ICAR-NRCP
ANNUAL REPORT 2021

ICAR- National Research Centre on Pomegranate,

NH-65, Solapur –Pune Highhway,

Kegaon,

Solapur- 413 255, Maharashtra

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Supervision and Guidance
Rajiv A Marathe
Director

Editorial Team

K. Dhinesh Babu
Principal Scientist (Hort. - Fruit Science)

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

Prakash G. Patil
Senior Scientist (Plant Biotechnology)

Nilesh Gaikwad
Senior Scientist (Agril. Structures and Process Engineering)

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

Technical Support
Yuvraj Shinde, Technical Officer
Bhausaheb Naikwadi, Senior Technical Assistant

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ICAR-NRCP website: nrcpomegranate.icar.gov.in
E-mail: nrcpomegranate@gmail.com

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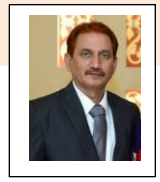
Preface



ICAR-National Research Centre on Pomegranate, Solapur, has completed 16 years of journey on September 25, 2021. 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 8 years. In 2019-20, the pomegranate was cultivated over 2.83 lakh ha, production of 31.25 lakh MT with productivity of 11.25 t/ha and in 2019-20, the export was 80.5 thousand MT.

ICAR-NRCP has significantly contributed in improving pomegranate scenario in India through its technologies on 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 different stakeholders including farmers, is the driving force keeps us move forward with commitment.

To introduce 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 and to fulfill the vision of our Honorable Prime Minster of Doubling farmer's income by 2022. 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 place on record my sincere gratitude to Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his encouragement. I am obliged to Dr. AK Singh, DDG (HS) for his moral support and guidance, which encourages us to move forward with confidence. The cooperation and support rendered by 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

Horticulture has moved from rural confines to commercial venture. Scenario of horticulture crops in India has become very encouraging in recent times. Horticulture production in 2001-02 was only 145.8 million tones, 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 remained higher than food grain production with continuous increase recording 313.85 million tonnes in 2018-19, whereas food grain production was only 283.37 million tonnes (http://agricoop.nic.in/sites/default/files/Horticulture2018) and http://nhb.gov.in/statistics/State_Level/2018-19). 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.

The pomegranate crop is considered as strategic crop in India to mitigate the future challenges like global warming, drought, alleviating the poverty by creating livelihood and improving the framers 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. Analysis of pomegranate statistics for last 8 years shows that, average increase in area was 133.93%, production 289.11%, productivity 67.83% and exports 55.58%. 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.

As per estimated global pomegranate acreage and production figures available on different internet sites, India is the largest producer with around 50% share globally. India in 2018-19, occupies an area of 2.62 lakh hectares with production of 30.34 lakh tonnes. The other countries after India are China (1.2 lakh ha and 12.0 lakh MT), Iran (0.75 lakh ha and 11.0 lakh MT), Turkey (0.35 lakh ha and 2.2 lakh MT). 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. Today 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) A well established, ‘Field Gene bank’ with 367 germplasm lines including indigenous and exotic lines established at ICAR-NRCP, Solapur which serves collection of genes for diverse characters.

(ii) Promising, cost effective, eco-friendly integrated nutrient, disease & insect pest management schedule with the use of bio-formulations and preventive strategies, resulting in quality fruit production.

(iii) Bio-hardened micro-propagation technology for propagation of disease free planting material.

(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 and with TSS around 17.6 is a boon for processing industries too.

(vii) 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 NRCP has popularized its promising technologies through licensing, consultancy extension activities, distribution of NRCP publications, digital mobile app 'Solapur Anar', demonstrations on framers field, providing on campus and off campus trainings to framers and entrepreneurs and TV shows.

Due to highest BCR 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 fulfill the vision of Honorable Primer Minister of India of Digital India, Doubling Farmer's Income 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.

Executive Summary

In the recent past, pomegranate recorded a remarkable progress in area of 2.83 lakh ha, production of 31.25 lakh MT in 2019-20 and export of 80,500 MT in 2019-20. The crop has shown its importance for improving the livelihood security of the farmers in arid and semi-arid regions of India with erratic rainfall. The ICAR-National Research Centre on Pomegranate, Solapur has been playing pivotal role in solving various researchable issues faced by the pomegranate growers and meeting the challenges of this popular crop.

During the year under report, the Centre has handled several Institutional Projects, Externally Funded Projects, two Inter-Institutional Collaborative Projects, one Schedule Castes Sub Plan (SCSP) and one Tribal Sub-Plan (TSP) Scheme. Out of fifteen Institutional Projects, one project has been completed successfully during the period under report. The major achievements are summarized below.

Genetic Resources:

- In total 367 pomegranate germplasm accessions consists of 140 Indigenous and 222 Exotic collections have been maintained ICAR-NRCP, Solapur. Out of which, **98 germplasm accessions (70 exotic**, **28 indigenous)** were evaluated for their genetic reaction to bacterial blight disease under challenge condition. One germplasm (EC-676992) found moderately resistant (SG: 2) and 9 accessions as moderately susceptible (SG: 3) genotypes (EC-798832; EC-798740; IC-318716; EC-676975; EC-798729; EC-676994; EC-798763; EC-676931; EC-676930). These will be valuable genetic resources for pomegranate breeding programmes.
- Previously identified six promising breeding lines (Sharad King, NRCPS-7, BBSC-1, BBSC-2, BBSC-3, BBSC-6-1 were also screened for their genetic reaction to bacterial blight disease XAP-90, 118 culture (108 pfu/ml; OD: 0.1031) under controlled condition. Based on disease severity grade, NRCPS-7 (SG: 2.50), BBSC-2 (SG: 2.92), BBSC-3 (SG: 2.86), were found to be moderately susceptible while others are susceptible.
- Identified and collected one “Bhagawa” variant from the farmer field which matures in about 135-145days. This variant will be characterized for other DUS characteristics including reaction to BBD. Breeding for early maturity, has been initiated between six diverse pomegranate genotypes (Ganesh, Patna-5, P-26, G-137, Arakta and Mridula) for inducing disease escape mechanism in pomegranate. Advanced F_2 segregant population of NRCP H-6 and BC_1F_1 generation of ‘NRCP H-6’ X ‘Bhagawa’ and ‘NRCP H-6’ X (GxNxD)’ has been developed to identify promising genotypes against bacterial blight disease.
- Creation of genetic variability for BBD resistance through induced mutation has been carried out. Among chemical mutagenesis, for EMS treatment fixed LD50 value in cv. “Bhagawa” (1% for 6hrs without pre-soaking with water and 1.4% for 4hrs with pre-soaking in water). M_1 mutant population treated with LD50 value of EMS (1% for 6hrs) has been generated for advanced genetic studies for bacterial blight disease resistance in pomegranate. Gamma irradiation of cv. ‘Bhagawa’ was carried also out for 4 different doses (3 kR, 5 kR, 7 kR, and 9 kR. The data on seed germination (%) has been completed. LD50 value will be calculated once after recording the data on seedling survival (%) and the population with the decided LD50 value will be advanced to rise the segregating mutant population for screening against BBD. *In vitro* mutagenesis for developing solid mutants

has been carried using EMS and Sodium Azide chemicals. Based on their effect on bud Sprouting (%), the LD50 was found to be EMS 0.5% 4 hr (36.67%) and SA 2mM 3hrs.

- First year on-site DUS characterization of farmer variety namely 'Sharad King' was carried out at Aurangabad, Maharashtra. The tested candidate variety was found to have distinctive characteristic features for petal length (long), petal width (large), Aril length (short) and fruit maturity (medium) in comparison to reference variety (medium, medium, medium and late maturity). In 2021, two hybrid varieties i. e., NRCP H-6 (Solapur Lal) and NRCP H-12 (Solapur Anardana) have been registered in the Plant Varieties Registry, PPV&FRA, New Delhi as new varieties.
- 48 pomegranate genotypes consist of both wild and cultivated types were assessed by using 30 SSR markers. Maximum genetic dissimilarity (0.53) was observed between IC-318712and IC-318718 as well as IC-318712 and Acc-08 collection. Three clusters (wild types) were derived from unweighted neighbour joining which uses a criterion of unweighted average on dissimilarity. The polymorphic information content ranged from 0.12 to 8.69 with an average of 0.53. The PgSSR 54, 57 and 32 were found to be highly polymorphic with given set of markers

Crop Improvement:

- Evaluation of pomegranate variety Solapur Lal in comparison to the ruling variety, Bhagawa during the sixth year of planting in mrig bahar recorded about 18.5 days early maturity, 25.8% higher yield (35.23kg/tree) over Bhagawa besides better fruit quality traits.
- Evaluation of pomegranate variety Solapur Anardana in comparison to Amlidana during the sixth year of planting in mrig bahar was done. Solapur Anardana recorded 28.94 kg/tree fruit yield, 4.82% titrable acidity and 460.5 mg/100g anthocyanin.
- Evaluation of twelve hybrids developed at ICAR-NRCP, Solapur in fifth year of planting revealed that the yield ranged from 15.15-25.59 kg/ tree. The highest yield was recorded by Ganesh x Nayana (25.59kg/tree) which was followed by Bhagawa x Nayana (25.41 kg/ tree).

Crop production & protection

- The level of susceptibility of different cultivated pomegranate varieties to Shot hole borer infestation during the first observations was Arakta > Ganesh > Mridula>S. Bahgawa > G-137 > Bahgawa and in the second observation, it was Ganesh> Arakta >Mridula > S. Bahgawa > Bhagawa > G-137. The average per cent infestation in the first and second observations was 40.79 and 47.56%.
- Emamectin benzoate 3% + Thiamethoxam 12% WG + Propiconazole 25% EC was found effective for the management of pomegranate shot hole borer 66.45 and 98.25% plants recovery in 1 and 2ml doses respectively.
- Emamectin benzoate 5% SG and Emamectin benzoate 3% + Thiamethoxam 12% WG were found promising for the management of pomegranate stem borer 66.67% plants recovery in all the three different methods of treatment viz. drenching, stem injection and Drenching + stem injecting.

- Flonicamid 50% W/W and Tolfenpyrad 15 % EC were found to be effective for the management of pomegranate thrips with 87.72% and 80.95% reduction of fruit damage respectively.
- Thiamethoxam 12.6 % +Lambda cyhalothrin 9.5% ZC and Emamectin benzoate 3% + Thiamethoxam 12% WG was found to be effective for the effective management of pomegranate mealybugs with 68.37% 66.26% of fruits free from mealybugs infestation.

- A detailed roving survey was conducted (Approx.1200 acres) to assess the disease and nematode incidence / severity of major diseases of pomegranate in different districts of Karnataka, Maharashtra and Madhya Pradesh during 2020-21.
- Incidence and severity of different diseases like (Bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae*; Leaf spots caused by *Cercospora* and *Alternaria spp.*, Anthracnose fruit rot caused by *Colletotrichum* spp. and scab caused by *Sphaceloma* spp. was recorded during the survey. The maximum disease severity (0 to 100%) of phylloplane diseases (Bacterial blight, Leaf spots, Anthracnose fruit rot and scab) was observed in Solapur district of Maharashtra. Root-knot nematode was present in the 70-90% of the orchards having wilt disease; from 5 to 80% root infection.
- Bronopol (95% 2-Bromo-2-Nitro-1, 3-Propanediol), a commonly used bactericide and The modified new mustard formulation prepared by CIPHET, Ludhiana were tested against three fungal pathogens of pomegranate. Bronopol was found effective against *Alternaria alternata* (causing heart rot and leaf spot/blight in pomegranate); *Colletotricum gloeosporioides* (the anthracnose pathogen) and *Ceratocystis fimbriata* (the pomegranate wilt pathogen) with 64% pathogen growth at lowest concentration (0.25 g/L). The radial growth was completely arrested (100% inhibition) at 0.75 g/L in all tested fungal pathogens of pomegranate. The *in vitro* tests were encouraging; however, more elaborate studies are required to affirm the final concentration and efficacy of bronopol under field conditions. In the case of mustard formulation highest inhibition was achieved at 5 ml/L dose with 53.77% inhibition of *A. alternata* and 50.68 % inhibition of *C. gloeosporioides* and 79.07% of *C. fimbriata*. Fifty endophytes were also tested *in vitro* for their inhibitory effect against above three pathogens. Two endophytic isolates (BE-5 and EB-7) were found to inhibit 51-75% growth of all three pathogens.
- Field demonstration of Stem solarization-Six-Step to control bacterial blight was conducted on 3 farmers' orchards (total 11 acres) in Malshiras tehsil of Solapur district in November 2020. In spite of the untimely intermittent rains in 2021 during Stem Solarization process of the technology, farmers got excellent blight control (88- 97%) with significant increase (132- 445%) in quality yield in comparison to previous year and reduction in cost of cultivation. The benefit: cost ratio in these three orchards ranged from 3.03 to 3.54:1. These demonstrations speak about the success of this technology for managing bacterial blight in arid and semi-arid regions where rainy season crop is preferred due to water shortage in other seasons.
- *Trichoderma* and other natively isolated bio-agents isolated during our survey coded as KA-40 and KA-54 from Bagalkot area of Karnataka were tested under *in-vitro* dual plate technique against the wilt causing fungi, *Ceratocystis fimbriata*. The isolate KA-40 species gives highest *Cf* inhibition (93.47%) followed by KA-54 species (84.78%) under *in-vitro* condition. These isolates are currently being evaluated under polyhouse condition. The

cultural filtrate of KA 54 56.88% mortality of Root Knot Nematode juveniles when they were exposed for 48 hrs. at 25% concentration.

Post-Harvest Technology

- Developed low calorie pomegranate Ready-To-Serve (RTS) drink using natural and artificial sweeteners which significantly reduced T.S.S. from 15.03% to 4.5% and energy value from 60.12 kcal/100ml to 18 kcal/100ml. The developed RTS drink is suitable for the consumers on low calorie intake.
- The pomegranate peel powder was used as a natural preservative in muffins and fortification of pomegranate peel powder in muffins resulted in prevention of lipid oxidation and extension of shelf life due to its antioxidant and antimicrobial activity in comparison with control sample. It also resulted to increase in fiber content from 4.39% to 10.66%, total phenols from 0.443 mg GAE/100g to 48.53 mg GAE/100g and antioxidant activity from 75.94% to 99.36%.

Other Activities

- The Centre has taken up promotion of pomegranate cultivation in the states of Maharashtra, Rajasthan, Chhattisgarh, Madhya Pradesh through SCSP, TSP and Mera Gaon Mera Gaurav through demonstration, supplying inputs, providing Soil Health Card, imparting trainings and technical guidance benefitting around 500 farmers.
- ICAR-NRCP commercialized three technologies to entrepreneurs and displayed its activity in seven exhibitions and more than 1500 visitors including farmers, students and other stakeholders visited the center for information.
- All the staff of ICAR-NRCP actively participated in activities under Swachch Bharat Abhiyan, Vigilance Awareness Week, 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 published 8 research papers in peer reviewed journals, out of which 2 was in journal with NAAS rating above \10 , one review article, 19 book chapters, 30 popular articles, besides 22 presentations in conferences and 31 poster presentations. The scientists also got recognitions from professional Societies viz., Awards/ Fellowships, besides best oral / poster presentation awards.

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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. NV Singh Dr.P Roopa Sowjanya	Ongoing	(1/08/2019-31/07/2024
2.	Draft genome sequencing of Pomegranate (*Punica granatum* L.) cv. Bhagwa	Dr. Roopa Sowjanya P.	Dr. Shilpa P. Dr. N.V. Singh, Dr. P.G.Patil	Ongoing	(21/02/2017-20/01/2022)
3.	Genetic Mapping of Bacterial Blight and Fruit Quality Traits in Pomegranate	Dr. P. G. Patil	Dr. J. Sharma Dr. Shilpa P. Dr. N. V. Sing Dr. K. D. Babu	Ongoing	(01/01/2018-31/12/2023)
4.	Combating stresses and improving quality in pomegranate (*Punica granatum* L.) by exploiting rootstocks	Dr. N.V. Singh	Dr. Roopa Sowjanya P. Dr. Prakash G. Patil Dr. Manjunath N. Dr. K.D. Babu Dr. Somnath Pokhare	Ongoing	(20/08/2020-19/08/2025)
5.	Crop regulation practices for improving productivity of pomegranate	Dr. K. Dhinesh Babu	Dr, N.V. Singh Dr A. Maity Dr J. Sharma	Ongoing	(01/04/2018-31/03/2023)
6.	Package of practices for organic cultivation of pomegranate	Dr. A. Maity	Dr. J. Sharma Dr. Gaikwad N.N. Dr. Mallikarjun, H.	Ongoing	(01/08/2018-31/07/2024)
7.	Development and refinement of integrated production technologies for improved productivity	Dr. P.S. Shirgure	Dr. K. D. Babu Dr. N.V. Singh Dr. A. Maity Dr. J. Sharma	Completed	(01/04/2019-31/03/2022)

	in Pomegranate (*Punica granatum* L.)-Intercropping				
8.	Sensor based irrigation scheduling for water productivity of Pomegranate (*Punica granatum* L.)	Dr. P.S. Shirgure	Dr. K. D. Babu Dr. N.V. Singh Dr. A. Maity Dr. J. Sharma	Completed	(01/04/2018-31/03/2023)
9.	Post-harvest management and value addition in pomegranate for Entrepreneurship development	Dr. Gaikwad N.N.	Dr. Namrata Giri Dr. K. Dhinesh Babu, Dr. Ashis Maity,	Ongoing	(01/07/2019-30/06/2024)
10.	Development of Functional food products and waste utilization from pomegranate	Dr. Namrata A Giri	Dr. Nilesh Gaikwad Dr. Ashis Maity Dr. Pinky R. Dr. Manjunatha N.	Ongoing	(20/08/2020-31/07/2025)
11.	Development of technologies for sustainable management of important insect pest of pomegranate	Dr. Mallikarjun	Dr. Manjunatha N Dr. Somnath S. Pokhare Dr. R A Marathe	Ongoing	(01/09/2020-31/08/2025)
12.	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)
13.	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. A Maity and Dr. R.A. Marathe	Ongoing	(01/01/2021-31/12/2026)
14.	Flagship project on Integrated approach to eradicate bacterial blight	Dr. Jyotsana Sharma	Dr.A.Maity Dr.N.V.Singh Dr.Shilpa. P Dr.K.D.Babu Dr.P.G.Patil	Ongoing	(01/10/2014-31/03/2023)

			Dr.A.Kumar, (IARI) Dr.Manjunatha N Dr.R.K.Mestha (UHSB**)**		
15.	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. N. V Singh Dr. Dhinesh Babu Dr. Shilpa Parshuram Dr. Manjunath N. Dr. Mallikarjun Harsur Dr. Rajiv Marathe	Ongoing	(01/06/2021-31-05/2026)

EXTERNALLY FUNDED PROJECTS

S. No.	Funding agency	Project	PI	Co-PIs	Status
1.	ICAR	ICAR-All India Coordinated Research Project on Arid Zone Fruits	Dr. K. Dhinesh Babu	Dr. N.V. Singh Dr. Mallikarjun	Ongoing
2.	M/s. Biostadt India Ltd	To study the effect of biozyme Fruit Plus L on yield and quality parameters	Dr. N.V. Singh	-	Completed
3.	PPV&FRA, New Delhi	Establishment of DUS centre at ICAR-NRCP, Solapur	Dr. Shilpa P.	Ms. Roopa P. Sowjanya	Ongoing
4.	RKVY, DAC, GoI	Horticulture Crop Pest Surveillance and Advisory Project for Mango, Pomegranate & Banana	Dr. Jyotsana Sharma	Dr. Mallikarjun	Ongoing
5.	Sirius Minerals India Pvt. Ltd.	Evaluating Poly-4 as multi-nutrients fertilizer in pomegranate for yield and quality	Dr. Ashis Maity	Dr. Nilesh Gaikwad	Ongoing
6.	UPL Pvt Ltd.	Bio-efficacy evaluation of fungicides AVANCER	Dr Manjunatha	Dr. Jyotsana Sharma, Dr.	On going

		GLOW (Azoxystrobin 8.3% + Mancozeb 66.7% WG) and CUPROFIX DISPERSS (Copper sulphate 47.15%+Mancozeb 30% WG) against disease complex of pomegranate	N	Somnath S. Pokhare, Mr. Vijay Lokhande	
7.	Bayer Crop Science Limited	Efficacy and crop safety evaluation of Glyphosate IPA salt 41% w/wsl in pomegranate	Dr. N.V. Singh	Dr. R.A. Marathe	Ongoing
8.	Fertis India Pvt Ltd	Bio-efficacy of Ecolaid freedom microbicide on bacterial blight of pomegranate	Dr Manjunatha N	Dr. Jyotsana Sharma, Dr R.A. Marathe, Mr. Vijay Lokhande	On going
9.	DuPont-Corteva Ltd	Efficacy of Q8U80 500SC for the management of root knot nematode on Pomegranate	Dr. Somnath S. Pokhare	Dr. Mallikarjun H. & Dr. Manjunatha N.	Ongoing

TRIBAL SUB-PLAN

S. No.	Project title	PI	Co-PIs	Status
1.	Promotion of pomegranate cultivation in tribal areas of M.P. and Chhattisgarh in collaboration with SRIJAN, India	Dr. N.V. Singh	-	Completed
2.	Tribal Sub-Plan of ICAR-NRCP, Solapur	Dr. Somnath S. Pokhare	Dr. Namrata Giri & Mr. Rahul Damale	Completed

SCHEDULED CASTES SUB-PLAN

S. No.	Project title	PI	Co-PI	Status
1.	Promotion of pomegranate cultivation and supporting SC farmers of Tikkamgarh, Alwar Barmer and Solapur in collaboration with SRIJAN, IBTADA, Gram Panchayats and KVKs	Dr. N.V. Singh	Dr. Shilpa P. Dr. Roopa Sowjanya P. Mr. Yuvraj Shinde Mr. Mahadev	Ongoing

			Gogaon	
2.	Supporting SC farmers of Kalaburgi, Karnataka through training and agri-input distribution	Dr. N.V. Singh	Dr. Shilpa P. Dr. Roopa Sowjanya P. Mr. Yuvraj Shinde Mr. Mahadev Gogaon	Ongoing

INTER-INSTITUTIONAL COLLABORATIVE PROJECTS

S. No.	Project title	Collaborative Institute	PI	Co-PIs	Status
1.	Delineation of potential areas for pomegranate cultivation in India using remote sensing and GIS techniques	ICAR-NBSS&LUP Nagpur		Dr. J. Sharma Dr. A. Maity	Ongoing
2.	Unraveling the mechanism and developing mitigation strategies for aril browning and fruit cracking in pomegranate	ICAR-NIASM, Baramati	Dr. N.V. Singh	Dr. K.Dhinesh Babu Dr. Ashis Maity Dr. Shilpa P. Dr. Pinki Raigald,	Ongoing

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Genetic Resources

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

(1) Study of genetic reaction of selected promising genotypes of pomegranate against bacterial blight disease

Previously identified six promising breeding lines (Sharad King, NRCPS-7, BBSC-1, BBSC-2, BBSC-3, BBSC-6-1 were evaluated for their genetic reaction to bacterial blight disease under challenge inoculation to XAP-90, 118 culture (108 pfu/ml ; OD: 0.1031) during 2021-22.The disease severity grade ranged from 2.5-5 with coefficient of variation (%) of 24.99%. Based on disease severity grade, **NRCPS-7** (**SG: 2.50**), **BBSC-2** (**SG: 2.92**), **BBSC-3** (**SG: 2.86**), were found to be moderately susceptible while **BBSC-1** (**SG: 3.08**), BBSC-6-1 (SG: 3.58) and 'Sharad King (SG: 4) are susceptible in comparison to highly susceptible variety 'Bhagawa' (SG: 5) (Fig. 1).

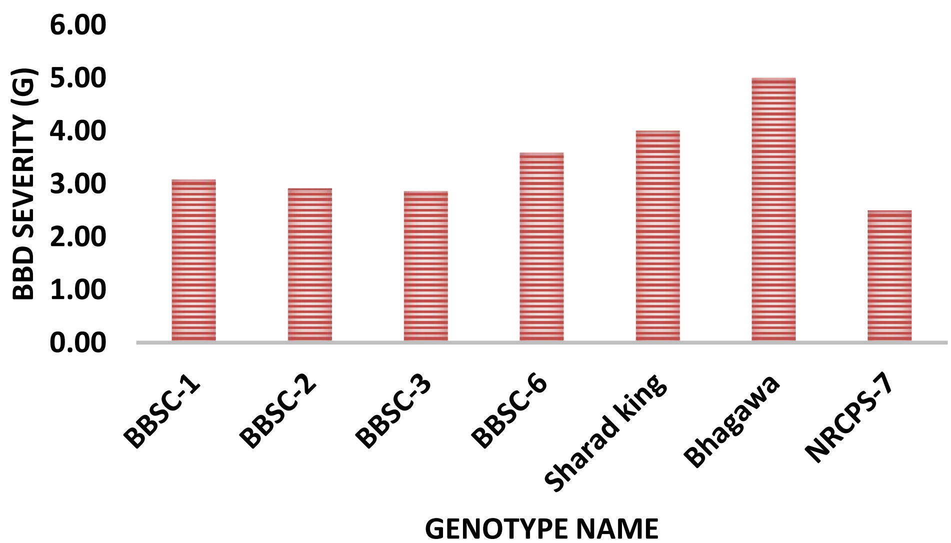


Fig. 1: Reaction of selected promising genotypes against BBD

(2) Screening of exotic and indigenous germplasm accessions against bacterial blight disease

In total 307 pomegranate accessions maintained in field gene banks at Kegaon and Hiraj research farms of ICAR-NRCP, Solapur during 2021-22. It includes 140 Indigenous (Uttarakhand, Jammu & Kashmir, Himachal Pradesh, Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Gujarat) and 222 Exotic (USA, Turkmenistan, Russia, Iran, Italy, Japan, Afghanistan, France) collections.

Out of which, **98 germplasm accessions** including **70 exotic** accessions and **28 indigenous accessions** were evaluated for their genetic reaction to bacterial blight disease under challenge inoculation to XAP-90, 118 culture (10^8 pfu/ml; OD: 0.154) and compared with the susceptible check variety "Bhagawa". Analysis of Variance (ANOVA) using R software package 1.0.1 has showed significant differences among the accessions for BBD screening at both 5% and 1% level of significance (Fcal – 8.47; p value- < 2.2e-16 **) with mean value of 4.16, range 1.83 – 5; R^2 - 0.81; SEm - 27; CV - 11.36; t-value - 1.97 and LSD - 0.76). Out of 98 accessions, one germplasm (EC-676992) found moderately resistant (SG: 2) and 9 accessions as moderately susceptible (SG: 3) genotypes (EC-798832; EC-798740; IC-318716; EC-676975; EC-798729; EC-676994; EC-798763; EC-676931; EC-676930) (Fig. 2). These will be valuable genetic resources for pomegranate breeding programmes.

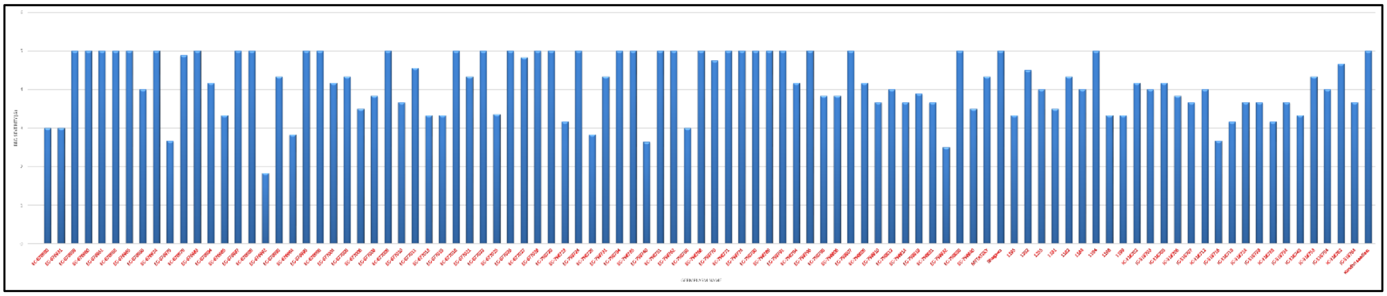


Fig. 2: Frequency distribution of BBD severity among 98 pomegranate accessions screened during 2021-22

(3) Development and utilization of new breeding population for identification of BBD resistance sources in pomegranate

Advanced F_2 segregant population of NRCP H-6 (459 idividuals) and BC_1F_1 generation of 'NRCP H-6' X 'Bhagawa' (57 individuals) and 'NRCP H-6' X (GxNxD)' (32 individuals) has been developed. These populations will be screened for reaction to bacterial blight disease under controlled condition (Fig. 3).

Fig. 3: Samplings of segregating population developed at ICAR-NRCP, Solapur

(4) Identification and development of early maturing genotypes for escaping BBD in pomegranate

- Identified and collected one "Bhagawa" variant from the farmer field which matures in about 135-145days with all other similar characters. This variant will be characterized for other DUS characteristics including reaction to BBD (Fig. 4).

Fig. 4: Early maturing variant identified from farmer field

- At ICAR-NRCP, Solapur hybridization for developing early maturing hybrids has been initiated between six diverse pomegranate genotypes (Ganesh, Patna-5, P-26, G-137, Arakta and Mridula) for inducing disease escape mechanism in pomegranate (Fig. 5).

Fig. 5: Hybrid seeds of crosses between selected parents in pomegranate

(5) Breaking the genetic linkage of BBD through hybridization programmes

- Breeding programme for reducing the genetic susceptibility load of BBD in the crop has been initiated by crossing highly susceptible (Mridula) with moderately resistant and moderately susceptible genotypes (1205, 1203, Yellow Nana, P-26, Patna-5, Yercaud) (Fig. 6).

Fig. 6: Hybrid seeds of crosses carried between selected parents in pomegranate

(6) Creation of genetic variability for BBD resistance through induced mutation

6.1 Chemical mutagenesis:

i. Fixed LD50 value for "Bhagawa" variety which found to be 1% for 6hrs for without pre-soaked water treatment and 1.4% for 4hrs with pre-soaked water treatment of seeds.

ii. Nearly about **179 M_1** population treated with LD50 value of EMS (1% for 6hrs) has been generated and will be utilized for advanced genetic studies for bacterial blight disease resistance in pomegranate (Fig. 7).

Fig. 7: Mutagenic population of pomegranate developed through chemical mutagenesis (EMS)

6.2 Physical Mutagenesis:

- Gamma irradiation of seeds of cv. 'Bhagawa' was carried out for 4 different doses (3 kR, 5 kR, 7 kR, and 9 kR. The data on seed germination (%) has been completed. LD50 value will be calculated once after the data on seedling survival (%) will be recorded. The mutant population with the decided LD50 value will be advanced to rise the segregating mutant population for screening against BBD (Fig. 8).

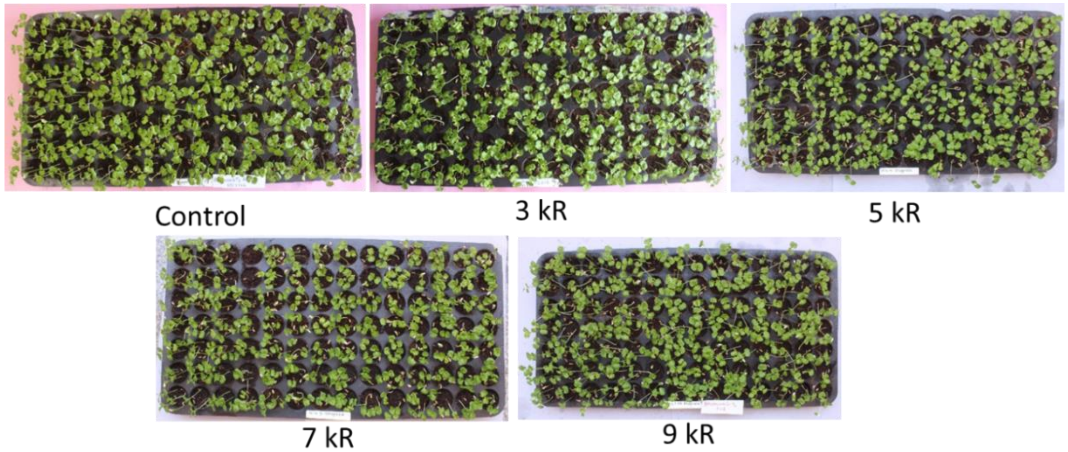


Fig. 8: Mutagenic population of pomegranate developed through chemical mutagenesis (EMS)

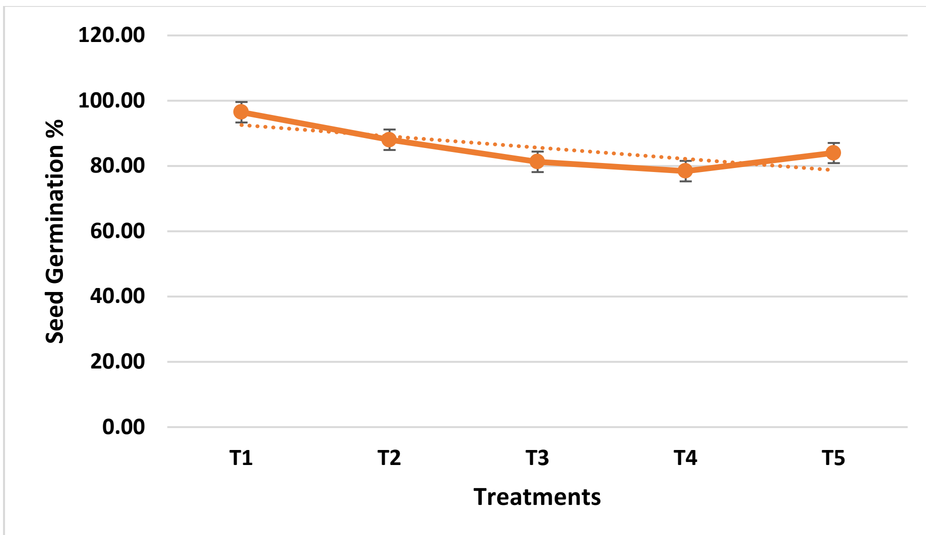


Fig. 9: Effect of Gamma irradiation on seed germination (%) in pomegranate

Mean	**85.62 % (68.41)**
Range	78.44 % - 96.46 % (64.37 - 72.09)
Fcal	0.80 ns
Coefficient of Variation (%)	9.310 (4.81)
Standard Error of Mean	3.13 (1.47)

() Arc Sine transformed values

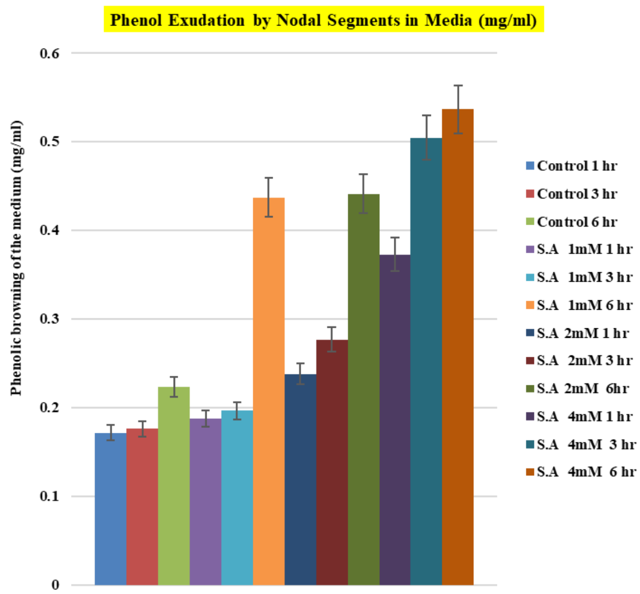
Fig. 10: Statistical data on Gamma irradiation effect on seed germination (%) in pomegranate

6.3 In vitro chemical mutagenesis in pomegranate cv. Super Bhagawa

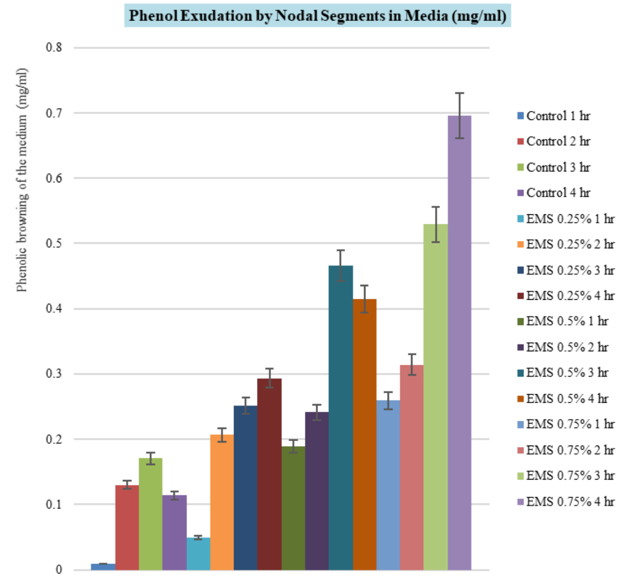
In vitro mutagenesis for developing solid mutants has been carried using EMS and Sodium Azide chemicals. Nodal segments of Super Bhagawa variety has been treated with EMS @ 0.25, 0.5, 0.75% for 1, 2, 3 and 4 hrs and Sodium Azide @1, 2 &4 mM @ 1, 3 and 6 hrs. Studied their effect on Bud Sprouting (%), Bud Necrosis (%), Phenol Exudation in Media (mg/ml), Chl. a (mg/g), Chl. B (mg/g), Total Chl. mg/g, Chl a/Chl b, RLWC (%), Avg. Shoot Length at 25 DAI (cm), Avg. No. Side Shoots, GI, Days to Sprout. Based on their effect on bud Sprouting (%), the LD50 was found to be EMS 0.5% 4 hr (36.67%) and SA 2mM 3hrs (Table 1; Fig. 10). The experiment will be repeated and validate the data for further consideration. Then a large mutant population will be generated for the fixed LD50 values for EMS and SA, further utilized for BBD resistance breeding programmes.

Table 1: Bud sprouting and necrosis as influenced by *in vitro* treatment of nodal segments with EMS and Sodium Azide

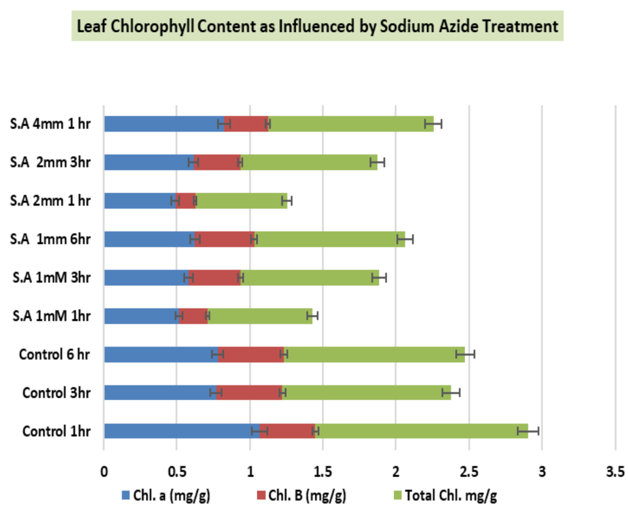
Treatment	Bud Sprouting (%)	Bud Necrosis (%)	Treatment	Sprouting (%)	Bud Necrosis (%)
Control 1 hr.	96.67 (83.32)*	3.33 (6.27)*	**Control 1 hr**	96.67 (81.35)	3.33 (8.65)
Control 2 hr.	80.00 (63.93)	20.00 (26.07)	**Control 3 hr**	93.33 (78.06)	6.67 (11.94)
Control 3 hr.	100.00 (89.82)	0.00 (0.19)	**Control 6 hr**	83.33 (66.26)	16.67 (23.74)
Control 4 hr.	100.00 (89.82)	0.00 (0.19)	**S.A 1mM 1hr**	80.00 (63.86)	20.00 (26.15)
EMS 0.25% 1 hr.	96.67 (83.73)	3.33 (6.27)	**S.A 1mM 3 hr**	66.67 (54.99)	33.33 (35.01)
EMS 0.25% 2 hr.	86.67 (72.72)	13.33 (17.28)	**S.A 1mM 6hr**	11.67 (19.50)	88.333 (70.50)
EMS 0.25% 3 hr.	70.00 (57.70)	30.00 (32.30)	**S.A 2mM 1hr**	93.33 (78.06)	6.67 (11.94)
EMS 0.25% 4 hr.	73.33 (59.00)	26.67 (31.00)	**S.A 2mM 3hr**	36.67 (37.09)	63.333 (52.91)
EMS 0.5% 1 hr.	100.00 (89.82)	0.00 (0.19)	**S.A 2mM 6hr**	6.67 (8.93)	93.333 (81.07)
EMS 0.5% 2 hr.	70.00 (62.15)	30.00 (27.85)	**S.A 4mM 1 hr**	86.67 (68.86)	13.333 (21.15)
EMS 0.5% 3 hr.	60.00 (50.77)	40.00 (39.23)	**S.A 4mM 3hr**	6.67 (11.94)	93.333 (78.06)
EMS 0.5% 4 hr.	36.67 (37.23)	63.33 (52.78)	**S.A 4mM 6hr**	00.00 (0.11)	100 (89.89)
EMS 0.75% 1 hr.	96.67 (83.73)	3.33 (6.27)	**CD (p=0.05)**	14.75	14.75
EMS 0.75% 2 hr.	60.00 (50.767)	40.00 (39.23)			
EMS 0.75% 3 hr.	60.00 (50.77)	40.00 (39.23)			
EMS 0.75% 4 hr.	46.67 (43.08)	53.33 (46.92)			
CD* (p=0.05)	17.04	17.04			


Phenol Exudation by Nodal Segments in Media (mg/ml)
Phenolic browning of the medium (mg/ml)
Control 1 hr
Control 3 hr
Control 6 hr
S.A 1mM 1 hr
S.A 1mM 3 hr
S.A 1mM 6 hr
S.A 2mM 1 hr
S.A 2mM 3 hr
S.A 2mM 6hr
S.A 4mM 1 hr
S.A 4mM 3 hr
S.A 4mM 6 hr

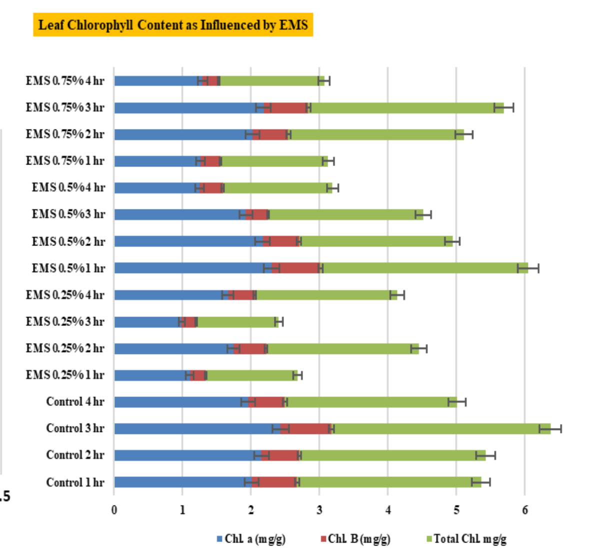
(A)


Phenol Exudation by Nodal Segments in Media (mg/ml)
Phenolic browning of the medium (mg/ml)
Control 1 hr
Control 2 hr
Control 3 hr
Control 4 hr
EMS 0.25% 1 hr
EMS 0.25% 2 hr
EMS 0.25% 3 hr
EMS 0.25% 4 hr
EMS 0.5% 1 hr
EMS 0.5% 2 hr
EMS 0.5% 3 hr
EMS 0.5% 4 hr
EMS 0.75% 1 hr
EMS 0.75% 2 hr
EMS 0.75% 3 hr
EMS 0.75% 4 hr

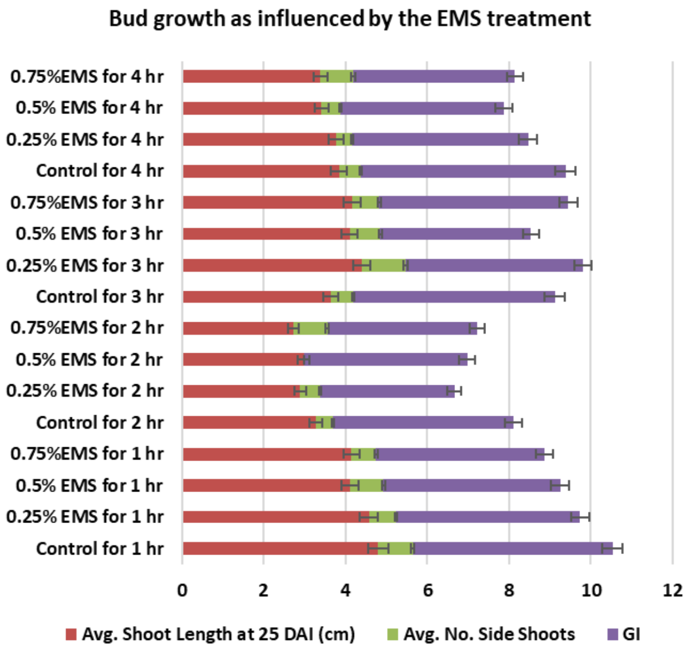
(I)

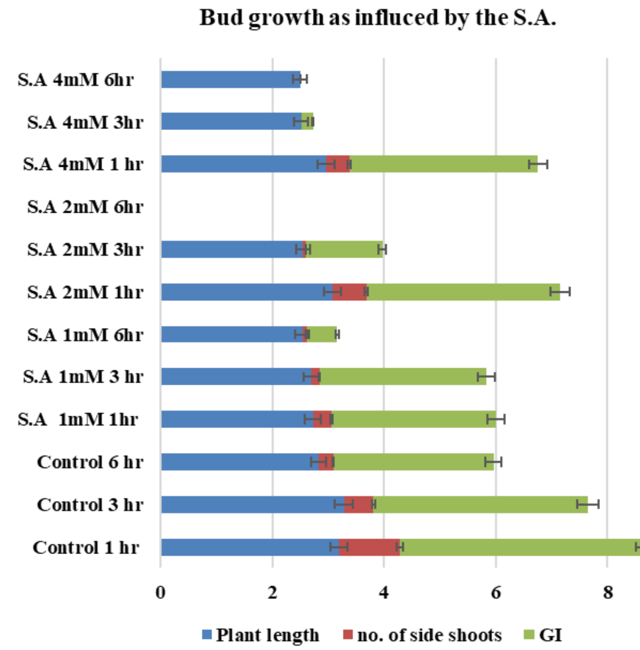

Leaf Chlorophyll Content as Influenced by Sodium Azide Treatment
S.A 4mm 1 hr
S.A 2mm 3hr
S.A 2mm 1 hr
S.A 1mm 6hr
S.A 1mM 3hr
S.A 1mM 1hr
Control 6 hr
Control 3hr
Control 1hr
Chl. a (mg/g)
Chl. B (mg/g)
Total Chl. mg/g

(B)


Leaf Chlorophyll Content as Influenced by EMS
EMS 0.75% 4 hr
EMS 0.75% 3 hr
EMS 0.75% 2 hr
EMS 0.75% 1 hr
EMS 0.5% 4 hr
EMS 0.5% 3 hr
EMS 0.5% 2 hr
EMS 0.5% 1 hr
EMS 0.25% 4 hr
EMS 0.25% 3 hr
EMS 0.25% 2 hr
EMS 0.25% 1 hr
Control 4 hr
Control 3 hr
Control 2 hr
Control 1 hr
Chl. a (mg/g)
Chl. B (mg/g)
Total Chl. mg/g

(II)





(C) (III)

Fig. 10: *In vitro* effect of Sodium Azide (A, B, C) and EMS (I, II, III) treatment in cv. Super Bhagawa on Phenol exudation by nodal segments in media (A, I); Leaf chlorophyll content (B, II) and Bud growth(C, III)

(7) Evaluation of varieties released from ICAR-NRCP

7.1 Comparative evaluation of Solapur Lal

Evaluation of pomegranate variety Solapur Lal in comparison to the ruling variety, Bhagawa during the seventh year of planting in mrig bahar recorded about 19.2 days early maturity, around 25.86% higher yield over Bhagawa besides better fruit quality traits.

			
Bearing plant	**Fruit**	**Fruit exposing arils**	**Arils**
Solapur Lal			

			
Bearing plant	**Fruit**	**Fruit exposing arils**	**Arils**
Bhagawa			

Fig 11. Comparative evaluation of Solapur Lal vs Bhagawa

Table 2. Comparative evaluation of Solapur Lal and Bhagawa

Characters	Solapur Lal	Bhagawa
Plant height (m)	2.30	2.05
Fruit maturity (days)	161.5	180.5
Fruit weight (g)	272.0	278.2
No. of fruits /tree	129.5	98.2
Yield (kg/plant)	35.22	27.31
Yield (t/ha)	26.06	20.2
Aril colour	Deep red	Red
Fruit colour	Red	Red
Rind thickness (mm)	Medium 3.42	Medium 3.38
Juice (%)	42.5	43.5
TSS (^{o}Brix)	17.6	15.7
Titrable acidity (%)	0.4	0.46
Ascorbic acid (mg/100g)	19.2	14.8
Anthocyanin (mg/100g)	395	355
Iron (mg/100g)	1.5	0.9
Zinc (mg/100g)	0.5	0.4

7.2 Comparative evaluation of Solapur Anardana

Evaluation of pomegranate variety Solapur Anardana in comparison to Amlidana during the seventh year of planting in mrig bahar was done. Solapur Anardana recorded 28.16 kg/tree fruit yield, 4.84% titrable acidity and 460.5 mg/100g anthocyanin.

