P and K nutrients using fertigation method for sustainable production of Pomegranate (cv. Bhagawa). 10th Indian Horticulture Congress-2023 organized by Indian Academy of Horticulture Sciences (IAS) New Delhi from November 06-09, 2023 at Guwahati, Assam.
2.	K. Dhinesh Babu, Singh N.V., Awachare C., Damale R., Rana J., Shilpa P, Sowjanya P. R., Raigond P., Sharma J. and Marathe, R.A. 2023. "Standardization of crop regulation practices for higher yield & better quality in pomegranate (*Punica granatum*)" in the International Seminar on Exotic and Underutilized Horticultural crops: Priorities & Emerging Trends held during 17-19 October, 2023 at ICAR-Indian Institute of Horticultural Research, Bengaluru.

S.No.	**ANNUAL REPORT/PROJECT REPORT**
1.	Mallikarjun H, Shilpa P, Damale RD and Marathe, RA. 2023. TSP-STC project quarterly progress report on Physical Output Targets/achievements (Fourth Quarter-Jan-March, 2023) NRCP, Solapur, NA:10.

S.No.	**MANUAL / COMPENDIUM**
1.	Roopa Sowjanya, P., Manjunatha, N., Singh, NV, Patil, P.G, Shilpa, P., Sharma J and Marathe, RA. 2023. Compendium of lectures for Workshop on "Igniting young minds for Scientific Innovations", March 27th , 2023 at ICAR – NRCP, Solapur, pp-45.

S.No.	**TECHNICAL /EXTENSTION/BULLETIN/ FOLDERS**
1.	Mallikarjun, M.H., and Fand D.N. 2023. Pomegranate mealybug and its management. Extension Bulletin/NRCP/2023/03. ICAR-NRCP, pp1-10.
2.	Gaikwad N.N**,** Giri, N.A and Marathe, RA. 2023. Pomegranate processing technologies & value added products. NRCP/02/2023. ICAR-NRCP, pp. 25.

3.	Raigond, P., Giri, NA, Gaikwad N.N and Marathe Rajiv A .2023. Analytical manual for pomegranate. *Technical Bulletin* no. NRCP/2023/3. ICAR-NRCP. Pp. 38.
4.	Shilpa P, Babu K.D., Roopa Sowjanya P, Raigond P, Awachare C, Mallikarjun MH, Gogaon Mahadev and Marathe, RA. 2023. Important commercial varieties of pomegranate. NRCP/Extension folder/2023/2, pp 4.
5.	Raigond P, Singh N.V., Shilpa Parashuram, Awachare C, Roopa Sowjanya and Marathe RA. 2023 Physiological disorders in pomegranate and their management. ICAR-NRCP. Extension folder in Kannada.
6.	Roopa Sowjanya P, Sharma J and Marathe, RA. 2023 ICAR – NRCP: A Profile, ICAR –NRCP, Solapur, Bulletin No. NRCP/2023/1. pp-30.
7.	Roopa Sowjanya P, Sharma J and Marathe, RA. 2023 ICAR – NRCP at a glance, ICAR –NRCP. Extension folder/NRCP/2023/1.