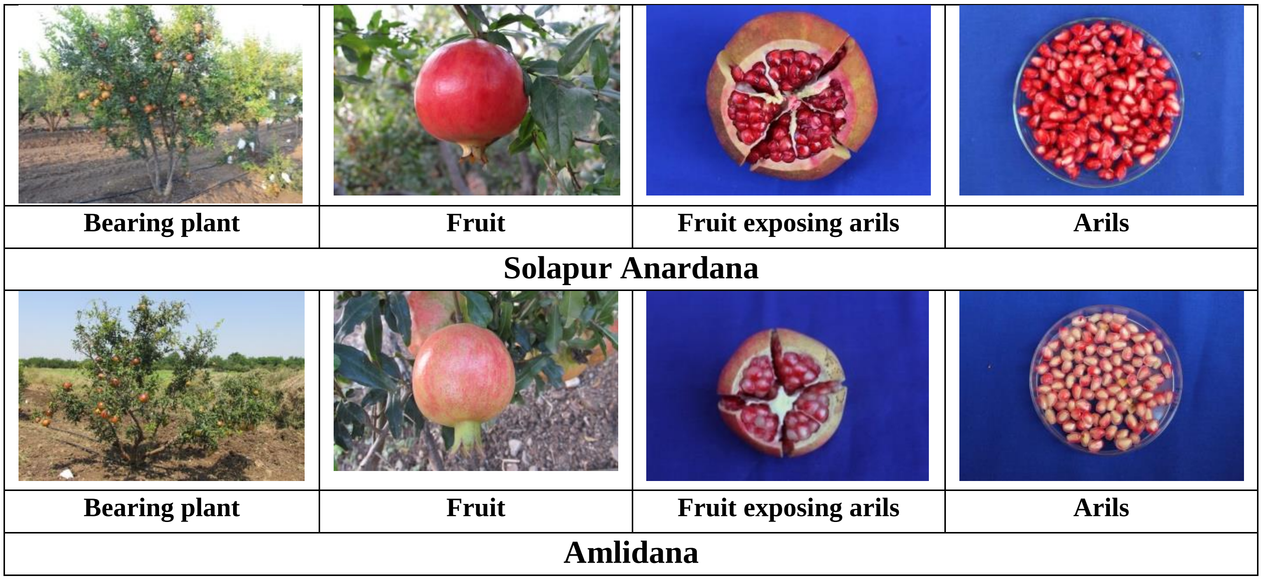


Fig 12. Comparative evaluation of Solapur Anardana with Amlidana

Table 3. Comparative evaluation of Solapur Anardana and Amlidana:

Characters	**Solapur Anardana**	**Amlidana**
Plant height (m)	2.4	1.75
Fruit maturity (days)	145.2	150.2
Fruit weight (g)	275	230.5
No. of fruits /tree	102.4	74.2
Yield (kg/plant)	28.16	17.10
Yield (t/ha)	20.83	12.65
Aril colour	Red	Light pink
Fruit colour	Red	Yellow
Seed texture	Medium	Medium
Juice (%)	41.5	40
TSS (^{o}Brix)	16.66	15.62
Ascorbic acid (mg/100g)	17.8	14
Anthocyanin (mg/100g)	460.5	63.5
Titrable acidity (%)	4.84	4.16

7.3 Evaluation of hybrids developed from ICAR-NRCP:

Twelve hybrids developed at ICAR-NRCP, Solapur were evaluated for yield and quality during sixth year of planting. The yield ranged from 16.73-29.21 kg/ tree. The highest yield was recorded by Bhagawa x [(Ganesh x Nana) x Daru] with 29.21kg/tree. This was followed by Bhagawa x Patna-5 (26.94kg/tree) and Ganesh x Nayana (26.62 kg/ tree).

Table 4. Evaluation of pomegranate hybrids developed by ICAR-NRCP

Hybrid	Fruit weight(g)	No. of fruits/tree	Yield (kg/tree)	TSS (^{o}B)	Titrable acidity (%)
Bhagawa	271.5	92.3	25.56	15.7	0.46
Bhagawa x Patna-5	298.3	90.3	26.94	16.6	0.35
Bhagawa x Nana	224.3	74.6	16.73	14	2.6
Bhagawa x Daru	252.6	84.3	21.29	17	2.8
Bhagawa x Kalpitiya	285.6	90.3	25.79	14.6	0.33
Bhagawa x Nayana	274.3	94.0	25.78	15.9	0.38
Bhagawa x IC-318712	240.6	88.3	21.24	14.8	2.8
Ganesh x Kalpitiya	246.3	84.6	20.84	15.7	0.46
Ganesh x Nayana	285.3	93.3	26.62	16	0.34
Bhagawa x [(Ganesh x Nana) x Daru]-HA	270.5	108.0	29.21	17.2	0.38
Kalpitiya x Ruby	285.3	89.6	25.56	15.7	0.39
Nayana x Ruby	274.6	93.0	25.54	15.5	0.4
Ruby x Nayana	220.3	86.3	19.01	15.4	0.36

		
Bhagwa	**Bhagawa x Patna-5**	**Bhagawa x Nana**
		
Bhagawa x Daru	**Bhagawa x Kalpitiya**	**Bhagawa x Nayana**
		
Bhagawa x IC-318712	**Ganesh x Kalpitiya**	**Ganesh x Nayana**

Bhagawa x [(Ganesh x Nana) x Daru]-HA

Kalpitiya x Ruby

Nayana x Ruby

Ruby x Nayana

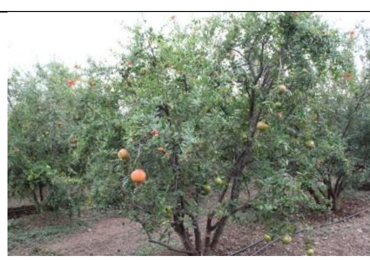
Fig 13. Evaluation of pomegranate hybrids developed by ICAR-NRCP

7.4 Evaluation of pomegranate selections:

Evaluation of fourteen pomegranate selections in comparison with Bhagawa was carried out during seventh year of planting. The study was carried out for various physicochemical characters in Mrig bahar. The results revealed that yield ranged from 26.07 – 30.59 kg/tree. The yield was highest in Sln. 348 (30.59 kg/tree) closely followed by Sln. 528 (30.40 kg/tree). Total soluble solids content ranged from 15.7 to 16.7°Brix.

Table 5. Evaluation of pomegranate selections

Genotype	Fruit weight (g/fruit)	No. of fruits/tree	Yield (kg/tree)	TSS (°B)	Acidity (%)	Fruit Color	Aril Color
Bhagawa	**276.8**	**96.2**	**26.63**	15.7	0.46	Red	Red
IC-24686	272	92.3	25.11	15.9	0.43	Red	Red
Sln.934	271.2	97.3	26.39	15.9	0.37	Yellowish red	Light red
Sln.391	271.6	96	26.07	15.8	0.42	Yellowish red	Light red
Sln.528	281.5	108	30.40	15.9	0.41	Yellowish red	Red
Sln.375	281	102.3	28.75	16.7	0.4	Yellowish red	Light Red
Sln.348	282.5	108.3	30.59	15.9	0.36	Red	Red
Sln.388	274.6	101.6	27.90	16.5	0.41	Yellowish pink	Light red
Sln.317	273.2	99.3	27.13	16.6	0.39	Yellowish pink	Light red
Sln.216	276.4	96.3	26.62	16.3	0.39	Yellowish pink	Light red
Sln.311	286.5	100.6	28.82	16	0.37	Red	Red
Sln.1128	283.2	99.3	28.12	15.9	0.38	Yellowish red	Light red
Sln.1129	273	98.6	26.92	15.8	0.41	Yellowish red	Light red
Sln.1121	269.8	99.3	26.79	15.9	0.39	Yellowish red	Light red
Sln.1130	273.4	103.6	28.32	15.9	0.41	Yellowish red	Red

	
Bhagawa	**Bhagawa**
	
IC-24686	**IC-24686**
	
Sln.934	**Sln.934**
	
Sln.391	**Sln.391**

	
Sln.528	**Sln.528**
	
Sln.375	**Sln.375**
	
Sln.348	**Sln.348**
	
Sln.388	**Sln.388**

	
Sln.317	**Sln.317**
	
Sln.216	**Sln.216**
	
Sln.311	**Sln.311**
	
Sln.1128	**Sln.1128**

	
Sln.1129	**Sln.1129**
	
Sln.1121	**Sln.1121**
	
Sln.1130	**Sln.1130**

Fig 14. Evaluation of pomegranate selections

7.5 Identification of promising hybrids for table and processing purpose:

Evaluation of 25 NRCP hybrids during seventh year of planting led to the identification of NRCP H-14 for table purpose and NRCP H-4 for anardana / processing purpose. The salient characters of NRCP H-14 is mentioned below.

Characters	NRCP H-14
Maturity (days)	164.5
No. of fruits/plant	121.2
Fruit weight (g)	279.8
Fruit yield (kg/plant)	33.9
100 aril weight (g)	32.8
TSS (^{o}Brix)	17.82
Acidity (%)	0.42
Ascorbic acid (mg/100g)	19
Anthocyanin (mg/100g)	124.1

NRCP H-14

Fig 15. Pomegranate hybrid NRCP H-14

Table 6: The salient features of pomegranate hybrid NRCP H-4 is as follows.

Characters	NRCP H-4
Maturity (days)	149.5
No. of fruits/plant	112
Fruit weight (g)	270.2
Fruit yield (kg/plant)	29.8
100 aril weight (g)	30.26
TSS (^{o}Brix)	16.24
Acidity (%)	5.76
Ascorbic acid (mg/100g)	18.6
Anthocyanin (mg/100g)	60.5

NRCP H-4

Fig 16. Pomegranate hybrid NRCP H-4

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Crop Improvement

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

Wet lab validation of chromosome-specific SSR markers -

For wet-lab validation of the SSRs, we screened 235 primer pairs on six pomegranate genotypes i.e. Bhagawa, Daru 17, Mridula, P-23, IC 318728, and IC 318790. As a result, 225 (94.5%) yielded the amplicons of expected size, whereas 10 remaining primer pairs did not show any amplification. A total of 221 (98.2%) SSRs were polymorphic across six pomegranate genotypes **(Fig 1A).** Using SSR markers, we detected 797 alleles among six genotypes. The number of alleles for loci ranged from 1 to 8, with an average of 3.59. The observed (*Ho*) and expected heterozygosity (*He*) for each locus ranged from 0 to 1 (with a mean of 0.58) and 0 to 0.86 (with a mean of 0.61), respectively, and the Shannon's information index ranged from 0.00 to 2.02 with a mean of 1.08. The polymorphism information content (PIC) ranged from 0 (for HvSSRT_416) to 0.96 (HvSSRT_891) with a mean value of 0.68. A total of 187 markers had PIC values ≥ 0.5. The frequency analysis of HvSSRT markers with respect to number of alleles showed that 78 markers had two alleles while eight alleles were obtained for two markers **(Fig.2 A &B).**

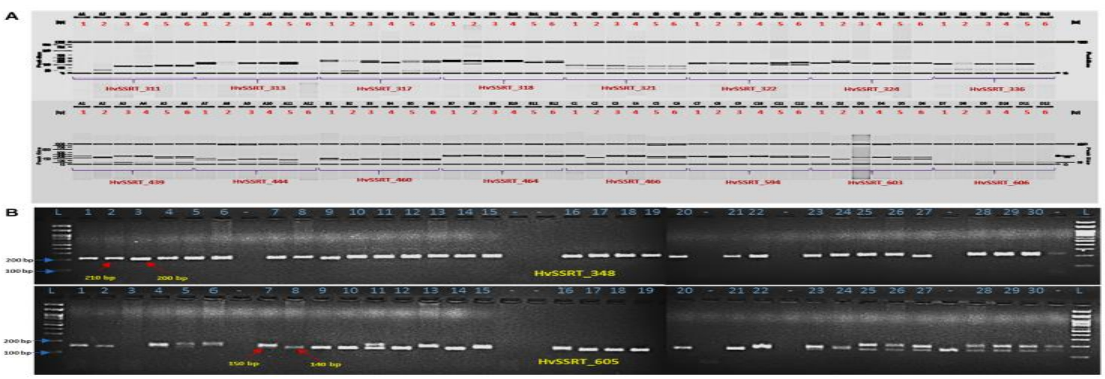


Fig.1 Gel images showing screening of HvSSRT markers on six pomegranate genotypes using fragment analyzer (A), HvSSRT markers 348 and 605 on 30 pomegranate genotypes on 3% metaphor gels (B).

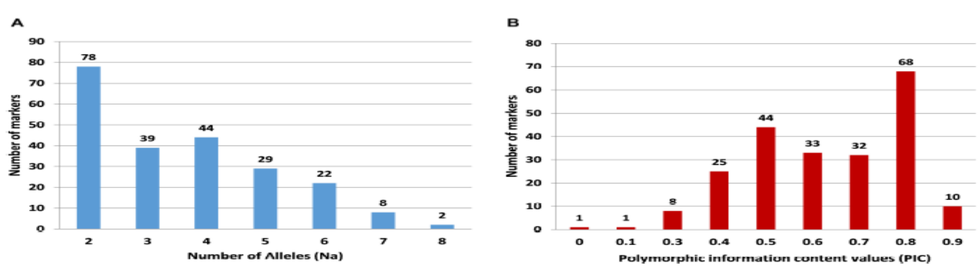


Fig.2 Frequency distribution of SSR with respect to number of alleles (A) and PIC values (B).

Genetic diversity analysis

A subset of 16 HvSSRs located on eight chromosomes, selected from each chromosome based on their clear amplification profiles observed on six genotypes, were tested on 30 pomegranate genotypes **(Fig. 1B),** and a total of 34 alleles were detected with an average of 2.13 alleles across the pomegranate genotypes. The Ho ranged from 0 to

0.52, with an average number of 0.23. The PIC values ranged from 0.33 to 0.60, with an average of 0.48. In the NJ tree, all 30 pomegranate genotypes were grouped into two major clusters: cluster 1 comprised 11 while cluster 2, 19 genotypes **(Fig. 3A).** Cluster 1 carried 9 wild genotypes with an exceptional placement of one wild genotype (Daru 17) within cluster 2. Cluster 2 had all cultivars (18), with exception of out grouping of two cultivars Muscat and Jodhpur Red in cluster 1. Furthermore, the PCoA assigned 30 genotypes to two major clusters **(Fig. 3B).** The principal coordinates (PCos) 1 and 2 explained 21.16 and 12.24%, respectively, of the total variance among the genotypes and accounted for 33.84% of the total variation. Interestingly, PCo 1 clearly separated two clusters into wild and cultivar groups.

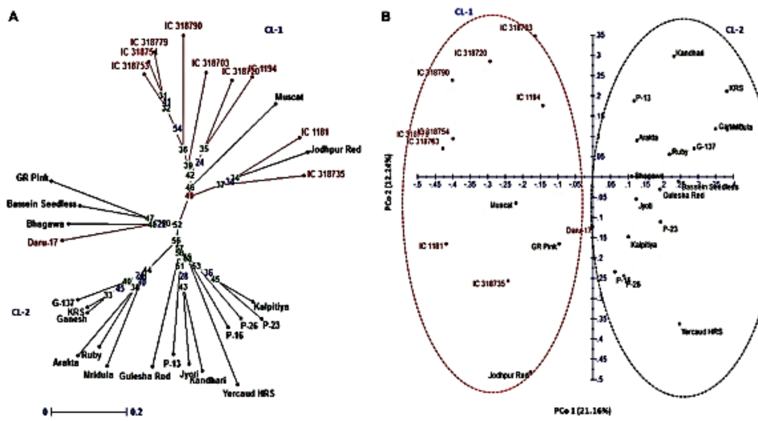


Fig. 3 Genetic relationships among 30 pomegranate genotypes based on 16 HvSSRT markers

Parental polymorphism study and genotyping of mapping population -

For parental polymorphism study screened 127 HvSSRT primers between Bhagawa x Daru 17 and identified 90 informative SSR markers for linkage map construction. Genotyping of F_1 mapping population (70 individuals) was initiated with 6 SSR markers i.e.HT178, HT115, HT16, P42, P13 and P19 **(Fig. 4)**.

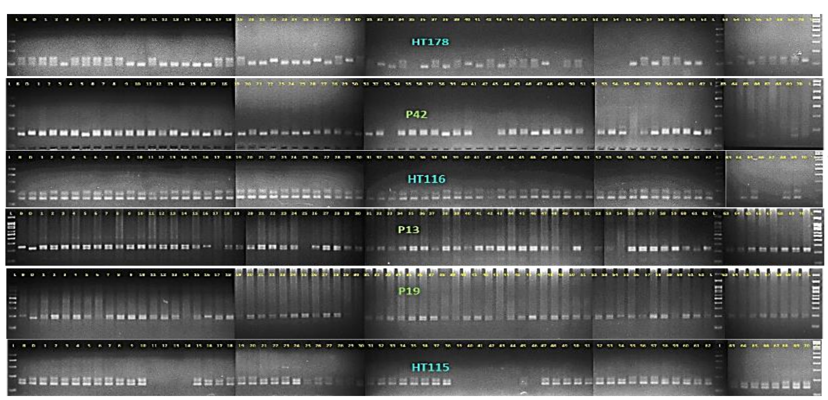


Fig.4 Genotyping of F_1 population Bhagawa X Daru 17 using hypervariable SSR markers

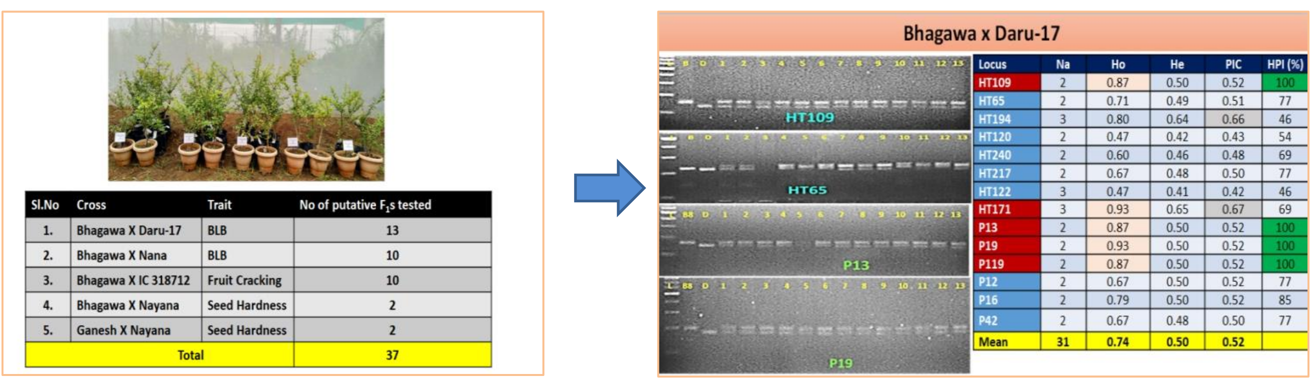
Development of mapping populations

The propagation, advancement and planting of F_1 population in the field were accomplished under Augmented Block design for mapping genes/QTLs for fruit quality traits **(Fig. 5A &B)**. Apart from this using 33

HvSSRs, we identified cross specific highly heterotic F_1 hybrid plants for five crosses *i.e.* Bhagawa x Daru 17, Bhagawa x Nana, Bhagawa x IC318712, Bhagawa x Nayana and Ganesh x Nayana for mapping important genes or QTLs for fruit quality traits in pomegranate **(Fig. 6).** Hybridity analysis of putative F_1s resulted in identification of highly informative SSR primers for hybridity analysis in each of the crosses *i.e.* 14 primers for the first cross, 10 for the second, 12 for the third and 6 markers each for the fourth and fifth cross. Further, for the first cross Bhagawa x Daru 17, four primers (HvSSRT_375, NRCP_SSR9, NRCP_SSR12 and NRCP_SSR92) were found highly informative with 100% hybrid purity index, higher PIC (~0.52) and Ho (range 0.87- 0.93) values, and two F_1s namely H1 and H2 were found highly heterotic with heterozygosity index of 92.85 %. Similarly, for Bhagawa x Nana three primers (HvSSRT_375, HvSSRT_605 and NRCP_SSR19) were found highly informative with hybrid purity index (70-100%), higher PIC (0.52- 0.69) and Ho (0.75- 0.33) values, and three F_1s H1, H2 and H4 had 70 % heterozygosity index. For Bhagawa x IC318712, four SSRs namely HvSSRT_254, HvSSRT_348, HvSSRT_826 and NRCP_SSR95 were found highly informative with higher Ho (~0.83), HPI (100%) and PIC (~0.52) values, and four F_1s H2, H7, H9 and H10 had 91.66 % heterozygosity index. However, for Bhagaw x Nayana cross three SSRs namely HvSSRT_605, HvSSRT_826 and HvSSRT_432 and for Ganesh x Nayana, HVSSRT_375, HVSSRT_605 and HvSSRT_826 revealed co-dominant allelic patterns in the putative F_1s to confirm true hybrids. Further, cluster and principal coordinate analysis revealed Bhagawa as female parent in combination with wild donors Daru17, Nana and IC318712 have revealed higher genetic diversity as compared to their hybrid progenies.

(A) **(B)**

Fig. 5 Multiplication and advancement of F_1 population in the nursery (A) and planted in the field (B).



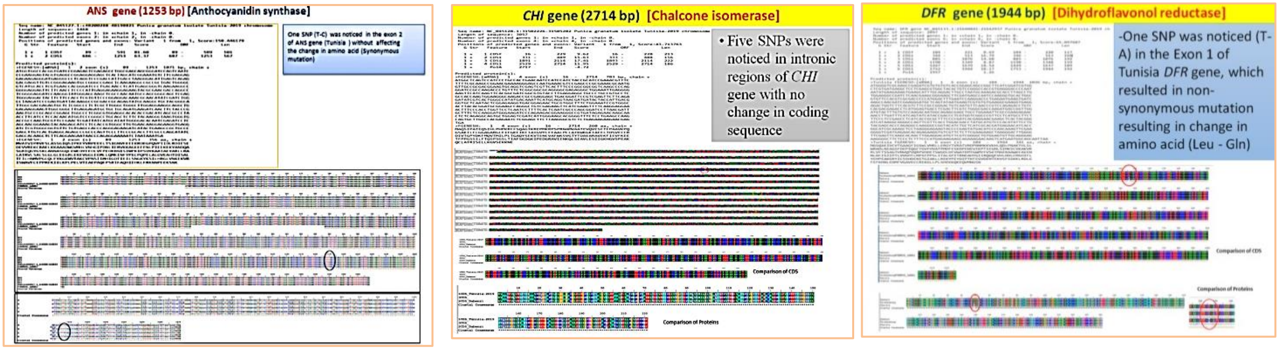
Sl.No	Cross	Trait	No of putative F_1s tested
1.	Bhagawa X Daru-17	BLB	13
2.	Bhagawa X Nana	BLB	10
3.	Bhagawa X IC 318712	Fruit Cracking	10
4.	Bhagawa X Nayana	Seed Hardness	2
5.	Ganesh X Nayana	Seed Hardness	2
Total			37

Locus	Na	Ho	He	PIC	HPI (%)
HT109	2	0.87	0.50	0.52	100
HT65	2	0.71	0.49	0.51	77
HT194	3	0.80	0.64	0.66	46
HT120	2	0.47	0.42	0.43	54
HT240	2	0.60	0.46	0.48	69
HT217	2	0.67	0.48	0.50	77
HT122	3	0.47	0.41	0.42	46
HT171	3	0.93	0.65	0.67	69
P13	2	0.87	0.50	0.52	100
P19	2	0.93	0.50	0.52	100
P119	2	0.87	0.50	0.52	100
P12	2	0.67	0.50	0.52	77
P16	2	0.79	0.50	0.52	85
P42	2	0.67	0.48	0.50	77
Mean	31	0.74	0.50	0.52	

Fig. 6 Hybridity analysis of putative F_1s using hypervariable SSR markers in five crosses of pomegranate

Structural variation analysis and PCR amplification of candidate genes involved in Anthocyanin synthesis pathway

In order to develop candidate gene based markers retrieved full length gene sequences of five genes (ANS, CHS, CHI, F3H and DFR) that are part of Anthocyanin biosynthesises pathway from NCBI database for Tunisia genome and compared with Dabenzi and Taishanhong genes. After multiple sequence alignment, we identified sequence variations in three key genes ANS (1.2 Kb), CHI (2.7 Kb) and DFR (1.9 Kb), designed primers, standardized PCR conditions to amplify in 10 pomegranate varieties differed for fruit and aril colour for allele mining **(Fig. 7).**



Phenotypic data on fruit and aril colour of ten commercial pomegranate varieties

Sl. No	Genotypes	Fruit colour			Aril colour		
		L* Average	a* Average	b*Average	L* Average	a* Average	b*Average
1	Solapur Lal	16.51	42.85	17.61	32.43	34.47	16.52
2	Bhagawa	15.978	42.311	23.619	31.982	34.266	17.788
3	Arakta	11.731	39.068	19.015	28.416	28.195	14.870
4	Mridula	10.943	38.745	18.016	25.305	25.742	12.488
5	Ruby	37.096	37.419	28.445	22.280	28.400	13.530
6	Kabul yellow	59.492	11.297	27.893	53.662	12.807	20.919
7	Kandhari	52.653	11.035	34.622	45.580	13.840	20.533
8	Ganesh	65.908	17.994	34.370	45.530	16.960	16.750
9	Jyoti	60.574	15.491	24.088	50.494	18.476	19.050
10	G137	51.567	18.220	11.020	46.860	18.220	18.380

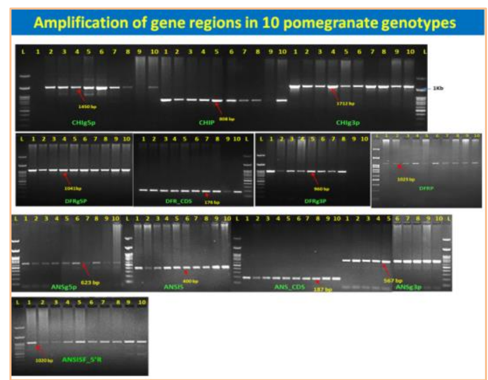


Fig.7 Structural variation analysis and amplification of candidate genes for fruit colour in 10 pomegranate varieties

Through *in silico* analysis reconfirmed that point mutation in Anthocyanidin reductase (ANR) gene could be responsible for black peel color in pomegranate **(Fig.8).**

Fig.7 Multiple sequence analysis to reconfirm point mutation in *ANR* gene for black peel colour

2.1 DRAFT GENOME SEQUENCING OF POMEGRANATE (*PUNICA GRANATUM* L.) CV. BHAGAWA

Mapping to the reference mitochondrial genome

Mitochondrial assembly: The PacBio reads were aligned against the plant mitochondrial genomes downloaded from NCBI and then sub sampled with minimum of 1000 read length. Then, the subsampled reads were aligned against the closest reference mitochondrial genome (*Eucalyptus grandis:* NC_040010.1). In case of Illumina reads, we mapped back all the clean reads to the reference mitochondria genome (*Eucalyptus grandis:* NC_040010.1). All the libraries were passed onto BWA for the alignment.

Table 1: Statistics of the Reference Genome

Name	Length of Genome (bp)
Eucalyptus grandis mitochondrion	478813

Table 2: Mito Reads Mapped against *Eucalyptus grandis*

Sample	No. Of Mito Reads
PacBio	154084
Illumina	584777 (R1)

Mitochondrial genome Assembly

All the samples were further processed for mitochondrial assembly. In case of Bhagawa sample (1) the assembly was performed using hybrid approach i.e. both Illumina and PacBio reads were used by MaSuRCA (Maryland Super-Read CAbog). The hybrid assembly approach provides a way to simplify and reduce the cost of the assembly by reducing long-read coverage requirements. Masurca uses short reads to correct sequencing errors in PacBio data and then creates an assembly from the corrected reads.

However, in case of other samples having only Illumina data was used by GetOrganelle tool. The GetOrganelle uses SPAdes assembler for k-mers building the initial de Bruijn graph and on following stages it performs graph-theoretical operations which are based on graph structure, coverage and sequence lengths. Moreover, it adjusts errors iteratively.

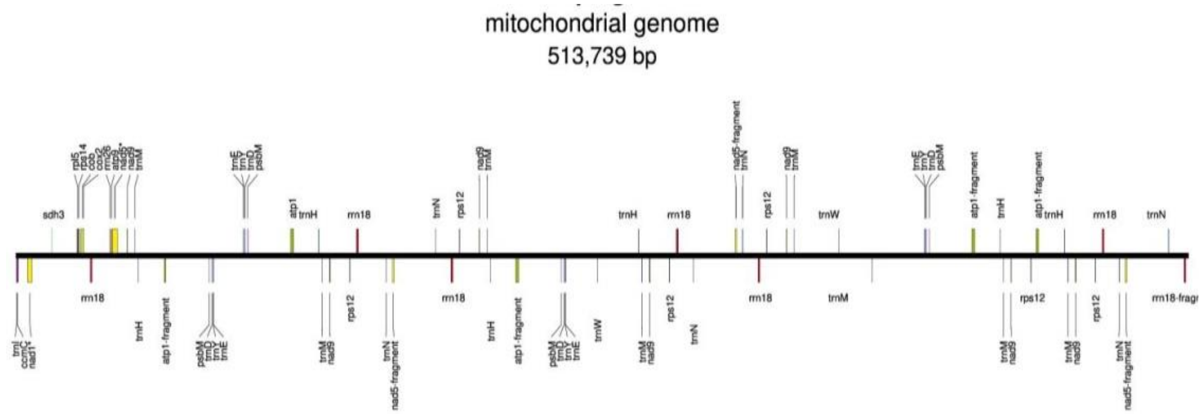
Mitochondrial assembly statistics for the given samples

Sample	Assembly Stats	GC_Content
1 (Bhagwa)	513739	0.38
2	305899	0.46
3	308572	0.46
4	307336	0.46
5	306567	0.46
6	305167	0.46
7	299394	0.46
9	399235	0.46
11	307341	0.46
12	307154	0.46
20	306737	0.46
29	307053	0.46
30	306881	0.46
35	304930	0.46

37	307242	0.46
48	307176	0.46

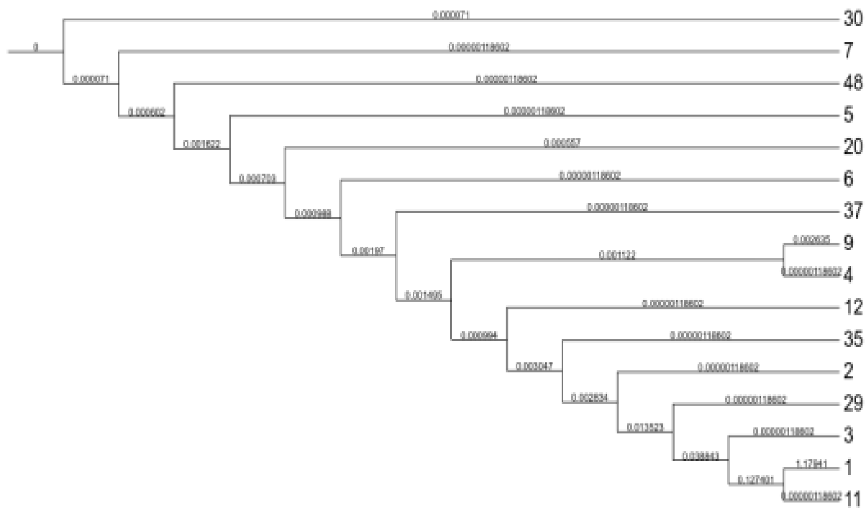
Mitochondrial Genome Annotation

The mitochondrial genome annotation for all 16 samples was performed using GeSeq tool. The GeSeq is used for the rapid and accurate annotation of organellar genome sequences. In contrast to existing tools, GeSeq combines batch processing with a fully customizable reference sequence selection of organellar genome records from NCBI and/or references uploaded by the user. GeSeq identifies genes or other feature-encoding regions by BLAT-based homology searches and additionally, by profile HMM searches for protein and rRNA coding genes and two *denovo* predictors for tRNA genes. Below figure highlights the annotation for bhagwa sample (1).



Phylogenetic relationship

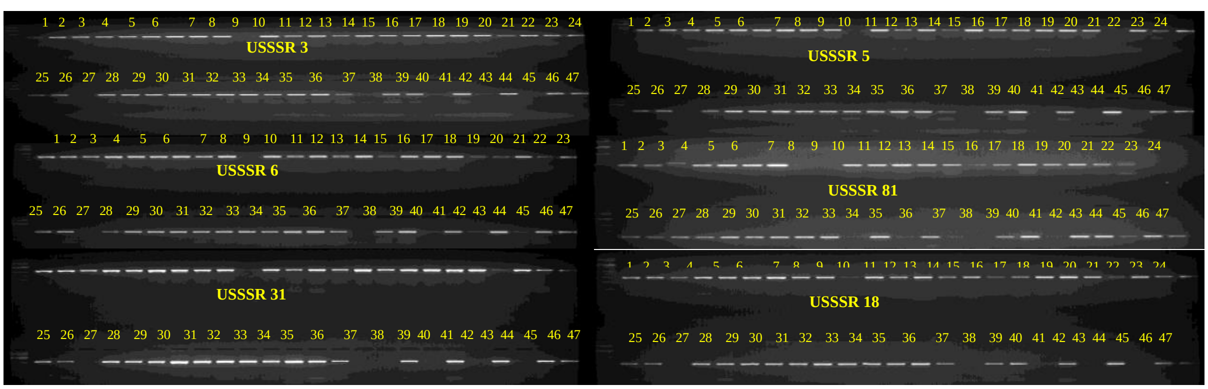
To infer orthogroups and to provide phylogenetic inference of orthologs, we have used OrthoFinder tool. It provides high accuracy orthogroup inference of orthologs, rooted gene trees, gene duplication events, the rooted species tree, and comparative genomics statistics. Finally, OrthoFinder's comprehensive phylogenetic analysis is achieved with equivalent speed and scalability to the fastest, score-based heuristic methods (Fig).



Phylogenetic relationships between the samples

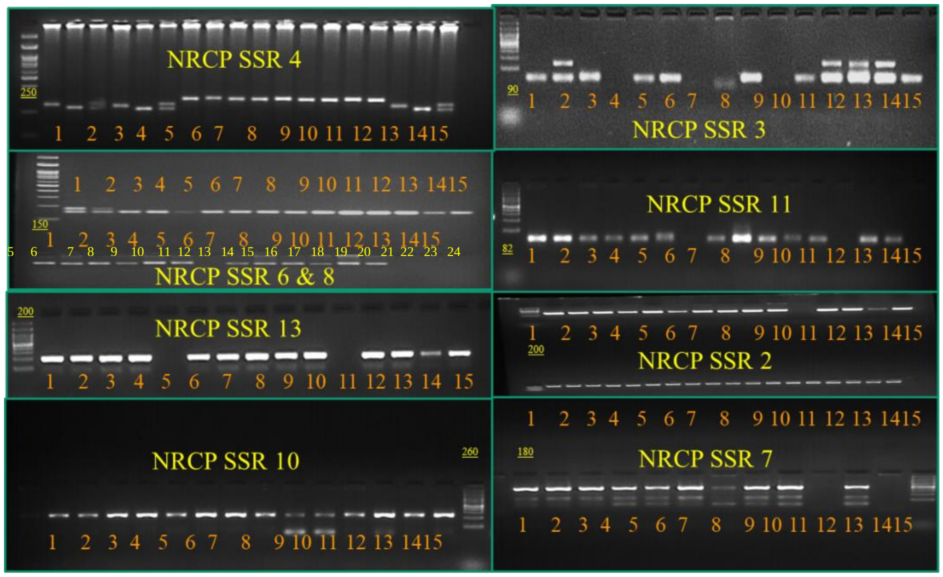
Genome wide Association mapping:

Out of 96 germplasm lines were selected based on morphological and quality trait for genome wide association mapping. In this year 48 germplasm lines has been genotyped of by using genome wide SSR markers. A total of 120 SSR markers has been screened, out of which only 35 SSR markers found to be polymorphic.

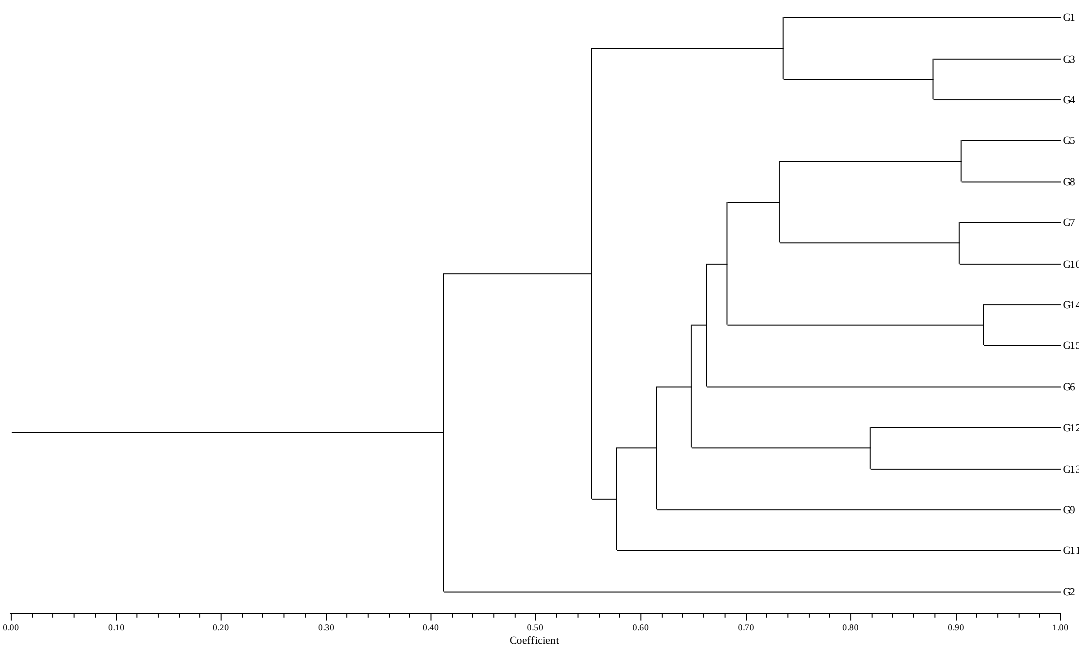


Validation of genomic SSR markers

On 15 selected genotypes the newly designed SSR markers has been validated. A set 30 SSR has been designed by using genome sequence of Bhagawa by using MISA and synthesised these have been validated. The results were reproducible on the genotypes studied out 30 SSR 15 were found polymorphic. The number alleles varied from 0 – 4 alleles. The PIC percent ranged from 0- 33.33. the large set of marker validation is under progress.



Validation of SSR Markers developed from Bhagawa genome sequence information



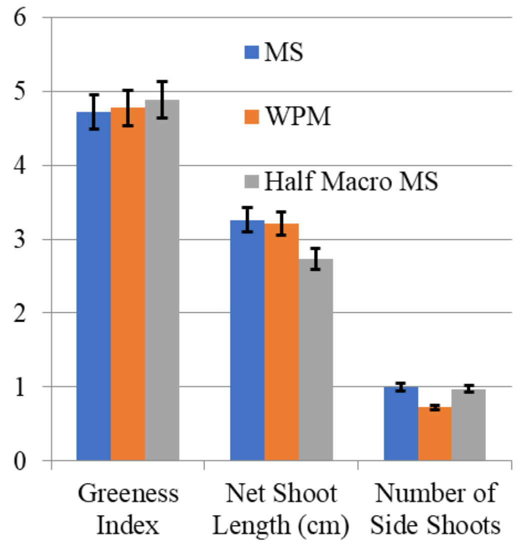
Cluster analysis of 15 genotypes based on new SSR markers designed by using genome sequence of bhagawa.

Plant Propagation

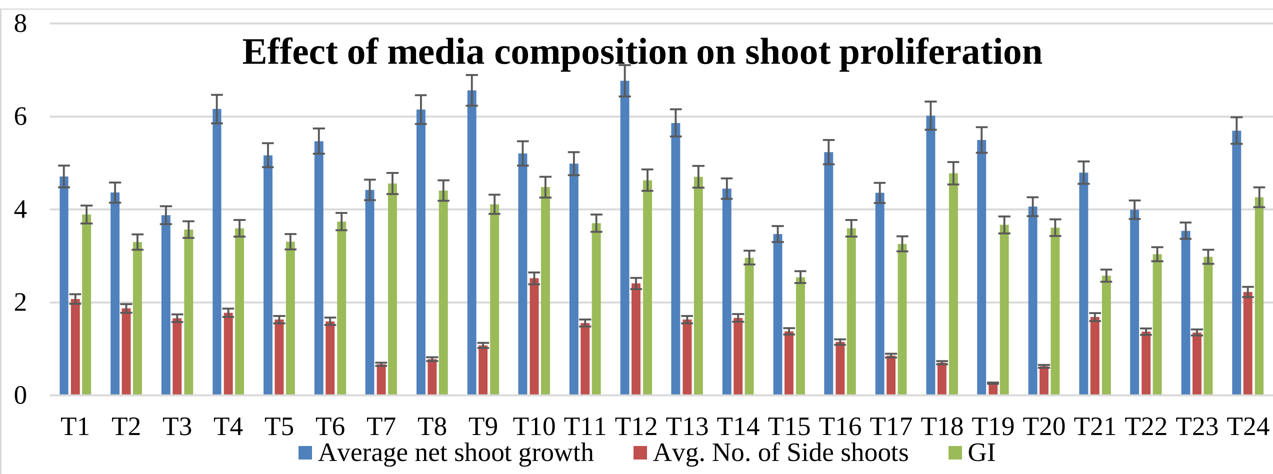
3.1 PROJECT: COMBATING STRESSES AND IMPROVING QUALITY IN POMEGRANATE (Punica granatum L.) BY EXPLOITING ROOTSTOCKS

***In vitro* propagation of 'Solapur Lal':** Various explant pre-treatments, basal media, growth regulator combinations and media supplement combinations were tried in experimental mode with 83.60% establishment, 3.67 proliferation and 51.54% *in vitro* rooting success, further refinement of protocol in under progress**.**

Solapur Lal- *in vitro* establishment, proliferation and rooting	
Establishment (E2SP- a modified MS medium)	**83.60%**
Avg. Proliferation Rate/ microshoot (side shoots+ vertical splitting)	**3.67**
In vitro rooting	**51.54 %**



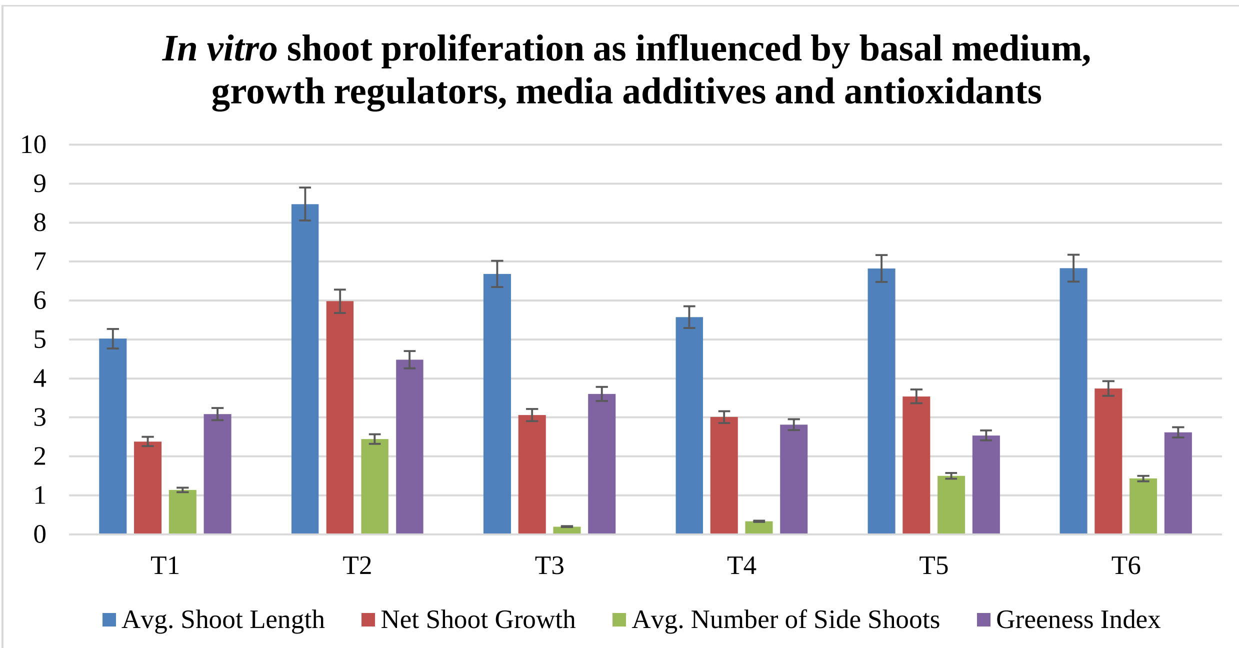
Refinement in *in vitro* propagation of 'Bhagawa' and 'Super Bhagawa': The maximum net shoot growth of microshoots and the average maximum side shoots were obtained on modified MS medium with proliferation rate of more than 7.32 per shoot (combining vertical splitting and side shoots).



T12: WPM basal Medium + additional NH_4NO_3 + 50 mg/l Adenine Sulphate + Sodium Phosphate Monobasic + IAA 0.25 mg/l + NAA 0.1 mg/l

T10: WPM basal Medium + additional NH_4NO_3+50 mg/l Adenine Sulphate + IAA 0.25 mg/l + NAA 0.1 mg/l

T24: MS basal medium with additional $CuSO_4$ and $COCl_2$ + NAA 0.15 mg/l + BAP 0.3 mg/l + 50 mg/l Adenine Sulphate + Ascorbic Acid



Treatment Details:

T1: Modified MS (Reduced NH_4NO_3 and enhanced $FeSO_4$-EDTA, KI, $CuSO_4$, $CoCl_2$ and Thiamine) + $AgNO_3$ + BAP (0.3)+NAA (0.15) + SPM (221) + AA (2)

T2: Modified MS (Reduced NH_4NO_3 and enhanced $FeSO_4$-EDTA, KI, $CuSO_4$, $CoCl_2$ and Thiamine) + $AgNO_3$ + BAP (0.3)+NAA (0.15) + SPM (221) + AA (2)

T3: DKWJ+ $AgNO_3$ + BAP (0.3)+NAA (0.15) + SPM (221) + AA (2)

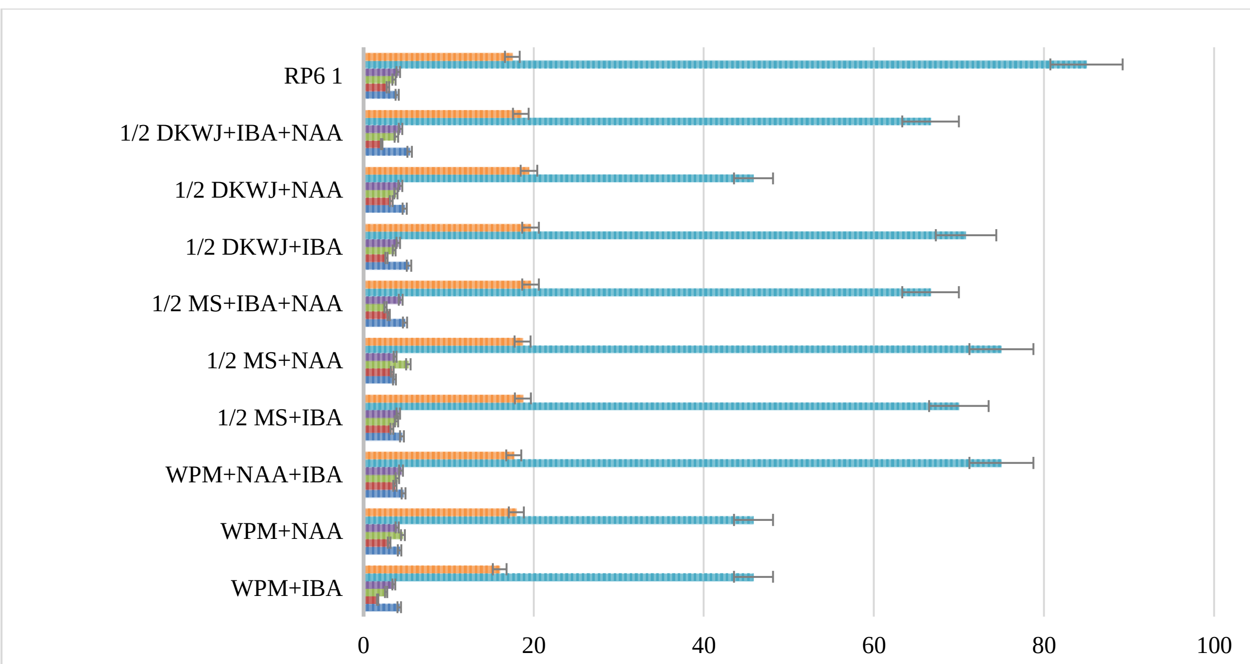
T4: DKWJ+ $AgNO_3$+ BAP (0.3)+NAA (0.15) + SPM (221) + AA (4)

T5: Modified WPM with enhanced NH_4NO_3 + $AgNO_3$ + BAP (0.3) + NAA (0.15) + SPM (221) + AA (2)

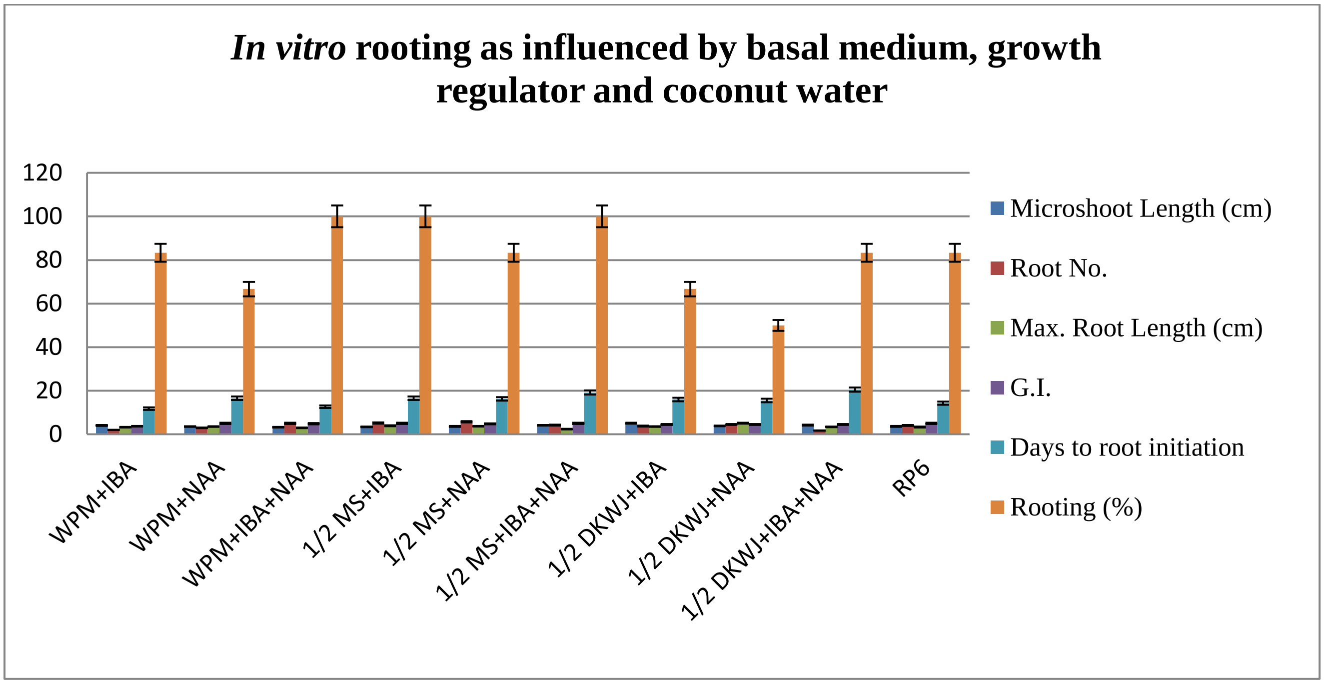
T6: Modified WPM with enhanced NH_4NO_3+ $AgNO_3$ + BAP (0.3) + NAA (0.15) + SPM (221) + AA (4)

In vitro shoot proliferation

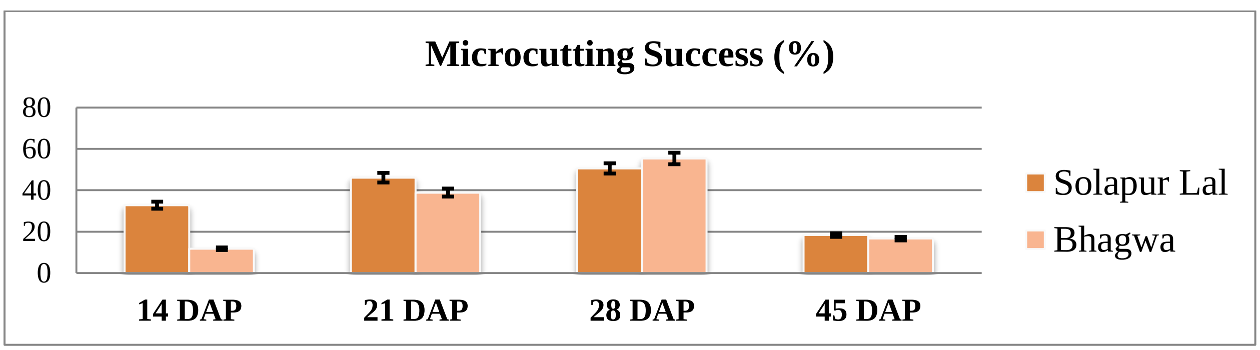
***In vitro* rooting of micro-shoots:** The average of *in vitro* rooting in different basal medium reveals the maximum *in vitro* rooting in WPM medium. The effect of addition of 5 % coconut water (v/v) to the medium was found to be very promising in enhancing *in vitro* rooting of pomegranate micro-shoots. Almost all the rooting parameters were found to be improved with the addition of coconut water as high as 100% *in vitro* rooting was observed with as low as 12.67 days to root initiation.