S.No.	E-NEWSLETTER / E-PUBLICATIONS
1.	Mallikarjun M.H. 2023. Advisory management of thrips in pomegranate.
2.	मल्लिकार्जुन एम .एच. 2023. डाळिंबातील फूल्कीड़ीचे (थ्रिप्सचे) व्यवस्थापन).
3.	Jyotsana Sharma; Somanth Pokhare; N. V. Singh, Mallikarjun; Manjunatha N. and Ashis Maity 2022. Bimonthly Advisory for Bearing Pomegranate Orchards. December 2022-January 2023.p 1-10.
4.	Sharma Jyotsana, Pokhare Somanth, Singh N. V., Mallikarjun H, Manjunatha N. and Ashis Maity 2023. Phaldhark Dalimb Baagesathi salla December 2022-January 2023.p 1-13. (Marathi).
5.	Sharma Jyotsana, Maithy Ashis, Singh N V, Mallikarjun H , Manjunatha N. and Somnath Pokhare 2023. Bimonthly Pomegranate Advisory for Bearing Orchards Feb-Mar 2023. p 1-8.
6.	Sharma Jyotsana, Maithy Ashis, Singh N V, Mallikarjun H , Manjunatha N. and Somnath Pokhare 2023. Phaldhark Dalimb Baagesathi salla February-March 2023.p 1-13. (Marathi).
7.	Sharma Jyotsana, Pokhare Somnath, Singh N. V., Manjunatha N., Mallikarjun H and Marathe RA .2023. Advisory for Pomegranate Crop Hit by Unseasonal Rains and Hail Storm March 2023. p 1-2.
8.	Sharma Jyotsana, Pokhare Somnath, Singh N. V., Manjunatha N., Mallikarjun H and Marathe R A. 2023. Aavkali Paus ani Garpitimule Nuksan Zalelya Dalimb Pikasathi Salla March 2023. p 1-3. (Marathi).
9.	Sharma Jyotsana, Maity Ashis, Singh N. V., Pokhare Somnath, Mallikarjun H, Manjunatha N. and Gogaon Mahadev. 2023. Bimonthly Pomegranate Advisory for Bearing Orchards April-May 2023. p 1-10.
10.	Sharma Jyotsana, Maity Ashis, Singh N. V., Pokhare Somnath, Mallikarjun, Manjunatha N. and Gogaon Mahadev. 2023. Dalimb Pikasathi Salla April-May 2023. p. 1-13. (Marathi).
11.	Sharma Jyotsana, Maity Ashis, Singh N.V., Mallikarjun H., Chaudhari Dinkar and Somnath S. Pokhare, 2023. Bimonthly Pomegranate Advisory for Bearing Orchards June- July 2023. p. 1-12.
12.	Sharma Jyotsana, Maity Ashis, Singh N.V., Mallikarjun H., Dinkar Chaudhari and Somnath S. Pokhare 2023. Dalimb Phaldhark Baagesathi Dvaimasik Salla June-July 2023. p. 1-15. (Marathi).
13.	Sharma J, Maithy Ashis, Singh N.V. , Mallikarjun H, Manjunatha N, Pokhare S and Gogaon Mahadev. 2023. Bimonthly Pomegranate Advisory for Bearing Orchards August-September 2023. p. 1-12.
14.	Pokhare Somanth, Sharma Jyotsana, Maithy Ashis, Singh N.V., Mallikarjun H, Manjunatha N., and Gogaon Mahadev .2023. Phaldhark Dalimb Baagesathi Salla August-September 2023. p. 1-10. (Marathi).
15.	Sharma Jyotsana, Mallikarjun H., K. Dhinesh Babu, Pokhare S and Manjunatha N., 2023. Adhoc List of Agrochemicals with European Union (EU) Maximum Residue Level (MRL)

	and Pre Harvest Interval (PHI) for Pomegranate Production. p. 1-6.
16.	Patil PG., Shilpa P, Singh N.V., Roopa Sowjanya and Marathe, RA 2023. Pomegranate Genome and its prospects for breeding elite pomegranate varieties. *Just Agriculture. e-Newletter* 3(9): 200-208.
17.	Marathe R.A, Raigond P, Pokhare S and Giri NA. 2023 (Jan -June) E-news letter for ICAR-NRC on Pomegranate, Solapur .pp.1-16
18.	Marathe R.A, Raigond P, Pokhare S and Giri NA. 2023 (July -Dec) E-news letter for ICAR-NRC on Pomegranate, Solapur .pp.1-30.
19.	डॉ. ज्योत्सना शर्मा, डॉ. सोमनाथ पोखरे आणि जयदीप शिरसट. ताजे बोर्डो मिश्रण आणि बोर्डो पेस्ट तयार करण्याची पद्धत (मे २०२३).
20.	डॉ. ज्योत्सना शर्मा, डॉ. सोमनाथ पोखरे आणि जयदीप शिरसट. ताजा बोर्डो मिश्रण और बोर्डो पेस्ट बनाने की विधि (मई २०२३).
21.	Sharma J, Pokhare S and Shirsat J.2023. Preparation of Fresh Bordeaux Mixture and Bordeaux paste (May 2023).
22.	Sharma J, Pokhare S, Manjunatha N., MallikarjunH., K. Dhinesh Babu and Marathe R. A. 2023. Integrated Disease and Insect Pest Management (IDIPM) Schedule for Pomegranate Cultivation (September,2023).
23.	Sharma J, Manjunatha N. and Pokhare S. 2023. Frequently Asked Questions on Bacterial Blight (September 2023).
24.	डॉ. ज्योत्सना शर्मा, डॉ. सोमनाथ पोखरे, डॉ. मंजुनाथा एन. व श्री. दिनकर चौधरी. बॅक्टेरियल ब्लाइट (तेलकट डाग रोग) वर वारंवार विचारले जाणारे प्रश्न (सप्टेबर२०२३)
25.	Sharma J, Pokhare S, Singh N. V.., Manjunatha N., Mallikarjun and Marathe RA.2023. Advisory for Pomegranate crop hit by unseasonal rains and hail storm (November 2023).
26.	डॉ. ज्योत्सना शर्मा, डॉ. सोमनाथ पोखरे, डॉ. एन व्ही सिंह, डॉ. मंजुनाथा एन., डॉ. मल्लिकार्जुन आणि डॉ. राजीव मराठे. अवकाळी पाऊस आणि गारपिटीमुळे नुकसान झालेल्या डाळिंब पिकासाठी सल्ला (नोहेंबर २०२३).