Effect of basal media, adsorbing agents and growth regulators on *in vitro* rooting of micro-shoots



Micro-cutting in pomegranate: Single nodal soft wood stem segments (4-5cm long) of ‘Bhagawa’ and ‘Solapur Lal’ were used as explant for *in vivo* micro-cutting after following sanitation protocol. The final micro-cutting success of ‘Solapur Lal’ and ‘Bhagawa’ at 45 days after planting was 18.33% and 16.67 %, respectively.



Screening for pomegranate genotypes/cultivars/accessions against *Ceratocystis* wilt for utilizing them as rootstocks:

Disease reaction type	Pomegranate accessions/genotypes/cultivars
Slow wilting type (6 to 12 months) (Wilting started 6 month API)	EC-626968, ACC9, IC-318706, IC-318707
Early wilting type (1 to 6 months) (Wilting started 1 month API)	Bhagwa, Solapur Lal EC- 676960, 676927, 676930, 676838, 676923 IC-318718, 318754, 1181,1182, 1202, Patna 5

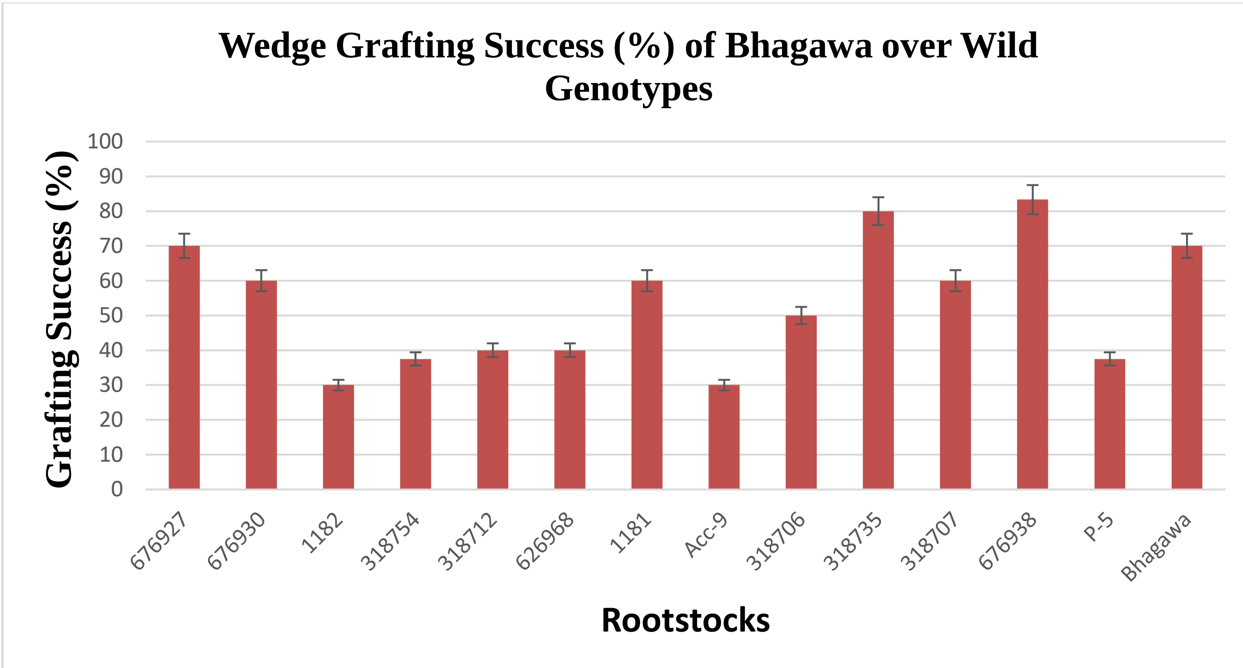
Note:

API: after pathogen inoculation, Pathogen: *Ceratocystis fimbriata*

Inoculum load: 1 X 10^8 cfu/ml, Number of germplasm screened (2020-2021): 20

Number of plants used for screening per genotype/cultivar/accessions:05

Slow Wilting Types **Wilt Susceptible Types**



Wedge grafting in pomegranate by using promising rootstocks: the promising genotypes against salinity and *Certocystis fimbriata* were utilized as rootstock using Bhagawa scion and wedge grafting. The grafting success ranged from 30% to 83.33%.

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Crop Production

4.1 Project: Crop Regulation Practices for Improving Productivity of Pomegranate

Crop load optimization through thinning in pomegranate variety Solapur Lal:

Pomegranate variety Solapur Lal is a hybrid variety with vigorous nature. It has a tendency to produce continuous bloom, profuse flowers and overbearing of fruits throughout the tertiary branches. This often leads to medium sized fruits due to competition for nutrients. In order to improve the fruit size, the surplus fruits beyond a limit should be removed after fruitset through fruit thinning. An experiment was conducted in Solapur Lal by adopting six thinning levels viz., without thinning (control): > 135 fruits/tree; verylight thinning: 121 - 135 fruits/tree; light thinning: 106-120 fruits/tree; medium thinning: 91- 105 fruits/tree; heavy thinning: 76-90 fruits/tree and very heavy thinning: 61-75 fruits/tree. The results revealed that light thinning of fruits resulted in better fruit size (274.8g/fruit) and optimum yield (30.99kg/tree) which is superior over the control.

Thinning Level	No. of fruits/ tree	Mean fruit weight (g)	Yield (kg/plant)	Yield (ton/ha)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100g)
Control (without thinning)	142.6	252.5	36.01	26.64	17.4	0.42	19.2
Very light thinning	130.3	265.2	34.56	25.57	17.5	0.42	19.2
Light thinning	115.6	275.6	**31.86**	23.58	**17.6**	0.4	19.4
Medium thinning	96.6	279.3	26.98	19.96	17.6	0.4	19.4
Heavy thinning	85.3	282.6	24.11	17.84	17.7	0.39	19.5
Very heavy thinning	72.3	284.5	20.57	15.22	17.8	0.39	19.6

Control

Very light thinning

Light thinning

Medium thinning	Heavy thinning	Very heavy thinning

Fig. Crop load optimization through thinning

Effect of 2,4 D on Flower / Fruit Drop:

In pomegranate, the crop regulation helps to produce uniform flowering and fruiting. However, there is fruitdrop during different stages of fruitgrowth, especially after fruitset. Fruit drop due to hormonal imbalance could be managed through extraneous application of suitable auxins. An experiment was conducted in pomegranate variety Bhagawa during hasthbahar. Foliar spray of growth regulator: 2,4-D at six concentrations (5,10,15,20,25 and 30ppm) along with a control. The increase in concentration of 2,4-D significantly reduced the flower drop. With minimum no. of dropped flowers (21.3 flowers/tree). Hence, 2,4-D @20ppm was found to be highly beneficial for management of fruit drop.

Concentration of 2,4-D (ppm)	Total No. of bisexual flowers	No. of bisexual flowers dropped	No. of bisexual flowers retained	Fruitset (%)	No. of fruits/ Plant	Fruit weight (g)	Yield (kg/tree)
5 ppm	195.6	37.3	158.3	52.11	82.5	260.2	21.47
10 ppm	194.3	33.3	161.0	52.16	84.5	263.4	22.26
15 ppm	191.9	26.6	165.3	53.84	89.0	266.3	23.70
20 ppm	188.3	**21.3**	167.0	58.06	**96.5**	**268.2**	**25.88**
25 ppm	184.2	21.6	162.6	57.81	94.0	267.4	25.14
30 ppm	182.6	22.3	160.3	55.83	89.5	265.6	23.77
Control (Unsprayed)	198.3	48.0	150.3	51.42	72.0	255.2	18.37

		
2,4-D@5ppm	2,4-D@10ppm	2,4-D@15ppm
		
2,4-D@20ppm	2,4-D@25ppm	2,4-D@30ppm
		
	Control	

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

Induction of flowering in pomegranate:

Crop regulation in pomegranate is done during different bahar viz., mrig, hasth and ambia bahar. Flowering in pomegranate often becomes a problem in hasth bahar due to dropdown of temperature. For induction of flowering in pomegranate, an experiment was conducted during hasth baharin A4 block, Kegaon, with the following treatments viz., foliar spray of Ammonium nitrate (0.25%, 0.50%, 0.75%), Naphthalene acetic acid (5ppm, 10ppm, 15ppm) and micronutrient mixture ie. Rexolin (0.1%,0.2%,0.3%) along with an unsprayed control. The results revealed that NAA @ 10ppm concentration was found to be extremely useful for induction of flowering in pomegranate.It resulted in highest fruitset (53.46%), no. of fruits/tree (98.0/tree) and yield (26.87kg/tree).

Treatment	**No. of bisexual flowers /plant**	**No. of fruits / plant**	**Fruitset (%)**	**Fruit weight (g)**	**Yield (kg/plant)**	**Yield (t/ha)**
Ammonium Nitrate@ 0.25%	179.6	87.6	48.78	261.5	22.91	16.95
Ammonium Nitrate@ 0.50%	186.3	92.6	49.70	268.4	24.85	18.39
Ammonium Nitrate@ 0.75%	183.6	94.3	51.36	269.6	25.42	18.81
NAA@5ppm	182.6	92.3	50.55	270.4	24.96	18.47
NAA@10ppm	183.3	**98.0**	**53.46**	**274.2**	**26.87**	**19.88**
NAA-@15ppm	181.3	96.6	53.28	273.5	26.42	19.55
Micronutrient mixture @0.1%	180.6	88.3	48.89	261.2	23.06	17.07
Micronutrient mixture @ 0.2%	197.3	92.3	46.78	264.2	24.39	18.05
Micronutrient mixture @0.3%	190.6	93.0	48.79	264.6	24.61	18.21
Control (Unsprayed)	178.3	79.6	44.64	242.5	19.30	14.28

		
Ammonium Nitrate @0.25%	Ammonium Nitrate @0.50%	Ammonium Nitrate @0.75%
		
NAA @ 5. ppm	NAA@ 10. ppm	NAA @15 ppm
		
Micronutrient @0.1%	Micronutrient @0.2%	Micronutrient @0.3%
		
	Control	

Fig. Induction of flowering in pomegranate

For induction of flowering in pomegranate during hasthbahar, another experiment was conducted in H4 block, Hiraj with the following 8 treatments compared with a control. The Growth regulators /chemicals were foliar sprayed twice to the pomegranate trees during second fortnight of November at 15 days interval. The treatments include : IAA @20ppm, 2,4-D@10ppm, Daminozide@500ppm, Ethephon@700ppm followed by BAP@10ppm at one week later, Nitrobenzene 20%@0.2%, potassium nitrate@1.0%, silver nitrate @0.01%, Micronutrient mixture ie.Yaravita @ 0.2% alongwith a control. Foliar spray of potassium nitrate@1.0% resulted in highest no. of fruits (98.2), fruit weight (275.4g) and yield (27.04kg/plant). Control recorded the lowest fruit yield (19.79kg/plant).

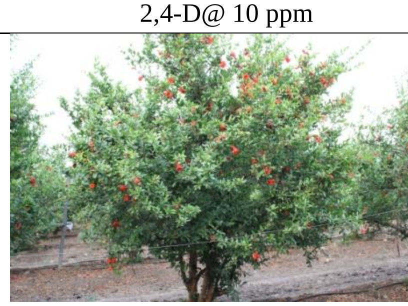
Treatments	No. of flowers /plant	No. of fruits / plant	Fruitset (%)	Fruit weight (g)	Yield (kg/plant)	Yield (t/ha)
IAA @20ppm	195.6	97.5	49.85	265.6	25.90	19.16
2,4-D@10ppm	188.0	101.5	53.99	273.2	27.73	20.52
Daminozide@500ppm	184.3	102.3	55.51	274.1	28.04	20.75
Ethephon@700ppm fb. BAP@10ppm at one week later	186.0	96.6	51.94	270.2	26.10	19.31
Nitrobenzene 20%@2ml/l	190.3	97.0	50.97	269.4	26.13	19.34
Potassium Nitrate@1%	185.6	**103.5**	**55.77**	**275.2**	**28.48**	**21.08**
Silver nitrate @0.01%	182.3	100.3	55.02	271.2	27.20	20.13
Micronutrient mixture @0.2%	193.6	97.0	50.10	261.4	25.36	18.76
Control	180.3	83.3	46.20	244.6	20.38	15.08


IAA @20 ppm


2,4-D@ 10 ppm


Daminozide@ 500 ppm


Ethrel@1.75 ml /l + BAP@10mg/l after one week


Nitrobenzene 20 % @2ml/l


Potassium Nitrate@ 1.0%


Silver Nitrate@0.01%


Micronutrient mixture@0.2%


Control

Fig. Induction of flowering in pomegranate

4.2. PACKAGE OF PRACTICES FOR ORGANIC CULTIVATION OF POMEGRANATE

Effect of new micronutrient formulations (Formulation I and Formulation II) on nutritional status, flowering, fruit yield and quality of pomegranate

Two new formulations (Formulation I & II) were evaluated for the third season under field condition and compared with commercially available EDTA-micronutrient formulation. The nutritional status of trees after foliar application of Formulation I revealed that there was significant increase in Mn and Cu concentration in leaves at higher dose (@ 2.5 ml l^{-1}) while at lower dose (@ 1 ml l^{-1}) significant increase in Fe and Cu concentration was noted. The effect of formulation was seen on the flowering behavior of the tree. Significant increase in male and hermaphrodite flowers and fruit set was noticed. The highest number of hermaphrodite flowers (38.89% increase) was recorded at higher dose while the highest number of male flowers (40.41% increase) was recorded with lower dose of the formulation. An increase of 14.24-18.84% in fruit set was noticed with the formulation. Spraying of formulations increased fruit yield by 31.39-42.96% over the commercial micronutrient formulation (Grade-II) and the highest fruit yield of 20.13 kg $tree^{-1}$ was recorded with higher dose of the formulations. Even the yield obtained with lower dose of formulations was at par with that recorded from the use of commercial micronutrient formulation plus two sprays of gibberellic acid (@50 ppm). Significant improvement in fruit size was also noticed. About 39.51-42.77% fruit was above 250g while it was only 34.27% with commercial micronutrient formulation. Substantial improvement in aril and juice percent, 100 arils weight and rind thickness was observed with the sprays of formulations. Besides, significant improvement in phenol, anthocyanin concentration and sugar content in fruit was also noted.

Table 1. Effect of new formulations on fruit yield and size distribution of pomegranate

Effect of bio-organic fertilizer on biomass partitioning, soil enzyme activity, microbial biomass carbon and nutrient uptake by pomegranate

Treatment	Fruit yield (kg tree^{-1})	Per cent fruit weighing >250 g	Per cent fruit weighing <250 g
T1: Control	11.96^{d}	24.08^{d}	75.92^{a}
T2: EDTA micronutrient @ 1 g l^{-1} (three sprays)	14.08^{c}	34.27^{c}	65.73^{b}
T3: Formulation I followed by two sprays of Formulation II @ 2.5 ml l^{-1}	20.13^{a}	42.77^{a}	57.23^{d}
T4: Formulation I followed by two sprays of Formulation II @ 1.0 ml l^{-1}	18.50^{b}	39.51^{b}	60.49^{c}
T5: EDTA micronutrient @ 1 g l^{-1}(three sprays + Gibberellic acid @ 50 ppm (two sprays)	19.08^{b}	40.63^{b}	59.37^{c}
LSD$\alpha_{0.05}$	0.67	1.97	2.02

A new bio-organic product has been developed and evaluated under pot culture experiment at graded dose in pomegranate. The data revealed that application of newly developed bio-organic fertilizer significantly enhanced shoot, root and total biomass and subsequently the shoot-root ratio. The highest increase in biomass (43.46% increase in shoot, 14.48% increase in root and 35.68% increase in total biomass) was noted with the application of bio-organic fertilizer at the rate of 150 g plant^{-1}.

Table 2. Effect of bio-organic fertilizer on plant biomass partitioning

Treatment	Above ground biomass (g plant^{-1})	Root biomass (g plant^{-1})	Total biomass (g plant^{-1})	Shoot-root ratio
T1: Control	165.86^{c}	60.96^{bc}	226.82^{c}	2.73^{c}
T2: K solubilizing bio-formulation @ 20 g plant^{-1}	219.18^{ab}	61.34^{bc}	280.52^{ab}	3.58^{a}
T3: Bio-organic fertilizer @ 150 g plant^{-1}	237.95^{a}	69.79^{a}	307.74^{a}	3.41^{ab}
T4: Bio-organic fertilizer @ 300 g plant^{-1}	222.37^{ab}	62.46^{abc}	284.83^{ab}	3.57^{a}
T5: Bio-organic fertilizer @ 600 g plant^{-1}	211.56^{b}	57.99^{c}	269.56^{b}	3.66^{a}
T6: Recommended dose of P and K through chemical fertilizers	203.64^{b}	68.35^{ab}	271.98^{b}	2.98^{bc}
LSDα0.05	22.20	8.22	28.66	0.48

Soil enzymes activities were assayed at 90 and 150 days after application of bio-organic fertilizer. The results indicated that application of bio-organic fertilizer significantly enhanced dehydrogenase, acid and alkaline phosphatase enzyme activities and the highest enzyme activities were recorded at the bio-organic fertilizer dose of 600 g plant^{-1} even after 150 days of application. Similarly, microbial biomass carbon content of soil increased significantly at both the times i.e. 90 and 150 days after application of bio-organic fertilizer. Like soil enzyme activities, the highest microbial biomass carbon was recorded with the bio-organic fertilizer when applied at the dose of 600 g plant^{-1}.

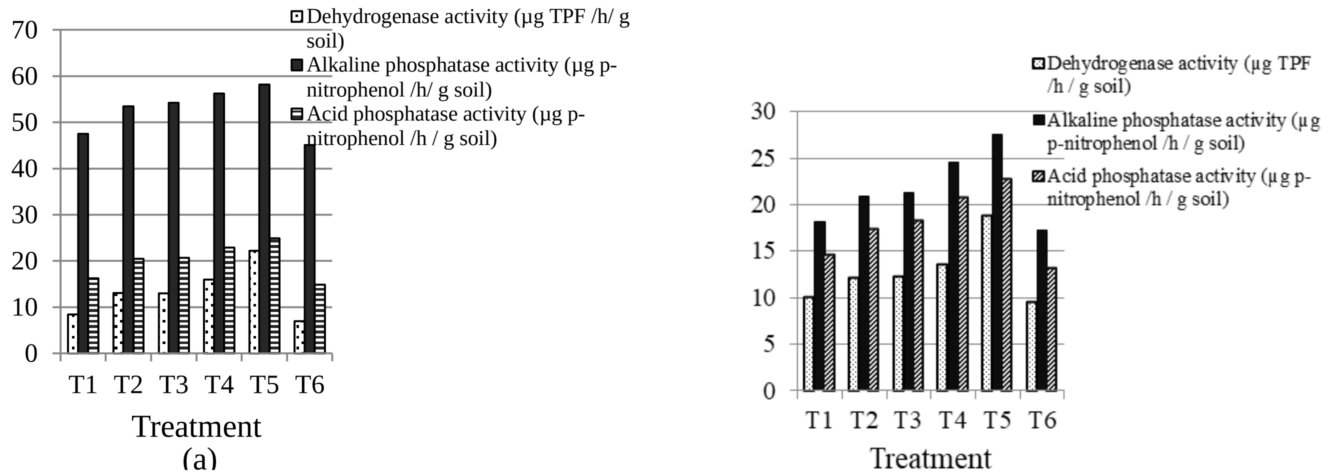


Fig. **1 Effect of bio-organic fertilizer on soil enzyme activities at (a) 90 and (b) 150 days after application**

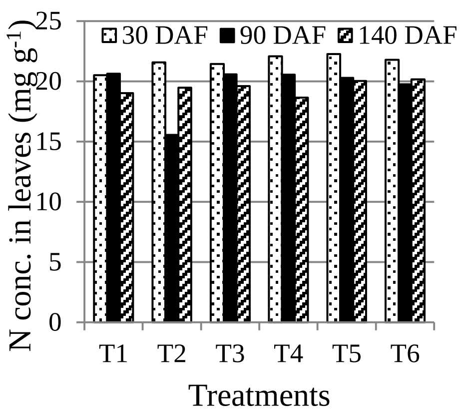
Significant increase in uptake of N, P and K was observed with the application of bio-organic fertilizer. The highest uptake of N, P and K (N-uptake increased by 53.98%, P-uptake increased by 32.44% and K-uptake increased by 33.42%) was recorded with the application of bio-organic fertilizer at the rate of 150 g plant^{-1} which was even significantly higher than that recorded with recommended dose of P and K fertilizers. The uptake of N, P and K with bio-organic fertilizer when applied at the rate of 150 g plant-1 was even significantly higher than that recorded with the application of *Penicillium pinophilum* based K-solubilizing bio-formulation at the rate of 20 g plant^{-1}.

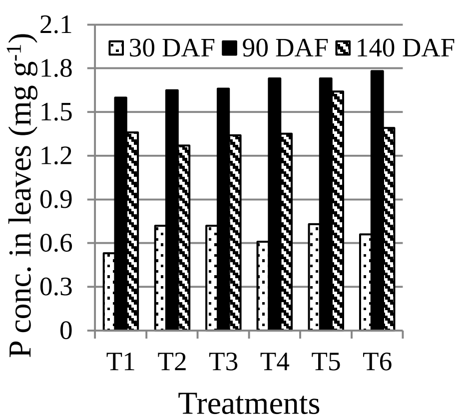
Table 3. Effect of bio-organic fertilizer on nutrient uptake by the plant

Treatment	Nutrient uptake (mg plant^{-1})		
	Nitrogen	Phosphorus	Potassium
T1: Control	1729.41^{e}	940.78^{e}	259.05^{d}
T2: K solubilizing bio-formulation @ 20 g plant^{-1}	2470.32^{b}	1105.54^{c}	311.88^{b}
T3: Bio-organic fertilizer @ 150 g plant^{-1}	2663.00^{a}	1245.95^{a}	345.63^{a}
T4: Bio-organic fertilizer @ 300 g plant^{-1}	2238.90^{c}	1059.75^{d}	313.34^{b}
T5: Bio-organic fertilizer @ 600 g plant^{-1}	2058.62^{d}	1074.57^{cd}	290.21^{c}
T6: Recommended dose of P and K through chemical fertilizers	2097.57^{d}	1171.48^{b}	311.44^{b}
LSDα0.05	44.45	38.85	17.02

Effect of bio-organic fertilizer on temporal changes of nutrients in leaves and soil

Leaves samples were collected at 30, 90 and 140 days after flowering (DAF) to assess the nutritional status of pomegranate trees in response to the application of bio-organic fertilizer. The data revealed that trees treated with bio-organic fertilizer @ 300 and 600 g tree^{-1} showed significant increase in leaf N concentration only at 30 DAF while at 90 and 140 DAF, no significant increase in leaf N concentration was noticed. Significant changes in leaf P concentration were noted in response to bio-organic fertilizer application. Application of *Penicillium pinophilum* based K-solubilizing bio-formulation and bio-organic fertilizer significantly increased leaf P concentration at 30 and 90 DAF and the leaf P concentration was even at par with that recorded in trees treated with chemical P and K fertilizers at recommended dose. While, application of bio-organic fertilizer @ 600 g tree^{-1} could significantly enhance leaf P concentration at 140 DAF which was at par with that recorded in trees treated with chemical P and K fertilizers at recommended dose. Although, application of K-solubilizing bio-formulation did not significantly enhanced leaf K concentration at 30 and 90 DAF, application of bio-organic fertilizer significantly increased leaf K concentration at all the sampling date i.e. 30, 90 and 140 DAF. At 30 DAF, the highest leaf K concentration was noted with the application of bio-organic fertilizer @ 600 g tree^{-1} which was at par with that recorded in trees treated with chemical P and K fertilizers at recommended dose. While the highest leaf K concentration at 90 and 140 DAF was recorded with the application of bio-organic fertilizer at the rate of 300 g tree^{-1} which was even significantly higher than that recorded with the chemical P and K fertilizers at recommended dose.





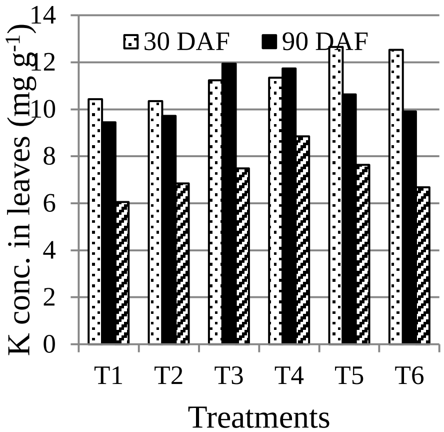


Fig. 5 Effect of bio-organic fertilizer on temporal changes of N, P and K concentration in leaves during the fruit growth and development period.

Soil available nutrient status was evaluated periodically at 30, 60, 90 and 120 DAF to monitor the changes in soil fertility in response to bio-organic fertilizer application. Significant increase in available N content was observed at 60, 90 and 120 DAF in bio-organic fertilizer treated soil. The highest available N content at 60 DAF was recorded with the application of bio-organic fertilizer @ 150 g tree^{-1} which was at par with that recorded in chemical P and K fertilizers application at recommended dose. While at 90 and 120 DAF, the highest available N content was observed with the application of bio-organic fertilizer @ 300 g tree^{-1} which was even higher than that recorded with chemical P and K fertilizers at recommended dose.

Unlike available N, significant increase in soil available P content was noted in bio-organic fertilizer treated soil at 30, 60 and 90 DAF. However, no significant improvement in available P content was observed at 120 DAF in response to bio-organic fertilizer application. The highest available P content at 30 DAF was recorded with bio-organic fertilizer applied at the rate of 150 g tree^{-1} and 600 g tree^{-1} which were at par with each other. At 60 DAF all the bio-organic fertilizer and K-solubilizing bio-formulation treated soil showed significantly higher available P content and they were all at par with each other. Application of bio-organic fertilizer @ 300 and 600 g tree^{-1} registered significantly higher available P content in soil at 90 DAF. So the effect of bio-organic fertilizer on available P content was seen as early as 30 DAF and lasted up to 90 DAF. Significant increase in available K content was noted with the application of bio-organic fertilizer at 30, 90 and 120 DAF. But the highest available K content in soil was recorded with the application of chemical P and K fertilizers at recommended dose. Application of K-solubilizing bio-formulation and bio-organic fertilizer significantly increased available S content at 60 DAF and the highest available S content was noted with the application of bio-organic fertilizer @ 150 g tree^{-1}. While application of K-solubilizing bio-formulation, bio-organic fertilizer @ 150 g tree^{-1} and chemical P and K fertilizer at recommended dose resulted significant increase in available S content in soil at 30 DAF and the highest available S content was recorded with chemical P and K fertilizers applied at recommended dose.

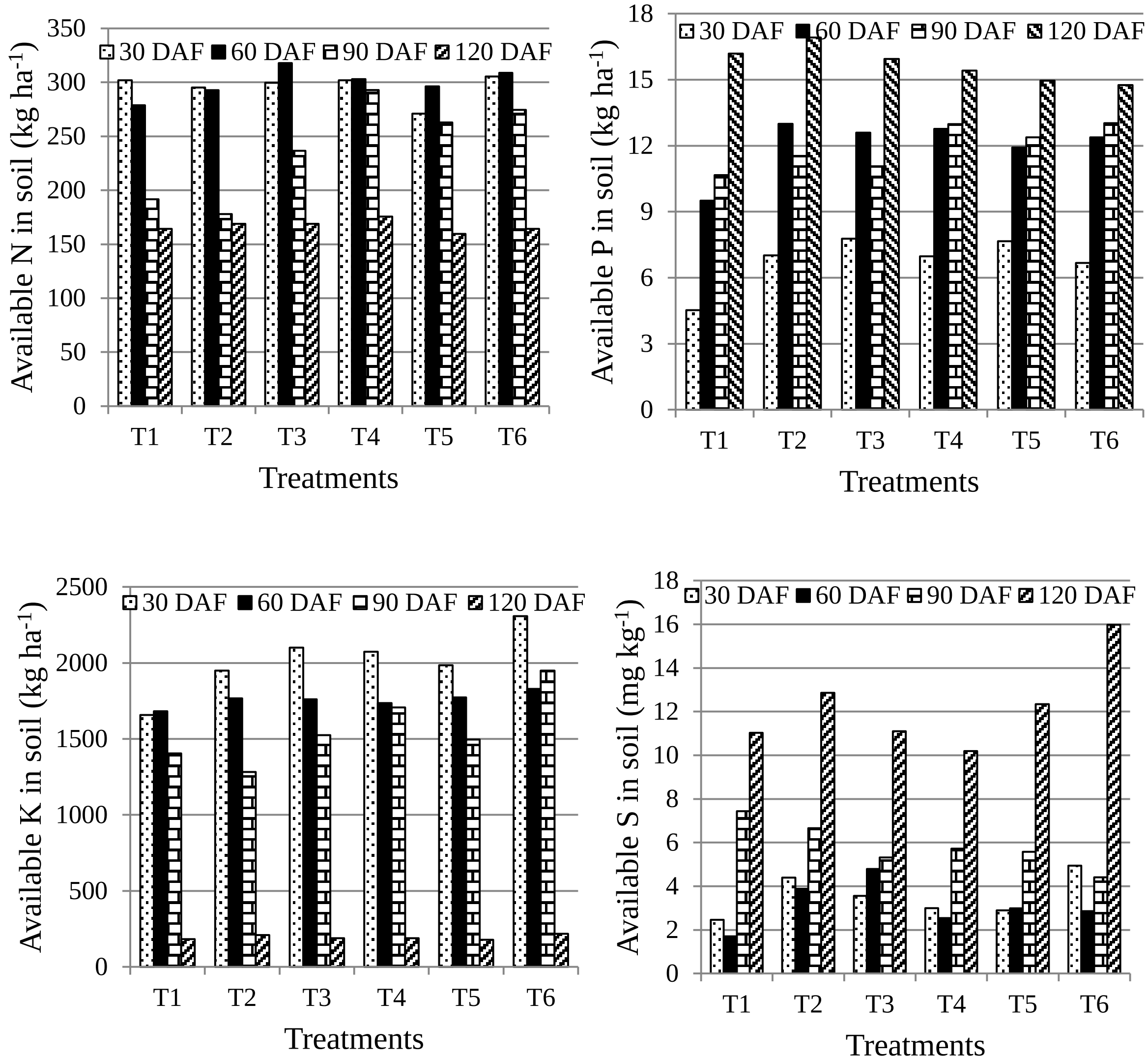


Fig. 6 Effect of bio-organic fertilizer on temporal changes of soil available N, P, K and S content during the fruit growth and development period.

Effect of bio-organic fertilizer on flowering, fruit yield and quality

A field experiment was conducted to evaluate the efficacy of bio-organic fertilizer in influencing flowering, fruit yield and quality of pomegranate. The data indicated that application of bio-organic fertilizer significantly increased number of male and hermaphrodite flowers and fruit set per cent. The highest number of hermaphrodite flowers was recorded with the chemical P and K fertilizers at recommended dose, while the highest per cent fruit set (69.90%) was noted with the application of bio-organic fertilizer when applied at the rate of 300 and 600 g tree^{-1} which were at par with each other. Application of bio-organic fertilizer significantly increased fruit yield by 48.23-55.32% over the *Penicillium pinophilum* based K-solubilizing bio-formulation application @ 20 g tree^{-1}. There was no significant difference in fruit yield with different doses of bio-organic fertilizer application. Even, the fruit yield obtained with the use of bio-organic fertilizer was significantly higher than recorded with the application of P and K chemical fertilizers at recommended dose. Significant improvement in fruit size was also observed with the application of bio-organic fertilizer. The per cent of fruits above 250 g weight ranged from 38.94-46.47% and the highest per cent of fruits weighing more than 250 g was obtained with the application of bio-organic fertilizer at the rate of 150 g tree^{-1}. While only 27.86% fruits was above 250 g weight in K-solubilizing bio-formulation treated trees.

Substantial increase in fruit attributes viz. aril and juice per cent and 100 arils test weight was noted with the application of bio-organic fertilizer. Significant improvement in juice acidity, ascorbic acid and anthocyanin concentration was recorded with the application of bio-organic fertilizer at the rate of 150-300 g tree^{-1}.

Table 4. Effect of bio-organic fertilizer on flowering, fruit set, yield and fruit size distribution

Treatments	Flowers (Nos.)			Fruit set (%)	Yield (kg tree^{-1})	Per cent fruit >250 g	Per cent fruit <250 g
	Male	Herma -phrodite	Total				
T1: Control	96^{d}	98^{c}	194^{d}	49.58^{e}	9.86^{d}	25.76^{d}	74.24^{a}
T2: K solubilizing bio-formulation @ 20 g tree^{-1}	107^{c}	100^{c}	207^{c}	59.42^{c}	12.98^{c}	27.86^{d}	72.14^{a}
T3: Bio-organic fertilizer @ 150 g tree^{-1}	153^{a}	132^{b}	285^{a}	66.21^{b}	20.16^{a}	46.47^{a}	53.53^{d}
T4: Bio-organic fertilizer @ 300 g tree^{-1}	133^{b}	128^{b}	261^{b}	69.90^{a}	20.09^{a}	43.34^{b}	56.66^{c}
T5: Bio-organic fertilizer @ 600 g tree^{-1}	137^{b}	128^{b}	264^{b}	69.56^{a}	19.24^{a}	38.94^{c}	61.06^{b}
T6: Recommended dose of P and K through chemical fertilizers	150^{a}	140^{a}	288^{a}	57.17^{d}	17.45^{b}	44.31^{ab}	55.69^{cd}
LSD$\alpha_{0.05}$	4.70	4.97	6.65	1.63	1.33	2.29	2.86

Evaluation of bio-efficacy of bio-pesticides in combination with insecticides against fruit borer and sucking pest of pomegranate

The combination of the two insecticides and three bio-pesticides were field evaluated for the for their bio-efficacy against the pomegranate sucking pests and pomegranate fruit borer. The treatment T1 (Spinosad+ Neem oil) recorded the least pest population at 3 and 7 days after spray and the results are consistent in all the three spays with 1.62, 0.87, 4.0 and 2.54, 0.87 and 3.16 at 3 and 7 days after spray respectively. The treatment T4 (Spinetoram+ Neem oil) in all the three recorded the 1.83, 1.0, 3.95 and 3.83, 0.83, 3.91 average no. of thrips in 3days after and 7 days after spray respectively (Table 1). The result indicates the neem oil is best compatible bio-pesticides with insecticide Spinosad and Spinetoram. The best combination will be further evaluated for further for the detailed study.

Table. 1 Bio-efficacy evaluation of the insecticides and bio-pesticide combinations against the sucking pests and pomegranate fruit borer

Treatments details	Dose ml/l	Pre-population count (Avg)	Ist spray		IInd spray		IIIrd spray	
			3DAS	7DAS	3DAS	7DAS	3DAS	7DAS
Spinosad+ Neem oil (T1)	0.5+3.0	7.62	1.62	2.54	0.83	0.87	4.00	3.16
Spinosad+ Karanja oil (T2)	0.5+3.0	7.12	2.25	2.91	0.91	1.00	4.91	3.66
Spinosad+ Mustard oil (T3)	0.5+3.0	6.75	1.58	3.41	0.95	0.70	4.00	3.87
Spinetoram+ Neem oil (T4)	1.0+ 3.0	6.12	1.83	3.83	1.00	0.83	3.95	3.91
Spinetoram+ Karanja oil (T5)	1.0+3.0	4.62	2.12	5.04	1.16	1.04	4.25	4.20
Spinetoram+ Mustard oil (T6)	1.0+3.0	7.87	2.91	6.79	1.70	1.04	4.95	4.25
Control (T7)	--	8.37	4.33	8.37	4.12	4.25	10.70	9.25

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Crop Protection

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

1. Bioefficacy evaluation of newer insecticides formulations against pomegranate stem borer (*Coelosterna spinator*)

An experiment was conducted to evaluate the bioefficacy of the six different insecticides against pomegranate stem borer in 3 different treatment methods viz., Stem injecting, Drenching, and, Stem injecting + Drenching (Fig.1) at 2ml/g/l water (Table.1).

Stem injecting: Among the seven treatments by injecting method, treatments T1 and T7 gave 66.67% plant recovery and in all remaining treatments it was 33.33%, and in control, no plant recovery was recorded.

Drenching: Among the seven treatments by drenching method, treatments T1 and T7 gave 100% plant recovery and in the other remaining treatments it is 66.67% the lowest (33.33%) was recorded in treatment T2 and in control, no plants recovered.

Stem injecting+ Drenching: Among the seven treatments by stem injecting+drenching method, treatment 7 gave 100% control and in all others, its 33.33% recovery was recorded. In the control treatment, no plants recovery was recorded

Conclusion: The treatment T1 and T7 were found to be promising for the management of pomegranate stem borer in different methods of treatment at the dose of 2g/l water.

Table 1. Bioeffficacy evaluation of different insecticide 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

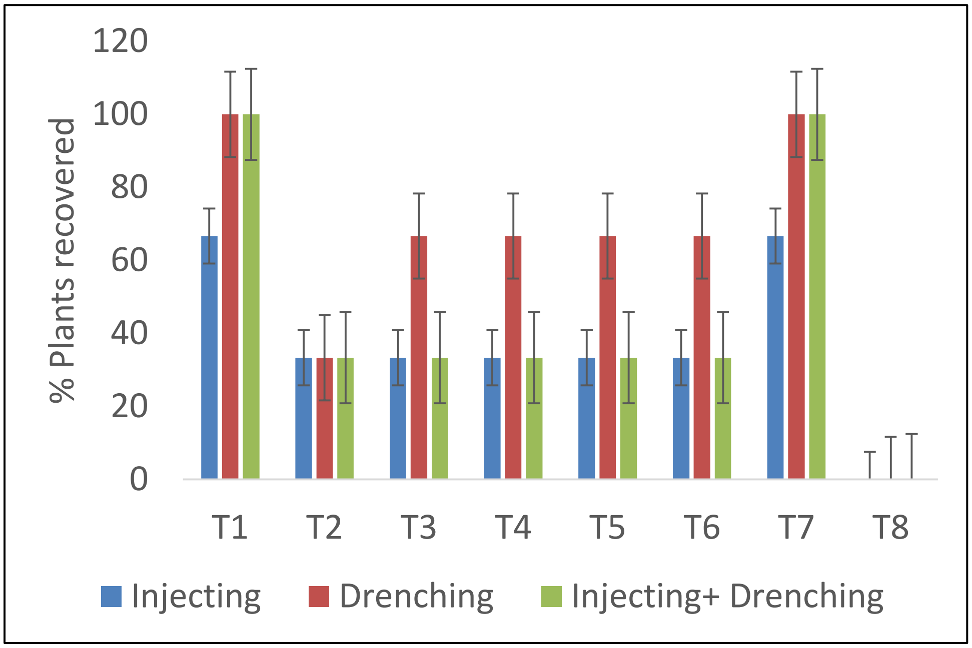


Fig. 1. Bioefficacy of newer insecticides against pomegranate stem borer in three different methods of treatment

2 . Bioefficacy evaluation of newer insecticides formulations against pomegranate shot hole borer

An experiment was conducted to evaluate the bioefficacy of the eight different insecticides against pomegranate shot hole borer at two doses (1 and 2ml/l water) through the drenching method (Table.2). Among the nine treatments, treatment T7 gave 66.45 and 98.25% plants recovery in 1 and 2ml dose respectively. The next best treatment was T1 gave 56.5 and 97.5% plant recovery in 1 and 2ml doses respectively. The standard check treatment T8 48.25 and 67.25% plants recovery was recorded respectively. The lowest % Plant recovery of 30.0 and 35.25% was recorded in treatment T5 and nil plant recovery was recorded in the control treatment. From the above experiments, it concludes that Treatment T7 and T1 are found to be best for the management of shot hole borer in pomegranate as a curative measure.

Table 2. Bioefficacy Evaluation of different insecticides against pomegranate shot hole borer (SHB)

Treatment	Treatment details	Dosage/g/ml/Lit	Dosage/g/ml/l
T1	Emamectin benzoate 5% SG+ Propiconazole 25% EC	1gm +1 ml	2+2
T2	Imidacloprid 30.5% SC + Propiconazole 25% EC	1ml + 1 ml	2+2
T3	Thiamethoxam 25 % WG+ Propiconazole 25% EC	1gm + 1 ml	2+2
T4	Tolfenpyrad 15 % EC + Propiconazole 25% EC	1ml + 1 ml	2+2
T5	Afidopyropen 50 g/L DC + Propiconazole 25% EC	1 ml + 1 ml	2+2
T6	Flonicamid 50 WG + Propiconazole 25% EC	1gm + 1 ml	2+2
T7	Emamectin benzoate 3%+ Thiamethoxam 12% WG + Propiconazole 25% EC	1 gm + 1 ml	2+2
T8	Chlorpyriphos 20% EC (Check) + Propiconazole 25% EC	1ml+ 1 ml	2+2
T9	Control	Water + Sticker	Water + Sticker

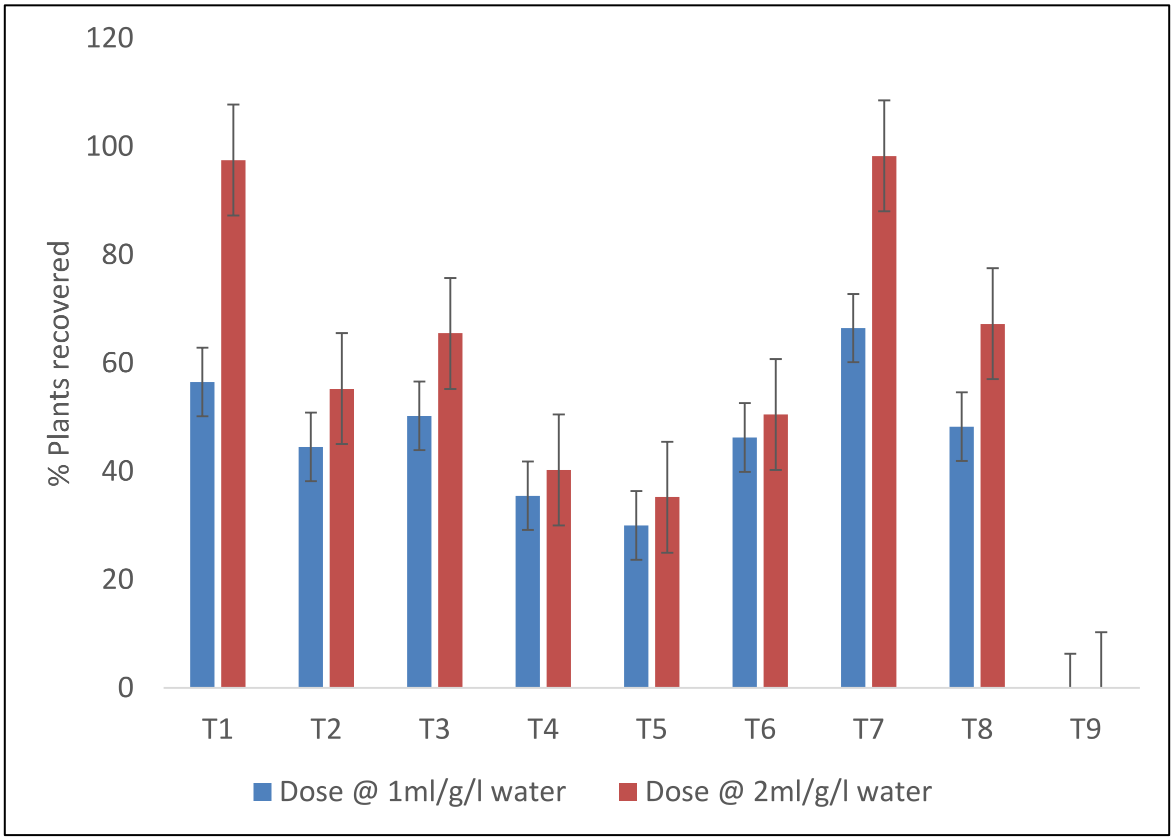


Fig. 2: Bioefficacy evaluation of different insecticides against pomegranate SHB

3: Record of relative susceptibility of pomegranate varieties to Shot hole borer (SHB) infestation

Table 3. Differential susceptibility of pomegranate varieties to SHB infestation

Variety	**Total no. of plants**	**Total no. of plants infested by SHB**	**% Infested pants**
Ganesh	58	54	53.45
S. Bhagawa	58	26	44.83
Arakta	56	34	60.71
Mridula	54	28	51.85
G-137	58	22	37.93
Bhagawa	351	138	33.62
Total	**635**	**302**	**40.79**
Ganesh	58	31	93.10
S. Bhagawa	58	26	44.83
Arakta	56	34	60.71
Mridula	54	28	51.85
G-137	58	22	37.93
Bhagawa	351	118	39.32
Total	**635**	**259**	**47.56**

The different cultivated commercial varieties of pomegranate were recorded with differential susceptibility to shot hole borer infestation. The data on the incidence of shot hole borer is recorded at 15 days intervals. Among the different varieties, the level of susceptibility at the first observation in the ascending order was Arakta > Ganesh >Mridula>S. Bahgawa>G-137> Bahgawa. The second observation of the level of susceptibility was Ganesh> Arakta>Mridula>S. Bahgawa> Bhagawa> G-137. The average percent infestation in the first and second observations was 40.79 and 47.56% (Table 2)

Fig. 3. The flooding of the experiment block H-24 due to heavy and extended rainfall

Level of Susceptibility-I: Arakta > Ganesh >Mridula>S. Bhagawa>G-137> Bhagawa

Level of susceptibility-II: Ganesh> Arakta >Mridula >S. Bhagawa> Bhagawa> G-137

Ganesh		G-137	
Range	Avg.	Range	Avg.
6.5-78.5	51.52	6-129	41.95

Fig. 4 SHB damage on pomegranate

4. Bioefficacy evaluation of newer insecticides and combi formulations against pomegranate thrips and fruit borer:

The treatment T5 (Flonicamid 50% W/W)) recorded the highest percentage (87.72%) of fruits free from thrips damage followed by T4 (Tolfenpyrad 15 % EC) (80.95%) and T9 (Spinetoram 11.7% SC) (80.51%) the and least was observed in T8 (Difenthiuron 40.1% + Acetamiprid 3.9% WP) (75.78%) wherein control it was 19.78%. The incidence of the fruit borer was very low during the experimental period in both control and treatments.