S.No.	VIDEOS
1.	Dr. Nilesh Gaikwad participated in phone in Live programme Krishidarshan of DD Sahyadri entitled “Opportunities in Pomegranate Processing”. It was telecasted on 23 February 2023 at 6.00 PM live on DD Sahyadri.

S.No.	NCBI data base
1.	Mallikarjun M.H. 2023. Submission of sequence *Fusarium oxysporum* to ITS Sequence ID. >0523-515_002_PCR_I2_Forward_E07.ab1 submitted to NCBI database in 2023.
2.	Mallikarjun M.H. 2023. Sequenced *Pacelomyces maximus* ITS Sequence ID. >0723-016_006_PCR_F_Forward_A04.ab1 submitted to NCBI database ACC No.
3.	Mallikarjun M.H. 2023. *Verticillium spp.* ITS Sequence ID >0622_708_002_PCR_E2_ITS_PI_B05.ab1. Isolate code E2. submitted to NCBI database with (Accession number MF034654.1).
4.	Mallikarjun M.H. 2023. 16S rRNA, Sequence ID >0622_708_009_PCR_E6_16S_RNA_PR_F05.ab1. Isolate code E6. submitted to NCBI database . Accession number EU249982.1.

Invited Talk:

S.No.	Invited Talk
1.	K. Dhinesh Babu (2023). Acted as a resource person to deliver a lecture in Good Horticultural Practices for Quality Pomegranate Production and Value Addition" for the farmers of Gujarat Date 18th -20th May, 2023.
2.	K. Dhinesh Babu (2023). Delivered lecture in training programme" Good Horticultural Practices for Quality Pomegranate Production and Value Addition "Establishment new pomegranate orchards and its management at initial stage" for the farmers of Rajasthan Date: 7-9 June, 2023.
3.	Giri NA. (2023). Acted as a resource person to deliver a lecture in training programme on "GMP for pomegranate production, protection and value addition" for the farmers from Rajasthan during 07-09 June, 2023 by ICAR-NRC on Pomegranate, Solapur.
4.	Roopa Sowjanya P (2023). Acted as a resource person to delivered lecture on "Conservation and utilization of Pomegranate genetic resources for quality pomegranate production" Online off-campus training programme on "Capacity Building Programme for Pomegranate Growers" organized by APEDA on 24.08.2023.
5.	Patil P.G. (2023). Delivered lecture on 'Genome editing and its Applications '. during one day workshop on Igniting Young Minds for scientific innovations, 27.03.2023, organized at ICAR–NRCP, Solapur