5. Bioefficacy evaluation of newer insecticides against Invasive mealybugs:

The treatment T1 (Thiamethoxam 12.6 % +Lambda cyhalothrin 9.5% ZC)) recorded the highest % Reduction over control (68.37%) of fruits free from thrips damage followed by T7 (Emamectin benzoate 3%+ Thiamethoxam 12% WG) (66.26%) and T9 (Spinetoram 11.7% SC) (80.51%) the and least was observed in T5 (Afidopyrofen 50G/L DC) (75.78%) wherein control it was 34.25%.

6. Isolation of Entomopathogens through soil baiting technique:

Though soil baiting techniques 1- Entomopathogenic nematode-1, Entomopathogenic Bacteria-4, and Entomopathogenic Fungi-1was isolated.

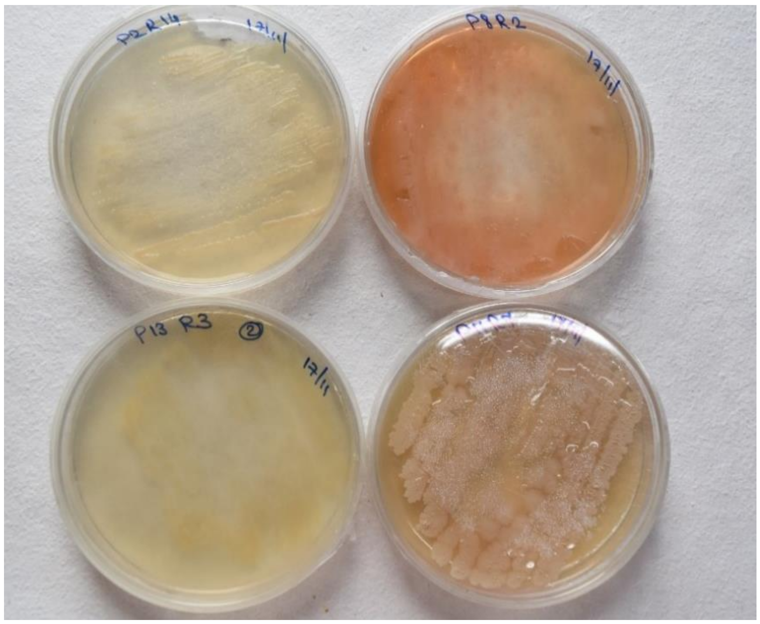


Fig. 5 Isolated Entomopathogens

7. Invitro evaluation of native entomopathogenic nematodes against pentatomid bugs

Table 4. Invitro evaluation of native EPN against pentatomid bugs and pomegranate fruit borer

IJs/2 Nymphs/ adult	Avg. % mortality Nymphs HAI		Avg. % mortality of adult HAI	
	48	72	48	72
10	25.25	27.35	20.20	22.25
50	28.50	33.55	23.45	25.35
100	35.50	40.15	30.55	38.15
150	42.25	60.45	41.45	58.45
200	55.42	74.55	46.24	62.54
250	62.25	98.55	52.52	65.52
300	65.55	99.15	55.25	67.18

IJs-Infective Juveniles HAI=Hours after inoculation

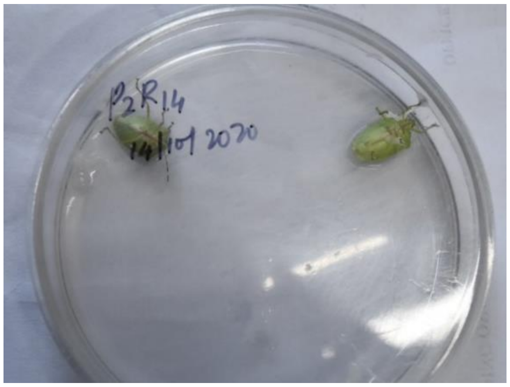



Fig. 6. The green stink bug infested by EPN

- The inoculation of 250 infective juveniles (IJs/ 2 bugs nymphs recorded 62.25 and 98.55 avg. % mortality of nymphs at 48 and 72 hours after inoculation.
- The inoculation of 300 infective juveniles (IJs/2 nymphs recorded 65.55 and 99.15 avg. % mortality of nymphs at 48 and 72 hours after inoculation.
- The inoculation of 300 infective juveniles (IJs/ adults recorded 52.52 and 65.52 avg. % mortality of adults at 48 and 72 hours after inoculation.
- The inoculation of 300 infective juveniles (IJs/ 2 adults recorded 55.25 and 67.18 avg. % mortality of adults at 48 and 72 hours after inoculation.

7. Evaluation of new mustard powder against scale insect in the Net house

Table 5. Evaluation of new mustard powder against scale insect in the Net house

Trts.	Dose g/l water + 0.25 ml sticker	Avg. Pre-population count /5cm shoot	Total No. dead 3DAS	% Dead	Total no. dead 7 DAS	% Dead
T1	1	23.0	20.0	86.9	20.0	86.9
T2	1.5	10.0	8.5	85.0	8.5	85.0
T3	2.5	16.0	13.0	81.2	13.0	81.2
T4	5	12.5	12.5	100.0	12.5	100.0
T5	Control	12.0	2.0	16.00	2.0	16.0

Fig. 7. Invitro evaluation of Solar light against fruit-sucking moths

The mustard powder @ 5 g/l water + 0.25 ml sticker gave 100% mortality of wax scale insect 3 days after and 7 days after treatment. Invitro Bioefficacy evaluation of brown Mustard powder alone and in combination with Neem and Pongamia oil against thrips**:** The combination of mustard powder and neem oil (10000ppm) @ 15+ 5 g and ml gave 76.87 and 78.36 % mortality 24 and 48 hours after treatment respectively.

Table 6. Invitro evaluation of Solar light against fruit-sucking moths

Time (pm)	No. of moth attracted	Male	Female
6.30	2	2	0
7.30	3	2	1
8.30	4	3	1
9.30	4	3	1
9.30	5	4	1
10.30	6	5	1
11.30	5	4	1
12.00	5	5	1

- The two light traps evaluated for their efficacy for attracting the fruit piercing moths were evaluated under Invitro conditions both the traps are having - 230 volts AC.
- Trap-1 has the main light source violet smd UV Led 3.2 volt 395nm wavelength and it attracted the 34 moths (28 males and 6 females). The Trap-2 having the water led blue led 3.2 volts 465nm wavelength no attract of moth was observed. Total no of moths attracted in trap-1= 34Total no of moths attracted in trap-2= 0

5.2 PROJECT: FLAGSHIP PROJECT ON INTEGRATED APPROACH TO ERADICATE BACTERIAL BLIGHT

(a) Stem solarization to manage bacterial blight

Developed Stem Solarization technology to manage bacterial blight in community approach with 100% blight control. It is ecofriendly, economical and effective technology and can eradicate the pathogen if done in community approach. It can also be used for organic cultivation plots. FLDs at 6 locations are in progress 3 at Rahata in Ahemadnagar and 3 in Malshirus at Solapur district in Maharshtra. The success of field trials at NRCP for 3 years and 1 farmer's plot at Akkalkot for 2 years have been reported in previous annuals reports as 'Six Steps to Manage Bacterial Blight', on the recommendations of RAC the technology name has been changed.

(b) Bacteriophages from blight control

Bacteriophages from pomegranate tree phylloplane were found effective in bacterial blight pathogen *Xanthomonas axonopodis* pv *punicae* of pomegranate *in vitro* trials. Studies are in progress for making formulation with UV protectants and long shelf life to take field trials.

(c) Weather-based prediction model

Work was initiated on weather-based prediction model for bacterial blight in pomegranate in collaboration with ICAR-CRIDA and weekly blight data for 10 years has been provided by NRCP.

5.3 EPIDEMIOLOGY AND SUSTAINABLE MANAGEMENT OF ECONOMICALLY IMPORTANT PHYLLOPLANE DISEASES OF POMEGRANATE

Survey of phylloplane diseases on pomegranate during 2020-21

A detailed roving survey was conducted (approx.1200 acres) to assess the disease severity/disease incidence of major diseases of pomegranate in different districts of Karnataka, Maharashtra and Madhya Pradesh during 2020-21 (Table). The maximum disease severity (0 to 100 %) of phylloplane diseases (bacterial blight, leaf spots caused by *Cercospora* and *Alternaria*, anthracnose (fruit rot) and scab) was observed in Solapur district of Maharashtra. The severity of leafspots and fruit rot was observed in all the areas surveyed. Similarly, A detailed roving survey was also conducted to assess the disease severity/disease incidence of wilt disease of pomegranate caused by *Ceratocystis fimbriata*, Root-Knot Nematode and Shot/Pin hole borer in different districts of Maharashtra, Karnataka, and Madhya Pradesh and surveyed data presented in the table. Numbers in parenthesis indicates number taluks covered during survey; DS: Disease severity. CF: *Ceratocystis fimbriata*; Root-knot nematode was present in the 70-90% of the orchards having wilt disease; from 5 to 80% root infection.

Table: Status of economically important phylloplane disease of pomegranate in different districts of Karnataka, Maharashtra and Madhya Pradesh

State	Districts	Area covered (acre)	Disease severity (%)				
			BBD	FR	CR	AR*	SB
Karnataka	Bijapur (3)	75.75	0.4-2.1	0.2-1.0	0-65	0-4.0	0-19.15
	Bagalkot (4)	135.45	0.0	0.1-0.5	0-46.2	0-4.0	0-0.40
	Koppal (2)	49.5	0.0	0.0	1.85-34.4	1-3.80	0.0
	Bangalore rural (2)	25.7	0-25	0-2.0	0 to 5.0	0.0	0.0
	Bangalore urban (1)	10.0	0.0	0-8.7	0-4.0	0.0	0.0
	Chikkaballapur (3)	56.0	0-5.0	1 to 13	0.5 -3.0	0.0	0.5- 5
	Total area/ DS (%)	352.4	0-25	0-13	0-65	0-4.0	0-19.15
Maharashtra	Pune (2)	8.5	0-15	0.0	0-48	0-2.15	0.0
	Ahmednagar (2)	41.25	0.6-20	0-31	0-80	0.0	0.0
	Solapur (10)	725.75	0-71	0-63	0-100	0-2.25	0-100
	Sangli (1)	21.80	0-6.0	0-8.5	1 -100	0.2-0.3	2.1-100
	Satara (1)	49.5	0-40	0.3-4.3	1-63	0.0	0-51
	Total area/ DS (%)	846.8	0-71	0-63	0-100	0-4.0	0-100
Madhya Pradesh	Chindwada (1)	9.5	0-13.5	0.0	0.0	2.00	0.0

Numbers in parenthesis indicates number of taluks covered during survey; DS: Disease severity; BBD: Bacterial blight; FR: Fruit rot/Anthracnose; CR: *Cercospora*; AR: *Alternaria* on leaves; SB: Scab.

Table 1: Status of wilt disease, Root knot nematode and shot hole borer on pomegranate in different districts of Karnataka, Maharashtra and Madhya Pradesh

State	Districts	Area covered (acre)	Wilt Disease incidence (%)	Shot/Pin hole borer (SHB)
			CF	
Maharashtra	Pune (2)	8.5	0-36	0.0
	Ahmednagar (2)	41.25	2-100	8.95-25.8
	Solapur (10)	725.75	0-57	0-59.42
	Sangli (1)	21.80	0-21	-
	Satara (1)	49.5	0-17	-
	Total area/ DS (%)	846.8	0-100	0-59.42
Karnataka	Bijapur (3)	75.75	0-8	0
	Bagalkot (4)	135.45	0-5	0
	Koppal (2)	49.5	0	0
	Bangalore rural (2)	25.7	0.5-17	-
	Bangalore urban (1)	10.0	1-5	-
	Chikkaballapur (3)	56.0	2-30	-
	Total area/ DS (%)	352.4	0-30	0
Madhya Pradesh	Chindwada (1)	9.5	0	1-2.5

***In-vitro* bio-efficacy of bactronol against fungal pathogens of pomegranate**

Bactronol, chemically known as bronopol (95 % 2-Bromo-2-Nitro-1, 3-Propanediol), is a commonly used bactericide to control bacterial diseases of various vegetables and fruit crops. However, its efficacy against fungal pathogens is less studied. Therefore, in the current study, *in-vitro* 'Poison Food Technique' was used to test bio-efficacy of different concentrations (0.25 g/L, 0.50 g/L and 0.75 g/L) of bactronol against three economically important fungal pathogens of pomegranate (Figure 1). These included *Alternaria alternata* causing heart rot and leaf spot/blight in pomegranate, *Colletotricum gloeosporioides* (the anthracnose pathogen) and *Ceratocystis fimbriata* (the pomegranate wilt pathogen). All the concentrations checked the pathogen growth above 64 % at lower concentration (0.25 g/L). The radial was completely arrested (100 % inhibition) at 0.75 g/L in all tested fungi. The *in vitro* tests were encouraging; however, studies that are more elaborate are required to affirm the final concentration for field conditions.

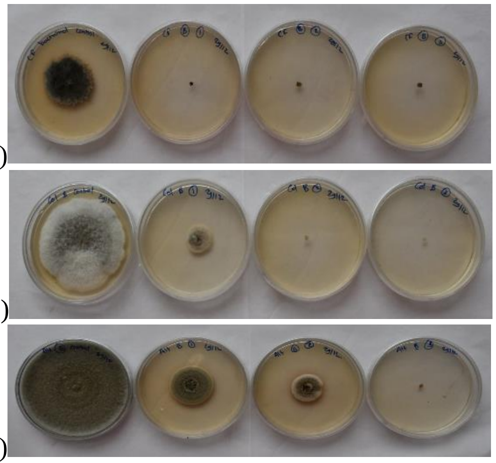
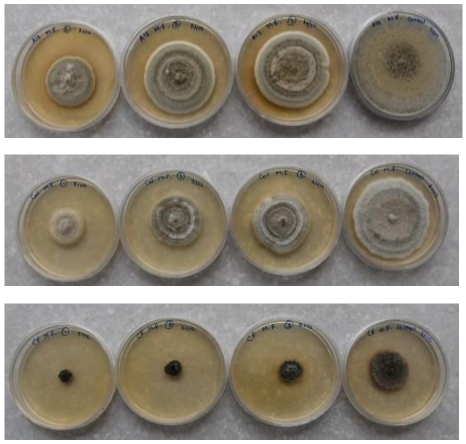
a)
b)
c)

Control 0.25 g/L 0.50 g/L 0.75 g/L

Figure: Radial growth of different pathogens at different concentrations of bactronol on potato dextrose agar media

In-vitro bio-efficacy of mustard formulation against fungal pathogens of pomegranate

The modified new mustard formulation prepared at CEPHT, Ludhiana was tested against three fungal pathogens of pomegranate *viz*. *Alternaria alternata* causing heart rot and leaf spot/blight in pomegranate, *Colletotricum gloeosporioides* the anthracnose pathogen and *Ceratocystis fimbriata* pomegranate wilt pathogen. All the 3 pathogens cause severe losses under favorable weather conditions and are cause of concern to the pomegranate farmers. Though promising chemicals for the control of these diseases are available, yet farmers opting for organic pomegranate cultivation face problems once the disease appears, hence the mustard formulation was tested *in vitro* at 3 doses (1, 2.5 and 5 ml per litre) using 'Poison Food Technique' against these pathogens. All the doses of mustard formulation used checked the pathogen growth above 37%, however highest inhibition was achieved at 5ml/l dose with 53.77% inhibition of *A. alternata* and 50.68 % inhibition of *C. gloeosporioides* and 79.07% of *C. fimbriata*. The *in vitro* tests were encouraging; however, the formulation will be tested in polyhouse and field trials before arriving at final conclusion. In case the formulation is found effective in field trials in checking these pathogens, it will be a promising formulation for organic pomegranate production.

(1) (2) (3)



a) b) c)

Figure: Radial growth of different pathogens a) *Alternaria alternata* b) *Colletotricum gloeosporioides* c) *Ceratocystis fimbriata* on PDA with different concentrations of mustard formulation (1) 5 ml/l (2) 2.5 ml/l (3) 1 ml/l (4) Control

In vitro **evaluation of endophytes against fungal pathogens of pomegranate**

Fifty endophytes were isolated from different medicinal plants (from different geographical locations) as well as tissue cultured pomegranate plants. These endophytes belonged to different taxonomic groups such as bacteria, fungi, actinobacteria and Trichoderma. They were tested *in vitro* for their inhibitory effect on growth of fungal pathogens: *Alternaria alternata*, *Colletotrichum gloeosporioides* and *Ceratocystis fimbriata* using dual culture technique. The endophytes were grouped according to their ability to inhibit growth of the fungal pathogen: 0-50% inhibition, 51-75% inhibition and more than 75% inhibition. Two endophytic isolates (BE-5 and EB-7) were found to inhibit upto 51-75% growth of all three pathogens. Seventeen isolates (TC-6, TC-Y, EBO-1, EBO-2, EBO-6, EBO-8, EBO-11, EBO-14, EBO-16, EBO-17, BE-4, E-7, EB-9, PG-10, PG-12, VADGAON, E2 BHAGAWA) were found to be the most effective endophytes against *Ceratocystis* showing more than 75% inhibition of the pathogen growth. Only three isolates (TC-4, TC-10 and PG-6) exhibited more than 75% growth inhibition of *Colletotrichum* while none of the isolates could show such a response against *Alternaria*. The preliminary results of the current study indicate that these endophytes especially BE-5 and EB-7 can be used as potential biocontrol agents against different fungal pathogens, however only after more elaborated field studies.

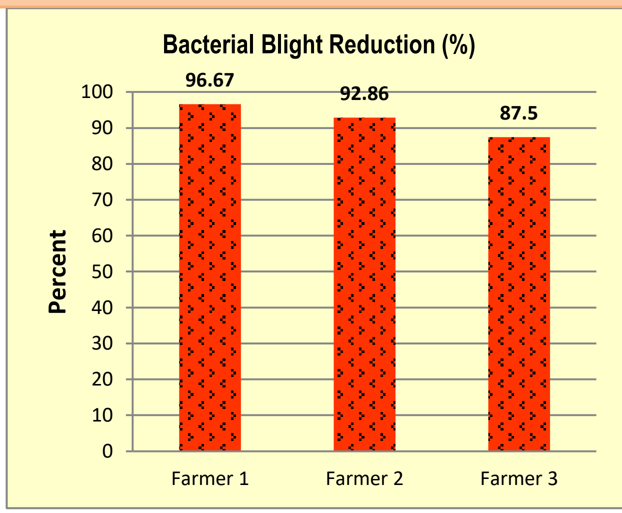
Figure: *In-vitro* inhibitory effect of endophytes on growth of fungal pathogens a) *Alternaria alternata*, b) *Colletotrichum gloeosporioides* c) *Ceratocystis fimbriata*

Field demonstration of Stem solarization-Six-Step to control bacterial blight

ICAR-NRC on Pomegranate, Solapur developed Stem Solarization-Six-Step disease management schedule with continuous research to make it as an eco-friendly, cost-effective and effective management strategy. Stem solarisation of naked stem kills all pathogenic bacteria giving 100% control if untimely rains are not there. Most significant feature of this technology is that farmers in arid and semi-arid regions facing loses due to bacterial blight disease can take the '*mrig bahar*' and late '*mrig bahar*' crop (rainy season) of pomegranate successfully. This has been successfully demonstrated for 3 years at ICAR-NRCP and in 1 farmers' orchard in 2018 and 2019 and in 3 farmers' orchards in 2020-21. With this technology antibiotics will not be required and arid and semi-arid regions can successfully take rainy season crop. Moreover, this technology can be used for organic pomegranate production also. The technology has been demonstrated in 3 farmers' plots in 2021.

Stem Solarization: Six Steps to Manage Bacterial Blight in Rainy Season Crop		
		
Step 1 **Main Pruning & fertilizer application Dec/Jan**	**Step 2** **Irrigate the crop till mid March**	**Steps 3** **Put crop on stress for complete defoliation till April**
		
Steps 4 **Stem Solarization for 10-20 days in May**	**Steps 5** **Light pruning, INM, take rainy season crop.**	**Steps 6** **During crop season follow recommended practices**
		
Harvest Bacterial Blight Free Pomegranate Produce from Heavily Blight affected Orchard in Previous Years		

Technology Demonstration in Farmers Plots (2021)						
Particulars	**Farmer 2**		**Farmer 3**		**Farmer 4**	
Farmer Name and Location	**Bira Waghmode, Malshirus, Solapur** 		**Vijay Narute, Malshirus, Solapur** 		**(Tannaji Navadkar), Malshirus, Solapur** 	
Year of demonstration	**2020-21**		**2020-21**		**2020-21**	
Area (acres)	4.5		2.5		4.0	
Technology demonstration	**Before**	**After**	**Before**	**After**	**Before**	**After**
Yield Loss Due to Bacterial Blight (%)	60	2	70	5	80	10
Total Yield (tonnes)	5	21.6	3.75	22	6.0	14
Input cost (Rs. Lakhs)	4.5	4.6	6.5	8	3.4	3.5
Income (Rs. Lakhs)	4.2	15.54	5.10	36.30	9.5	16
Profit (Rs. Lakhs)	* Loss	13.94	** Loss	28.30	6.1	12.5
Benefit: Cost	* Loss	3.03:1	** Loss	3.54:1	1.79: 1	3.57:1
Note: **BBD: bacterial blight disease;** ***Rs 30,000 loss,** **** Rs.1.4 lakh loss; BD/AD: before demonstration/after demonstration**						



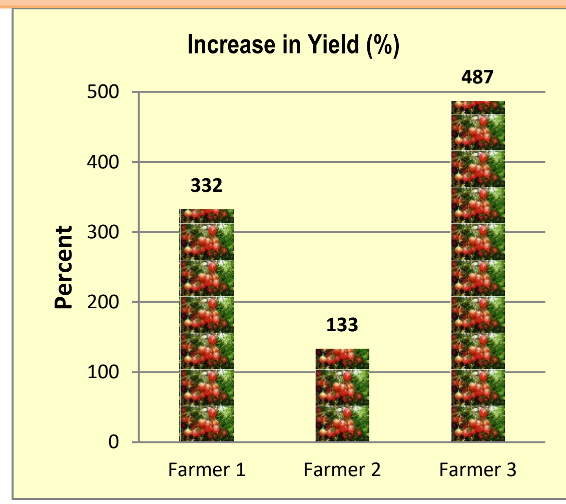


Figure: Effect of stem solarization on bacterial blight control and increase in yield on farmers' plots in 2019-20 to 2020-21

Streptomycin and copper sensitivity in *Xanthomonas axonopodis* pv. *punicae*

Sensitivity to streptomycin was checked for all the isolates *in vitro*. These isolates could grow on media containing 250 ppm to 1500 ppm streptomycin. The zone of inhibition (ZOI) at the highest concentration (1500ppm) was below 50% (ranged between 26.3% to 37.8%) indicating a lower sensitivity to the antibiotic. Notably, 7 isolates had less than 30% growth inhibition indicating the lowest sensitivity in these isolates. A positive correlation was found between the concentration of streptomycin and ZOI *i.e*., as the concentration increased the ZOI also increased indicating higher sensitivity at higher concentration of the antibiotic. To analyse the molecular basis of the observed lower sensitivity to antibiotic, the presence of *strAB* gene pair was confirmed through PCR amplification using gene specific primers. Ninety percent isolates showed the presence of either of the gene *strA*-*strB* of which 60% isolates showed the presence of the complete gene pair *strAB*.

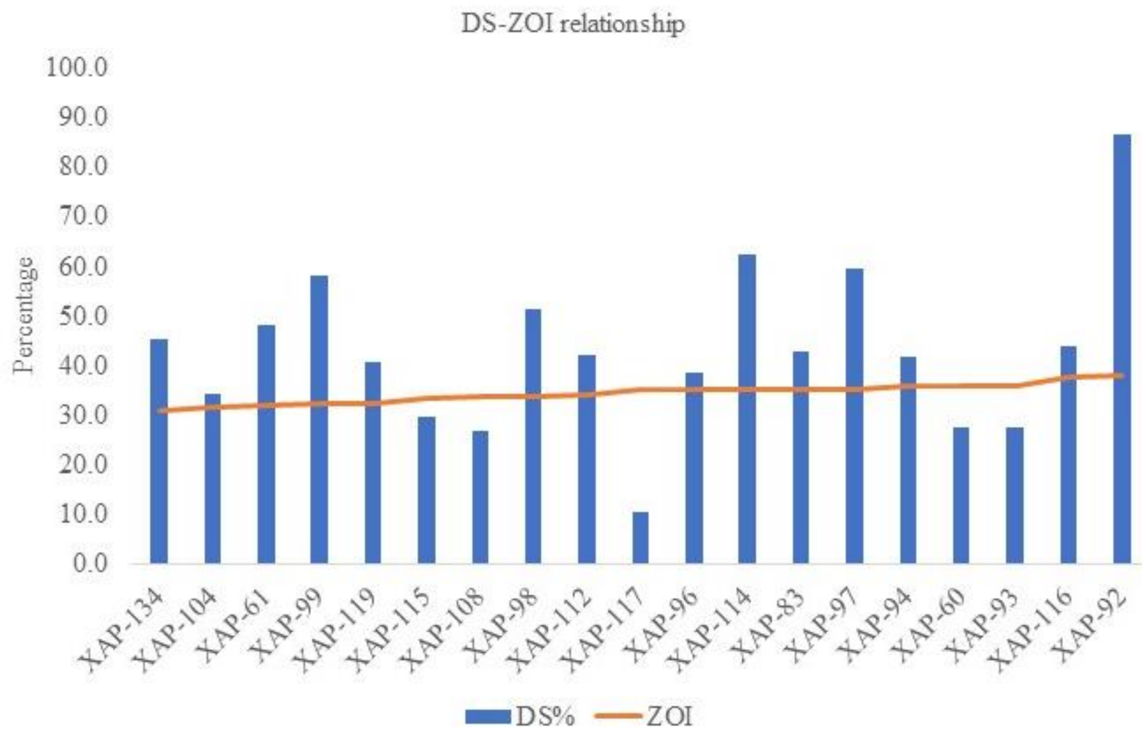


Figure 4 Relationship between percent disease severity (%DS) observed after 6 weeks and zone of inhibition (ZOI) at the highest concentration (1500ppm).

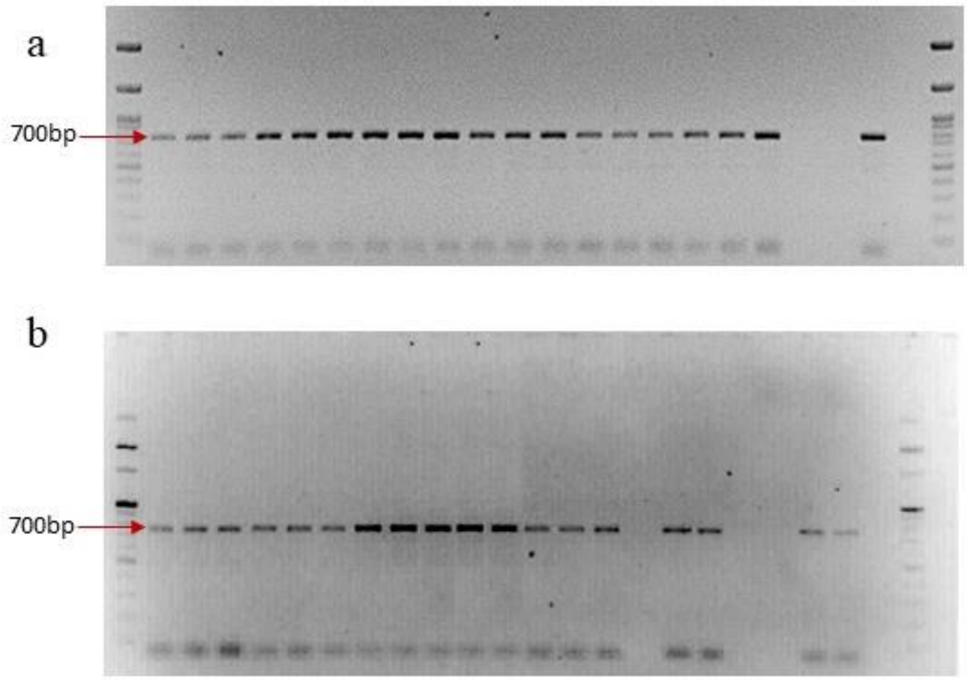


Figure: Gel electrophoresis image showing amplification of *strA* (a) and *strB* (b) genes in isolates of Xap

Genetic diversity of *Xanthomonas axonopodis* pv. *punicae* (Xap) using SSR markers

Genetic diversity amongst Xap isolates (n= 20) was analyzed using SSR markers (n=18). Based on the results, isolates could be grouped into two major clusters. Cluster I contained 5 isolates and cluster II contained remaining 15 isolates. Xap-97 and Xap-116 displayed the maximum value for Jaccards similarity coefficient (0.80) indicating that these two isolates are highly similar. The disease severity exhibited by the two isolates also did not show much of a difference. On the other hand, Xap-60 and Xap-92 displayed minimum Jaccards similarity coefficient (0.13) and were grouped into two different clusters indicating high diversity between them. These two isolates also highly differed in their level of pathogenicity in terms of disease severity, Xap-92 being highly pathogenic (86.7%) while Xap-60 displayed low pathogenicity (27.3%).

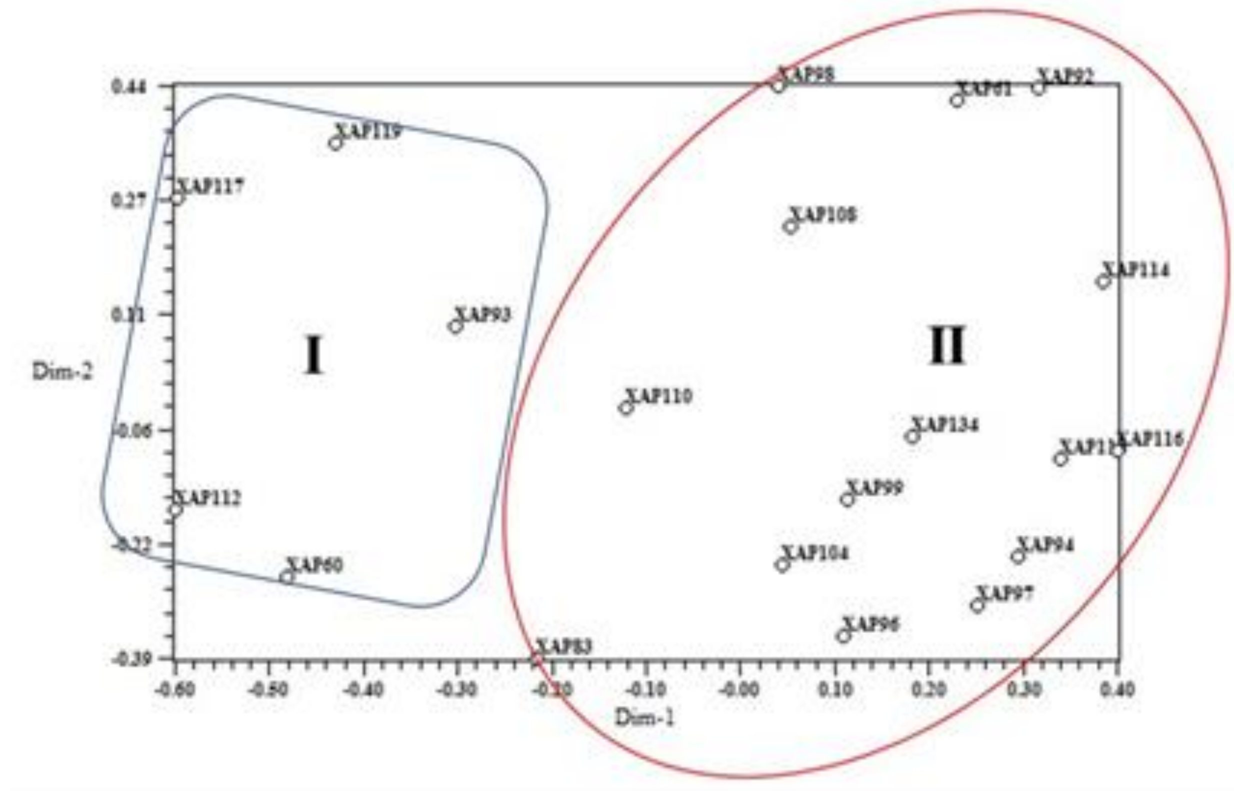


Figure: Dendrogram showing genetic diversity amongst Xap isolates on the basis of SSRs

Evaluation of potential bio agents and new chemicals for their bio efficacy against wilt disease

During the survey of pomegranate orchards, we have collected the soil samples and from that we have isolated the *Trichoderma* and other bioagents coded as KA-40 and KA-54 from Bagalkot area of Karnataka. This species was tested under in-vitro dual plate technique against the wilt causing fungi, *Ceratocystis fimbriata*. The newly isolate KA-40 species gives highest *Ceratocystis fimbriata* inhibition (93.47%) followed by KA-54 species (84.78%) under in-vitro condition.

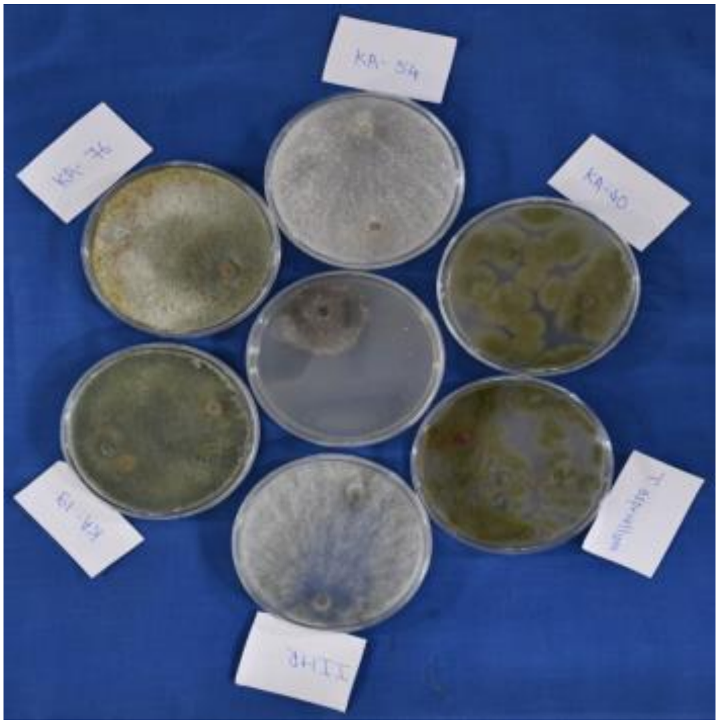


Figure: Bio-efficacy of bioagents against *Ceratocystis fimbriata* under *in-vitro* conditions

S.N.	Bioagent	Mean radial growth (cm)	% inhibition
1	IIHR *Trichoderma*	0.6	73.91
2	KA- 76	0.85	63.04
3	**KA- 54**	**0.35**	**84.78**
4	KA-19	0.45	80.43
5	**KA-40**	**0.15**	**93.47**
6	*T. asperellum*	0.15	93.47
7	Control	2.3	0.00

The cultural filtrate of the KA-54 species was also tested against Root-Knot Nematode under *in-vitro* condition. The results indicated that filtrate concentration of 25% can cause 31% death in 24 hrs. of exposure while 56.88% mortality occurs after juveniles were exposed for 48 hrs. at 25% concentration.

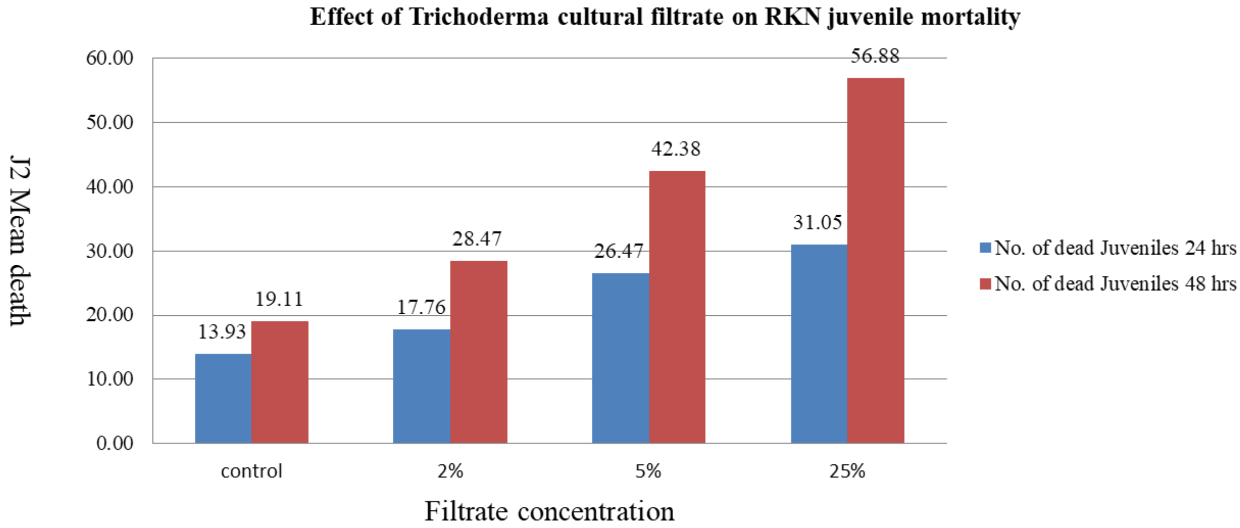


Figure: Mortality of RKN juveniles after treatment of KA-54 cultural filtrate

Evaluation of newer nematicides under polyhouse conditions

Primary trial for the evaluation of newer nematicidal chemicals like Nimitz (Fluensulfone 2% GR), Velum Prime (Fluopyrum 34.48% SC), Reklemel (fluazaindolizine 500 SC) and Vegetable oil based nematicide *i.e*. Nemon against Root-Knot Nematode on new roots under pot condition for the period of 5 months. About 20 selected plants for trial were already heavily infested by RKN (>100 galls/plant, highest galling index scale 5). We have randomly assigned 4 plants per treatment out of which 2 were root pruned and root were mixed in the same pot soil. Treatments with nematicides were given as recommended with and without root pruning of the pomegranate plants. Lowest no. of galls were observed in the plants with intact roots treated with Reklemel @ 2 ml/2L (0.5 liter/plant) followed by Velum Prime @ 2 ml/2L (0.5 liter/plant) and Nimitz @ 10 g/ plant. In the case of root pruned plants, no galls were observed in the plants treated with Nimitz and Velum prime in the above-mentioned concentrations.

Treatment	Nematicide	Rec. dose	Dose taken per pot	Galls on New white roots	
				Plants with intact roots	Plants with pruned roots
T1	**Nimitz**	10g/dripper (Max 40 gm/plant)	10 g/ plant	25 galls	No galls
T2	**Reklemel**	2ml/2L	0.5 liter/plant	18 galls	Plant dead
T3	**Suzan**	4 ml/2L	0.5 liter/plant	43 galls	10 galls
T4	**Velum Prime**	2ml/2L	0.5 liter/plant	21 galls	No galls
T5	**Nemon**	200 µl/2L	0.5 liter/plant	27 galls	Plant dead
T6	**Control**	0.5 liter/plant	0.5 liter/plant	80 galls	15 galls

Figure: Testing of Nematicides under pot condition with and without root punning of heavily infested pomegranate plants

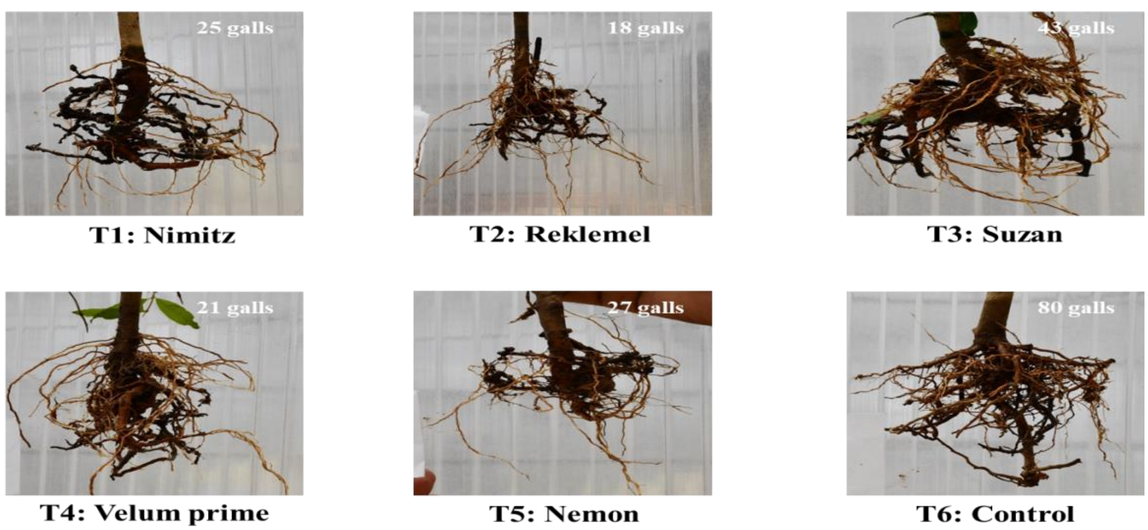


Figure: Effect of nematicides treatment of galls caused by Root-Knot Nematode in the plants with intact root system.

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Post-harvest Management and Value Addition

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

A. FOAM MAT DRYING OF POMEGRANATE JUICE

Pomegranate juice is well known for health benefits owing to presence of various bioactive compounds. However, the seasonality of the fruits, and susceptibility of the pomegranate juice for microbial contamination curtails its accessibility to masses. Further, transportation of pure juice to distant markets is costly affair due to larger volume. The above mentioned factors are important impediment for the marketing of pomegranate juice in distant markets. The Foam mat drying is an innovative approach for the drying of the juices especially with higher sugars. It is a process of drying liquid - solid foods by being mixed with foaming agent and or stabilizing agent to produce stable foam, which undergoes air drying. Thus experiment was planned to study the effect of level of Whey Protein Isolate (WPI) as foaming agent and Carboxymethyl Cellulose (CMC) as stabilizing agent on foam expansion (FE) and foam drainage volume (FDV) of juice foam, drying behavior and quality of dried powder and reconstituted juice.

The pomegranate juice is extracted from the fruits of the cv. Bhagawa. The biochemical properties of the fresh juice were determined and tabulated in table 1.

Table 1. Fresh Juice Biochemical Properties

Parameters	Means (± SD)
pH	3.44±0.01
TSS (ºBrix)	15.55±0.06
Colour	
L*	7.81±0.03
a*	22.74±0.15
b*	10.42±0.08
Density	1.03
Titratable acidity (%)	0.55±0.04
Ascorbic acid (mg/100ml)	17.5±0.00
Total phenolic content (g/lit of GAE)	2787.2±5.00
Antioxidant Capacity (mg/100 ml AAE)	47.29±0.19
Total monomeric anthocyanin content (mg/100 ml)	32.90±0.67
Total sugar (%)	14.95±0.51
Reducing sugar (%)	13.764±0.22
Non reducing sugar (%)	1.186±0.44

The effect of different percentages of the whey protein isolate (WPI) (5, 7.5, and 10%) as foaming agent and carboxy methyl cellulose (CMC) (0, 0.25, 0.5 and 0.75 %) as stabilizing agent were observed on foam expansion, foam density and foam drainage volume. About 100ml of pomegranate juice was taken in 500ml glass beaker. The requisite amount WPI and CMC is added and whipping was done using a blender at high speed for 2 mins. The various parameters for the foam were measured. The pomegranate foam is then poured into a suitable measuring cylinder without breaking the foam structure at all and also without trapping the air bubbles. The weight and the volume of the foam were then noted down. The density of the pomegranate juice was calculated before and after foaming by dividing the measured weight by the volume.

$$\textbf{Foam Density (\%)} = \frac{\textbf{Mass of the foam (g)}}{\textbf{Volume of the foam (ml)}}$$

Foam expansion denotes the percentage increase in volume of the juice. Foam expansion indicates the amount of air incorporated into the juice during whipping was calculated using the difference in the volume of juice before and after foaming.

$$\textbf{Foam Expansion (\%)} = \frac{(V_1 - V_0)}{V_0} \times 100$$

Where, V_1 is the volume of juice after foaming (cm³) and V_0 is the volume of juice before foaming (cm³).

Foam drainage volume (FDV) was used to determine the stability of foam. It gives us the rate at which liquid drains from the foam. Some of the foam was transferred to a Büchner funnel (110 mm) placed on a 100 mL measuring cylinder, and the weight of the foam was recorded. Then, the volume of liquid drained from the foam was determined at the end of 30 min. The drainage volume was calculated for 50 g of foam.

Table 2. Effect of WPI and CMC on FE, FD and FDV

Treatment	WPI %	CMC %	FE %	FD %	FDV %
T1	**5**	**0**	424.40 ±7.80bc	0.2050±0.0078de	65.59±1.93a
T2	**5**	**0.25**	449.07 ±7.91a	0.1940±0.0044fg	58.36±1.76b
T3	**5**	**0.5**	340.70 ±9.45f	0.2470±0.0075b	40.72±1.19c
T4	**5**	**0.75**	285.73±8.22g	0.2820±0.0075a	34.85±0.92d
T5	**7.5**	**0**	431.91±8.31b	0.2020±0.0052ef	34.19±0.73d
T6	**7.5**	**0.25**	425.23 ±8.66bc	0.2050±0.0040de	29.46±0.62e
T7	**7.5**	**0.5**	413.00 ±8.10cd	0.2100±0.0026de	27.01±0.11f
T8	**7.5**	**0.75**	405.18 ±9.02d	0.2140±0.0085d	22.29±0.42g
T9	**10**	**0**	457.07 ±7.91a	0.1880±0.0026g	22.31±1.16g
T10	**10**	**0.25**	455.28±2.11a	0.2030±0.005g	20.10±0.02h
T11	**10**	**0.5**	417.85 ±2.26cd	0.2080±0.0062de	20.07±0.05h
T12	**10**	**0.75**	390.77 ±4.19e	0.2210±0.0075cd	18.76±0.21h

The FE values were found to be in the range of 285.73–457.07% (table 2) during the present experimental studies. This data reveals that WPI and CMC affected the foam expansion. It is evident from the table 2 that the FE increased with increase in concentration of WPI. The FE of 424.40%, 431.91% and 457.07 % were observed with 5, 7.5 and 10% of WPI respectively. However, the addition of the CMC% which is being added as stabilization agent affected negatively to the foam expansion. At 5% WPI the variation in the CMC from 0% to 0.75% has led to reduction in foam expansion by 138.67 %. Similarly at 7.5 % and 10% WPI this reduction in foam expansion due to addition of CMC was 25.16% and 66.30 % respectively. Similar to FD, the increased concentration of WPI at constant whipping time showed a gradual rise in foam volume followed by a slow decreasing trend.

FD was measured after incorporating the air into the pomegranate juice by whipping. The FD for the series of WPI and CMC treated experiments varied from 0.188 to 0.282 g/cc. The density of fresh pomegranate juice was found to be 1.03 g/cc. The significant reduction in the foam density has been observed due to the use WPI and CMC. The FD of 0.205, 0.202 and 0.188 g/cc were observed with 5, 7.5 and 10% of WPI respectively. This shows the decrease in the foam density with increase in WPI which is in line with results for foam expansion.

The stability of any foam can very well be judged by the rate at which the liquid drains from the foam. In present investigation FDV ranged from 18.76 to 65.59 ml (table 2). Higher value of FDV implied lower water holding capacity of foam. It has been observed that the FDV has been decreased with increase in concentration of WPI from 5 to 10%. The high concentration of foaming agents increases the stability by increasing viscosity and yield stress of the liquid phase and or increasing thickness (or strength) of the interface. It is also observed from Table 2 that the absence of foam stabilizer showed a greater degree of foam expansion.

The incorporation of CMC as foam stabilizer did improved the foam stability by reducing the FDV at particular concentration of foaming agent.

Foam Mat Drying

The pomegranate juice foam produced using10% WPI and 0.25% CMC owing to its high FE (455.28 %) and low FDV (20.10 ml) was selected for foam mat drying experiments. The drying experiments were conducted at 50, 60 and 70 °C, and foam thickness of 3 mm and 6 mm (table 3). The drying experiments were conducted up to the moisture content of 4 % (db). The approximate instantaneous moisture content at different drying temperature and thickness of the foam were depicted in table 3. The drying time required for drying of foam at 70°C was 120 and 180 minutes (Fig. 1), at 60°C it was 180 and 240 minutes (Fig. 2), and at 50 °C it was 210 and 300 minutes (Fig. 3) respectively for 3- and 6-mm thickness. The drying time decreases with the increase in drying temperature. Further, at 6 mm thickness additional 60 minutes are required for drying when compared with 3 mm thickness at 70°C and 60 °C. However, at low temperature of 50 °C the increase in drying time is 90 minutes at 6 mm thickness as compared to that of 3 mm thickness.

Table 3 Effect of drying temperature and thickness of foam on instantaneous moisture content (db) and drying time.

Drying Time (min.)	**Drying Temperature (°C)**					
	70		**60**		**50**	
	Thickness (mm)					
	3 mm	**6 mm**	**3 mm**	**6 mm**	**3 mm**	**6 mm**
0	354.5455	354.5455	354.5455	354.5455	354.5455	354.5455
60	82.82828	125.7576	32.323	144.9495	112.6263	183.3333
90	9.59596	24.74747	13.63636	58.08081	32.32323	92.17172
120	**4.040404**	7.828283	4.545455	18.56061	11.11111	57.19697
150		5.555556	6.565657	13.63636	7.070707	27.39899
180		4.419192	**4.292929**	7.070707	3.838384	13.13131
210				4.671717	**4.69697**	7.19697
240				**4.419192**		5.808081
270						5.176768
300						**4.545455**

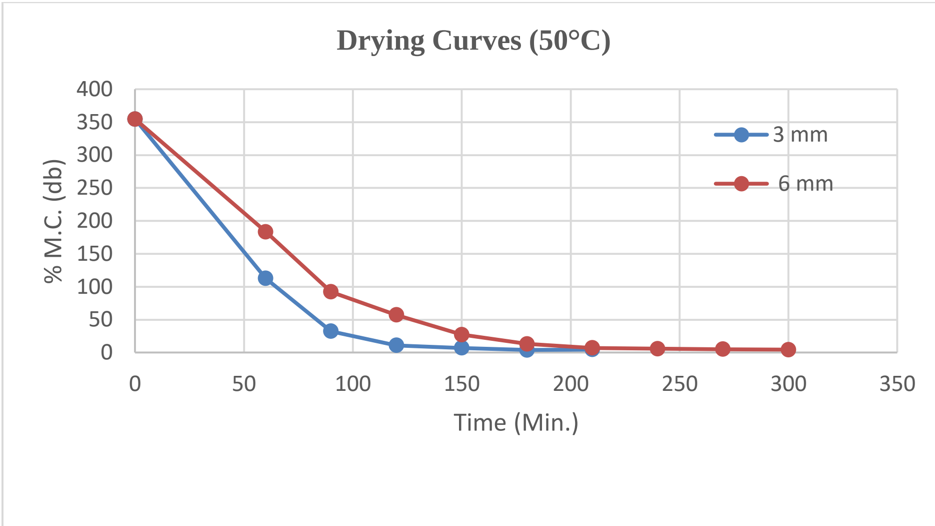

Fig. 1. Drying curves for foam mat drying at 50°C and different thickness of foam

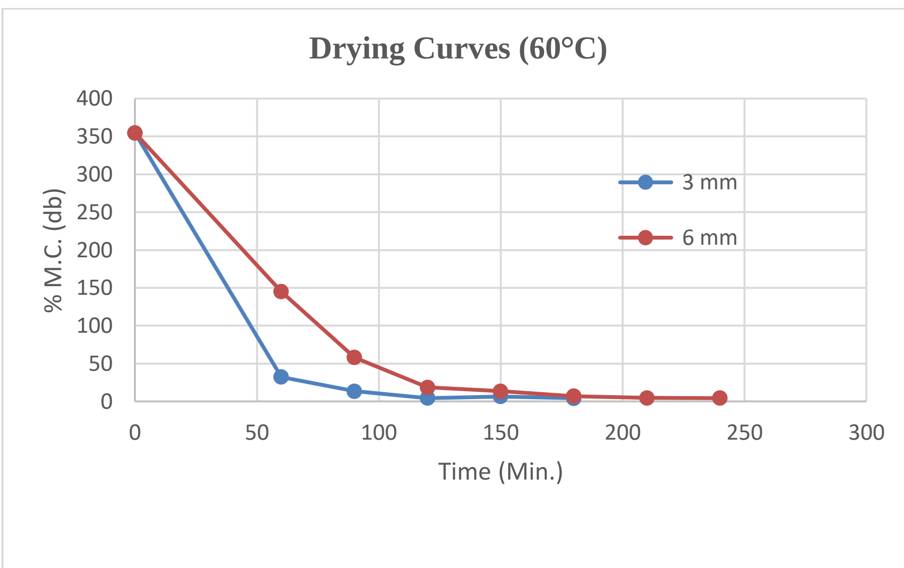

Fig. 2. Drying curves for foam mat drying at 60°C and different thickness of foam

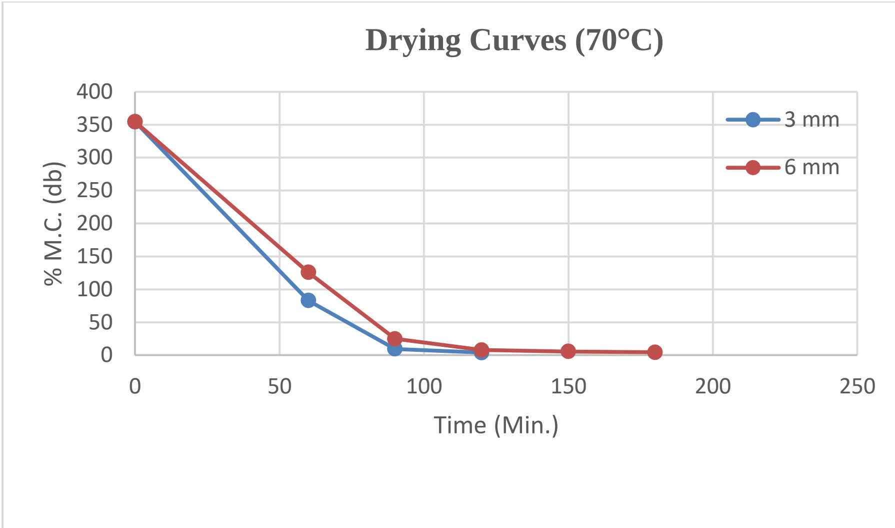

Fig. 3. Drying curves for foam mat drying at 70°C and different thickness of foam

Colour of Foam Mat Dried Powder

The *L**, *a** and *b** values of foam mat dried pomegranate powder for different drying conditions is depicted in table 4. The lightness value indicates a measure of colour in light-dark axis, which in turn denotes that the sample turned dark at reduced *L** value. The *L** value ranged from 48.56 to 52.12. It has been observed that *L** value which shows the lightness of the sample decreased with drying temperature and increase in the thickness. Furthermore, the foaming process increased the lightness in pomegranate powders due to the incorporation of air into it. The reduction in *a* and b* value* is evident from table 4. The reduction in a* value shows the decrease in red colour of the powder with increase in temperature of drying and thickness of the drying.

Table 4 Colour values of foam mat dried pomegranate powder for different drying conditions

Treatment	**Colour of foam mat dried powder**		
	L*	a*	b*
70°C 3mm	51.35±0.76	8.6±0.33	17.61±0.64
70°C 6mm	51.27±0.83	8.21±0.38	16.96±0.84
60°C 3mm	53.12±0.84	8.09±0.28	16.32±0.50
60°C 6mm	51.62±2.55	7.6±0.64	15.05±0.61
50°C 3mm	50.63±1.00	8.39±0.20	17.3±0.24
50°C 6mm	48.56±1.12	8.47±0.24	16.05±0.15

Bulk density, tapped density, carr's index and Hausner's ratio of foam mat dried pomegranate powder

Bulk density is defined as the mass of solid particles plus moisture divided by the total volume engaged by the particles, surface moisture, and all pores are closed or open, in the surrounding atmosphere. Bulk density is a parameter of the powder product which represent for economical and practical reason. Bulk density of foam mat dried pomegranate powders was ranged between 0.43–0.53 g/cm^3 (table 5). The tapped density of the foam mat dried samples at different conditions was ranged from 0.45-0.56 g/cm$^{3.}$ The bulk density at 3 mm is lower as compared to that for 6mm thickness. This is because of the faster drying at low thickness leading to porous dried powder. The carr's index for all the samples was less than 10 and Hausner's ratio was within 1.00 to 1.11 (table 5) thereby showing that the foam mat dried powder developed in all the treatments is having excellent flow characteristics.

Table 5 Bulk density, tapped density, carr's index and Hausner's ratio of foam mat dried pomegranate powder for different drying conditions

Samples	Bulk density(g/cm3)	Tapped Density(g/cm3)	Carr's index	Hausner's ratio
70°C 3mm	0.51	0.56	5.26	1.06
70°C 6mm	0.53	0.56	9.09	1.10
60°C3mm	0.43	0.45	4.35	1.05
60°C6mm	0.49	0.51	4.85	1.05
50°C 3mm	0.43	0.46	5.22	1.06
50°C 6mm	0.51	0.53	4.04	1.04

Biochemical Analysis

TSS, pH, Acidity, Colour

The TSS, pH, titratable acidity and sugars of the reconstituted foam mat-dried pomegranate juice powder dried under different conditions are given in the table 6a. The TSS of the sample were shown in table found to be 15.3 and 15.4 for all the samples. The titratable acidity of the samples was ranged in between 0.70 to 1.40. Similarly, the pH values ranged in between 4.71 to 4.81.

Table6a. Quality of reconstituted juice

Sr. No.	Samples	pH	Titratable Acidity	TSS	%Total sugar	%Reducing sugar	%Non-Reducing Sugar
1	70°C 3mm	4.78(±0.00)	0.82(±0.02)	15.3(±0.06)	13.76(±0.00)	11.36(±0.00)	2.40(±0.00)
2	70°C 6mm	4.71±0.00)	0.7(±0.04)	15.4(±0.00)	13.28(±0.41)	10.95(±0.14)	2.33(±0.27)
3	60°C3mm	4.81(±0.00)	1.15(±0.24)	15.3(±0.06)	14.60(±0.00)	12.50(±0.00)	2.10(±0.00)
4	60°C6mm	4.77(±0.01)	0.88(±0.06)	15.4(±0.00)	14.05(±0.45)	11.90(±0.00)	2.14(±0.45)
5	50°C 3mm	4.77(±0.01)	1.4(±0.22)	15.4(±0.06)	14.91(±0.51)	13.05(±0.19)	1.87(±0.44)
6	50°C 6mm	4.75(±0.00)	0.82(±0.02)	15.3(±0.06)	13.84(±0.00)	12.82(±0.00)	1.01(±0.00)

All the bioactive compounds viz. total phenolic content, antioxidant capacity, anthocyanin and ascorbic acid had shown similar trend showing reduction in bioactive with increase in the drying temperature and thickness of the foam. The drying temperature directly affects the bioactive compounds present. In case of the thickness of the foam the effect is indirect in nature. The increase in thickness leads to the increase in drying time and thereby exposing the foam to drying process for longer duration leading to loss of bioactive compounds. Further, it has been observed that the advantage of decrease in drying temperature in terms of reduction in the losses in bioactive is comparatively lower when temperature of drying is reduced from 60°C to 50°C as compared to reduction from 70°C to 60°C (table 6b). In other words, for 3 mm foam thickness when temperature has been increased from 50°C to 60°C the loss of phenols was 92 mg/ml and for increase from 60°C to 70°C its 326.34. Thus, the losses are higher at 70°C when compared at 60 °C. Similar is the case for 6 mm thickness. It can be seen from the table 3.6 that the significant loss in antioxidant activity can be observed for the increase in temperature from 60 °C to 70°C as compared to that for 50°C to 60°C. The similar trend as that of the total phenol and antioxidant activity was evident in case of anthocyanin content. Further the ascorbic acid being thermo labile in nature has shown losses in ascorbic acid for increase in temperature as well as increase in thickness of drying.

Table6b. Quality of reconstituted juice

Treatment	Phenol (g/L GAE)	Antioxidant capacity (mg/100ml AAE)	Anthocyanin (mg/100ml)	Ascorbic acid (mg/100 ml)
70°C 3mm	2352.53±16.62e	40.35±0.44b	23.43±0.48c	13.33±1.44bc
70°C 6mm	2251.53±15.28f	38.39±0.69c	22.43±1.18c	12.50±0.00c
60°C 3mm	2678.87±5.77c	41.19±0.08ab	24.60±0.26b	14.17±1.44abc
60°C 6mm	2494.53±67.49d	40.53±0.62b	23.10±0.70c	12.50±0.00c
50°C 3mm	2770.87±12.66a	41.96±0.34a	28.83±0.19a	15.83±1.44a
50°C 6mm	2731.87±43.02b	41.73±0.27a	28.17±0.10a	15.00±0.00ab

The results leads to the following conclusions for the experiments conducted for foam mat drying. In foaming experiment the 10 % whey protein isolate and 0.25 % of CMC has shown the best results in terms of foam expansion, foam density and foam drainage volume of 455.28 %, 0.2030 g/cc and 20.10 ml respectively. This optimum combination arrived at after foaming experiments has been used for the drying experiments. The drying time required for drying of foam at 70°C was 120 and 180 minutes, at 60°C it was 180 and 240 minutes, and at 50 °C it was 210 and 300 minutes respectively for 3 and 6 mm thickness. Thus, it can be observed that drying time increases with decrease in temperature and increase in foam thickness. Further, data on biochemical analysis reveals that the bioactive compounds have shown the higher losses when temperature rose to 70°C from 60°C when compared with increase from 50°C to 60°C. Thus, keeping in mind, the drying time required and bioactive compound retention the 60°C temperature and 3 mm drying thickness seems to be the best combination for lower drying time of 180 minutes with optimum retention of the bioactive compounds during drying process.

B. Comparative studies on fermentation process in wine development from pomegranate juice of Bhagawa, Ganesh and Arkta varieties.

The experiments were conducted for comparative evaluation of the fermentation process and quality of the wine from pomegranate juice of Bhagawa, Ganesh and Arakta varieties.

Biochemical Profile of Pomegranate Juices

Biochemical and bioactive compounds of pomegranate juices of different varieties were tabulated in Table 1 and 2. It has been clear from critical difference values (Table 1) that TSS, acidity, pH and reducing sugars were significantly different for all the three varieties namely Bhagwa, Ganesh, and Arakta. The difference in anthocyanin concentrations of the three varieties studied was statistically significant with Arakta being richest in anthocyanin followed by Bhagwa and Ganesh. The Arakta has significantly higher total phenols than Bhagwa and Ganesh. The phenol content in Bhagwa and Ganesh were not significantly different. The antioxidant capacity of the pomegranate juice has been contributed by total phenols, anthocyanin content and ascorbic acid content. Since, Arakta has highest content of the phenolics and anthocyanin as compared to Bhagwa and Ganesh making it rich source of antioxidants. In present study the pomegranate juice of Arakta had the highest total flavonoid contents of 81.42, followed by 75.36 in Bhagwa and 65.06 mg QuE/L in Ganesh varieties respectively.

Table 1. Biochemical profile for pomegranate juice of different varieties

Pomegranate Variety	**TSS (^{0}B)**	**Acidity (%)**	**pH**	**Reducing sugar (%)**	**Total sugar (%)**	**Non Reducing Sugar (%)**
Bhagwa	16.10	0.32	3.49	15.31	15.80	0.49
Ganesh	17.10	0.35	3.17	16.49	16.73	0.24
Arakta	15.80	0.38	3.54	14.15	15.74	1.59
C.D.	0.10	0.02	0.02	0.56	0.43	0.41
SE(m)	0.03	0.01	0.01	0.16	0.12	0.12
SE(d)	0.04	0.01	0.01	0.22	0.17	0.17
C.V.	0.31	2.43	0.30	1.78	1.30	22.73

Table 2: Bioactive compounds for pomegranate juice of different varieties

Pomegranate Variety	Anthocyanine (mg cyanidine /100ml)	Total phenol (mg/L GAE)	Antioxidant capacity (mg/100ml AAE)	Total Flavonoid contents (mg QuE /L)
Bhagwa	24.04	2730.10	37.37	75.36
Ganesh	13.65	2702.77	26.37	65.06
Arakta	29.54	2862.10	41.03	81.42
C.D.	0.40	46.61	2.04	7.53
SE(m)	0.16	13.21	0.58	2.14
SE(d)	0.16	18.68	0.82	3.02
C.V.	0.89	0.83	2.86	5.00

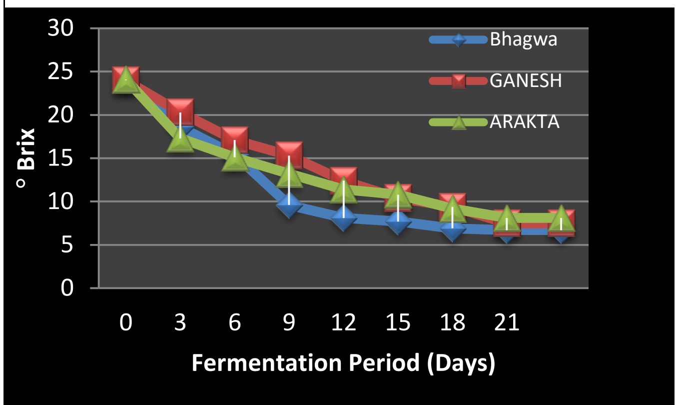	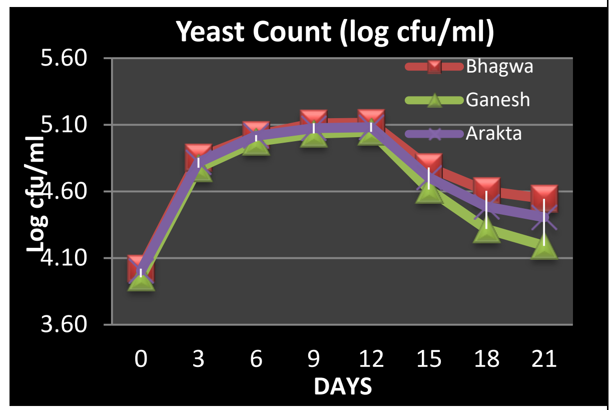
Fig. 1. Temporal changes in TSS during fermentation	**Fig. 2. Yeast count (log CFU/ml) during fermentation**

Changes in TSS and Yeast Count (cfu/ml)

The changes in total soluble solids (TSS) of three varieties were presented (Fig.3). The TSS adjusted to 24 °B. It has been observed that TSS has been reduced progressively during fermentation period up to 21 days (Fig 1). It has also been observed that major reduction in TSS was during initial 6 days. The 49.71, 41.81 and 55.97 % of the TSS reduction was observed during first six days for Bhagwa, Ganesh and Arakta varieties and remaining reduction was seen during last fifteen days. Further, the data on yeast count (Fig 2) shows that it exponentially increased up to sixth day and thereafter there was slow growth up to twelfth day followed by reduction in the yeast cell count. It can be concluded from the data that, the increase in the yeast count can be correlated to the corresponding fast utilization of TSS which comprises mainly sugars. Further, the reduction in rate of consumption of the sugars can be correlated to the quick dying of the yeast cells.

Biochemical Profile of the Wines of Different Varieties

Biochemical parameters of the developed wines were tabulated (Table 3). The TSS (°B) for different varieties for pomegranate wine namely Bhagwa, Ganesh and Arakta were 6.7, 7.5 and 8.1 respectively. The pH values for different varieties of pomegranate wine were from 3.65, 3.66 and 3.59 of Bhagwa, Ganesh and Arakta wines respectively. The TSS values for all the wines were statistically significantly different from each other and was highest for Arakta followed by Ganesh and Bhagwa. The residual sugars in the pomegranate wine were depicted by total sugars, reducing sugar and non-reducing sugars. The different wine varieties have shown significantly different residual total sugars (Table 3). The total sugars were mainly composed of reducing sugars similar to the juice. The reducing sugars in the wines are mainly composed of the fructose followed by glucose. The ethanol content in different varieties for pomegranate wine were 13.65, 13.65 and 13.27 % for Bhagwa, Ganesh and Arakta respectively. Thus it can be seen that the Ganesh and Bhagwa had highest ethanol content. Based on the residual sugar content the pomegranate wines developed can be categorized as sweet wines.

Bhagwa, Ganesh, and Arakta wines had total phenolics of 1980.43, 1716.10, and 1986.10 mg/LGAE, respectively. When compared with the total phenols present in the juice (Table 2) the phenols were found to be degraded during the process of the fermentation. This might be due to the decrease in the ellagitannins which are hydrolysable tannins present in the juice and were undergo hydrolysis during fermentation process.

The anthocyanin content has been decreased during the fermentation process. The table 2 and 4 shows that the reduction in the total anthocyanin content was 5.11, 6.88 and 21.40% respectively for Bhagwa, Ganesh and Arakta respectively. The reduction of anthocyanins in wines, might be due to the reactions of polymerization with acetaldehyde, generated by the metabolic activity of yeasts, with the formation of complex compounds causing loses of the red color. The total flavonoids in the juice were also reduced during the fermentation process.

Table 3 Biochemical profile of pomegranate wines of different varieties

Pomegranate Variety	TSS (^{0}B)	Total Acid (%)	Malic Acid (%)	pH	Reducing sugar (%)	Total sugar (%)	Non Reducing Sugar (%)	Ethanol (%)
Bhagwa	6.70	4.50	3.65	3.65	6.25	6.81	0.56	13.65
Ganesh	7.50	4.50	3.65	3.66	7.14	7.55	0.41	13.65
Arakta	8.10	4.25	3.15	3.59	7.92	8.42	0.50	13.27
C.D.	0.003	0.059	0.102	0.015	0.017	0.024	0.029	0.108
SE(m)	0.001	0.017	0.029	0.004	0.005	0.007	0.008	0.031
SE(d)	0.001	0.024	0.041	0.006	0.007	0.010	0.012	0.043
C.V.	0.020	0.654	1.435	0.199	0.116	0.157	2.909	0.392

Table 4 Bioactive compounds for pomegranate wine of different varieties

Pomegranate Variety	Anthocyanin (mg/100ml of cyanidine)	Total Phenol Content (mg/L GAE)	Antioxidant capacity (mg/100ml AAE)	Total Flavonoid Content (mg QE/L)
Bhagwa	22.81	1980.43	28.70	61.73
Ganesh	12.79	1716.10	21.03	46.58
Arakta	23.22	1986.10	31.03	66.27
C.D.	0.316	25.521	4.016	7.880
SE(m)	0.090	7.234	1.139	2.234
SE(d)	0.127	10.231	1.610	3.159
C.V.	0.792	0.662	7.325	6.648

Color and Sensory Analysis

During fermentation the L* and b* values were increased for all wines during fermentation with and corresponding increased lightness and yellowness. The* values (redness) in wines were increased for Bhagwa and Arakta and decreased for Ganesh as compared to initial values for juice. The results of the sensory evaluation of the three varieties namely Bhagwa, Ganesh and Arakta were depicted in Fig.3 In all the sensory quality parameters viz. color, aroma, taste, style the Arakta wine was found to be the best acceptable wine followed by the Bhagwa and Ganesh (Fig. 4).

Table 5. Color of pomegranate juice and wine

Pomegranate Variety	Juice			Wine		
	L*	a*	b*	L*	a*	b*
Bhagwa	14.41	18.37	6.04	17.47	40.38	27.02
Ganesh	35.28	42.18	18.14	43.24	21.77	30.32
Arakta	15.10	11.87	3.22	22.13	32.30	16.01

Fig. 3 Radar plot for sensory score of pomegranate wines of Bhagwa, Ganesh and Arakta

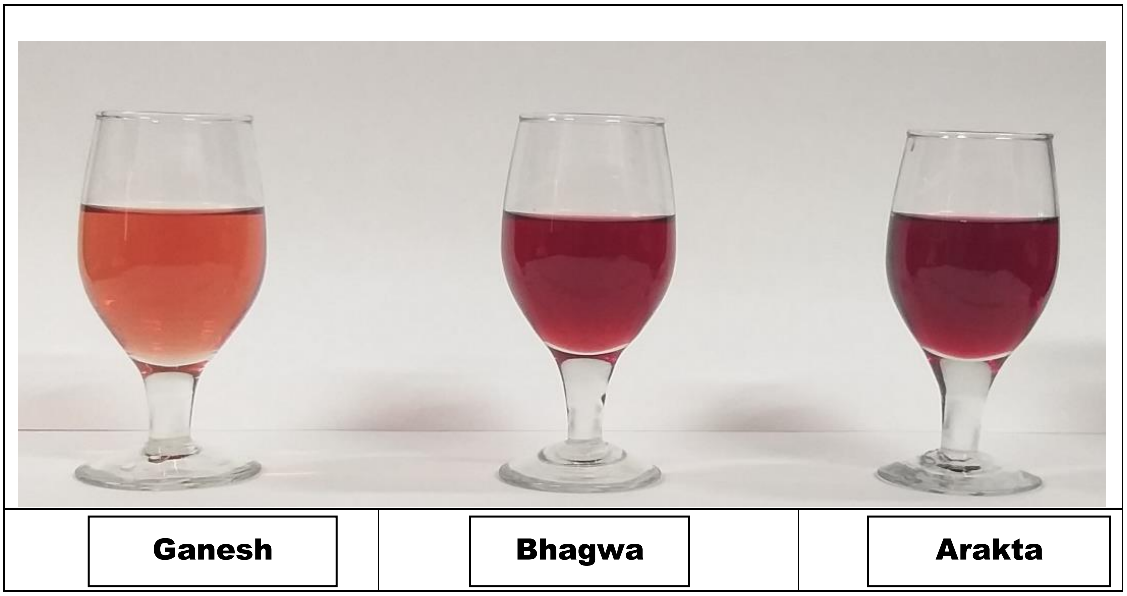

Fig. 4. Pomegranate wines of Bhagwa, Ganesh and Arakta varieties

Determination of maturity indices for pomegranate variety Solapur Lal

To determine the maturity indices for harvesting of pomegranate var. Solapur Lal, the flowers were tagged on the day of anthesis. The fruit samples were collected after fruitset at an interval of 15 days. Once maturity is approached, the samples were collected at 5 days interval to fix up the appropriate maturity indices for harvesting. Solapur Lal attained maturity at 160 days after anthesis with highest total soluble solids content (17.6^{o}Brix).

Table. Maturity indices for pomegranate variety Solapur Lal

Stage of fruit development (Days after anthesis)	Fruit weight (g)	TSS (^{o}Brix)	Titrable acidity (%)	TSS/Acid ratio
90 days	170.6	13.0	0.58	22.41
105 days	196.2	14.2	0.52	27.30
120 days	222.8	15.3	0.49	31.22
135 days	245.2	16.1	0.46	35.00
150 days	263.2	16.9	0.43	39.30
160 days	271.6	17.6	0.40	44.00
165 days	272.5	17.8	0.40	44.50

6.1.3. Determination of anardana recovery:

Anardana is the dried form of arils. 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 17.5-21.2°B. Anardana recovery was highest in Solapur

Anardana (21.2%) closely followed by NRCP H-4 (20.8%). The recovery was lowest in Amlidana (17.5%).

Table. Anardana recovery from pomegranate hybrids

S.No.	Variety/ Hybrid	Anardana recovery from arils (%)
1	NRCP H-1	19.8
3	NRCP H-3	18.8
4	NRCP H-4	20.8
5	NRCP H-11	20.4
6	NRCP H-12 (Solapur Anardana)	21.2
7	NRCP H-15	20.6
8	6/4	19.4
9	6/5	18.6
10	Hybrid A	20.2
11	Amlidana	17.5

6.2 DEVELOPMENT OF FUNCTIONAL FOOD PRODUCTS AND WASTE UTILIZATION FROM POMEGRANATE

Activity 1: Development and evaluation of **Low calorie pomegranate fruit drink** using natural and artificial sweeteners

- Low calorie pomegranate Ready-To-Serve (RTS) drink was prepared using natural (stevia) and artificial sweeteners (sucralose and aspartame) by substituting sucrose (refined white sugar) at the rate of 0, 25%, 50%, 75% and 100%. RTS drink was prepared as per the FSSAI Specification as Juice: 20%, T.S.S.: 15% and Acidity: 0.375%. The sweeteners were added within the limit as described by FSSAI.
- The physicochemical properties of the low calorie pomegranate RTS drink were evaluated with respect to total sugar, energy value, T.S.S., acidity, pH, colour, total phenol content, antioxidant activity, ascorbic acid content and sensory properties.
- The total sugar content of RTS was significantly reduced from 15.03% to 4.5% due to use of non-calorific sweeteners. The energy value was also reduced from 60.12 kcal/100ml to 18 kcal/100ml (Fig.1a and 1b). The developed RTS drink is suitable for the consumers on low calorie diet and also for patient with type II diabetics.

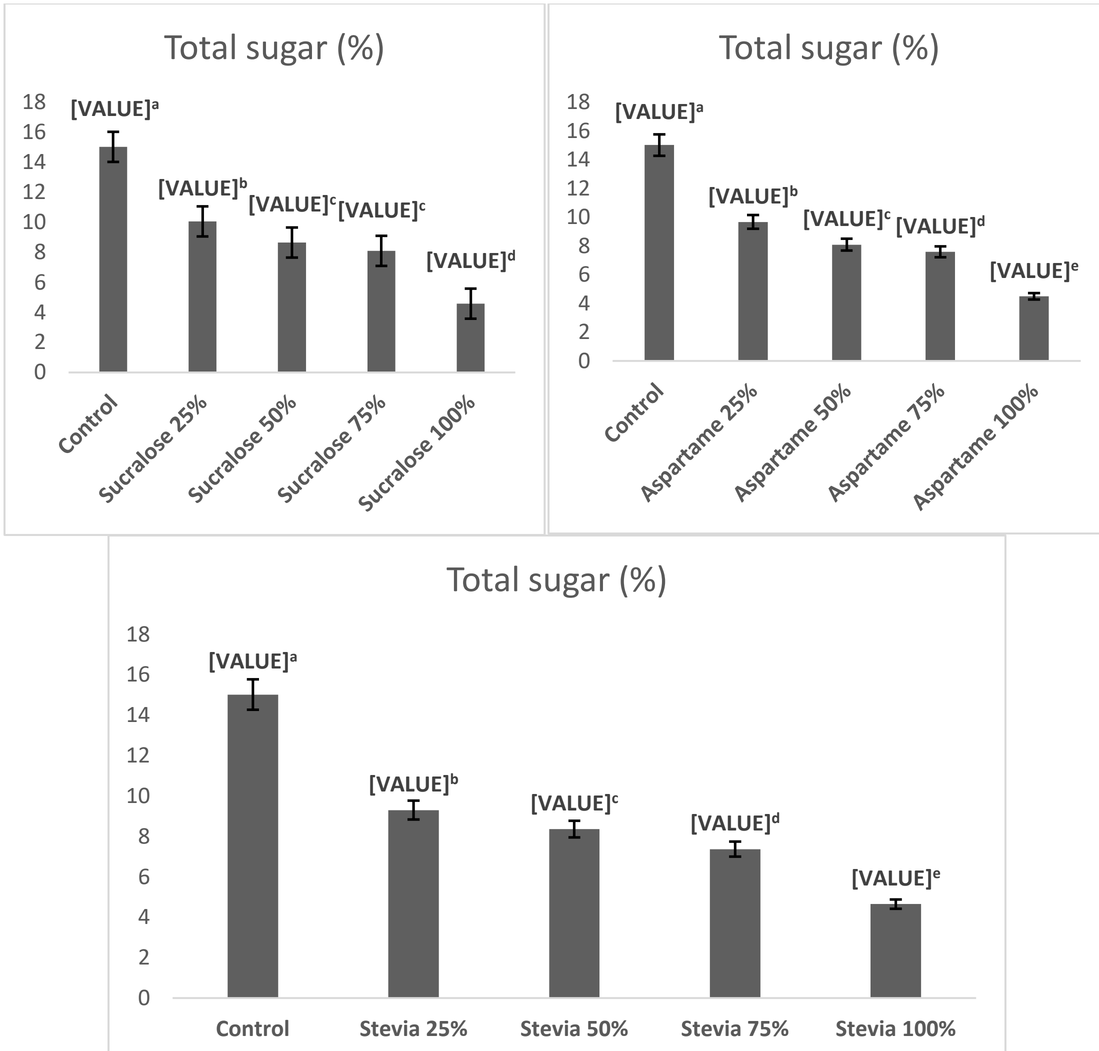

Fig.1 (a) Total sugar content of low calorie pomegranate fruit drink with different sweeteners

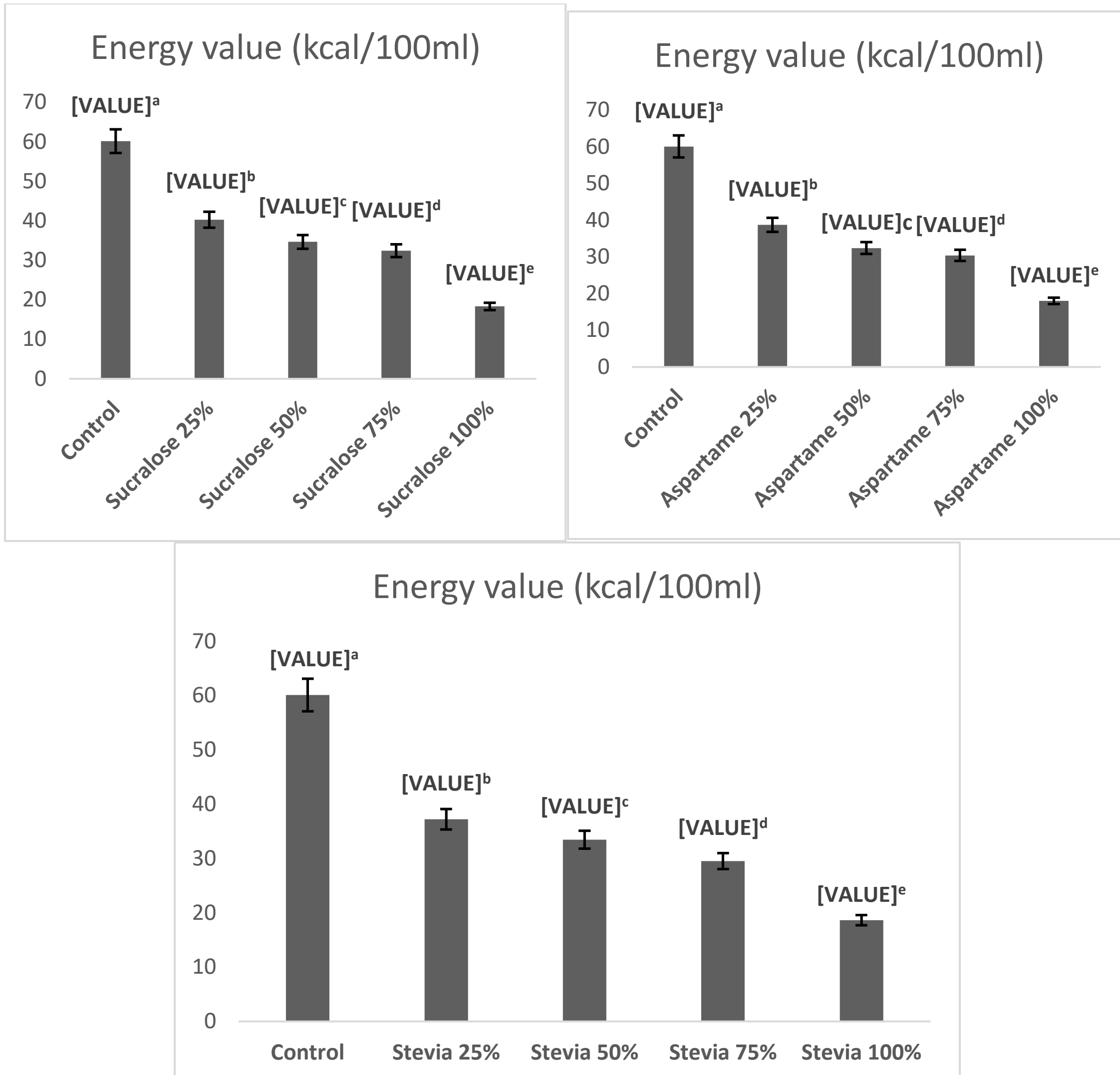

Fig.1 (b) Energy value of low calorie pomegranate fruit drink with different sweeteners

- The chemical composition and physico-chemical properties of low calorie pomegranate fruit drink is given in Table 1 and 2 respectively. The substitution of white refined sugar with natural and artificial sweeteners at different levels significantly affected on chemical composition, T.S.S, colour value and overall acceptability.
- The sensory evaluation resulted to acceptable score to the low calorie pomegranate fruit drink with 75% replacement of refined sugar with natural and artificial sweeteners.

Table 1. Chemical composition of low calorie pomegranate fruit RTS drink

Treatments	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	Energy value (kcal/100ml)	Ascorbic acid (mg/100ml)	Total phenols (mg GAE/100ml)	In-vitro Antioxidant activity (%)	Antioxidant capacity (mg/100ml)	Total anthocyanin (mg/100ml)
RTS with Sucralose sweeteners									
Control	3.62±0.1^{a}	11.41±0.3^{a}	15.03±0.1^{a}	60.12±0.2^{a}	6.25±0.3^{d}	0.15±0.3^{a}	92.85±0.1^{a}	2.44±0.3^{a}	43.584±0.1^{a}
Sucralose 25%	3.67±0.2^{a}	6.4±0.3^{b}	10.07±0.1^{b}	40.28±0.2^{b}	6.25±0.3^{d}	0.148±0.3^{b}	88.21±0.1^{b}	2.23±0.3^{b}	39.91±0.2^{b}
Sucralose 50%	3.7±0.1^{a}	4.96±0.2^{c}	8.66±0.2^{c}	34.64±0.3^{c}	8.12±0.2^{c}	0.132±0.2^{c}	81.84±0.2^{c}	1.93±0.2^{c}	39.91±0.2^{b}
Sucralose 75%	3.67±0.3^{a}	4.43±0.2^{d}	8.1±0.2^{d}	32.4±0.3^{d}	11.87±0.2^{b}	0.122±0.1^{d}	75.65±0.2^{d}	1.56±0.2^{d}	38.24±0.3^{c}
Sucralose 100%	3.67±0.2^{a}	0.91±0.3^{e}	4.58±0.3^{e}	18.32±0.1^{e}	12.5±0.1^{a}	0.113±0.1^{e}	65.31±0.1^{e}	1.4±0.1^{e}	38.073±0.1^{c}
RTS with Aspartame sweeteners									
Control	3.62±0.1^{a}	11.41±0.3^{a}	15.03±0.1^{a}	60.12±0.2^{a}	6.25±0.3^{e}	0.15±0.3^{a}	92.85±0.1^{a}	2.44±0.3^{a}	43.584±0.1^{a}
Aspartame 25%	3.67±0.1^{a}	6.01±0.1^{b}	9.68±0.3^{b}	38.72±0.1^{b}	6.87±0.1^{d}	0.122±0.2^{b}	89.86±0.1^{b}	2.13±0.1^{b}	38.908±0.1^{b}
Aspartame 50%	3.7±0.1 ^{a}	4.4±0.1^{c}	8.1±0.2^{c}	32.4±0.1^{c}	7.5±0.2^{c}	0.119±0.2^{c}	87.05±0.1^{c}	1.82±0.2^{c}	37.571±0.1^{c}
Aspartame 75%	3.7±0.3^{a}	3.9±0.2^{d}	7.6±0.1^{d}	30.4±0.2^{d}	10±0.2^{b}	0.113±0.1^{d}	83.09±0.2^{d}	1.48±0.2^{d}	36.239±0.2^{d}
Aspartame 100%	3.67±0.2^{a}	0.83±0.4^{e}	4.5±0.1^{e}	18±0.3^{e}	12.5±0.1^{a}	0.11±0.2^{d}	74.98±0.3^{e}	1.36±0.1^{e}	36.06±0.3^{d}
RTS with Stevia sweeteners									
Control	3.62±0.1^{a}	11.41±0.3^{a}	15.03±0.1^{a}	60.12±0.2^{a}	6.25±0.3^{d}	0.15±0.3^{a}	92.85±0.1^{a}	2.44±0.3^{a}	43.584±0.1^{a}
Stevia 25%	3.64±0.1^{a}	5.67±0.1^{b}	9.31±0.2^{b}	37.24±0.2^{b}	7.5±0.3^{c}	0.119±0.1^{b}	86.28±0.2^{b}	2.06±0.1^{b}	39.50±0.1^{b}
Stevia 50%	3.7±0.1^{a}	4.67±0.2^{c}	8.37±0.1^{c}	33.48±0.2^{c}	7.5±0.3^{c}	0.117±0.2^{c}	78.55±0.2^{c}	1.74±0.1^{c}	38.572±0.2^{c}
Stevia 75%	3.7±0.2^{a}	3.68±0.2^{d}	7.38±0.2^{d}	29.52±0.1^{d}	11.87±0.1^{b}	0.113±0.3^{d}	63.29±0.1^{d}	1.35±0.2^{d}	37.576±0.2^{d}
Stevia 100%	3.67±0.2^{a}	0.99±0.2^{e}	4.66±0.1^{e}	18.64±0.1^{e}	12.5±0.1^{a}	0.11±0.3^{d}	53.24±0.1^{e}	1.29±0.2^{e}	37.574±0.3^{d}

Values are expressed as mean ± SD of three independent determinations. Values in columns followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

Table 2. Physico-chemical properties and overall acceptability of low calorie pomegranate fruit RTS drink

Treatments	**T.S.S. (°BX)**	**Acidity (%)**	**pH**	**L**	**a**	**b**	**Hue**	**Croma**	**ΔE**	**Overall acceptability**
					RTS with sucralose sweeteners					
Control	16.07±0.06^{a}	0.353±0.35^{d}	2.653±2.65^{a}	34.30±0.01^{e}	49.23±0.01^{b}	30.23 ±0.01^{a}	31.55±0.01^{a}	57.77 ±0.01^{a}	0	8.70±0.17^{a}
Sucralose 25%	13.23±0.06^{b}	0.353±0^{d}	2.643±0.01^{ab}	34.75± 0.01^{d}	49.28±0.01^{a}	29.31±0.01^{b}	30.75± 0.01^{b}	57.34 ±0.01^{b}	1.03±0.01^{d}	8.30±0.17^{b}
Sucralose 50%	9.27±0.06^{c}	0.362±0^{c}	2.643±0.01^{ab}	36.08±0.01^{b}	48.67 ±0.01^{d}	28.15± 0.01^{d}	30.03 ±0.01^{d}	56.23 ±0.01^{d}	2.80± 0.01^{b}	8.30±0.17^{b}
Sucralose 75%	7.63±0.06^{d}	0.368±0^{b}	2.633±0.01^{b}	36.02± 0.01^{c}	49.14 ±0.01^{c}	28.79 ±0.01^{c}	30.37 ±0.01^{c}	56.95 ±0.01^{c}	2.25 ±0.01^{c}	8.30±0.17^{b}
Sucralose 100%	4.63±0.06^{e}	0.374±0^{a}	2.633±0.01^{b}	36.76± 0.01^{a}	48.57±0.01^{e}	27.57 ±0.01^{e}	29.63±0.01^{e}	55.85 ±0.01^{e}	3.68 ±0.01^{a}	7.80±0.17^{c}
					RTS with Aspartame sweeteners					
Control	16.07±0.06^{a}	0.353±0.35^{d}	2.653±2.65^{a}	34.30±0.01^{e}	49.23±0.01^{a}	30.23 ±0.01^{a}	31.55±0.01^{a}	57.77 ±0.01^{a}	0	8.70±0.17^{a}
Aspertame 25%	12.70±0.06^{b}	0.361±0^{c}	2.643±0.01^{ab}	35.62±0.01^{d}	48.83±0.01^{b}	27.97± 0.01^{b}	29.82± 0.01^{b}	56.27±0.01^{b}	2.65± 0.01^{d}	8.13±0.25^{b}
Aspertame 50%	10.10±0.06^{c}	0.368±0^{b}	2.643±0.01^{ab}	36.43± 0.01^{c}	48.35± 0.01^{d}	26.88±0.01^{c}	29.07±0.01^{c}	55.32± 0.01^{c}	4.07± 0.01^{c}	8.13±0.25^{b}
Aspertame 75%	7.50±0.06^{d}	0.373±0^{ab}	2.643±0.01^{ab}	36.68±0.01^{b}	48.39± 0.01^{c}	26.73± 0.01^{d}	28.93± 0.01^{d}	55.28± 0.01^{d}	4.32±0.01^{b}	8.13±0.25^{b}
Aspertame 100%	4.60±0.06^{e}	0.375±0^{a}	2.633±0.01^{b}	37.05±0.01^{a}	48.02±0.01^{e}	26.49± 0.01^{e}	28.93±0.01^{d}	54.84± 0.01^{e}	4.83± 0.01^{a}	7.56±0.25^{c}
					RTS with stevia sweeteners					
Control	16.07±0.06^{a}	0.353±0.35^{d}	2.653±2.65^{a}	34.30±0.01^{e}	49.23±0.01^{b}	30.23 ±0.01^{a}	31.55±0.01^{a}	57.77 ±0.01^{a}	0	8.70±0.17^{a}
Stevia 25%	13.10±0.06^{b}	0.365±0^{c}	2.633±0.01^{b}	34.88± 0.01^{d}	49.39± 0.01^{a}	28.73±0.01^{b}	30.20± 0.01^{b}	57.14±0.01^{b}	1.62± 0.01^{d}	8.60±0.25^{a}
Stevia 50%	10.90±0.06^{c}	0.369±0^{bc}	2.623±0.01^{bc}	35.46±0.01^{c}	49.08±0.01^{c}	28.54±0.01^{c}	30.16± 0.01^{c}	56.78± 0.01^{d}	2.06±0.01^{c}	8.16±0.25^{ab}
Stevia 75%	8.46±0.06^{d}	0.372±0^{b}	2.623±0.01^{bc}	35.59±0.01^{b}	49.23±0.01^{b}	28.43± 0.01^{d}	29.99±0.01^{d}	56.83±0.01^{c}	2.24±0.01^{b}	8.16±0.25^{ab}
Stevia 100%	5.73±0.06^{e}	0.379±0^{a}	2.633±0.01^{c}	35.89±0.01^{a}	48.86±0.01^{d}	26.87± 0.01^{e}	28.81± 0.01^{e}	55.76±0.01^{e}	3.74± 0.01^{a}	7.66±0.25^{b}

Values are expressed as mean ± SD of three independent determinations. Values in columns followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

Objective 2:

To standardize, optimize and evaluate the pomegranate waste utilization process for development of functional foods from peel and seed powder.

Activity 1. Oxidative stability of muffins incorporated with pomegranate peel powder

- **Experiment 1. Phytochemical, nutritional, thermal and functional properties of pomegranate peel powder and its extract**

- The studies were carried out to evaluate the effect of different drying methods (cabinet tray drying and sun drying) and particle size (260µm, 710µm and 2000µm) of the pomegranate peel powder (Fig.2) on the biochemical composition of the pomegranate peel powder and its extract for its further utilization as natural preservative for oxidative and microbial stability in food products.
- The surface disinfection of pomegranate peel was done by washing with sodium hypochloride (80 ppm, pH 7) followed by drying at 50^{o}C for 24-48h till get moisture content about 5 to 7% using cabinet tray dryer. Moreover, sun drying was also applied for preparation of pomegranate peel powder. The dried pomegranate peel was pulverized into powder with varying particle size of 260µm, 710µm and 2000µm. The pomegranate peel extract was prepared using already standardized aqueous method and further concentrated by rotary evaporator.
- A significant variation was observed with respect to biochemical composition of pomegranate peel extract of different particle size of pomegranate peel powder (PPP). The highest total phenol content (1988.33 mg/L GAE) and antioxidant activity (67.77% radical scavenging activity) of peel powder revealed with smallest particle size (260µm) and vice versa. But, no significant different was observed in protein and fiber content of peel powder with respect to variation in particle size (Table 3).
- The minerals content of peel powder showed slight variation but not significant when there is variation in particle size of the powder. The phosphorus (0.31%), potassium (1.51%), calcium (1.80%), magnesium (0.14 %), iron (445 mg/100g) and manganese (101 mg/100g) was found higher in sample with 260µm whereas, higher amount of copper (96mg/kg), zinc (161mg/kg) was noted in peel powder with 2000µm (Table 3).

Table 3. Phytochemical and nutritional properties of pomegranate peel powder of different particle size

Parameters	Particle size of pomegranate peel powder		
	260um	710um	2000um
Total phenols (mg GAE/L)	1988.33±0.05[a]	1601.36±0.05[b]	1559.54±0.03[c]
Antioxidant activity FRAP (mg/100ml AAE)	41.10±0.03[a]	39.87±0.03[b]	33.21±0.05[c]
Antioxidant activity DPPH (%)	67.77±0.01[a]	56.99±0.01[b]	37.77±0.01[c]
Total tannin content (mg GAE/L)	-	-	231±0.04[a]
Protein (%)	2.53±0.03[a]	2.45±0.03[a]	2.39±0.03[a]
Fiber content (%)	12.2±0.02[a]	11.57±0.05[a]	12.22±0.05[a]
P%	0.31±0.01[a]	0.28±0.01[a]	0.31±0.01[a]
K%	1.51±0.03[a]	1.235±0.03[a]	1.215±0.05[a]
Calcium (%)	1.80±0.02[a]	1.60±0.05[a]	1.60±0.05[a]
Magnesium(%)	0.14±0.01[a]	0.10±0.01[a]	0.10±0.01[a]
Iron (mg/100g)	445±0.07[a]	365±0.02[b]	355±0.06[c]
Mn (mg/100g)	101±0.03[a]	58±0.06[b]	53±0.01[c]
Cu (mg/100g)	83±0.02[c]	92±0.03[b]	96±0.02[a]
Zinc (mg/100g)	139±0.01[c]	158±0.02[b]	161±0.02[a]

Values are expressed as mean ± SD of three independent determinations. Values in rows followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

Fig 2. Dried pomegranate peel and powder

- The functional properties such as water absorption capacity (340%), oil absorption capacity (260%), bulk density (0.48g/ml), foaming capacity (1%) and stability (40%), emulsification capacity (78.57%), swelling capacity (44ml) and dispersibility (52%) of pomegranate peel powder has been evaluated. There was no significant difference was observed for functional properties of cabinet tray and sun dried pomegranate peel powder. Thermal properties of food materials give an idea about the quality of food components under the effect of high temperature. The thermal properties of cabinet tray dried peel powder was recorded significantly higher especially peak temperature and conclusion temperature. Whereas, enthalpy of sundried peel powder was found as 3.848 J/g which was slightly higher than cabinet tray dried peel powder (3.070J/g) (Table 4).