Guided students

- Ms. Aditi Bhangale. B. Tech. (Food Science & Technology). 2023. Guided by Dr. Giri NA. "A Comparative study on chemical preservatives and pomegranate peel powder as a natural preservative on the quality of muffins". School of Biotechnology and Bioinformatics, D.Y.Patil Deemed to be University, Navi Mumbai.
- Mr. Ganesh Dattatray Kumbhar. B. Tech. (Biotechnology). 2023. Guided by Dr. Giri NA. "Development and evaluation of pomegranate based iron rich probiotic drink". Aditya Agricultural Biotechnology College, Beed, Affiliated to VNMKV, Parbhani.
- Mr. Shekhar More, M.Sc (Fruit Science) guided by Dr. K. Dhinesh Babu. student of Lovely Professional University has been guided for Research Project work. Oct 2023-Dec 2023.
- Mr. Pranavraj Rajaram Patil BSc (Biotechnology) 2023. Guided by Dr. PG Patil " Genetic diversity study in pomegranate using SSR markers student of Walchand college of Arts and science, Solapur.
- Mr. Nitish Bhardwaj ,B.Tech (Food Science & Technology). 2023 Guided by Gaikwad NN. " Microencapsulation of pomegranate peel extract using ionic gelation method". School of Biotechnology and Bioinformatics, D.Y.Patil Deemed to be University, Navi Mumbai.

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Awards and Recognition

AWARDS

S.No.	Name of Scientist	Award	Year	Awarding Organization
Fellowship/ Associateship/Young Scientist/ Other Awards				
1.	Dr. Mallikarjun M.H	Outstanding Achievement Award-2023	2023	Agricultural and Environmental Technology Development Society (AETDS) Uttarakhand, India
2.	Dr.Pinky Raigond	NAAS Associate (Horticulture)	2023	National Academy of Agricultural Sciences
3.	Dr.Pinky Raigond	R.H. Dastur Gold Medal Award	2023	Indian Society for Plant Physiology
4.	Dr.Pinky Raigond	Certificate of Appreciation (for the efforts in developing the Institute Ranking Proforma for ICAR Central Potato Research Institute)	2023	Central Potato Research Institute
5.	Dr. Nilesh N. Gaikwad	Technology certificate for the technology of "Microencapsulation of pomegranate seed oil using ionic gelation technique"	2023	ICAR-New Delhi
6.	Dr. PG Patil	Development of chromosome specific hyper variable SSR markers in Pomegranate	2023	ICAR-New Delhi
7.	Dr. Mallikarjun H	Standerdization the moths production protocol for pomegranate fruit piercing moths (*Eulocima materna*)	2023	ICAR-New Delhi
Best oral presentation awards				
1.	Dr.K. Dhinesh Babu	Awarded **best oral presentation** award entitled "Development of bio-fortified pomegranate var. Solapur Lal for table purpose & Solapur Anardana" in the International Seminar	2023	at ICAR-Indian Institute of Horticultural Research, Bengaluru.

		on Exotic and Underutilized Horticultural crops: Priorities & Emerging Trends held during October 17-19, 2023		
2.	Dr. PG Patil	Best oral presentation award for the topic entitled 'Development of gene family derived InDel markers for genetic improvement of Pomegranate' presented through online mode. during June, 2023, organized	2023	4th International conference "Innovations to transform Agriculture, Horticulture and Allied Sectors' (ITAHAS 2023) from 21st -23rd at Malla Reddy University, Hyderabad.
3.	Dr. Shilpa, P.,	Best Oral presentation award for the paper presented on "Combined evaluation of morphological, physiological and microsatellite markers in relation to fruit cracking resistance in pomegranate"	2023	In: 4th International Conference, ITAHAS-2023 "Innovations to Transform Agriculture, Horticulture and Allied Sectors" Malla Reddy University, Hyderabad in collaboration with ISAHRD, Chandigarh, JUST AGRICULTURE Education Group.

Technology certificate for the technology of "Microencapsulation of pomegranate seed oil using ionic gelation technique"

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Budget Estimate

Table 1: Financial outlay in 2022-23

Head of Account	Rupees (in Lakhs)	
	2022-23	
	Govt. Grant	
	RE	Expenditure
(A) Recurring		
Establishment Charge	532.52	532.52
T.A.	13.05	13.05
Other Charges	248.95	248.20
Total A	794.52	793.77
(B) Non-recurring		
Equipment	71.15	71.01
Minor Works	1.30	1.30
Library	0.00	0.00
Furniture	7.26	7.26
Information Technology	11.79	11.79
Total B	91.50	91.36
(C) Loan & Advances	116.00	90.47
(D) Pension	0.00	0.00
(E) Vehicles & Vessels	11.50	11.50
Grand total (A+B+C+D)	**1013.52**	**987.10**