Table 4. Functional and thermal properties of pomegranate peel powder

Parameters	Pomegranate peel powder	
	Sun dried	**Cabinet Tray dried**
Water absorption capacity (%)	340±0.3[a]	340±0.1[a]
Oil absorption capacity (%)	260±0.5[a]	260±0.5[a]
Bulk density (g/ml)	0.49±0.5[a]	0.48±0.5[a]
Foaming capacity (%)	1±0.1[a]	1±0.1[a]
Foam stability (%)	40±0.1[a]	40±0.1[a]
Emulsification capacity (%)	78.57±0.5[a]	78.57±0.5[a]
Swelling capacity (ml)	42±0.3[b]	44±0.3[a]
Dispersibility (%)	51±0.3[b]	52±0.3[a]
Onset temperature (To)	40±0.1[a]	40.2±0.1[a]
Peak temperature (Tp)	63.9±0.1[b]	67.1±0.2[a]
Conclusion temperature (Tc)	93.3±0.2[b]	95.2±0.1[a]
Enthalpy (ΔH) (J/g)	3.848±0.2[a]	3.070±0.2[b]

Values are expressed as mean ± SD of three independent determinations. Values in rows followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

- Thermogravimetric analysis (TGA) was done for sun dried and cabinet tray dried pomegranate peel powder samples to know the thermal stability of the material and its fraction of volatile components by monitoring the weight change that occurs when sample is heated at constant rate. The sample was heated at a constant rate of 10°C/min from 35 °C to 800 °C. From TGA curve, it can be seen that as temperature increases there was decrease in mass of the sample due to thermal treatment. The loss in mass at initial stage of sundried pomegranate peel powder was 13.99% and for cabinet tray dried peel powder as 9.89% which was increased to 48.28% and 41.52% respectively. The residual mass recorded as 3.69% and 28.81% for sundried and cabinet tray dried pomegranate peel powder respectively (Fig 3).

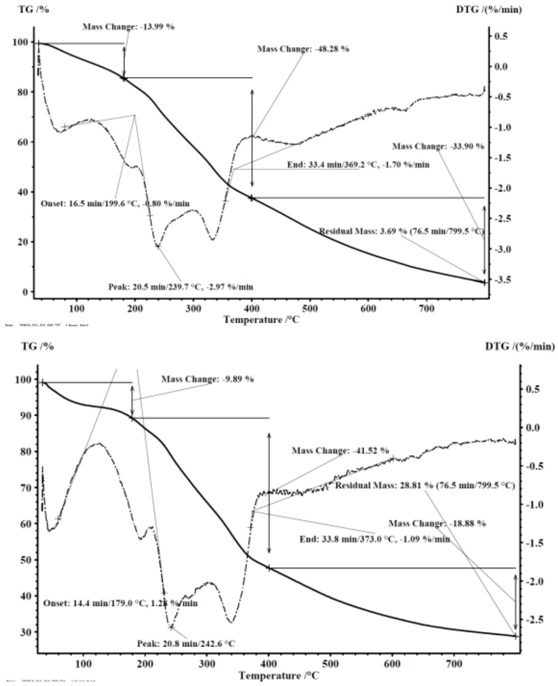

Fig.3 The TGA curve for sundried and cabinet tray dried pomegranate peel powder

- **Experiment 2: Development and evaluation of pomegranate peel powder fortified muffins**

- The cabinet tray dried pomegranate peel powder were utilized as a natural preservative to evaluate the oxidative stability of muffins. The pomegranate peel powder was incorporated at the rate of 0, 2, 4, 6, 8 and 10% by substituting refined wheat flour in the formulations (Table 5). The process including the level of different ingredients, baking temperature, baking time etc. were standardized for the development of muffins (Fig.4).
- The physical, nutritional, pasting, sensorial and microbial properties of developed muffins with pomegranate peel powder along with control (without pomegranates peel powder) samples were evaluated.

Table 5. Formulation for the development of muffins fortified with pomegranate peel powder (PPP)

Ingredients (%)	Control	2%PPP	4%PPP	6%PPP	8%PPP	10%PPP
Refined wheat flour	26	24	22	20	18	16
Pomegranate peel powder	--	2	4	6	8	10
Refined Sugar	26	26	26	26	26	26
Sunflower oil	12	12	12	12	12	12
Egg	22	22	22	22	22	22
Milk	13	13	13	13	13	13
Baking powder	1	1	1	1	1	1

Table 6. Nutritional compositions of muffins fortified with pomegranate peel powder

Treat-ments	Moisture (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrates (%)	Energy value (Kcal/100g)	Antioxidant activity (%)	Total phenols (mg GAE/100g)
Control	16.68 ± 0.01^{f}	12.66 ± 0.01^{a}	7.37 ± 0.01^{a}	4.39 ± 0.43^{f}	57.09 ± 0.42^{b}	371.85 ± 0.42^{a}	75.94 ± 0.01^{f}	0.443 ± 0.01^{f}
2%PPP	17.38 ± 0.01^{e}	10.76 ± 0.01^{b}	7.00 ± 0.01^{b}	5.09 ± 0.06^{e}	57.83 ± 0.08^{a}	356.20 ± 0.26^{b}	78.89 ± 0.01^{e}	21.08 ± 0.0^{e}
4%PPP	18.03 ± 0.01^{d}	9.63 ± 0.01^{c}	6.82 ± 0.01^{c}	6.23 ± 0.30^{d}	56.88 ± 0.29^{b}	341.54 ± 0.18^{c}	85.31 ± 0.01^{d}	23.93 ± 0.0^{d}
6%PPP	18.38 ± 0.01^{c}	9.17 ± 0.01^{d}	6.39 ± 0.01^{d}	7.32 ± 0.12^{c}	56.06±0.12c	332.40 ± 0.50^{d}	89.47 ± 0.01^{c}	34.96 ± 0.0^{c}
8%PPP	18.67 ± 0.01^{b}	8.09 ± 0.01^{e}	6.33 ± 0.06^{e}	8.43 ± 0.47^{b}	55.70±0.44c	320.99 ± 0.47^{e}	98.55 ± 0.01^{b}	48.15 ± 0.0^{b}
10%PPP	19.08 ± 0.01^{a}	7.74 ± 0.01^{f}	5.86 ± 0.01^{f}	10.66 ± 0.30^{a}	53.81±0.29d	308.38 ± 0.19^{f}	99.36 ± 0.01^{a}	48.53 ± 0.06^{a}

Values are expressed as mean ± SD of three independent determinations. Values in columns followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

Fig.4 Muffins fortified with pomegranate peel powder

- The muffins fortified with pomegranate peel powder resulted to increase in fiber content from 4.39% to 10.66%, total phenols from 0.443 mg GAE/100g to 48.53 mg

GAE/100g and antioxidant activity from 75.94% to 99.36%. On positive sides, for consumers on low calorie diet, can prefer the muffins with pomegranate peel powder which showed the reduction in energy values from 371.85 kcal/100g to 308.38kcal/100g (Table 6).

- The significant changes were recorded in the physical properties of muffin batter as well as muffins incorporated with pomegranate peel powder. The significant reduction in the height, volume and specific volume of muffins was found with increase in the level of pomegranate peel powder. Moreover, the specific gravity and viscosity of muffins batter increased with incorporation of pomegranate peel powder. The substitution of refined wheat flour with pomegranate peel powder resulted to dilution in gluten content which is responsible for the desirable physical properties of muffins and higher fiber content of pomegranate peel powder leads to higher moisture absorption caused increase in the viscosity of batter (Table 7).

Table 7. Physical properties of muffin batter and muffins fortified with pomegranate peel powder

Treatments	Height of muffins (mm)	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Weight loss (g/100g)	Viscosity of muffin batter (cP)	Specific gravity of muffin batter
Control	37.43±0.06[a]	31.28±0.01[e]	62.33±0.48[a]	1.99±0.02[a]	11.73±0[a]	8240.3±0.58[f]	1.056±0.01[f]
2%PPP	33.36±0.01[b]	31.42±0.01[d]	60.33±0.48[b]	1.92±0.02[b]	11.71±0[b]	9272.4±0.51[e]	1.268±0[e]
4%PPP	32.68±0.01[c]	31.58±0.01[c]	59.33±0.48[b]	1.88±0.02[c]	11.46±0.01[c]	10019.7±0.58[d]	1.360±0[d]
6%PPP	31.14±0.01[d]	31.65±0.01[b]	55.33±0.45[c]	1.75±0.02[d]	10.96±0.01[d]	11024.8±0.40[c]	1.438±0[c]
8%PPP	28.01±0.01[e]	31.68±0.01[b]	53.33±0.45[d]	1.68±0.02[e]	10.79±0.01[e]	12027.3±0.58[b]	1.462±0[b]
10%PPP	26.62±0.01[f]	32.03±0.06[a]	50.33±0.30[e]	1.57±0.02[f]	10.14±0.01[f]	13019.7±0.40[a]	1.481±0[a]

Values are expressed as mean ± SD of three independent determinations. Values in columns followed by the same letter are not significantly different at $p \leq 0.05$ as measured by Duncan's test

- The organoleptic properties of the muffins fortified with pomegranate peel powder were assessed using 9-point hedonic scale and the significant variation was recorded in pomegranate peel powder muffins with respect to sensorial properties especially texture, taste and mouthfeel when compared with control sample. The increase in level of pomegranate peel powder resulted to increase in the hardness and slightly grittiness. The fortification levels up to 8% in muffin was within acceptable range by the panel members.
- The shelf life of muffins was evaluated by storage at room temperature and low temperature (5^{o}C) using high density polyethylene (HDPE) as packaging material. The effect of fortification of pomegranate peel powder on oxidative and microbial stability of muffins were investigated during the storage period of 4 weeks at different

storage conditions. The moisture content, free fatty acid content, peroxide value, texture profile analysis and microbial analysis were carried out for all the treatments.

- The muffins sample stored at room temperature showed visible microbial growth during 3rd week of the storage and parameters recorded at the interval of each week. The moisture content of muffins decreased during storage period (3weeks) from 16.68% to 11.62% (control) and 19.08% to 14.11% (10%PPP). The oxidative stability of muffins was measured in terms of free fatty acid content (%) and peroxide value (meq.of O_2/kg of oil). The free fatty acid content was significantly increased from 0.27% to 1.36% in control sample and 0.18% to 0.71% in muffin with pomegranate peel powder. The increase in free fatty acid content in pomegranate peel powder fortified muffins was significantly lower when compared with control. Similarly peroxide value was increased from 3.04 to 6.08 meq.of O_2/kg of oil (control) and 2.50 to 3.15 meq.of O_2/kg of oil (10%PPP). The muffins fortified with pomegranate peel powder showed higher oxidative stability when compared with control sample due to high phenols content and antioxidant activity.
- Similar trends with respect to moisture content, free fatty acids and peroxide value were observed for the muffins stored at low temperature (5^{o}C). In both the cases muffins with pomegranate peel powder showed significantly higher oxidative stability in comparison with control. The shelf life of muffins at low temperature (5^{o}C) recorded as 4 weeks.
- **Microscopy images of muffin batter**

  Micrograph obtained for the control batter, and for the batter with 2%, 4%, 6%, 8% and 10% pomegranate peel powder as shown in Fig 5. When refined wheat flour was replaced by increasing quantities of pomegranate peel powder, a change in air bubble size and quantity was observed. There was decrease in the number of air cell with increase in the level of pomegranate peel powder but the radius of air cell (µm) was recorded as increased. Bigger air cell in pomegranate peel powder added muffin batter was observed as compared to control.

Table 8. Air cells of pomegranate peel powder fortified muffins batter observed under light microscopy

Treatments	Control	2%PPP	4%PPP	6%PPP	8%PPP	10%PPP
No. of air cells	11	11	8	8	7	5
Air cells radius range	8.01 to 33.58	18.65 to 42.84	19.92 to 44.02	20.57 to 44.07	28.32 to 44.32	49.36 to 70.14

(µm)						
Area range (µm²)	201.46 to 3540.71	1092.16 to 4996.4	1245.97 to 6084.56	1666.57 to 6094.4	2518.35 to 6167.78	7650.32 to 15447.61

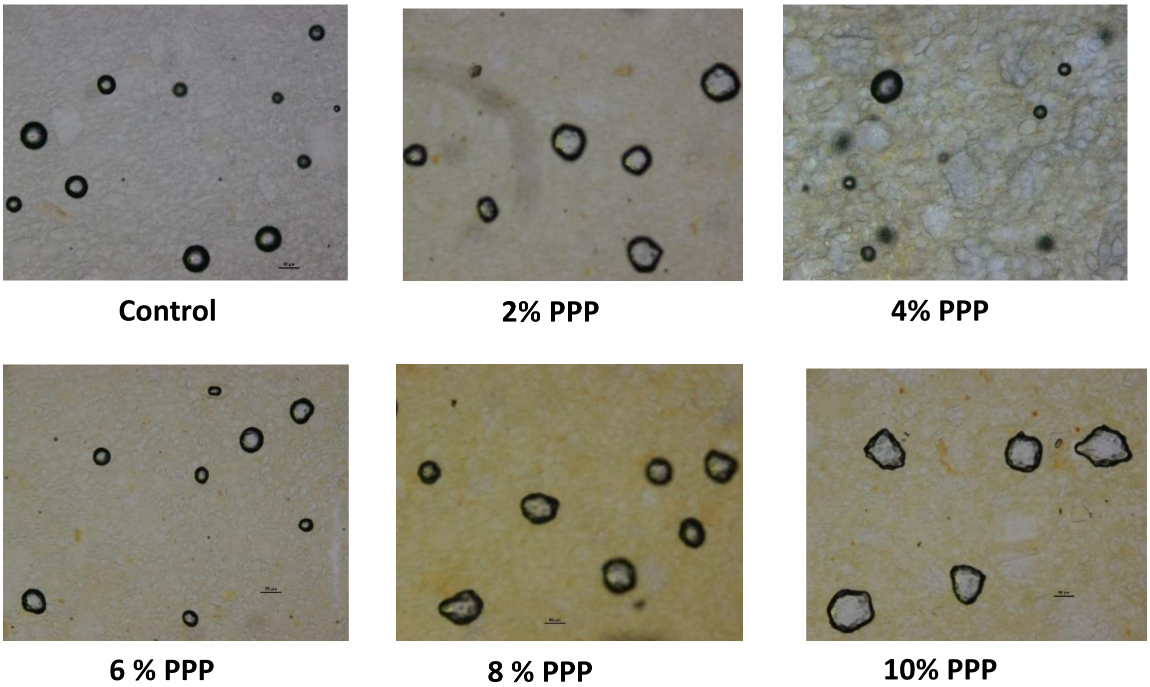

Fig 5. Micrographs for the muffin batter prepared with pomegranate peel powder obtained with light microscopy

- **Pasting properties of flour blend for muffins incorporated with pomegranate peel powder**

  The pasting properties of muffins flour blend fortified with pomegranate peel powder was evaluated using Rapid Visco Analyzer (RVA Tech Master, Perten Instruments, Australia) and it measured the pasting temperature, peak viscosity, trough, breakdown viscosity, final viscosity, set back viscosity and peak time. The RVA graph for the control sample along with sample containing pomegranate peel powder is shown in Fig 6. The increase in the level of pomegranate peel powder in muffins resulted to significant reduction in peak viscosity, trough viscosity and final viscosity. The peak viscosity attained during the heating portion of tests indicates the water binding capacity of the mixture.

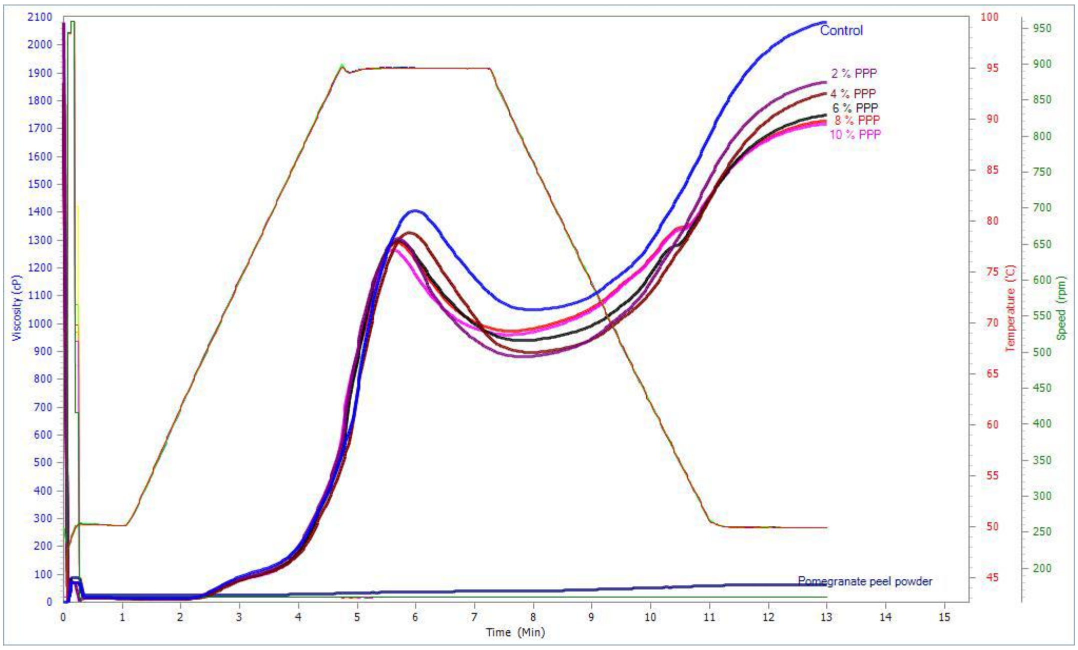

Fig 6. RVA graph for the muffins flour blend fortified with different levels of pomegranate peel powder

- **Rheological properties of the muffins flour blend fortified with different levels of pomegranate peel powder by rheometer**

In dynamic oscillation measurements, the potential energy that is dissipated as heat is separated into storage modulus and loss modulus. Storage dynamic modulus (G') is a measure of the energy stored in the material and recovered from it per cycle while the loss modulus (G") is a measure of the energy dissipated or lost per cycle of sinusoidal deformation. In dynamic oscillation measurements, the frequency sweep of the two moduli (G' and G"), used to distinguish between the elastic and viscous properties of a material over a spectrum of times. When the viscous properties dominate, G" exceeds G', and *vice versa* (G' > G") when the elastic properties prevail.

The dynamic rheological properties (storage modulus, loss modulus and phase angle) for the 10% (w/v) gel suspension of the muffin batter samples obtained from RVA studies were determined using Rheoplus MCR 51 Rheometer (M/s Anton Paar GmbH. Germany) at 30ºC, using a parallel plate geometry system (PP20-SN5912, 1mm diameter) at 1 mm gap. The following experimental conditions were selected: frequency 1 to 10 Hz; strain of 1 per cent (%). For each treatment, storage modulus

(G'), loss modulus (G''), complex modulus (G_{max}), phase angle (δ) were recorded and the measurements were conducted in duplicates.

The frequency dependence of storage modulus (G'), loss modulus (G'') and complex modulus (G_{max}) were increased with increase in the value of frequency from 0 to 10 Hz and with increase in the level of pomegranate peel powder. The value for loss modulus (G'') of sample was greater than value of storage modulus (G') in the frequency range studied, showing a predominantly viscous behavior of the muffin batter. The phase angle for all the sample showed sharp increase at initial frequency range of 0 to 5 Hz and tends to constant at 5 to 10 Hz (Fig.7).

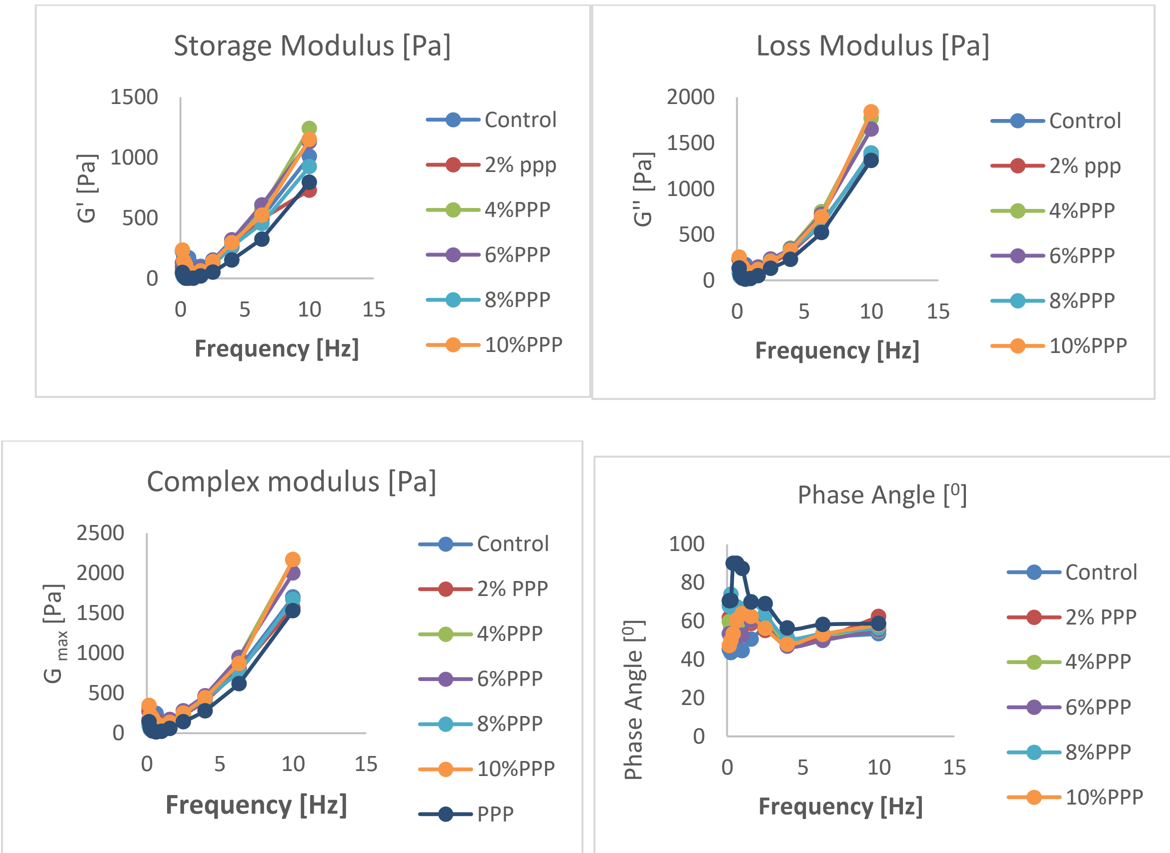

Fig 7. Storage modulus, loss modulus, complex modulus and phase angle of control batter and batters fortified with pomegranate peel powder

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Externally Funded/ Collaborative Projects

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

(1) On-Site DUS characterization of farmer variety 'Sharad king'

First year on-site DUS characterization of farmer variety namely 'Sharad king' was carried out in 2021-22 at Tupewadi (V), Aurangabad (D), Maharashtra and it was compared with the reference variety (Bhagawa) for 36 DUS characters (Fig. 17). The tested candidate variety was found to have distinctive characteristic features for petal length (long), petal width (large), Aril length (short) and fruit maturity (medium) in comparison to reference variety (medium, medium, medium and late maturity) (Fig. 18).

The two years consolidated report of the two hybrid varieties (NRCP H-4 and NRCP H-14) has showed that the NRCP H-14 is having vigorous plant growth habit with yellow with red tinge fruits, pink very sweet arils and hard seeds. While, NRCP H-4 also observed to be a vigorous hybrid variety whose fruit rind is yellow with red tinge colored, arils are pink with acidic juice embedded with hard seeds. All these are medium duration varieties takes about 140-165 days to mature after anthesis. In 2021, two hybrid varieties i. e., NRCP H-6 (Solapur Lal) and NRCP H-12 (Solapur Anardana) have been registered in the Plant Varieties Registry, PPV&FRA, New Delhi as new varieties.

Fig. 17: On-site DUS characterization of farmer variety ("Sharad King") at Aurangabad, Maharashtra

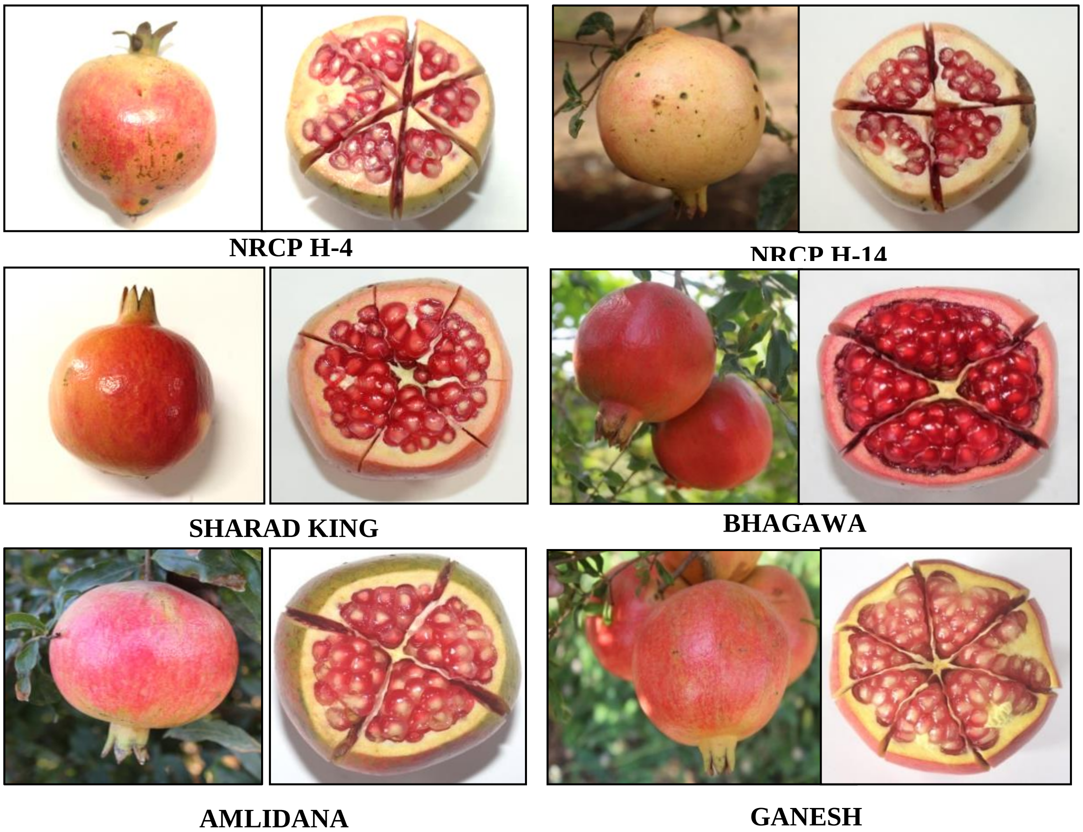


Fig. 18: Glimpses of pomegranate varieties characterized for DUS traits during 2021-22

(2) Molecular characterization of pomegranate germplasm accessions:

48 pomegranate genotypes consist of both wild and cultivated types were assessed by using 30 SSR markers. All the 48 genotypes genotypic data was scored and analyzed. The number of alleles of loci was varied from 2 to 4. Total of 40 alleles were found in the studied genotypes. DARwin ver.2.0 was used to analyze the data. Maximum genetic dissimilarity (0.53) was observed between IC-318712and IC-318718 as well as IC-318712 and Acc-08collection, while non-significant/lower dissimilarity was observed between Acc-11and IC-318702 (0.09). Three clusters (wild types) were derived from unweighted neighbour joining which uses a criterion of unweighted average on dissimilarity. The polymorphic information content ranged from 0.12 to 8.69 with an average of 0.53. The clustering analysis was well supported by principle component analysis (PCA). The first two axis of PCA with positive two values 0.0197 and 0.0122 accounted for 46.71% of the total variation. The first axis has accounted 28.76%, whereas second axis covered 17.95% of variance. The molecular with high Polymorphic information content will help in

future molecular diversity studies. The pgssr 54, 57 and 32 were found to be highly polymorphic with given set of markers (Fig 19).

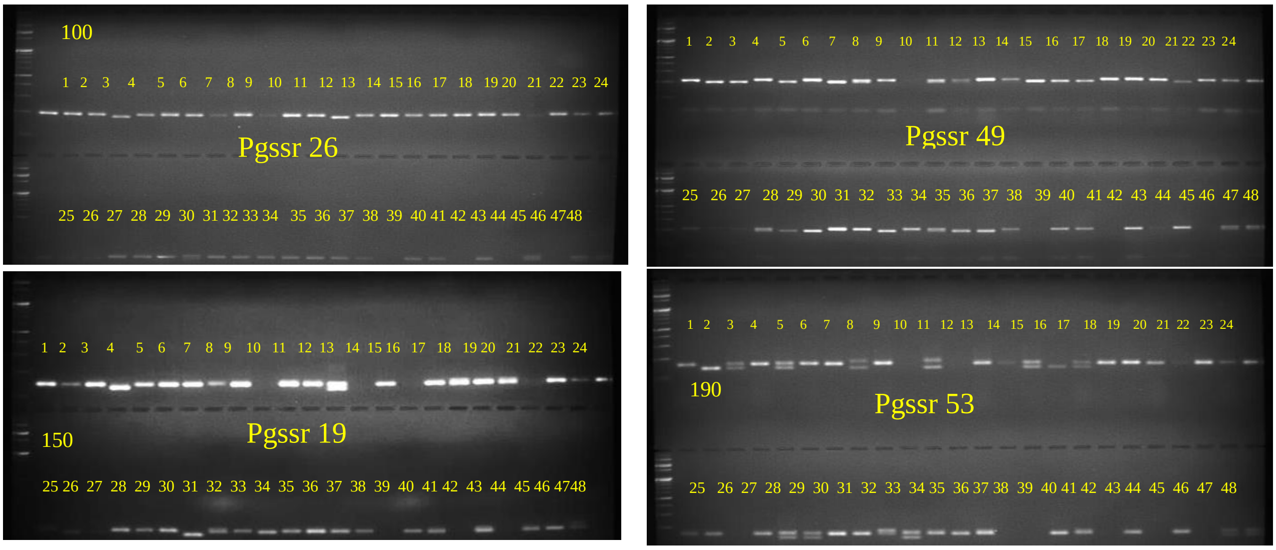


Fig 19. Molecular diversity analysis of germplasm lines by using SSR markers (1: IC-318706; 2: IC-318743; 3: IC-318764 ; 4: IC-318734; 5: IC-318724; 6: IC-318762; 7: IC-318703; 8: IC-318744; 9: IC-318749; 10: IC-318733; 11: IC-318702 ; 12: IC–318707; 13: IC-318740; 14: IC-318716 ; 15: IC-318712; 16: IC-318793 ; 17: 1185; 18: 1197; 19: Acc. No.-1; 20: Mukteshwar; 21: 1184 ; 22: EC-676951; 23: Acc. No.-5; 24: Acc. No.-2 ; 25: Acc. No.-4; 26: 1181; 27: 1195; 28: 1252; 29: BBSC-6(3); 30: 1255; 31: Almoda; 32: 1180; 33: IC-318749; 34: IC-318733; 35: IC-318702; 36: IC-318707; 37: IC-318740; 38: IC-318716; 39: IC-318712; 40: IC-318793; 41: 1185; 42: 1197; 43: Acc. No.-1; 44: Mukteshwar; 45: 1185; 46: EC-676951; 47: Acc. No.-5; 48: Acc. No.-2.

PROJECT : ALL INDIA COORDINATED RESEARCH PROJECT ON ARID ZONE FRUITS

MLT on Evaluation of sweet type 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 2020-21. 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.

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 two years after planting (Table).

The results 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 (167.9cm), E-W spread (160.0cm), N-S spread (152.1cm) and stem girth (12.9cm) due to its hybrid vigour. This was closely followed by Ganesh and performance of Solapur Lal and Ganesh were found to be on par. The check variety, Bhagawa recorded the lowest value for different growth parameters.

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

Variety	Plant height (cm)	Plant spread East-West (cm)	Plant spread North-South (cm)	Stem girth (cm)
Ganesh	156.4	149.3	144.3	12.3
Solapur Lal	167.9	160.0	152.1	12.9
Phule Bhagawa Super	140.7	136.4	130.7	9.6
Bhagawa (Check variety)	136.4	131.4	125.7	9.0
CD (5%)	6.75	4.14	6.04	0.73

MLT on Evaluation of sour type 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 Zond Fruits during 2020-21. The planting material distributed to other centres for MLT include, HRS, Ananthapuram; ICAR-CIAH, Bikaner, ICAR-IIHR, Bengaluru & 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.

Design : Randomized Block Design
Treatments : IC-1181, Solapur Anardana, Amlidana (03)
Replications : Seven (03)
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 two 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 (175.0cm), E-W spread (165.7 cm), N-S spread (158.6cm) and stem girth (12.5cm) due to its hybrid vigour. This was followed by IC-1181. The check variety, Amlidana recorded the lowest value for different growth parameters.

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

Variety	Plant height (cm)	Plant spread East-West (cm)	Plant spread North-South (cm)	Stem girth (cm)
IC-1181	145.7	138.6	132.1	11.5
Solapur Anardana	175.0	165.7	158.6	12.5
Amlidana	98.6	95.0	92.5	3.40
CD (5%)	3.36	4.12	3.40	0.60

Brief report on insect pests of pomegranate:

1. **Report of Pomegranate a new host for the invasive mealybug *Pseudococcus jackbeardsleyi* (Newstead)**

Mealybugs were found scattered on the leaves, fruits and trunks and were observed sucking the sap from various parts of the pomegranate plants including leaves, stems, flowers and fruits (Fig. 1). The mealybug was identified as *P. jackbeardsleyi (*Gimpel and Miller), at the National Bureau of Agriculturally Important Insects, Bengaluru through slide mounting techniques. The invasive mealybug is greyish; thin filaments around the body, caudal pair about one half of the length of the body, and ovisac covering hind part of the body. This mealybug infests on different parts of the plant viz., Shoots, Flower bud, flower and all stages of the fruits. The per cent infestation of varies from 25-30 if timely proper management practices were not taken its infestation may increase further. The shoots infested by mealybugs exhibits the stunted growth, yellowing of leaves with no or poor flower induction and dropping of flower and drop of young fruits. Symptoms on the maturing, developing and ripening fruits indicates the eruptions, reddening of the rind deformation in shape and browning of arils was recorded.

Fig. 1 Mealybug infestation on ripening pomegranate fruits

2. Report of *scale insect Hemiberlesia lataniae* (Signoret) and *Ceroplastes sp.* damage on pomegranate

The diapsid and Coccidae scales *Hemiberlesia lataniae* (Signoret) and *Ceroplastes sp.* occasionally infest on a pomegranate but they of minor in status. The hard scales generally infest fruits and twigs and if allowed to multiply unchecked they will affect the fruit quality and they can kill the terminal growth, and in the case of young trees may threaten their vitality.

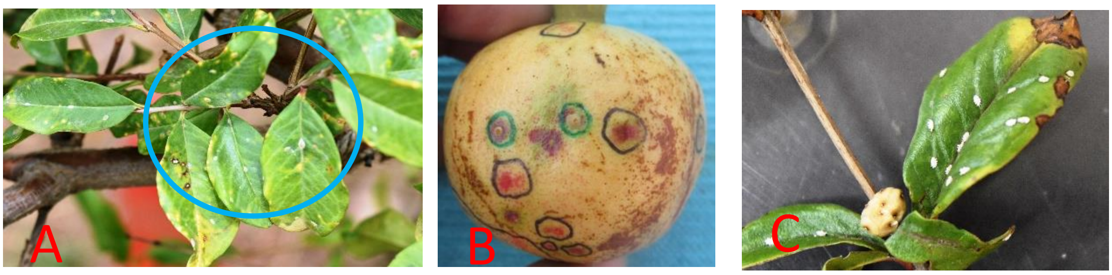


Fig. 2 A. *Hemiberlesia lataniae infestation* on leaf B. *H. lataniae* on fruit and C. *Ceroplastes sp.* on the leaf and twig

X. <u>Report of Leaf eating caterpillar's damages on pomegranate</u>

The damage is mainly caused by caterpillars and the adult moths have been recorded as a secondary feeder on the pomegranate fruits. The caterpillars feed voraciously on pomegranate leaves. Feeding on the edges inwards, leaving behind only the midrib and the stalk. The damage is maximum during Mrig and hasta bahar crops.

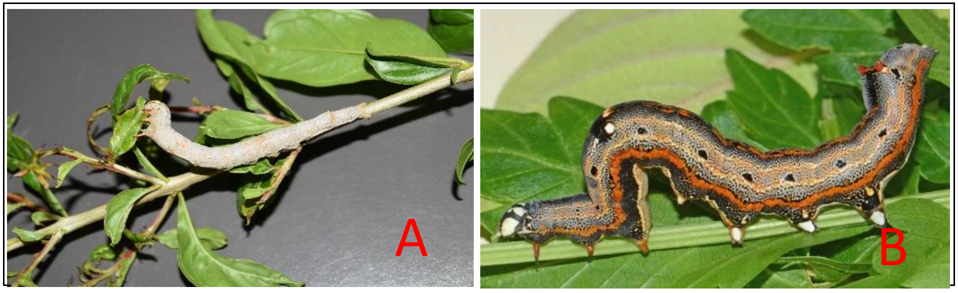


Fig. 3 A. *Ophusia tirhaca* B. *Achaea janata* damage Symptoms

Project: Horticulture Crop Pest Surveillance and Advisory Project (HORTSAP) Sub Scheme under Crop Surveillance and Advisory Project for Mango, Pomegranate & Banana (CROPSAP) Scheme (Funded by Commisionerate of Agriculture (Horticulture Department), Government of Maharashtra, Pune.)

The survey of insect pest of pomegranate was carried out in Maharashtra in an area of 530.75 care covering the 3 districts and 13 talukas and major incidence reported was Thrips, fruit sucking moth, shot hole borer, stem borer and green stink bug and in Karnataka in an area of 314.15 acres covering the 4 districts and 13 talukas. The major incidence was Thrips, green stink bug and stem borer (Table-1). Report of pomegranate fruit borer natural enemies: *Brachymeria sp.* has been collected from the field-infested pupae. The percent pupal parasitization recorded was 13-14.

Table 7: Occurrence (% incidence) of important insect pests on pomegranate in different districts of Karnataka, Maharashtra and Madhya Pradesh

State	**District**	**Area surveyed (Acre)**	**Average % incidence**					
			Thrips	**FB**	**FSM**	**SHB**	**SB**	**GSB**
M.H	Pune (1)	8.5	7.75-16.15	1.0-1.85	1.5-2.0	0.0	0.0	**1.5-4.8**
	Solapur (10)	504.5	15.5-75.24	2.5-11.58	0-20.75	0-59.42	4.5-12.8	0-36.5
	A.nagar (2)	17.75	0-66.55	1.5-3.5	0.0	8.95-25.8	3.5-11.95	5.5-15.45
	Total area/ %Incidence	**530.75**	0-75.24	1.0-11.58	0-20.75	0-59.42	0-12.8	0-36.5
K.A	Kalaburgi (1)	20.0	1.5-15.44	1.25-4.5	0.0	0.0	-	1-2.0
	Vijapur (3)	69.75	0-71.25	2.33-5.6	0.0	0.0	1.5-3.8	0.0
	Bagalkot (6)	133.2	15.33-56.75	2.5-6.45	0.0	0.0	2.5-4.2	1.5 – 25.5
	Koppal (3)	91.2	13.45-46.45	2.25-5.5	0.0	0.0	0-2.5	0.0
	Total area/ % Incidence	314.15	0-71.25	1.25-6.45	0.0	0.0	0.0	0-25.5
M.P	Chindwada (1)	9.5	0-5.6	0.0	0.0	1-2.5	0.0	0.0

Numbers in parenthesis indicate the number of taluks covered during the survey; T= Twigs F= Fruits FB= Fruit borer FSM= Fruit sucking moth SHB=Shot hole borer SB=Stem borer GSB= Green stink bug

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

1. **Protocols standardized during the year**
   - Polygalacturonase
   - Polyphenol oxidase activity
   - Hydrogen peroxide generation
   - Peroxidase
   - H_2O_2 release
   - Ascorbic acid,
   - Total soluble proteins
   - Malondialdehyde
   - Proline
   - Starch
   - Total carbohydrates

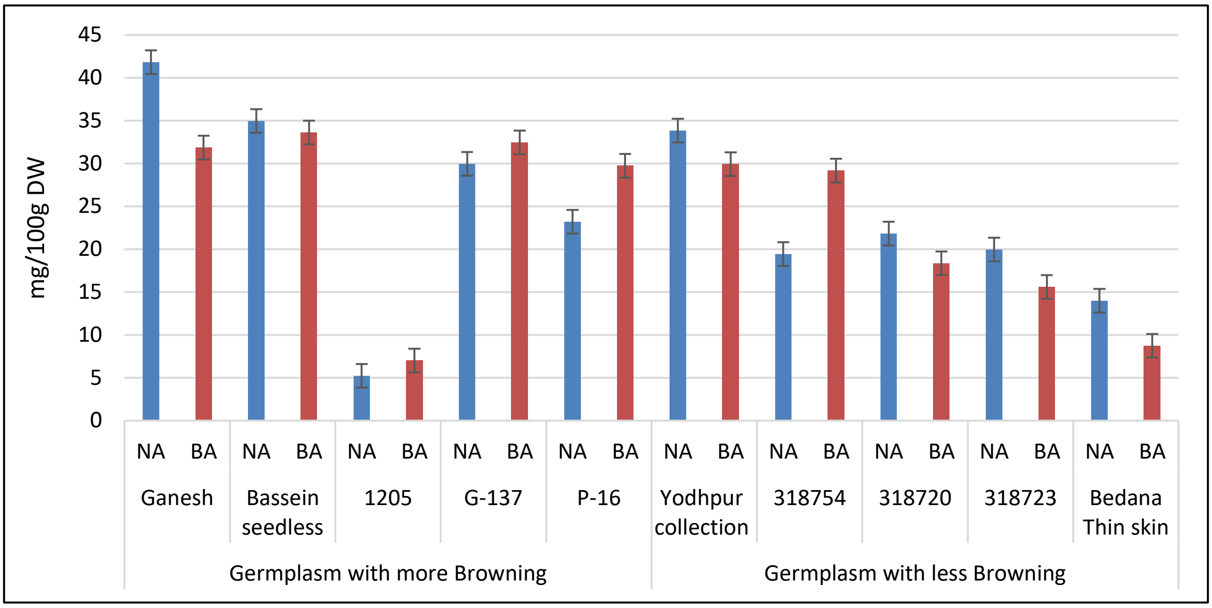
2. **Biochemical characterization of healthy and brown arils**

   Based on the previous results 10 germplasm were selected for study

	More browning (above 10%)	Less browning (below 10%)
1.	Ganesh	Yodhpur collection
2.	Bassein seedless	IC-318754
3.	1205	IC-318720
4.	G-137	IC-318723
5.	P-16	Bedana thin skin

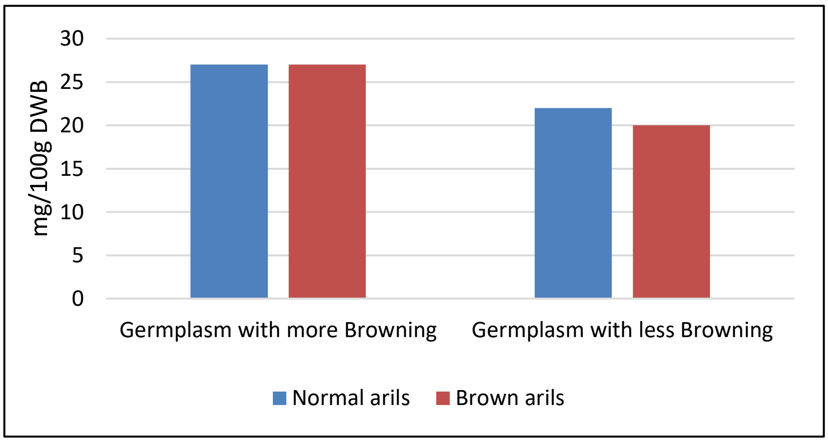
Aril browning is one of the major physiological disorders of pomegranate that hampers its quality and hence exports of fruits. Germplasm was grouped into a less severity group (LSG; less than 10% browning) and high severity group (HSG; more than 10% browning) based on the severity of browning. Five germplasm viz. Yodhpur collection, IC-318754, IC-318720, IC-318723, Bedana thin skin were selected under LSG and five germplasm viz. Ganesh, Bassein seedless, 1205, G-137, P-16 selected under HSG. For the present study, both normal and brown arils were collected from the same fruits and dried in oven. The raisins formed after drying were used for biochemical evaluations. Results are presented as the average under both severity groups.

- Results showed that the HSG germplasm exhibited more proline content i.e 27 mg/100g DW compared to the LSG germplasm that contained 21 mg/100g DW proline in dried pomegranate raisins.



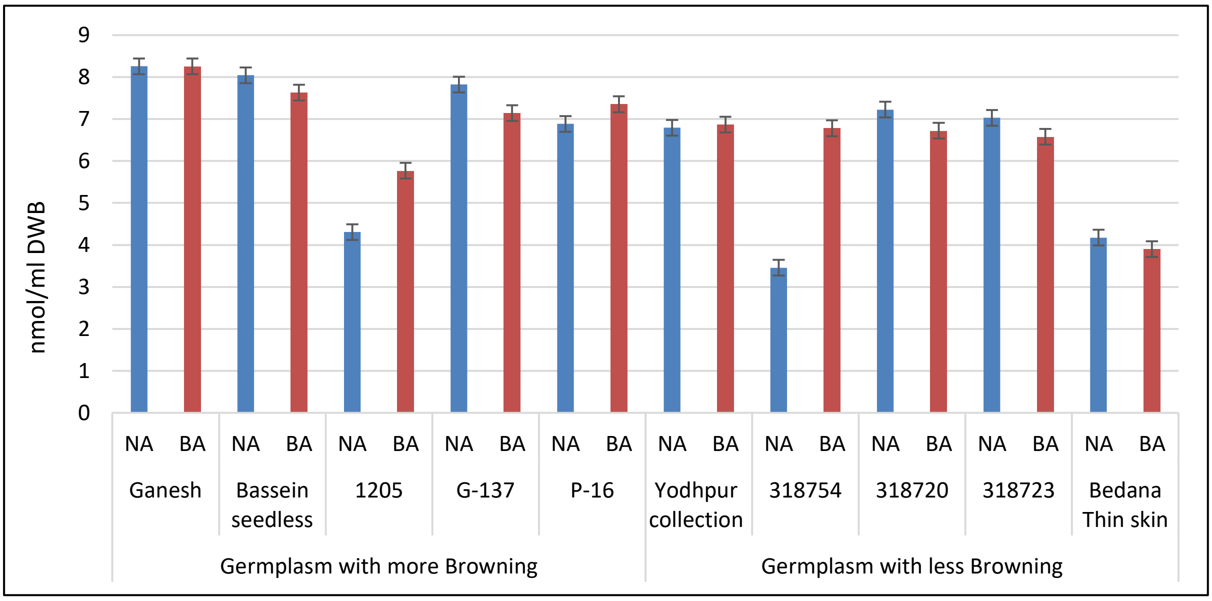
Difference in Proline Content in healthy and brown arils (NA: normal aril; BA brown aril)

Coefficient of Variation	**17.803**		
CD (0.01)	9.479	Value range	5.33-41.67
CD (0.05)	7.085	Mean	24.117
F cal	17.157**	SE means	1.38



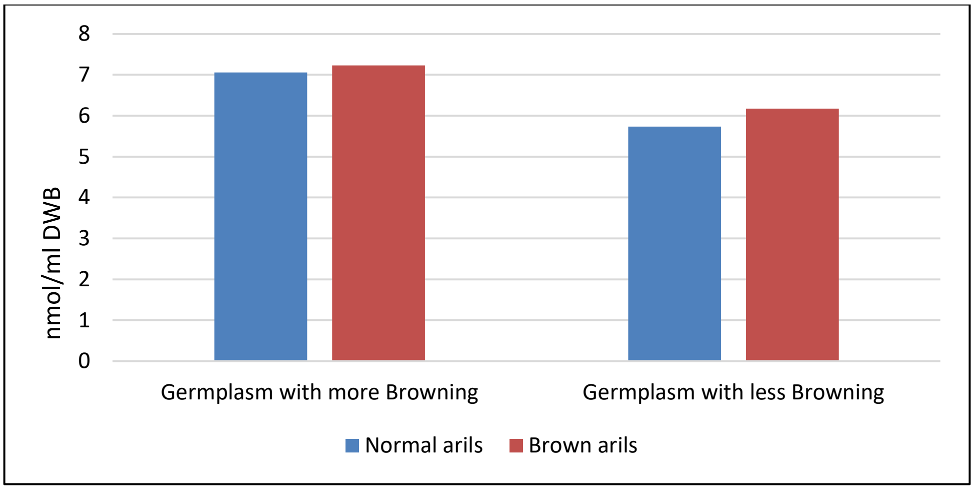
Comparison of Proline content in more and less browning group

- Malondialdehyde, a stress indicator also followed same pattern as proline does. Malondialdehyde was high in the HSG (7.14 nmol.ml^{-1}) than in the LSG germplasm (5.95 nmol.ml^{-1}).



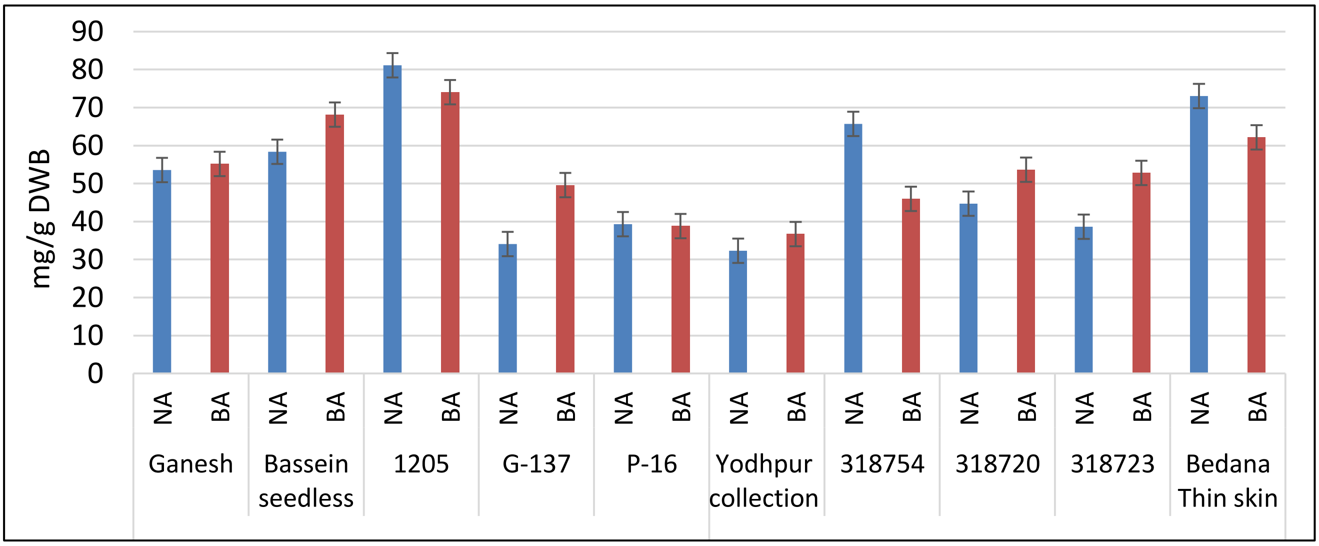
Difference in Malondialdehyde Content in healthy and brown arils (NA: normal aril; BA brown aril)

Coefficient of Variation	**3.52**		
CD (0.01)	0.509	Value range	3.45-8.25
CD (0.05)	0.381	Mean	6.55
F cal	120.79**	SE means	0.187



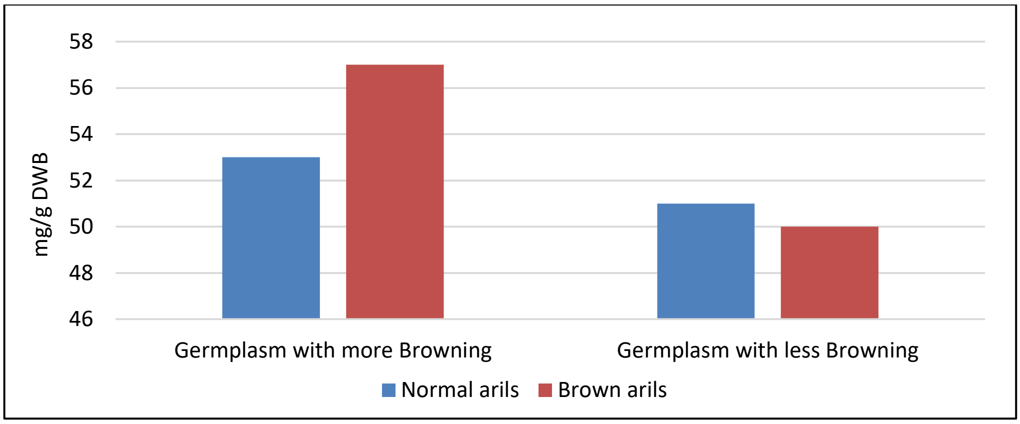
Comparison of total soluble protein in more and less browning group

- Protein content was 52.6 mg/g DW in LSG and 55.2 mg/g DW in HSG germplasm. More protein in HSG germplasm could be due to the activation of a certain group of proteins under stress conditions.



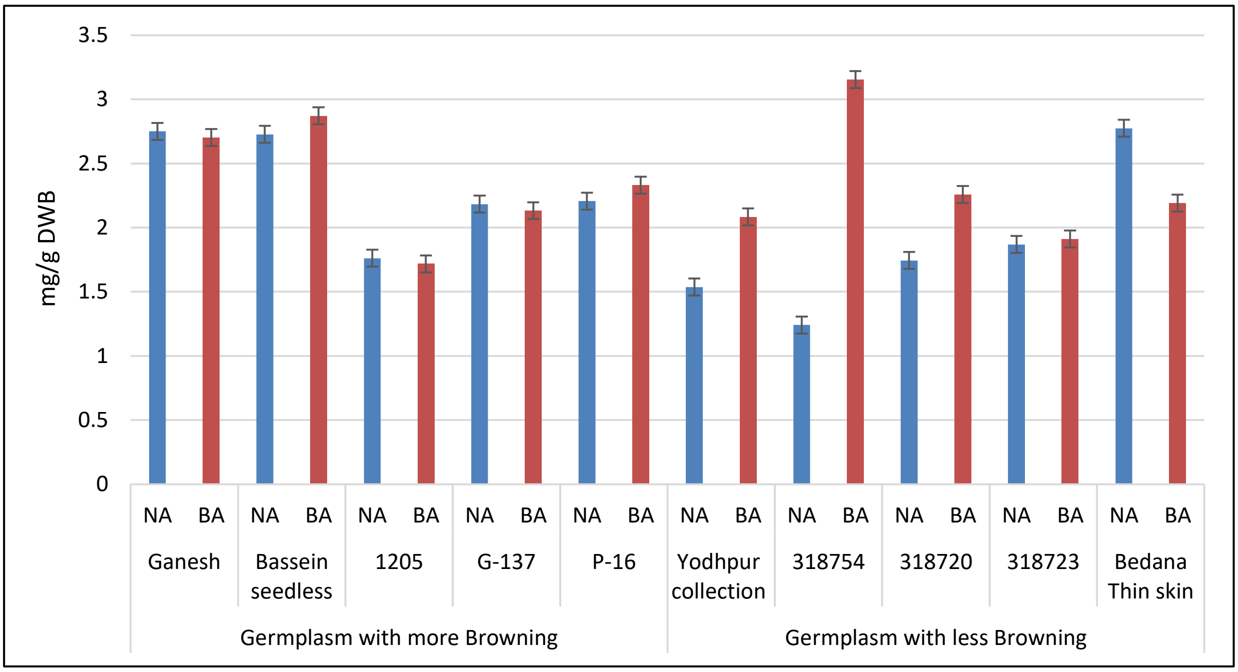
Difference in Total Soluble Protein Content in healthy and brown arils (NA: normal aril; BA brown aril)

Coefficient of Variation	**9.334**		
CD (0.01)	10.902	Value range	32-80
CD (0.05)	8.148	Mean	53
F cal	25.466**	SE means	3.203



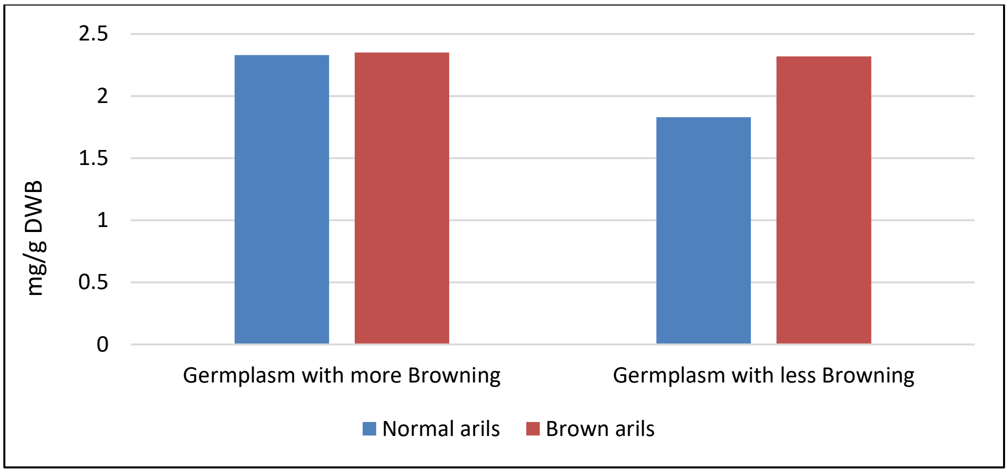
Comparison of total soluble protein in more and less browning group

- Ascorbic acid showed similar trend as protein, and was more in HSG (2.34 mg/g DW) and lower in LSG germplasm (2.08 mg/g DW).



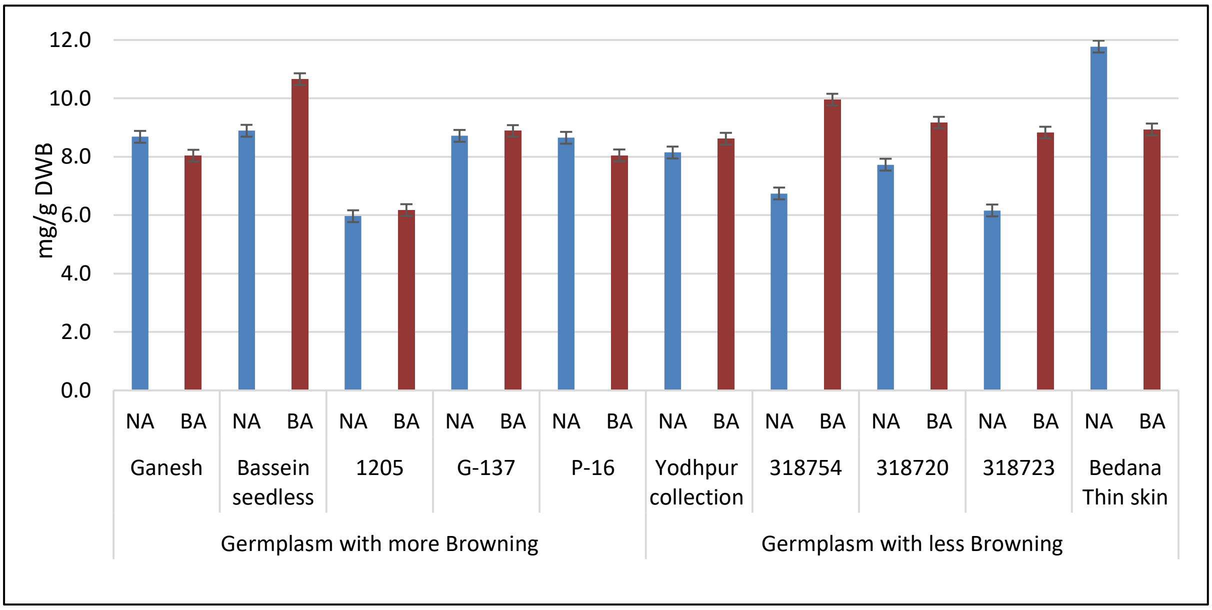
Difference in Ascorbic acid content in healthy and brown arils
(NA: normal aril; BA brown aril)

Coefficient of Variation	7.111		
CD (0.01)	0.347	Value range	1.24-3.15
CD (0.05)	0.259	Mean	2.208
F cal	30.511**	SE means	0.066



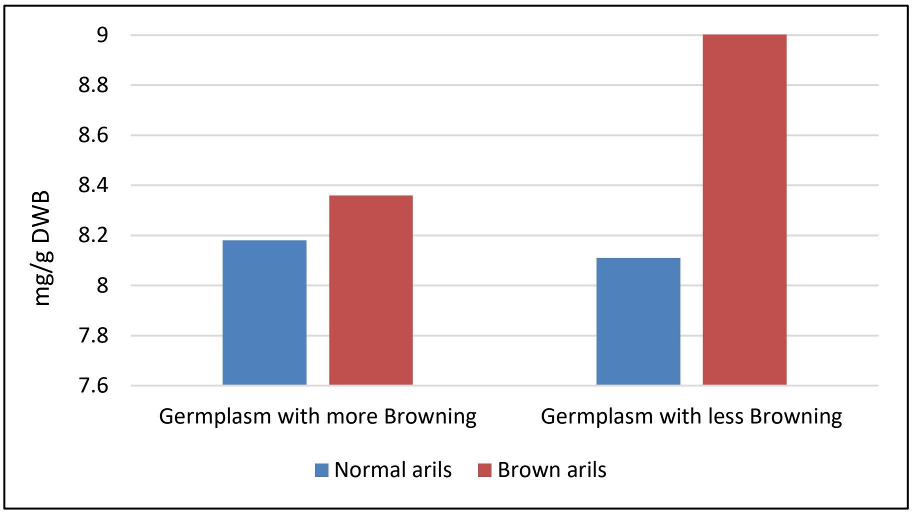
Comparison of Ascorbic acid content in more and less browning group

- Total phenolics decreased in HSG (8.3 mg/g DW) and was 8.6 mg/g DW in LSG.



Difference in Total polyphenols Content in healthy and brown arils (NA: normal aril; BA brown aril)

Coefficient of Variation	**9.206**		
CD (0.01)	1.715	Value range	5.97-11.77
CD (0.05)	1.282	Mean	8.44
F cal	10.494**	SE means	0.202



Comparison of total polyphenols in more and less browning group

- Both stress indicators i.e malondialdehyde and proline content showed a positive correlation (r = 0.776), ascorbic acid also showed positive correlation with malondialdehyde (r = 0.424) and proline (r = 0.444). Results of proline, malondialdehyde and ascorbic acid indicated that lipid peroxidation is involved in aril browning mechanism.

Correlation among different parameters

Parameters		Correlation
Malondialdehyde	Proline	0.776
Phenol	Protein	0.582
Proline	Ascorbic acid	0.444
Malondialdehyde	Ascorbic acid	0.424
Ascorbic acid	Phenol	0.327
Ascorbic acid	Protein	0.054
Malondialdehyde	Phenol	-0.047
Proline	Phenol	-0.257
Protein	Proline	-0.544
Malondialdehyde	Protein	-0.571

Activities under Tribal Sub-plan / STC

Table 1: Tribal farmers adopted by ICAR-NRCP, Solapur under TSP/STC

State	District	Sub-district	Village	ST population benefit-ed	Year of adoption	Status as on 31.12.2021
Madhya Pradesh	Anuppur	Kotma	Manmari Reusa Baskhala Baskhali Chaka Changeri Reula Behratola Jamunia Chapani Chhauhari Chapani Kadmaha Pathroudi Thouda	115 (including family members)	2017-18	Pomegranate orchards established & in bearing stage Agri-input and technical support provided Capacity building programmes organized Master trainers groomed
Chhatisgarh	Koriya	Manendra garh	Kerabehara Dorki	10 (including family members)	2017-18	Pomegranate orchards established & in bearing stage Agri-input and technical support provided Capacity building programmes organized Master trainers groomed

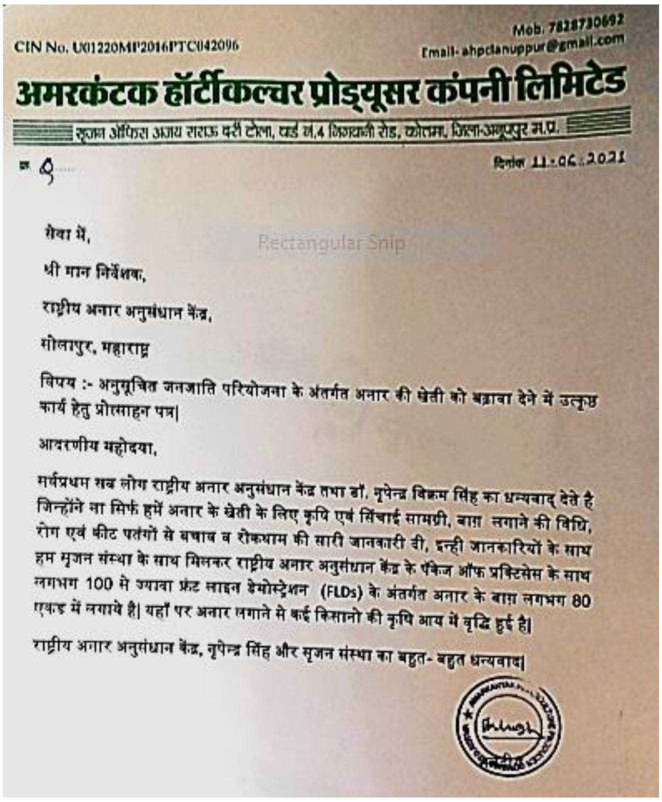
Agri-input distribution to ST farmers by the SDM at Jatara, Anuppur under STC/TSP scheme of ICAR-NRCP

Jansampark Anuppur
13 June at 10:38 · Facebook for Android ·

■ आम एवं अनार के बगीचों का भ्रमण

➡️आम एवं अनार की खेती के फायदे को देखते हुए इनकी खेती को किसानों के बीच लोकप्रिय बनाने के उद्देश्य से भारतीय कृषि अनुसंधान परिषद के सहयोग से सृजन संस्था द्वारा बसखला ग्राम के किसान श्री शिवदास के खेत में लगवाए गए आम एवं अनार के बगीचों का अनुविभागीय अधिकारी कोतमा श्री ऋषि सिंघई ने भ्रमण कर फसलों का जायजा लिया। इस मौके पर सृजन संस्था के टीम लीडर श्री आशीष त्रिपाठी भी मौजूद थे।

बगीचे के भ्रमण के दौरान किसान श्री शिवदास ने बताया कि उसने 2014-15 में सृजन संस्था के माध्यम से 90 आम एवं 64 अनार के पौधे लगाए थे। आज इन बगीचों के माध्यम से 40 से 50 हजार तक वार्षिक आमदनी हो रही है।
#JansamparkMP


CIN No. U01220MP2016PTC042096
Mob. 7828730692
Email- ahpclanuppur@gmail.com

अमरकंटक हॉर्टीकल्चर प्रोड्यूसर कंपनी लिमिटेड

सृजन ऑफिस अजय सराफ दरी टोला, वार्ड नं.4 शिवाजी रोड, कोतमा, जिला-अनूपपुर म.प्र.

क्र. 9 दिनांक 11.06.2021

सेवा में,

श्री मान निर्देशक,

राष्ट्रीय अनार अनुसंधान केंद्र,

सोलापुर, महाराष्ट्र

विषय :- अनुसूचित जनजाति परियोजना के अंतर्गत अनार की खेती को बढ़ावा देने में उत्कृष्ठ कार्य हेतु प्रोत्साहन पत्र|

आदरणीय महोदया,

सर्वप्रथम सब लोग राष्ट्रीय अनार अनुसंधान केंद्र तथा डॉ. नृपेन्द्र विक्रम सिंह का धन्यवाद देते है जिन्होंने ना सिर्फ हमें अनार के खेती के लिए कृषि एवं सिंचाई सामग्री, बाग़ लगाने की विधि, रोग एवं कीट पतंगों से बचाव व रोकथाम की सारी जानकारी दी, इन्ही जानकारियों के साथ हम सृजन संस्था के साथ मिलकर राष्ट्रीय अनार अनुसंधान केंद्र के पैकेज ऑफ प्रक्टिसेस के साथ लगभग 100 से ज्यादा फ्रंट लाइन डेमोस्ट्रेशन (FLDs) के अंतर्गत अनार के बाग़ लगभग 80 एकड़ में लगाये है| यहाँ पर अनार लगाने से कई किसानो की कृषि आय में वृद्धि हुई है|

राष्ट्रीय अनार अनुसंधान केंद्र, नृपेन्द्र सिंह और सृजन संस्था का बहुत- बहुत धन्यवाद|

Adopted orchard visit by the SDM Jatara and Letter of Appreciation by the FPC

Activities under SCSP

Table 1. Farmers adopted by ICAR-NRCP, Solapur under SCSP scheme

State	District	Sub-district	Village	SC population benefitted	Year of adoption	Status as on 31.12.2021
M.P.	Tikkamgarh	Jatara	Tal Lidhora Barmadang Dor	85 (including family members)	2019-20	Pomegranate orchards established and are in bearing stage Agri-input and technical support provided Capacity building programmes organized
Karnataka	Kalaburgi	Aland	Santanur Vaijapur	15 (including family members)	2020-21	Technical and agri-input support provided Trainings organized Agri-input and technical support provided Capacity building programmes organized
Maharashtra	Solapur	Madha	Nimgaon and Solankarwadi	20 (including family members)	2019 and 2021	Pomegranate orchards established and are in bearing stage Agri-input and technical support

						provided Capacity building programmes organized
Rajasthan	Barmer and Alwar	Balotra and Rampur	Rajeshwar Nagar, Roopbas, Sherpur	20 (including family members)	2019	Pomegranate orchards established and are in bearing stage Agri-input and technical support provided Capacity building programmes organized

दैनिक भास्कर

टीकमगढ़ भास्कर 08-08-2021

कृषि • राष्ट्रीय कृषि अनार अनुसंधान केन्द्र सोलापुर के कृषि वैज्ञानिक दे रहे प्रशिक्षण

नई तकनीक से किसान अनार की खेती से कमा रहे हैं लाभ

भास्कर संवाददाता | जतारा

अनार की खेती को बढ़ावा देने के लिए भारत सरकार की अनुसूचित जाति परियोजना राष्ट्रीय अनार अनुसंधान केंद्र किसानों को अनार की खेती से अधिक फायदा पहुंचाने के लिए काम कर रहा है। राष्ट्रीय अनार अनुसंधान केन्द्र सोलापुर के वरिष्ठ वैज्ञानिक डॉ. नृपेन्द्र विक्रम सिंह ने बताया कि ब्लॉक जतारा के 16 अनुसूचित जाति के किसानों को अनार फसल संबंधित दवाई, खाद, कीट नियंत्रण संबंधित सामग्री उपलब्ध कराई गई हैं। जिससे किसानों ने इसकी खेती कर लाभ लिया है। किसानों को नई तकनीक कम लागत में ज्यादा उत्पादन के लिए प्रोत्साहित किया जा रहा है। डॉ. एनवी के सिंह वरिष्ठ वैज्ञानिक राष्ट्रीय अनुसंधान संस्था केंद्र सोलापुर के द्वारा बुन्देलखंड के 500 किसानों को अभी तक अनार की खेती को बढ़ावा देने के लिए प्रशिक्षण दिया जा चुका है। जिससे किसानों को अधिक लाभ हो रहा है।

किसान ने पिछले साल 8 क्विंटल अनार बेचे

कुमार शाक्य सहित राष्ट्रीय कृषि अनार अनुसंधान केन्द्र सोलापुर के कृषि वैज्ञानिकों द्वारा समय-समय पर प्रशिक्षण एवं मार्गदर्शन दिया गया है। जिससे जतारा क्षेत्र के किसानों को फायदा हो रहा है। किसान बालचन्द्र अहिरवार ग्राम लिधौरा ताल ने बताया कि संस्थान के सहयोग से प्रशिक्षण दिया गया है। जिससे मुझे अनार की खेती में फायदा मिलने लगा है। पिछले साल अहिरवार ने 8 क्विंटल अनार बेचे थे और इस साल भी अनार के फल तैयार होने लगे हैं।

Agri-input distribution to SCSP beneficiery during training programme

Agri-input distribution and orientation programme for SC beneficiary farmers of Kalaburgi and demonstration plot at Barmer

Adopted pomegranate orchards at Alwar under SCSP scheme

Table 2. Training programmes/ workshop/farmers' field day organized for tribal and SC farmers under SSCP / STC

S. No.	Name of the training programme	Place	Date	SC Farmers benefited (Nos.)
1.	Model Propagation and Pomegranate Production Technologies for Farmers and Coordinating Agencies under SCSP, TSP and MGMG	ICAR-NRCP (Virtual mode)	11th -13th Jan, 2021	33
2.	Material distribution and orientation programme for SC beneficiary farmers of Vaijapur and Santanur	ICAR-NRCP, Solapur	25th March, 2021	5
3.	Model propagation and orchard management practices for sustainable pomegranate production for farmers and coordinating agencies under SCSP	ICAR-NRCP, Solapur	26th-29th Oct, 2021	30

Release of technical bulletin during inaugural session of the training programme for SCSP beneficiary farmers

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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.	Title of Trainings/ Workshops/ Farmers Fair/ Field Day/ FLD	Venue	Date	No. of participants
	Training:			
1.	Quality pomegranate production value addition for doubling farmer's income.	ICAR-NRCP, Solapur	15-17 Feb.2021	26
2.	Collabrative training programme on modern practices for export quality pomegranate production and value addition	ICAR-NRCP, Solapur	28-30 Feb 2021	51
3.	Training program on "Good Agricultural Practices for export quality pomegranate production" to farmers of S. Solapur Tehsil, Solapur during 10-12 January 2022.	ICAR-NRCP	10.01.2022- 12.01.2022	30 farmers of South Solapur Taluk, Solapur Dist, MS.
4.	Four days MANAGE, Hyderabad sponsored collaborative online training program on "Modern practices for export quality pomegranate production and value addition" for extension officers of State Agri./Hort.	NRCP, Solapur	28-31st July 2021	49
5.	Model Propagation and Pomegranate Production Technologies for Farmers and Coordinating Agencies under SCSP, TSP and MGMG	ICAR-NRCP (Virtual mode)	11th-13th Jan, 2021	33

6.	Material distribution and orientation programme for SC beneficiary farmers of Vaijapur and Santanur	ICAR-NRCP, Solapur	25th March, 2021	05
7.	Model propagation and orchard management practices for sustainable pomegranate production for farmers and coordinating agencies under SCSP	ICAR-NRCP, Solapur	26th-29th October, 2021	30
8.	Conducted one day training programme of SC/Sub-project of at Malumbra, Tuljapur on 16th March 2021.	ICAR-NRCP, Solapur	16th March 2021.	30
	Workshop:			
1.	Workshop on Insect pest disease management of Pomegranate, at Sangewadi, Sangola	Sangewadi, Sangola	27.07.2021	78
2.	Workshop on Insect pest disease management of Pomegranate, at Kadalas, Sangola	Kadalas, Sangola	04.08.2021	60
3.	Organized International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur,	ICAR-NRCP, Solapur	25-27th August 2021	
4.	Organized Webinar on “Pomegranate production in dry land region: An alternative for higher income” under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	16^{th} July 2021	
5.	Organized Webinar on “Pomegranate Nutrition and its Therapeutic Utility” under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	8th Sep. 2021	
6.	Organized Webinar on “Solapur Lal and Solapur Anardana: NRCP Contribution in Bio fortified Food” under *Azadi Ka Amrit*	ICAR-NRCP, Solapur	16th Sep. 2021	

	Mahotsav			
7.	Organized Webinar on "Pomegranate miracle health fruit for livelihood and nutrition for women" under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	16th Oct 2021	
8.	Organized Webinar on "Pomegranate Value addition: NRCP contribution in technologies and entrepreneurship development" under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	6th Oct. 2021	
9.	Organized Webinar on "Entrepreneurship Opportunities for small land holding pomegranate farmers" under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	28th Dec. 2021	
10.	Organized Webinar on "Hi-tech Pomegranate Cultivation for Higher Productivity and Income" under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	4th Jan. 2022	
11.	Organized Webinar on "Smart Cities and Vertical Gardening" under *Azadi Ka Amrit Mahotsav*	ICAR-NRCP, Solapur	8th Feb. 2022	
	Farmers fair:			
1.	Field day cum farmer fair on impact of "Stem Solarization – Six Step Technology for the Management of Bacterial Blight Disease in Pomegranate"	Village - Tamshewadi, Malshiras, Solapur	November 13, 2021	A total of 150 farmers were actively participated in the field day.
2.	Agrovision	ICAR-CCRI, Nagpur	24-27 Dec.2021	500

	Field Day:			
1.	Six Steps Bacterial Blight management	Tamshedwadi ,Malshiras ,Solapur	13 Nov. 2021	102
2.	Participated in Farmers scientists' interaction on Climate Resilient varieties, technologies and practices at ICAR-NRCP, Solapur	ICAR-NRCP, Solapur	28th December 2021	Around 50 farmers were present for this interaction.
3.	Participated in pomegranate stakeholders meet and delivered lecture on pomegranate processing	Jaloli, Solapur	6th January 2022	Around 125 farmers were present for this interaction.
4.	Pomegranate Field Day organized on the occasion of the first harvest to of the demonstration plot H13	ICAR-NRCP	26th March, 2021	30
5.	Field day on Management of Bacterial blight and Wilt in Pomegranate on jointly organized by ICAR-NIASM, Baramati and ICAR-NRCP, Solapur at NIASM, Baramati.	ICAR-NIASM, Baramati	21st October 2021	60 farmers
6.	Farmer-Scientist Interface meet: live webcasting of Hon'ble Prime Minister's programme of Dedication of 35 Crop Varieties and establishment of ICAR – National Institute of Biotic Stress Management, Raipur to the Nation and Farmer-Scientist Interface meet	ICAR-NRCP, Solapur	28th September 2021	80 farmers and institute staff members

Farmers trainee from S.Solapur Tk, Solapur

Certificate distribution to trainee, 12.01.2022

Live Webcasting of Hon'ble Prime Minister's programme and Famer-Scientist Interaction meet on 28th September 2021

Field day cum farmer fair on impact of “Stem Solarization – Six Step Technology for the Management of Bacterial Blight Disease in Pomegranate” at Tamshewadi, Malshiras, Solapur on November 13, 2021

SCIENTIFIC AGRO ADVISORIES

Likewise every , this year (2021) five bimonthly scientific agro-advisories were published on office website, Dalimbmitra-a social digital platform and daily newspaper for the benefit of farmers regulating three bahars in English, Hindi, Marathi, Kannada language for updating their knowledge.

21/10/2021 Solapur Main GO Page 14

फलोत्पादन

१४

सकाळ अॅग्रोवन

मृग बहार डाळिंब बागेसाठी नियोजन

छोट्या जाहिराती

Pune 21 Sep 2021 Page 11

अॅग्रो प्लॅनिंग

११

सकाळ अॅग्रोवन

डाळिंब पिकावरील खोड किडा व्यवस्थापन

In response to queries of farmers, information on pomegranate was provided to the farmers through e-mail and phone. Scientific agro-advisories were sent to more than 4961 pomegranate growers through the “m-Kisan portal” during the period under report.

Providing inputs to stakeholders through Dalimb Mitra platform and other social media platforms.

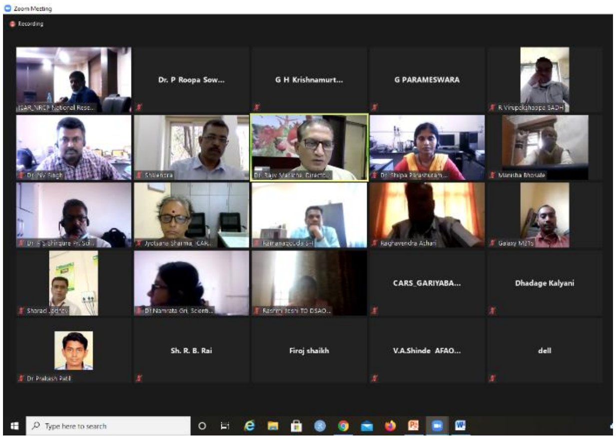
Transfer of Technology and Entrepreneurship Development

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.

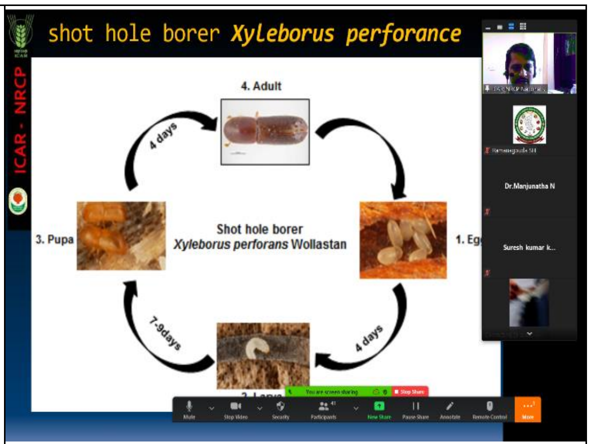
Table 1: Trainings conducted by ICAR-NRCP, Solapur

S. No.	**Name of Training Programmes (Duration: 3 or more days)**	**No. of participants**	**Period**
1	Quality pomegranate production value addition for doubling farmer's income.	30	15-17 Feb,2021
2	Collabrative training programme on modern practices for export quality pomegranate production and value addition	30	-
3	Four days MANAGE, Hyderabad sponsored a collaborative online training program on "Modern practices for export quality pomegranate production and value addition" for extension officers of State Agri./Hort.	49	28-31 July, 2021
4	Training program on 'Quality pomegranate production and value addition for doubling farmer's income' for bio squad team of Valagro Pvt. Ltd.	27	15-17 Feb, 2021

Quality pomegranate production value addition for doubling farmer's income.(15-17 Feb 2021)



Address by Dr. Rajiv Marathe, Director ICAR-NRCP, Solapur



Lecture by Dr. Mallikarjun, on Insect pest management in pomegranate

Training title, date: **"Modern practices for export quality pomegranate production and value addition" 28-31st July 2021.**

- **Workshop/ Field day/FLD conducted**

S. No.	Name of Training Programme	No of Participants	Date
1.	Webinar on "Balanced Use of Fertilizers"	85	18.6. 2021
2.	Workshop on Insect pest disease management of Pomegranate,at Sangewadi,Sangola	78	27.07.2021
3.	Workshop on Insect pest disease management of Pomegranate, at Kadalas, Sangola	60	04.08.2021
4.	Field day cum Farmers fair Tamshedwadi Tal, Malshiras	102	13.09.2021
5.	Programme on celebration of International year of millets at ICAR-NRCP	25	17.09.2021
6.	Field visit cum-training programme on Short hole borer management in Pomegranate, Ajanale ,Sangola	250	25.09.2021
7.	Scientist- farmers interactive training programme on occasion of PM's web based Live telecast , at ICAR-NRCP	57	28.09.2021

8.	Interacted with the pomegranate farmers on various pomegranate issues and surveyed orchards at Chikka-sanshi, Tal. Bagalkot, Dist. Bagalkot. and at Anagawadi, Aheri & Shindagi, Tal Shindagi Dist. Vijayapur	35	26-27 Dec, 2021

Webinar on "**Balanced Use of Fertilizers on 18.6.2021**

AGREEMENT WITH VARIOUS STAKEHOLDERS

For Entrepreneurs

ICAR-NRCP's 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.	Process of minimal processing and shelf life extension of minimally processed arils licensed to for	M/S Gnanam Foods, Bhuj- Bhachau Highway, RS NO 426, Opp. Essar pump, Village-Morgar, Tal-Bhachau, District-Kutch, State-Gujarat, 370140	20th July 2021.	Rs. 1,18,000/-

Process of minimal processing and shelf life extension of minimally processed arils licensed to M/S Gnanam Foods, Bhuj- Bhachau, Gujarat on 20.7.2021

For Students

Table 4: MoU with Academic Institutions

S. No.	Programme	Address of beneficiary	Date	Revenue generated (Rs.)
1	B.Sc./B.Tech./M.Sc./M.Tech./Ph.D.	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, MS	February 7th 2021	Nil

Table 5: Exhibitions

S. No.	Name of the exhibition	Organizer	Venue	No. of participants	Date
1	Field day cum farmers fair Tamshedwadi Tal, Malshiras	ICAR-NRCP Solapur	Tamshedwadi Tal, Malshiras Dist Pune	102	13Nov. 2021
2	Agrovision	Agrovision Foundation	ICAR-CCRI Nagpur	500	24-27 Dec.2021

POMEGRANATE GROWERS/ VISITORS TO ICAR-NRCP, SOLAPUR

Following beneficiaries/ visitors visited this Centre during 2021

Table 6: Visitors to ICAR-NRCP, Solapur

S. No.	Date	Organization/ Place of beneficiaries	Category	No. of beneficiaries
1	16.09.2021	Farmers exposure visit from Department of Agriculture Badmer, Rajasthan		50
2	29.09.2021	State Agriculture Department Gadchiroli (MS)		52 Farmers
3	16.12.2021	Kvk Mohol under DEASI project		40 Agri input dealers
4	17.12.2021	Kvk Mohol Solapur		27 Farmers
5	30.12.2021	State Agriculture Department		25 Farmers
6	26.03.2022	Farmers' exposure visit to ICAR-NRCP, Solapur coordinated by KVK, Bidar, Karnataka.	Farmers	50

Farmers exposure visit from Department of Agriculture Badmer, Rajasthan, visited ICAR-NRCP, 16/09/2021

S. No.	Date	Organization/ Place of beneficiaries	Category	No. of beneficiaries
			Student	
1	08.09.2021	Dnyaan prabhodini krushi tantra vidyalai Harali Osmanabad.(MS)		40 students
2	29.10.2021	AD, college of agriculture ,Dapoli (MS)		89 Students
3	25.11.2021	PG students of Aahilyabai holkar University Solapur.		58 Students
4	02.12.2021	College of agriculture Karkere Hasan, Karnataka		60 Students
5	15.07.2021	Virtual tour- College of Agriculture, Hassan, Karnataka	Final year B. Tech (Biotechnology)	60
6	05.12.2021	College of Agriculture, Hassan, Karnataka	IIIrd year B. Tech (Biotechnology)	59

PG students of Aahilyabai holkar University, Solapur visited NRCP farm 25/11/2021

IIIrd year B. Tech (Biotechnology) students from College of Agriculture, Hassan, Karnataka visited ICAR-NRCP, Solapur on Educational tour on 05.12.2021

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Institutional Activities

COMMITTEE MEETINGS (RAC, IRC, IMC, IJSC)

Research Advisory Committee (RAC) Meeting

The fifteenth Research Advisory Committee (RAC) meeting of ICAR- National Research Centre on Pomegranate was held from November 29th-30th, 2021, at ICAR-NRCP, Kegaon, Solapur under the Chairmanship of Dr. N Kumar, Vice Chancellor, TNAU, Coimbatore, Tamil Nadu. The Progressive Pomegranate Farmer (MS) Shri. M.S. Mugle, could not attend the meeting due to pre-occupation elsewhere. The RAC members and scientists of ICAR-NRCP, Solapur who participated in the meeting are given below:

	Chairman		
1.	Dr. N. Kumar Vice- Chancellor TNAU, Coimbatore	**5.**	Dr. V.V. Sulladmath Ex-PS, ICAR-IIHR Bengaluru
	Members		
2.	Dr. D.P.Waskar Director of Research VNMKV, Parbhani.	**6.**	Dr. R.A.Marathe Director, ICAR-NRCP, Solapur.
3.	Dr. S. K.Panda Ex-Head, OUAT Bhubaneshwar	**7.**	Mr. Shahajirao Gulchand Pawar, Progressive Farmer Mardi, North Solapur
			Ic /Member Secretary
4.	Dr. Madan Pal PS, ICAR-IARI, New Delhi.	**8.**	Dr.Prakash G.Patil Sr.Scientist (Plant Biotech.) ICAR-NRCP, Solapur

The technical meeting on Nov 29, 2021 started at 10.30 am in the Director's Board Room. Dr. Prakash G. Patil, Sr. Scientist (Plant Biotech) & I/c Member Secretary extended a warm welcome to the Hon'ble chairman and esteemed members of the RAC. The RAC team was felicitated with ICAR-NRCP product basket by the honourable Director, ICAR-NRCP, Dr. R. A. Marathe. Then the all the ICAR-NRCP scientists gave their self-introduction to RAC members with their specialization and area of research work on pomegranate. Then Director, ICAR-NRCP briefed all the members about 16 Years Journey of ICAR-NRCP with success stories at Solapur through a brief presentation. The major research achievements highlighted by the Director included, germplasm conservation, protection of 'Solapur Lal' and 'Solapur Anardana' varieties under PPV&FRA, New Delhi, DUS testing of new varieties, finished genome assembly of Bhagawa, mapping of suitable areas of pomegranate cultivation, tissue culture and bio-hardening and technology transfer, novel bio formulations for K supplement, special micronutrient formulations for pomegranate, amino acid based supplements, water management, organic cultivation, development of modified IDIPM, Six step management of BBD and its success stories. Similarly, large-scale screening of germplasm lines against *Ceratocystis fimbriata* and root knot nematode *Meloidogyne incognita* and identification EC-676923 and ACC-2 as showing resistance to wilt. Development of novel genomic hybervariable SSR and micro RNA markers for seed hardness, fruit colour, bacterial blight, fruit size traits, technologies developed for value added products, pome mat drying for Juice powder preparation, Pomegranate Probiotics, functional beverage at ICAR-NRCP and their cost benefit ratios, patent filed for seed oil extraction, technology transfer, infrastructure, mobile app, publications, and capacity building programs organized at ICAR-NRCP. The overall research efforts made by the Centre.

The in-charge member secretary presented the 'Action Taken Report' in front of RAC committee on the recommendations of 14th RAC meeting held through virtual mode from November 6-7, 2020. At the end of the opening session, the Chairman addressed the house and appreciated the research effort made by ICAR-NRCP. The technical sessions started thereafter with the presentation on detailed work done during 2020-21 by the Principal Investigators of 13 projects. The Chairman and all members of RAC interacted with the scientists on each project. After detailed deliberations on the progress made by the Centre, several valuable suggestions and recommendations as listed below were given by the RAC members.

Recommendations of 15th RAC held during Nov., 29th-30th, 2021

Recommendations of 15th RAC held during Nov., 29th-30th, 2021

- Integration of different biomolecules and successful demonstration of a bio-intensive plant protection schedule for management of diseases and insect pests.
- Efforts should be made to create variability through intraspecific hybridization programme and interspecific hybridization after introduction of *Punica protopunica* from Socotra Island.
- Focused breeding programme to develop varieties resistant to bacterial blight and wilt by screening germplasm lines, advanced F_2 segregating populations and mutation breeding etc.
- Work on high density planting, canopy management, new fertigation schedule for cost effective crop management and production in pomegranate.
- Popularization and commercialization of NRCP technologies for successful entrepreneurship development and revenue generation among stakeholders.

The meeting ended with vote of thanks by Dr. Prakash G. Patil, I/c Member Secretary, RAC.

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

भा.कृ.अनु.प.- राष्ट्रीय अनार अनुसंधान केन्द्र, सोलापुर
ICAR-National Research Centre on Pomegranate, Solapur
15th Research Advisory Committee Meeting
Chairman

Institute Research Council (IRC) Meeting

The meeting of sixteenth Institute Research Council (IRC) of ICAR- National Research Centre on Pomegranate was held on November 24th, 2021, at ICAR-NRCP, Solapur under the Chairmanship of Dr. R. A. Marathe, Director, ICAR-NRCP, Solapur. The following Scientists/IRC members attended the meeting.

Table. Institute Research Council of ICAR-NRCP, Solapur

	Chairman IRC		
1	Dr. R. A. Marathe, Director, ICAR-NRCP, Solapur (MS)	**9**	Dr. Somnath Pokhare, Scientist (Nematology), ICAR-NRCP
	Members	**10.**	Dr. Shilpa Parashuram, Scientist (Plant Breeding), ICAR-NRCP
2	Dr. Jyotsana Sharma, Pr. Scientist (Plant Pathology), ICAR-NRCP	**11.**	Dr. Namrata Giri, Scientist (Food Technology), ICAR-NRCP
3	Dr. P. S. Shirgure, Pr. Scientist (L&W Mg.Engg), ICAR-NRCP	**12.**	Dr. Chandrakant Awachare, Scientist (Hort.-Fruit Sc.,), ICAR-NRCP
4	Dr. Ashis Maity, Sr. Sci. (Soil Sc.-Pedo), ICAR-NRCP	**13.**	Dr. Mallikarjun Harsur, Scientist (Entomology), ICAR-NRCP
5	Dr. N.V. Singh, Sr. Scientist (Hort.-Fruit Sc.), ICAR-NRCP	**14.**	Dr. Roopa Sowjanya P, Scientist (Plant Breeding), ICAR-NRCP
6	Dr. Nilesh N. Gaikwad, Sr. Scientist (AS & PE), ICAR-NRCP	**15**	Mr. Rahul Damale, Scientist (Plant Biochemistry), ICAR-NRCP
7	Dr. Pinky Raigond, Sr. Scientist (Plant Physiology), ICAR-NRCP		**I/c Member Secretary**
8	Dr. Manjunatha N, Scientist (Plant Pathology), ICAR-NRCP	**16**	Dr. Prakash G. Patil, Sr. Scientist (Plant Biotech), ICAR-NRCP

The IRC meeting was started on Nov 24th, 2021 at 9.30 am in the Director's Board Room. Dr. Prakash G. Patil, Sr. Scientist, I/c Member Secretary IRC extended a warm welcome to Hon'ble Chairman Dr. R.A Marathe, Director, ICAR-NRCP, Solapur and all the members. Then presentations on salient achievements of 17 ongoing research projects besides 2 new research project proposal and future line of work were made by each scientist.

Suggestions & Recommendations:

General

- All the Scientists were asked to submit hard copy of their research project RPPs eight days before the commencement of IRC meeting, this will helps to thoroughly review, evaluate the progress of each projects and documentation purpose also for further improvements by the Chairman.
- Scientists asked to submit their project RPP II in time to the PME for record.
- It was decided by the chairman that the extended IRC may be arranged or during RAC all the new projects proposals will be reviewed.
- Scientists were asked to keep good balance between applied and basic research which can address most of the field oriented problems of pomegranate farmers.

- Scientists were asked to submit RPF-II of their projects and information in short for their project achievements presented in IRC to the publication committee for compiling and printing of Annual Report 2020-21.
- It was decided that progress of externally funded projects may be also presented and reviewed during each IRC.
- All the experimental results and tables presenting in the IRC should have proper statistical analysis.
- It was observed that Scientists are including/excluding the names of Co-PIs as per their own. This should be strictly avoided and any inclusion/exclusion of Co-PIs will be decided as per approved in IRC only.

The meeting ended with vote of thanks by Dr. Prakash G. Patil, I/c Member Secretary, IRC.

OTHER ACTIVITIES

Following visitors visited ICAR-NRC on Pomegranate,Solapur during 2021

Distinguished Visitors:

EX VC Dr Dhavan VNMKV Parbhani visited NRCP 07.02.2021

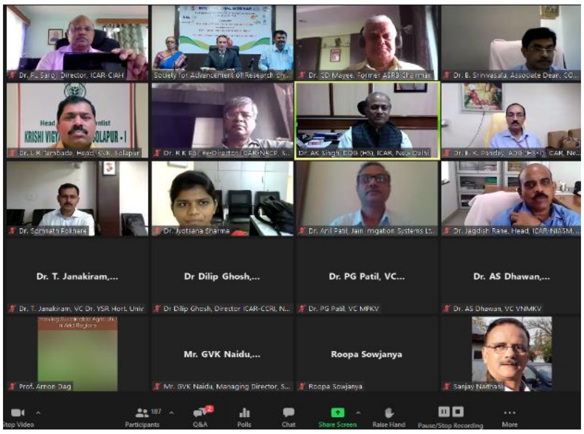
Dr Smt Poonam Malakondaiah SPL Chief Secretary visited to NRCP ,03.03.2021

Ms G Madhumita Das IPoS and Sh Milind Shambharkar DM Solapur 26.08.2021

Sh Ankush Shinde Ex CP Solapur 24.09.2021

Team Bhartiya Agrow Economic Research centre New Delhi 15.11.2021

NABAARD Officer 20.12.2021



Sl No	Date	Events conducted	Coordinator	Team	No of beneficiary
1.	23.03.3021	Co-organized and hosted 'Dalimb Mitra' launch Programme on	Dr. Mallikarjun	Dr. Mallikarjun Dr. Nilesh Gaikwad Dr. N. V. Singh	50
2.	25^{th} August - 27^{th} August, 2021	International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture	Dr. R.A. Marathe- Convener Dr. Jyotsana Sharma- Joint Convener Dr. P.S Shirgure & Dr. K.D. Babu: Co-Convener Dr. N.V. Singh- Organizing Secretary	All Scientists	200

"International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture", August 25-27, 2021

The ICAR–National Research Centre on Pomegranate has organized an International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture" during August 25-27, 2021 in collaboration with Society for Advancement of Research on Pomegranate, Solapur and ICAR-CIAH, Bikaner.

A total of 47 Invited Speakers including 7 international speakers and 200 delegates from 9 countries of the world namely, Israel, Iran, Spain, USA, Turkey, Italy, South Africa, Germany, Pakistan and India have participated in this mega scientific event. In this webinar representatives of many MNCs like UPL, ICL, Jain Irrigations, Sam AgriTech, Coromandel, Bayer, Corteva, etc., also participated. The Padma Shri awardee pomegranate farmer Sh. Genabhai Dargabhai Patel has also shared his experiences to inspire the other pomegranate growers.

The Inaugural program of the International Webinar was chaired by Dr. CD Mayee, Former Chairman, ASRB and Dr. AK Singh, DDG, HS. The webinar also witnessed the august presence of by Dr. NK Krishna Kumar, Former DDG HS; Dr. PL Saroj, Director, ICAR-CIAH, Bikaner; Dr. T Jankiram, VC, Dr. YSRHU (AP); Dr. AS Dhawan VC, VNMKV, Prabhani; Dr. PG Patil VC, MPKV, Rahuri, Dr. DK Ghosh, Director, ICAR-CCRI, Nagpur; Dr. BK Pandey, ADG (HS-II), ICAR, New Delhi; Dr. RT Patil, Former Director, ICAR-CIPHET; Dr. RK Pal, Former Director, ICAR-NRCP and Dr. VI Benagi, Ex-VC, UAS Dharwad. The International Webinar was convened by Dr. RA Marathe and coordinated by Dr. NV Singh.