Table 2: Revenue Receipt in 2022-23

S. No.	Items	Amount (Rs.)
1.	Income from farm produce	1408559.00
2.	Income from royalty and publications	32691.00
3.	Income from other sources	68603.00
4.	Interest on loans and advances	36988.00
5.	Interest earned on short term deposits	255328.00
6.	Recovery of loans and advances	412381.00
7.	Training programs	261000.00
8.	Analytical testing fee	34958.00
9.	License fee/ Guest house	75862.00
	Total revenue receipt	**2586370.00**

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Staff Position & Personnel

Joining/ Promotion/ Relieving

STAFF POSITION

Category	Sanctioned during XIIIth Plan	Staff position	Vacant
RMP	1	1	0
Scientific	22	13	9
Technical	6	6	0
Administrative	11	4	7
Supporting	2	2	0
Total	42	26	16

PERSONNEL

RMP		
Dr. R.A. Marathe Director		
Scientific staff	**Technical staff**	**Administrative staff**
Dr. Jyotsana Sharma, Principal Scientist (Plant Pathology)	**Sh. D.T. Chaudhari** Technical Officer	**Sh. R.B. Rai** AO
Dr. P.S. Shirgure Principal Scientist (Land and Water Management Engg.)	**Sh. Yuvaraj Shinde** Technical Officer	**Sh. V.A. Shinde** Finance & Account Officer (FAO)
Dr. K. Dhinesh Babu Principal Scientist (Hort.-Fruit Science)	**Sh. Bhausaheb Naikwadi** Sr.Technical Assistant	**Sh. Kiran Khatmode** UDC
Dr. Prakash G. Patil Senior Scientist (Plant Biotechnology)	**Sh. Vijay Lokhande** Technical Assistant	**Sh. A.S. Babar** LDC
Dr. N.N. Gaikwad Senior Scientist (Agrl. Structures and Process Engg.)	**Sh. Mahadev Gogaon** Senior Technician	**Supporting staff**
Dr. Shilpa P. Scientist (Genetics & Plant Breeding)	**Sh. Govind Salunke** Senior Technician	**Sh. Shailesh Bayas** SSS
Dr. Mallikarjun Scientist (Agrl. Entomology)		**Sh. Vishal Gangane** SSS
Dr. Roopa Sowajanya P. Scientist (Genetics & Plant Breeding)		
Dr. Somnath Pokhare, Scientist (Nematology)		
Dr. Manjunatha N, Sr. Scientist (Plant Pathology)		
Dr. Namrata Ankhush Giri,		

Scientist (Food Technology)		
Mr. Rahul Damale, Scientist (Biochemistry)		
Dr. Pinky Raigond, Senior Scientist (Plant Physiology)		
Dr. Chandrakant Awachare, Scientist, (Fruit Science)		

JOINING: NIL

PROMOTION:

- Dr. Prakash G. Patil, Sr. Scientist (Plant Biotechnology) & Dr. Pinky Raigond, Sr. Scientist (Plant Physiology) got promoted from RGP 8000/- to RGP 9000/-
- Dr. Somnath Pokhare, Scientist (Nematology) got promoted from RGP 7000/- to RGP 8000/-
- Dr. Roopa Sowjanya P., Scientist (Genetics and Plant Breeding) got promoted from RGP 6000/- to RGP 7000/-
- Dr. Nilesh Gaikwad, Sr. Scientist (Agril. Structure and Process Engg.) has been promoted from RGP 8000/- to Sr. Scientist (Agril. Structure and Process Engg) PB-4 RGP 9000 w.e.f. 23.06.2019.

RELIEVING:

- Dr. N.V. Singh, Senior Scientist (Fruit Science)., transferred to ICAR-IARI, New Delhi, relieved on 29.03.2023.

RETIREMENT:

- Dr. Jyotsana Sharma, Principal Scientist (Plant Pathology) was retired on 31.10.2023.

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Dr. Rajiv A Marathe, Director, ICAR-National Research Centre on Pomegranate, Solapur selected for the prestigious 'Fellow of National Academy of Agricultural Sciences- 2024'