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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.	Completed online training workshop on “Response Surface Methodology	24-26 August,2021	(Online) Organized by ICAR-NAARM, Hyderabad	Dr.Namrata A. Giri
2.	Training Programme on Analysis of Experimental Data	17-22 Jan, 2022	Online- NRCP, Solapur	Awachare Chandrakant Mahadev
3.	Plant Genetic Resources Management and Utilization	19 July to 1 Aug, 2021	Online – NRCP, Solapur	Dr. Shilpa Parashuram
4.	Online workshop on “response surface methodology	24-26 Aug, 2021	Online – NRCP, Solapur	Dr. Namrata Giri
5.	Advances in applications of phenomic tools for assessment of abiotic stress responses in crop plants	28 Feb to 9 March, 2022	Baramati NIASM, Baramati	Dr. Roopa Sowjanya
6.	Competency Enhancement Program for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR	21-23 Feb, 2022	Online – NRCP, Solapur	Dr. Mallikarjun
7.	Training Programme on “Quality pomegranate production and value addition for doubling farmer’s income”	15-17 Feb, 2021	ICAR-NRCP	Dr. N.V. Singh

	for Valagro Biosciences organized by ICAR-NRC on Pomegranate, Solapur.			
8.	A Four days Collaborative **Training** Programme on "Modern practices for export quality pomegranate production and value addition" jointly organized by MANAGE and ICAR-NRCP.	28-31 July, 2021	ICAR-NRCP and MANAGE	Dr. N.V. Singh
9.	Online Training Programme on "DUS Testing" conducted by PPV&FRA, New Delhi.	1 July, 2021	On-line	Dr. Shilpa Parashuram
10.	Virtual Training Programme on 'Plant Genetic Resources Management and Utilization' organized by ICAR-National Bureau of Plant Genetic Resources, New Delhi.	19 July to 1 Aug, 2021	On-line	Dr. Shilpa Parashuram
11.	On-line training programme on "Advanced statistical techniques for data analysis using R" organized by ICAR - Indian Institute of Rice Research and Society for Advancement of Rice Research, Hyderabad, Telangana.	3-15 Jan, 2022	On-line	Dr. Shilpa Parashuram
12.	Attended virtual training on "Analysis of Experimental data" organized by ICAR-NAARM, Hyderabad, during 17th to 22nd January, 2022.	17th to 22nd January, 2022	ICAR-NAARM, Hyderabad (**Virtual mode**)	Mr. Chandrakant Awachare
13.	Virtual training course on "**Management of Fruit Genetic Resources**" organized by ICAR-NBPGR, New Delhi, ICAR-AICRP (F) and ICAR-IIHR, Bangalore during	Feb., 1-2, 2021	**Virtual mode**	Mr. Chandrakant Awachare

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, *etc.* attended

S. No.	Title of Conference/ Seminar/ Symposia	Date	Venue	Name of the participant(s)
1.	International Webinar on "Pomegranate: Ancient fruit in modern horticulture"	25-27 Aug,2021	ICAR-NRCP, Solapur	Dr. Ashis Maity
2.	4th Global Meet of Science and Technology for staying healthy and feeding ever-growing population world- wide"	12-13 Sept, 2021	SVP University of Agriculture and Technology, Meerut	Dr. Ashis Maity
3.	National Seminar on "Managing soils in a changing climate"	24-26 March,2022	ICAR-NBSS & LUP, Nagpur	Dr. Ashis Maity
4.	International e-Conference on Postharvest disease management and value addition of horticultural crops.	18-20 August, 2021	ICAR-IARI, New Delhi. (Online)	Dr.Namrata Ankush Giri
5.	International Webinar on Pomegranate: Ancient fruit in Modern Horticulture.	25-27 August, 2021	ICAR-NRC on Pomegranate, Solapur in collaboration with ICAR-CIAH, Bikaner.	Dr.Namrata Ankush Giri
6.	National conference on "Oil Palm- A right choice towards self-sufficiency in edible oil production".	6 September, 2021	(Online) ICAR-Indian Institute of Oil Palm Research, Pedavegi, A.P.	Dr.Namrata Ankush Giri

7.	International webinar on “Fighting the hunger using smart technology”.	26 October, 2021	(Online) ICAR-Indian Institute of Oil Palm Research, Pedavegi, A.P.	Dr.Namrata Ankush Giri
8.	Webinar on Prospects of underutilized fruits in India for nutritional security & entrepreneurship	24.05.2021	SKNAU, Jobner, Online	K.Dhinesh Babu
9.	International Webinar on Pomegranate : An ancient fruit to modern horticulture	25-27 Aug, 2021	ICAR-NRCP Solapur Online	K. Dhinesh Babu / All staff
11.	9th Indian Horticulture Congress, organized by IAHS, New Delhi	18-21 Nov, 2021	CSAUA&T, Kanpur	K.Dhinesh Babu
12.	International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture, NRCP, Solapur, India	25-27 Aug, 2021	NRCP, Solapur, India	Dr. Manjunatha N
13.	International Webinar on “Pomegranate: Ancient Fruit in Modern Horticulture” organized by ICAR-NRC on pomegranate and SARP, Solapur.	25-27 Aug, 2021	NRCP, Solapur	Dr. Mallikarjun
14.	*National Agricultural Scientist Conclave on “Sustainable Agriculture Through Integrated Inputs” at JNKVV, Jabalpur, Madhya Pradesh organized by Bhartiya Agro- Economic Research Centre, New Delhi,*	9-12 Dec, 2021	JNKVV, Jabalpur, Madhya Pradesh	Dr. Mallikarjun
15.	Online webinar on "Smart Cities and Vertical Gardening" organized by ICAR-NRCP, Solapur	08 Feb, 2022	NRCP, Solapur	Dr. Mallikarjun
16.	Attended the lecture on Containing Malnutrition through Horticulture- by Dr. Anand Kumar Singh, DDG (Hort. Sci), ICAR	5 April, 2021	Online NRCP, Solapur	Dr. Mallikarjun

17.	Online National webinar on the use of Nontechnology in Agriculture: Nano fertilizer Jointly organized by ICAR-Research Complex for Eastern Region, Patna, and Indian farmers, fertilizer Cooperative limited Patna, Bihar.	23 Sept, 2021	Online NRCP, Solapur	Dr. Mallikarjun
18.	Attended The Virtual Workshop On Science Communication December Organized By ICAR-IIHR, Bengaluru.	29 Dec, 2021	Online NRCP, Solapur	Dr. Mallikarjun
19.	International E Conference on post-harvest disease management and value addition of horticultural crops. Delivered Invited oral paper Gaikwad N.N., Giri, N.A. and Marathe, R.A. 2021. Pomegranate utilization for food, pharmaceutical and cosmetic industry	18-20 Aug, 2021	ICAR-IARI, New Delhi, India I(S06B)04.	Gaikwad N.N., Giri, N.A. and Marathe, R.A.
20.	Virtual Webinar on Increasing the Yield, Qualitv and Income of Pomegranate Farmers organized by Dhanuka Group in partnership with the University of Horticultural Sciences, Bagalkot, Karnataka	24 July, 2021	UHS Bagalkot	Dr. N.V. Singh
21.	International Webinar on Pomegranate-Ancient Fruit in Modern Horticulture	25-27 Aug, 2021	ICAR-NRCP (Hybrid Mode)	Dr. N.V. Singh
22.	National Agricultural Scientists Conclave on Sustainable Agriculture through integrated inputs organized by Bhartiya Agro-Economic Research Center in Collaboration with Bhartiya Kisan Sangh. The conclave will be held at JNKVV, Jabalpur	10-11 Dec, 2021	JNKVV, Jabalpur	Dr. N.V. Singh
23.	13th Swadesh Prem Jagriti Sangosthi International Conference on Innovative Approaches for Enhancing	16-19 Sept, 2021	PJTSAU, Rajendranagar	Dr. N.V. Singh

	Water Productivity in Agriculture including Horticulture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India			
24.	International web conference on Innovative & Current Advances in Agri & Allied Sciences	19-21 July, 2021	Society for Scientific Development in Agriculture & Technology (SSDAT), Meerut, India	Mr. Rahul Damale
25.	Attended the International webinar on "Exchange of Post PVP Control Measures" organized by PPV&FRA, New Delhi.	8th April, 2021	On-line	Dr. Shilpa Parashuram
26.	One day National webinar on 'IPR & Patents' organised by V. G. Shivdare College of Arts, Commerce & Science, Solapur .	19 June 2021	On-line	Dr. Shilpa Parashuram
27.	International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Bikaner and SARP, Solapur	25-27 Aug, 2021	On-line	Dr. Shilpa Parashuram
28.	International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture" organized by SARP and NRCP, Solapur	25-27 Aug, 2021	NRCP, Solapur, India	Dr. Somnath S. Pokhare
29.	National Webinar on "Nematodes A Continuing Bottleneck in Crop Production : Available Technologies and Recent Advances" organized by Department of Nematology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.	6 April, 2021	Online platform	Dr. Somnath S. Pokhare

Table 3. WORKSHOPS ATTENDED

S. No.	Title of Workshop	Date	Venue	Name of Participant(S)
1.	Pest and disease management in Pomegranate, KVK, Vijayapura, Karnataka	26 June, 2021	KVK, Vijayapura, Karnataka	Dr Manjunatha N
2.	Review and sensitization workshop of ZTMUs/ITMUs/PMEs under NAIF.	6 Oct, 2021	Online	Dr. Gaikwad Nilesh N.
3.	One day online Awareness Programme on “Germplasm registration in Horticultural Crops” organized by Germplasm Advisory Committee, ICAR-IIHR Bengaluru	1 Oct, 2021	On-line	Dr. Shilpa Parashuram
4.	Attended as Expert in One day workshop on ‘Wilt and Nematode management in Pomegranate’. At Kadlas, Sangola, Maharashtra organised by Adama India Limited on 12/02/2021. Experts: Dr. Jyotsana Sharma, Dr. Somnath Pokhare and Dr. Mallikarjun. More than 300 farmers were participated in this workshop.	12 Feb, 2021	At Kadlas, Sangola, Maharashtra	300 farmers

Table 4. MEETINGS ATTENDED

S. No.	Title of meeting	Date	Venue	Name of participant(s)
1.	26th Research Workers Annual Group Meet, AICRP on Arid Zone Fruits	28-30 April, 2021	ANDUAT, Kumarganj, Ayodhya	K.Dhinesh Babu
2.	Farmer interface meeting on management of shot hole borer and	-	Ajnale, Sangola	Dr Manjunatha N

	pomegranate at Ajnale, Sangola			
3.	HORTSAP meeting on modification of the pomegranate survey proforma for pest scouts and monitors at Sakhar Sankul Shivajinagar, Pune, Maharashtra	11.03.2022	Sakhar Sankul Shivajinagar, Pune, Maharashtra	Dr. Mallikarjun
4.	Outreach Programme at Nagpur organized by APEDA, Ministry of Commerce and Industries, GOI and Agrovision, Nagpur. Delivered lecture on"cultivation and value addition of pomegranate for improvement in export" as Invited Speaker in session on "Cultivation Practices & Export Quality production of Pomegranate"	9th October 2021	Nagpur	Dr. Gaikwad Nilesh N.
5.	Board of studies, Cosmetic Technology department, Solapur University for designing and finalization of the course wise syllabus, marking system etc. for B.Tech (Cosmetic Technology)	13th May 2021	Solapur	Dr. Gaikwad Nilesh N.
6.	Gap assessment in infrastructure & processing facilities for development of potential value chains for perishable products under Operation Greens Scheme of MoFPI for Pomegranate organized by Deloit for Ministry of Food Processing Industries GOI.	14th July 2021	Online	Dr. Gaikwad Nilesh N.
7.	College Development Committee Meeting of DSTS Mandal's College of Pharmacy, Solapur as Member on 26th November 2021.	26th Nov. 2021	Solapur	Dr. Gaikwad Nilesh N.
8.	13th Foundation Day Function of ICAR-NIASM, Baramati and Panel Discussion	18-19 Feb, 2021	ICAR-NIASM, Baramati	Dr. N.V. Singh

9.	Discussion session organized by Maharashtra Pomegranate Growers' Research Association, Pune on the occasion of Foundation Day of MPGRA, Pune.	5-10 June, 2021	Online Mode, MPGRA, Pune	Dr. N.V. Singh
10.	Webinar Organized for officers of Telangana State Government on Pomegranate cultivation	6 May, 2021	Virtual Mode (Telangana Government)	Dr. N.V. Singh
11.	Three-Day Farmers' Training Programme Organized by VNMKV, Parbhani	1-3 May, 2021	Virtual mode (KVK Aurangabad, VNMKV)	Dr. N.V. Singh
12.	16th Foundation Day Ceremony of ICAR-NRCP	25 Sept, 2021	ICAR-NRCP (Hybrid Mode)	Dr. N.V. Singh
13.	Tree plantation campaign. Theme-Har med par ped, organized by ICAR-CAFRI, Jhansi	16 July, 2021	ICAR-CAFRI, Jhansi	Dr. N.V. Singh
14.	Review meeting of DUS centres under the Chairmanship of Dr. K. V. Prabhu, Chairperson of PPV&FRA, New Delhi.	10th June, 2021	On-line	Dr. Shilpa Parashuram
15.	Scientists-Farmer interaction meeting organized by ICAR-National Research Centre on Pomegranate, Solapur in the eve of 17th Foundation Day	25th Sept, 2021	ICAR-NRCP, Solapur	Dr. Shilpa Parashuram

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Publications

Research articles

S. No.	Research paper	NAAS Rating
1.	Patil, P. G., Singh, N. V., Bohra, A., Sowjanya, R., Raghvendra, K.P., Mane, R., *et al.* 2021. Comprehensive characterization and validation of chromosome-specific highly polymorphic SSR markers from pomegranate (*Punica granatum* L.) cv. Tunisia genome. *Frontiers in Plant Science* **12**: 645055. doi: 1 0.3389/fpls.2021.645055	11.75
2.	Maity, A. Marathe, R.A., Sarkar, A., Basak, B. (2022) Phosphorus and potassium supplementing bio-mineral fertilizer augments soil fertility and improves fruit yield and quality of pomegranate. Scientia Horticulturae, https://doi.org/10.1016/j.scienta.2022.111234	9.46
3.	Gaikwad NN, Kalal AY, Suryavanshi SK, Patil PG, Sharma D, Sharma J. 2021. Process optimization by response surface methodology for microencapsulation of pomegranate seed oil. Journal of Food Processing and Preservation. 45 (6) e15561. https://doi.org/10.1111/jfpp.15561 .	7.41
4.	Kumar, R.A., Rajpurohit, V.S., Gaikwad N. N. 2021. Image dataset of pomegranate fruits (*Punica granatum*) for various machine vision applications. Data in Brief. 37:107249 https://doi.org/10.1016/j.dib.2021.107249 .	7.70
5.	Tonde A.B., Bhoite, A.A. and Gaikwad N.N. (2022) Studies on microencapsulation of Lactobacillus acidophilus NCIM 5306 and evaluation of matrix material efficiency in pomegranate juice. Food Research 6(2): 255-264.	-
6.	Singh, N.V., Karwa, N.N., Birajdar, S.B., Parashuram, S., Patil, P.G., Babu, K.D. et al. 2021. Evaluation of plant beneficial microbes for bio-hardening of in-vitro raised pomegranate saplings. Indian Journal of Agricultural Sciences 91(1): 29-33.	6.37
7.	Singh, N.V., Patil, P.G., Sowjanya, P.R, Shilpa, P., Natarjan, P., Reddy, U.K., Babu, K.D., Pal, R.K. and Sharma J. 2021. Chloroplast Genome Sequencing, Comparative Analysis and Discovery of Unique Cytoplasmic Variants in Pomegranate (Punica granatum L.). Frontiers in Genetics, doi: 10.3389/fgene.2021.704075	10.60
8.	K.J. Jeyabaskaran, P.S. Shirgure, Vikramaditya Pandey, A.K. Srivastava and S. Uma. (2021) Fertigation in Horticulture : A Guarantee to Economized Quality Production. Indian Journal of Fertilisers 17 (4) : 364-383	4.76

	Review Article	
1.	Babu KD, Sharma J, Maity A, Singh NV, Patil PG, Shilpa P, and Marathe, RA. 2021. Pomegranate: An ancient fruit for health and nutrition. Progressive Horticulture. 53 (1): 3-13.	4.49

S.No.	BOOK CHAPTERS
1.	Maity A. and Kashyap P. (2022) Integrated nutrient management for sustainable pomegranate production. In: Natural Resource Management in Horticultural Crops (Eds. Roy, S.S., Kashyap, P., and Adak, T.). Today & Tomorrow's Printers and Publishers, New Delhi-110002 pp. 31-47.
2.	Babu N., Kashyap P., Prusty A.K., Samant D. and Maity A. (2022) Role of horticulture for sustainable food production under climate change scenario. In: Natural Resource Management in Horticultural Crops (Eds. Roy, S.S., Kashyap, P., and Adak, T.). Today & Tomorrow's Printers and Publishers, New Delhi-110002 pp. 293-313.
3.	Maity, A. and Marathe, R. (2021) Nutrient Management. In: Good management practices in pomegranate (Eds. Pokhare, S.S., Sharma, J., Patil, P.G., Manjunatha, N., Mallikarjun, M.H.), Technical Manual No. 1/NRCP/2021, ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp.44-59.
4.	Sowjanya, R.P., Sharma, J. Maity, A. and Marathe, R.A. (2021) Abiotic stresses of pomegranate and their management. In: Good management practices in pomegranate (Eds. Pokhare, S.S., Sharma, J., Patil, P.G., Manjunatha, N., Mallikarjun, M.H.), Technical Manual No. 1/NRCP/2021, ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp. 114-120.
5.	Nilesh N. Gaikwad, K. Dhinesh Babu and Namrata Giri (2021) Harvesting and Post-Harvest Handling, In Good Management Practices in Pomegranate, Eds. R A Marathe, S. Pokhare, J. Sharma, PG Patil, N. Manjunatha, Mallikarjun, M.H., Technical Manual No.1/NRCP/2021 ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, 121-128.
6.	Nilesh N. Gaikwad, Namrata Giri and K. Dhinesh Babu (2021) Processing and Value addition, In Good Management Practices in Pomegranate, Eds. R A Marathe, S. Pokhare, J. Sharma, PG Patil, N. Manjunatha, Mallikarjun, M.H., Technical Manual No.1/NRCP/2021 ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, 129-132.
7.	Namrata Ankush Giri, Sajeev M.S., Bansode V.V., Krishnakumar T. and Pradeepika Chintha. (2021). Sweet potato (*Ipomoea batatas* L.): Nutritional importance and value addition In: Recent Advances in Root and Tuber Crops, Brillion Publishers, New Delhi,355-376.

8.	Krishnakumar, T, Sajeev M.S and Namrata Giri. (2021). Tapioca: Processing and Storage. In: Recent Advances in Root and Tuber Crops, Brillion Publishers, New Delhi, 341-353.
9.	Sajeev M.S., Namrata A. Giri, Krishnakumar T. and Bansode V. (2021). Primary and Secondary Processed Value Added Food Products from Cassava. In: Recent Advances in Root and Tuber Crops, Brillion Publishers, New Delhi, 319-340.
10.	Bansode V.V., Namrata A. Giri, Sajeev M.S., Chauhan V.B.S., Nedunchezhiyan M., Kalidas Pati. (2021). Nutritional importance and value addition of Elephant Foot yam and Taro. In: Recent Advances in Root and Tuber Crops, Brillion Publishers, New Delhi,377-389.
11.	Sankaran, M, Babu, KD, Jai Prakash, Karale, AR. 2021. Pomegranate. In: Fruits : Tropical & subtropical. Vol.2 (Eds. Parthasarathy VA, Bose TK, MItra SK, Bhosh B, Chakraborty I, SAnyal D) . Daya Publishing House, N.Delhi. pp.165-242.
12.	Ferrara, G., Palasciano, M., Sarkhosh, A., Cossio, F., Babu, K.D., Mazzeo, A. 2021. Orchard Establishment and Tree Management. In : The Pomegranate: Botany, Production and Uses (Eds Sarkhosh, A., Yavari, A. and Zamani, Z), CABI Publishing – Wallingford OX10 8DE, United Kingdom. 247-284.
13.	Singh, N.V., Karimi, H.R., Sharma, J. and Babu, K.D. 2021. Propagation Techniques and Nursery Management. In: The Pomegranate: Botany, Production and Uses (Eds. Sarkhosh, A., Yavari, A. and Zamani, Z). CABI Publishing – Wallingford OX10 8DE, United Kingdom. 196-224.
14.	Carter JM, Yavari A, Sarkhosh A, Jia Z, Merhaut DJ, Preece JE, Cossio F, Qin G, Liu C., Li J, Shilpa P., Babu K.D., Sharma J, Yilmaz C, Bartual J, Mustafayeva Z, Saeedi, MA., Awd NA, Moersfelder J and Hou L. 2021. World pomegranate cultivars. In:.The Pomegranate: Botany, Production and Uses (Eds. Sarkhosh, A., Yavari, A. and Zamani, Z.), CABI Publishing – Wallingford OX10 8DE, United Kingdom. 157-195.
15.	Mallikarjun H., 2021. Insect and non-insect pests and their management. Technical Manual No.1/NRCP/2021 on Good Management Practices in Pomegranate, published by ICAR-NRC on Pomegranate, Solapur-413255 (Maharashtra), India, pp170.
16.	Singh, N.V., Babu, K.D. and Sharma, J. 2021. Pomegranate. In: Subtropical fruit crops: theory to practical (Ghosh, S.N. and Sharma, R.R. eds.), Jaya Publishing House, New Delhi, Pp. 454-523.
17.	Patil PG, Singh NV, Shilpa P, Sowjanya R, Jyotsana S, Marathe RA (2021). Recent Advances in Pomegranate Genomics: Status and Prospects (Book: Omics in Horticulture crops, Elsevier publisher). (Accepted).

18.	Bohra A, Jha U, Satheesh Naik S J, Mehta S, Tiwari A, Maurya AK, Singh D, Yadav V, Patil PG, Saxena RK and Varshney RK (2021). Genomics: Shaping Legume Improvement. In book: Genetic Enhancement in Major Food Legumes (Eds. Saxena K.B et al.). DOI: 10.1007/978-3-030-64500-7_3.
19.	Shilpa P., Roopa Sowjanya, P., Babu K. D., Singh N. V., Prakash Patil, G. and Jyotsana S. Pomegranate - A Miracle Fruit Crop in Handbooks of Agro-biodiversity: Conservation and Use of Plant Genetic Resources for Springer Nature (Communicated).
S.No.	**POPULAR ARTICLES**
1.	Sharma, J., Maity, A., Singh, N.V., Mallikarjun, H., Manjunatha, N., Pokhre, S., Chaudhary, D. (2021) Mrigha bahar dalimba bagache Vyavasthāpana. Agro One, 5th August, 14 pp.
2.	Sharma, J., Maity, A., and Mallikarjun, H. (2021) Mrigh bahar dalimba bagesathi niyojan. Agro One, 21st October, 14 pp.
3.	Sharma, J., Maity, A., Singh, N.V., Pokhare, S., Mallikarjun, H., and Chaudhari, D. (April-May, 2021) Dalimba pikasathi sallha. Published online on the institute's website.
4.	Sharma, J., Maity, A., Singh, N.V., Mallikarjun, H., Pokhare, S., and Chaudhari, D. (June-July, 2021). Dalimba phaldharak baghsathi daimashik sallha. Published online on the institute's website.
5.	Sharma, J., Maity, A., Singh, N.V., Pokhare, S., Mallikarjun, H., and Chaudhari, D. (October-November, 2021) Dalimba pikasathi sallha. Published online on the institute's website.
6.	Jyotsana Sharma, Somnath Pokhare and Mallikarjun, 2021. Dalimbatil Keed Rog Niyantran. Sakal-Agrowon, 11th April 2021.
7.	Jyotsana Sharma, Somnath Pokhare and Mallikarjun, 2021. Ambya Baharatil Keed-Rog. Vyavstapan. Sakal-Agrowon, 20th April 2021.
8.	Jyotsana Sharma, Ashis Maity, N.V. Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary, 2021. Mrug Bahar Dalimb Baagecha Vyavstapan. Sakal-Agrowon, 5th August 2021.
9.	Jyotsana Sharma, Somnath S. Pokhare, Manjunatha, N., Mallikarun, H. and Vijay Lokhande, 2021. SIX-STEP Management Schedule for Bacterial Blight Disease. Agro India Magazine, pp36-38.
10.	डॉ. सोमनाथ पोखरे, डॉ. मंजूनाथा एन., डॉ. ज्योत्स्ना शर्मा, श्री दिनकर चौधरी, व श्री विजय लोखंडे तेलकट डाग रोग व्यवस्थापनाच्या सहा पायऱ्या'ॲग्रो प्लनिंग, सकाळ अग्रोवन, ७ मार्च २०२१.

11.	डॉ. सोमनाथ पोखरे, डॉ. मंजूनाथा एन., डॉ. ज्योत्स्ना शर्मा, श्री दिनकर चौधरी, व श्री विजय लोखंडे. 'डाळिंबामधील तेलकट डाग रोग व्यवस्थापनाच्या सोप्या सहा पायऱ्या'शेतकरी मासिक, एप्रिल २०२१:43-44.
12.	Mallikarjun, Rajiv Marathe and Dinkar Chaudhary 2021. Dalimb Pikaavaril Khod Keed Vyavstapan. Sakal-Agrowon, 29th September 2021.
13.	Mallikarjun, K.D. Babu, Ashok Walunj, Parakash More, Anil Durgude. Shetphale Dalimb baganchi pahani on 21.09.2021.
14.	Mallikarjun, Manjunatah, N, Somnath Pokhare and Rajkumar Kori; Soalpur ke Krushi vaignikone Dekha annarke bagiche date: 18.08.2021.
15.	Shilpa P., Roopa Sowjanya, P., Singh, N. V., Patil, P. G., Babu, K.D. and Marathe, R. A. 2021. New commercial varieties of pomegranate in India. Agro India, pp. 24-25.
16.	Babu, K.D. and Singh, N.V. 2021. Orchard management. In: Good Management Practices in Pomegranate, (Eds: Marathe, R.A., Pokhare, S.S., Manjunatha, N., Sharma, J., Mallikarjun, M.H., and Patil, P.G.) Technical Manual No.1/NRCP/2021 ICAR-NRC on Pomegranate, Solapur-413255 (Maharashtra), India, pp 38-43.
17.	Singh, N.V. and Chaudhari, D.T. 2021. Pomegranate advisory-crop regulation for *hast bahar*. *Sakal Agrowon,* April 18, 2021, 7p.
18.	Singh, N.V., Chandra, R., Babu, K.D. and Shilpa, P. 2021. Healthy planting material for sustainable production. In: Good Management Practices in Pomegranate, (Eds: Marathe, R.A., Pokhare, S.S., Manjunatha, N., Sharma, J., Mallikarjun, M.H., and Patil, P.G.) Technical Manual No.1/NRCP/2021 ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp 8-11.
19.	Singh, N.V., Chandra, R., Marathe, R.A., Babu, K.D. and Patil, P.G. 2021. Establishing new orchard. In: Good Management Practices in Pomegranate, (Eds: Marathe, R.A., Pokhare, S.S., Manjunatha, N., Sharma, J., Mallikarjun, M.H., and Patil, P.G.) Technical Manual No.1/NRCP/2021 ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp 12-16.
20.	Singh, N.V., Sharma, J., Shinde, Y., Babu, K.D. and Shilpa, P. 2021. Economics of pomegranate cultivation. In: Good management practices in pomegranate, (Eds: Marathe, R.A., Pokhare, S.S., Manjunatha, N., Sharma, J., Mallikarjun, M.H., and Patil, P.G.) Technical Manual No.1/NRCP/2021 ICAR-NRC on Pomegranate, Solapur-413255 (Maharashtra), India, pp 141-143.
21.	Singh, N.V., Sharma, J., Babu, K.D. Patil, P.G. 2021. Supply chain management, marketing and export issues in pomegranate. In: Good Management Practices in Pomegranate, (Eds: Marathe, R.A., Pokhare, S.S., Manjunatha, N., Sharma, J., Mallikarjun, M.H., and Patil, P.G.) Technical Manual No.1/NRCP/2021 ICAR-

	National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp 133-140.
22.	Awachare, C., Singh, N.V., Babu, K.D., Marathe, R.A., 2021. Canopy management in pomegranate for improved quality and yield. *Biotics Research Today*, 4(1); 11-13.
23.	Rajiv Marathe, Jyotsana Sharma, Rahul Damale and Mallikarjun 2021. Gaajar Gavat Nirmoolan Jagaruktaa Saptaha. Sakal-Agrowon, 22nd August 2021.
24.	Wadne S. S., Meshram D. T. and Shirgure P. S. (2021). Dalimba Baget Achadancha Wapar. Agrowan March 22, 2021 p-5. World Water Day 2021 Special issue.
25.	Giri N.A., Gaikwad N. N. & Marathe R.A. (2021). Potential application of Pomegranate Peel as a natural food additive. Kerala Karshakan (E-journal). 13-18.
26.	Giri N.A., Gaikwad N. N., Marathe R.A. & Chaudhari D. T. (2021). Karonda: A protective hedge around pomegranate orchard. Agro India. 24-25.
27.	Giri N.A. and Marathe R.A. (2021). Benefits for Processing of Karonda fruit (Marathi). Agrowon Newspaper. Page No.10.
28.	More S. and Giri N.A. (2021). Scientific farming of Sweet potato. Agrotouch (Marathi) magazine, 2 (12), 13-14.
29.	Giri N. A. and More S. (2021). Sweet potato- Nutritional value and value addition. Agrotouch (Marathi) magazine, 3 (2), 38-40.
30.	निलेश गायकवाड़ एवं नम्रता गिरी (२०२०) अनार बीज का तेल : स्वास्थ्य लाभ, निष्कर्षण प्रक्रिया और मैक्रोईनकॅप्सूलेशन. प्रसंस्करण प्रगति, अर्धवार्षिक राजभाषापत्रिक, वर्ष ४, अंक २, १२-१५.

PRESENTATIONS IN CONFERENCES/ SYMPOSIA/ SEMINAR/ OTHER FORA

S.No.	ORAL PRESENTATIONS
1.	Maity, A., Marathe, R.A., Sharma, J. and Babu, K.D. (2021) Nutrient management – a key to successful pomegranate production and protection. In Souvenir of International Webinar on “Pomegrante: Ancient fruit in modern horticulture”, held on August, 25-27, 2021 jointly organized by ICAR-NRCP, Solapur, ICAR-CIAH, Bikaner and SARP, Solapur, pp. 42-47.
2.	Maity, A., and Marathe, R.A. (2021) Bio-mineral fertilizer can replace the need of potassic and phosphatic fertilizer in pomegranate. In Souvenir of 4th Global Meet of Science and Technology for staying healthy and feeding evergrowing population world- wide” held on September, 12-13, 2021 jointly organized by Hi Tech Horticultural Society and Prerna Foundation, pp.213.

3.	Maity, A., Marathe, R.A., and Babu, K.D. (2022) Bio-integration of Rock Materials can Revamp Rhizospheric Activity and Supplement P and K Requirement of Pomegranate Tree (*Punica granatum* L.). In Souvenir cum Abstract of National Seminar on "Managing soils in a changing climate" held on March, 24-26, 2022 organized by Indian Society of Soil Survey & Land Use Planning (ISSLUP), Nagpur, pp. 195.
4.	Giri, N. A. (2021). Oral presentation in International e-Conference on Postharvest disease management and value addition of horticultural crops during 18-20August 2021 organized ICAR-IARI, New Delhi.
5.	Gaikwad N.N., Giri, N.A. and Marathe, R.A. (2021). Pomegranate utilization for food, pharmaceutical and cosmetic industry an Invited oral paper in Souvenir and abstracts of International E Conference on post-harvest disease management and value addition of horticultural crops, August 18-20th 2021, ICAR-IARI, New Delhi, India I(S06B)04.
6.	Gaikwad N.N., Giri, N.A. and Marathe, R.A. (2021). Value Added products and dietary supplements from pomegranate Invited oral paper in International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 158.
7.	K. Dhinesh Babu, NV Singh, Shilpa P, Sowjanya PR, J.Sharma, PG Patil, RA Marathe, RK Meena & PL Saroj , M.Sankaran and BNS Murthy. (2021). Promising pomegranate varieties for different agroclimatic regions : Global Scenario. International Webinar on Pomegranate, NRCP, Solapur, 25-27 Aug 2021. (Oral)
8.	K. D. Babu, NV Singh, R. Chandra, A.Maity, J Sharma, VT Jadhav, RK Pal, RA Marathe, Shilpa P, N.Gaikwad, PG Patil, R Damale, SH Jalkiop, BNS Murthy & PS Kumar, PL Saroj.(2021).Solapur Lal: A biofortified HYV of pomegranate for nutrition & livelihood. 9th Indian Horticulture Congress-2021: Horticulture for Health, Livelihoods and Economy, IAHS, CSUA&T, Kanpur, Nov 18-21,2021 (Oral)
9.	Harnessing endophytes as biocontrol agents for the management of important diseases of pomegranate. In: International webinar on Pomegranate: Ancient fruit in Modern Horticulture August 25th -27th , 2021 conducted by SARP in collaboration with NRC on Pomegranate, Solapur, Maharashtra, India.pp89.
10.	Pomegranate diseases and their management: *In*: webinar on Pest and Disease management in Pomegranate organized on 26th June, 2021, by KVK, Bijapur, Karnataka.
11.	Insect pest of pomegranate and their management: *In*: webinar on Pest and Disease management in Pomegranate organized on 26th June, 2021, by KVK, Bijapur, Karnataka
12.	Singh, N.V., Sharma, J., Maity, A., Manjunatha, N., Parashuram, S., Patil, P.G., Marathe, R.A. 2021. Bio-priming and innovative propagation techniques for climate smart pomegranate production. In: International Webinar on Pomegranate: Ancient

	Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 38-41.
13.	Marathe, R.A., Sharma, J. and Singh N.V. 2022. "Current Status of the Pomegranate Industry in India: Challenges and Opportunities". Vth International Symposium on Pomegranate and Minor Mediterranean Fruits, 14-18th Feb, 2022.
14.	Babu, K.D., Singh, N.V., Shilpa, P., Roopa Sowjanyna, P., Sharma, J., Patil, P.G., Marathe, R.A., Meena, R.K., Saroj, P.L., Sankaran, M. and Murthy, B.N.S. 2021. Promising cultivars in different agro-climatic regions: global scenario. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 89-96.
15.	Shilpa Parashuram, Dhinesh Babu, N.V. Singh, P.G. Patil, Roopa Sowjanya P., Rahul A. Kade, Dipali C. Jadhav, Tukaram H. Daphale and R.A. Marathe. 2021. Evaluation and identification of promising genotypes for important fruit characters in pomegranate. In: 9th Indian Horticulture Congress - 2021 on "Horticulture for Health, Livelihoods and Economy" organized by Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh and Indian Academy of Horticultural Sciences, New Delhi, November 18-21, 2021. pp. 49.
16.	Shilpa Parashuram, Babu K. D., Singh, N. V., Roopa Sowjanya, P., Patil P. G., Kade, R. A., Jadhav, D. C., Daphale, T. H. and R. A. Marathe, 2021. Pomegranate genetic resource management in India. In: 5th Conference (ESDACON-2021) as '2nd World Environment Summit 2021' organized by Environment and Social Development Association (ESDA), New Delhi, 1st- 3rd October 2021.
17.	Shilpa P., Roopa Sowjanya P., Singh N. V., Patil, P. G., Babu, K. D., Sharma, J. and Marathe, R. A. 2021. Promising germplasm resources for pomegranate improvement. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 84-88.
18.	Shilpa P., 2022, Prospective of biotechnology in crop improvement. *In*: International Conference Emerging perspectives in Biotechnology organized by Department of Biotechnology, V. G. Shivdare College of Arts, Commerce & Science, Solapur, on 7th January 2022.
19.	Patil PG, Singh NV, Jamma SM, Shilpa P, Roopa Sowjanya, Jyotsana S, Babu KD and Marathe RA (2021). Genomics Assisted Breeding for Accelerated Crop Improvement in Pomegranate. International Webinar on 'Pomegranate: Ancient fruit in modern horticulture'. Organized by SARP, ICAR-NRCP, Solapur, (M.S) 25-27th Aug, 2021.

20.	N.V. Singh, Shilpa P., Mahesh Kumar, Roopa Sowjanya P., P.G. Patil, K.D. Babu and RA Marathe, 2021. Aril Browning and fruit cracking in pomegranate: unravelling mechanism and devising mitigation strategy. In: National Conference of Plant Physiology-Frontiers of Plant Physiology for climate smart agriculture organized by ICAR-NIASM, Baramati, Pune and Indian Society for Plant Physiology, New Delhi during December 09-11, 2021. pp. 19. Virtual
21.	Patil PG., Singh, N.V., Jamma SM., Shilpa P., Roopa Sowjanya P., Sharma J., Babu DK. and Marathe RA, 2021. Genomics assisted breeding for accelerated crop improvement in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 82-83.
22.	Invited speaker on a topic "Scenario of Plant Parasitic Nematodes in Pomegranate and their Management" in the International webinar on Pomegranate: Ancient Fruit in Modern Horticulture on 25-27 August 2021.
S.No.	**POSTERS**
1.	Maity, A., Marathe, R. A., Sharma, J., Babu, K. D., Sarkar, A. and Shinde, Y. (2021) Zinc nutrition improves fruit yield, quality and reduces bacterial blight disease severity in pomegranate (*Punica granatum* L.). In Souvenir of International Webinar on "Pomegrante: Ancient fruit in modern horticulture", held on August, 25-27, 2021 jointly organized by ICAR-NRCP, Solapur, ICAR-CIAH, Bikaner and SARP, Solapur, pp. 141.
2.	K. Dhinesh Babu, NV Singh, R. Chandra, A. Maity, J.Sharma, VT Jadhav , RK Pal, RA Marathe, Shilpa P, N. Gaikwad , PG Patil, R. Damale , Jalikop SH , Murthy BNS and PS Kumar. 2021. Solapur Lal : A bio-fortified, high yielding variety of pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur ; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021.
3.	Babu, K.D., Singh, N.V., Chandra, R., Maity, A., Sharma, J., Jadhav, V.T., Pal, R.K., Shilpa, P., Gaikwad, N., Patil, P.G., Damale, R., Jalikop, S.H., Murthy, B.N.S., Kumar, P.S., Saroj, P.L. (2021). Solapur Lal: A bio-fortified, HYV of pomegranate for nutrition and livelihood. In Souvenir of 9th Indian Horticulture Congress on "Horticulture for health, livelihood and economy" held on November, 18-21, 2021, organized by Indian Academy of Horticultural Sciences, New Delhi, pp.
4.	Gaikwad N.N., Kadam A., Giri, N.A. and Suryavanshi S.K. (2021). Foam mat drying of pomegranate juice using whey protein isolate and carboxy methyl cellulose in International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 167.

5.	Giri, N.A., Gaikwad N.N., and Suryavanshi S.K. (2021). Optimizing the formulation for a pomegranate-lemon-ginger based mixed fruit beverage using D-optimal mixture design of response surface methodology in International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 168.
6.	K. D. Babu, NV Singh, R. Chandra, A.Maity, J Sharma, VT Jadhav, RK Pal, RA Marathe, Shilpa P, N.Gaikwad, PG Patil, R Damale, SH Jalkiop, BNS Murthy & PS Kumar. 2021. Solapur Lal : A bio-fortified HYV of pomegranate, International Webinar on Pomegranate : Ancient fruit in Modern Horticulture, NRCP & SARP, Aug 25-27, 2021 (Poster).
7.	KD Babu, NV Singh, A.Maity, PG Patil, Shilpa P, Sowjanya PR, R Damale, J.Sharma, RA Marathe and BV Naikwadi. Poster entitled Gibberellic acid mediated fruit size enhancement in pomegranate. International Webinar on Pomegranate : Ancient fruit in Modern Horticulture, NRCP & SARP, Aug 25-27, 2021 (Poster)
8.	KD Babu, NV Singh, N.Gaikwad, A.Maity, PG Patil, RA Marathe, J.Sharma, RK Pal, Shilpa P, Sowjanya PR, R Damale, NA Giri and BV Naikwadi. Poster entitled Determination of maturity indices for pomegranate variety Solapur Lal. International Webinar on Pomegranate : Ancient fruit in Modern Horticulture, NRCP & SARP, Aug 25-27, 2021 (Poster)
9.	*In-vitro* evaluation of endophytes against fungal pathogens of pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture, 25th - 27th August, 2021
10.	Poster Presented on: First report pentatomid bugs (Hemiptera: Pentatomidae) infestation on pomegranate. International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture" held from August 25-27, 2021. Souvenir and abstract. page no. 142.
11.	Poster Presented on: Pomegranate: A new host for the invasive scale insect *Aonidiella orientalis* (Newstead) (Hemiptera: Diaspididae) from Gujrat, India. International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture" held from August 25-27, 2021. Souvenir and abstract. page no. 143.
12.	Poster Presented on: Pomegranate: A new host for the invasive mealybug *Pseudococcus jackbeardsleyi* (Gimpel and Miller) (Hemiptera: Pseudococcidae) from Solapur, Maharashtra. International Webinar on "Pomegranate: Ancient Fruit in Modern Horticulture" held from August 25-27, 2021. Souvenir and abstract. page no. 144.
13.	Damale R.D., Banerjee K., Anirban D., Shaikh N.I. , Khan, Z. Babu K.D. and Gaikwad N.N. Evaluation of matrix effect on pesticide residues quantified using matrix matched calibration of four different pomegranate (punica granatum) varieties by GC-MS/MS and LC-MS/MS cellulose in International webinar on Pomegranate

	ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 204.
14.	NV Singh, Shweta Bute, AS Shinde, DM Mudewadikar, Shilpa Parashuram, Roopa Sowjanya P, PG Patil and RA Marathe. 2021. Strategies to manage phenolic browning for efficient *in vitro* culture establishment in pomegranate cv. Bhagwa. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp 60.
15.	Unnati Salutgi, NV Singh, VR Sangnure, Shilpa Parashuram, Roopa Sowjanya P., PG Patil, VA Gargade and RA Marathe. 2021. Standardizing micropropagation protocol and genetic fidelity testing of micropropagated clones of pomegranate cv. Super Bhagwa. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 69.
16.	Raghavendra Gunnaiah, Dattatraya Hegde Radhika, M. Nandan, Pushpa Doddaraju, Pavan Dumble, Girigowda Manjunatha and Nripendra Singh. 2021. Genome-wide analysis of resistance gene analogues (RGAs) in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 105.
17.	Prakash G. Patil, Shivani M. Jamma, Singh N. V., Manjunatha N., Dhinesh Babu K. and Marathe R. A. 2021. Hybridity and heterozygosity analysis of putative F1s using genome-wide SSR markers in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 107.
18.	Tatiya, M.M, Sharma Jyotsana, Singh N.V., Mundewadikar D.M., Aralimar Anita and Godale C.H. 2021. Evaluation of endophytes against *Xanthomonas axonopodis pv. Punicae.* In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 146.
19.	Shivani M. Jamma, Prakash G. Patil, N. V. Singh,Abhishek Bohra ,Shilpa Parashuram, Mansi G. Chakranarayan, Unnati D. Salutgi, Archana S. Injal, Vaishali A. Gargade, K. Dhinesh Babu, Jyotsana Sharma. 2021. *In silico* mining and characterisation of novel hypervariable microsatellite markers for genetic analysis in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 111.
20.	Roopa Sowjanya P., Kiran Gudaghe , Vipul R Sangnure, Singh N. V., Ajinkya Mandave , Shilpa Parashuram, Sharma J. and Marathe R. A. 2021. Standardization

	of SRAP markers for assessing pomegranate (*Punica granatum* L.) genetic diversity. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021, pp. 106.
21.	Shilpa P., Maity, A., Babu K. D., Singh N. V., Roopa Sowjanya, P. and Jyotsana S. 2021. Pomegranate – Varieties and their Role in Health Security. In: National E-Conference "Biodynamic Calendar and Technological Intervention for Horticulture Sustainability and Health Security in Changing Climate" organised by College of Horticulture, Bidar, Karnataka. p. 97.
22.	Shilpa, P., Sharma, J., Gaikwad, N. G., Singh, N. V., Roopa Sowjanya, P., and Babu, K. D. 2021. Identification of fruit morphological and biochemical traits correlated to bacterial blight disease in Pomegranate. In: National Virtual Conference (NVC-2021) on 'Genomics to Phenomics: A New Horizon in Plant Science Research' organized by Department of Botany, University of Calcutta from 28th February to 1st March, 2021.
23.	Shilpa, P., Sharma, J., Maity, A., Babu, K. D., Gaikwad, N. N., Singh, N. V., Patil, P. G., Roopa Sowjanya, P. and Marathe, R. A. 2021. Study of correlation between fruit quantitative traits and bacterial blight disease in Pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 108-109.
24.	Shilpa, P., Babu, K. D., Singh, N. V., Gaikwad, N. N., Roopa Sowjanya, P., Kade, R. A., Jadhav, D. C. and Sharma, J. 2021. DUS characterization of new candidate varieties of Pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 109.
25.	Chakranarayan, M. G., Shilpa Parashuram, Singh, N.V., Patil, P. G., Roopa Sowjanya, P., Babu, K. D., Sangnure V. R., Mundewadikar, D. M. and Godhale, C. H. 2021. Utilization of Simple Sequence Repeats (SSRs) markers for cultivar identification in Pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 110.
26.	Patil PG, Jamma SM, Singh NV, Manjunatha N, Babu KD and Marathe RA (2021). Hybridity and heterozygosity analysis of putative F_1s using genome-wide SSR markers in Pomegranate. International Webinar on 'Pomegranate: Ancient fruit in modern horticulture' .Organized by SARP, ICAR-NRCP, Solapur, (M.S) 25-27th Aug, 2021.
27.	Chakranarayan, M. G., Shilpa Parashuram, Singh, N.V., Patil, P. G., Roopa Sowjanya, P., Babu, K. D., Sangnure V. R., Mundewadikar, D. M. and Godhale, C.

	H. 2021. Utilization of Simple Sequence Repeats (SSRs) markers for cultivar identification in Pomegranate. In: International Webinar on Pomegranate : Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 110.
28.	Roopa Sowjanya P., Kiran Gudaghe, Sangnure VR, Singh N.V., Ajinkya Mandave, Shilpa P., Sharma J. and R.A. Marathe. 2021. Standardization of SRAP markers for assessing pomegranate (Punica granatum L.) genetic diversity. In: International Webinar on Pomegranate : Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021. pp. 106-107.
29.	Rahul D. Damalea., Banerjeea K., Shaikha, N. I., Khana, Z and Babub, K. D. 2021. Profiling of bioactive phytochemicals in pomegranate variety Solapur Lal by LC-HRMS. Organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021.
30.	Rahul D. Damale, Banerjee K., Anirban D., Shaikh, N. I., Khan, Z., Babu, K. D and Gaikwad, N. N.2021. 2. Evaluation of matrix effect on pesticide residues quantified using matrix matched calibration of four different pomegranate (Punica granatum) varieties by GC-MS/MS and LC-MS/MS. Organised by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur August 25-27, 2021.
31.	Anuradha Sane, B.N.S. Murthy, Chandrakant Awachare, Anushma P.L. and Linta Vincent. 2021. Assessment of open pollinated progenies of Pomegranate for the yield and quality. In: International webinar on "Pomegranate: An ancient Fruit in Modern Horticulture" Organized by Society for Advancement of Research on Pomegranate (SARP) and ICAR- NRC on Pomegranate, Solapur during August 25-27, 2021.

S.No.	ANNUAL REPORT
1	Maity, A., Babu, K.D., Singh, N.V., Patil, P.G. and Gaikwad, N. 2020. ICAR-NRCP Annual Report 2020, ICAR-National Research Centre on Pomegranate, Solapur-413255, Maharashtra, p. 1-193.

S.No.	MANUAL / COMPENDIUM/ OTHERS/ Scientific/ teaching reviews
1.	Basak, B.B., Maity, A., Ray, P., Biswas, D.R. and Roy, S., (2022). Potassium supply in agriculture through biological potassium fertilizer: A promising and sustainable option for developing countries. Achieves in Agronomy and Soil Science, 68(1), 101-114. DOI: 10.1080/03650340.2020.1821191.

3.	Somnath S. Pokhare, Manjunath N., Jyotsana Sharma, Mallikarjun M.H. and Prakash Patil (2021). Good Management Practices in Pomegranate, Technical Manual No.1/NRCP/2021 ICAR-National Research Centre on Pomegranate, Solapur-413255 (Maharashtra), India, pp170.
4.	M. H. Mallikarjun, N. Manjunatha, Jyotsana Sharma, K. Dhinesh Babu, P.S. Shirgure, Ashis Maity, N.V. Singh, N. Gaikwad, S. S. Pokhare, P. Shilpa, Roopa Sowjanya, Gunwant Garad, Govind Hande, K.N. Rao and Shalendra. 'Course Compendium of Lectures for Training Programme on "Modern practices for export quality pomegranate production and value addition" for Extension Officers from July 28th -31st 2021 at ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra, India.pp89.
5.	Souvenir of International webinar on Pomegranate: ancient fruit in Modern Horticulture.
6.	Nripendra Vikram Singh, Shilpa Parashuram, Roopa Sowjanya P., Jyotsana Sharma, Mallikarjun M.H, Ashis Maity, Nilesh Gaikwad, KD Babu, Somnath Pokhare, Manjunatha N. and Rajiv Marathe 2021. Promotion of ICAR-NRCP Technologies under SCSP programme. Technical Bulletin No. NRCP/2022/1, ICAR-National Research Centre on Pomegranate, Solapur. p.36.
7.	Somnath Pokhare, Nilesh Gaikwad, Namrata Giri and Rahul Damale. 2022. Tribal Sub Plan (STC) Report for Three Days' Workshop on Awareness and Promotion of Good Agricultural Practices; Demonstration of ICAR-NRCP Technologies and Distribution of Farm Inputs to Tribal Farmers of Gadchiroli District for the period of 2021-22.
8.	Singh, N.V., Roopa Sowjnaya, P., Shilpa, P., Sharma, J., Mallikarjun, M.H., Manjunatha, N., Babu, K.D., Pokhare, S., Maity, A., Shirgure, P.S., Gaikwad, N.N., Giri, N. and Marathe, R.A.2021. Course Compendium of Lectures for Training Programme on Model Propagation and Orchard management Practices for Sustainable pomegranate production -SCSP farmers and coordinating agencies. October 26- 29th, 2021 at ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra, India, 93p.

S.No.	Technical Bulletin/ Folders
1.	Mallikarjun H. Jyotsana Sharma Somnath S. Pokhare Manjunatha, N. Rajiv Marathe 2021. Pomegranate Shot hole borer Management. ICAR-NRCP/EXTN/2022/1. Published under CROPSAP.
2.	Mallikarjun H. Jyotsana Sharma Somnath S. Pokhare Manjunatha, N. Rajiv Marathe 2021. Dalimb Pikaavaril khod keed (Bhungera) vyavstapan. ICAR-NRCP/Vistar Patrika/2022/1. Published under CROPSAP.

3.	Manjunatha, N, Somnath S. Pokhare, Jyotsana sharma, Mallikarjun M.H., and Siddalingayya S. Salimath 2021. Dalimbe Beyela Beru Gantu Jantuhulu Roga mattu adar samagra nirvahane. NRCP. Extension- 2021/3. p. 04.
4.	Mallikarjun 2022. Dalimb pikaavaril khod Kidiche (Pin hole borer) Ekatmik Vyavstapan. Published as Krushi Salla by Department of Agriculture- Solapur 04.03.2022.
5.	Singh, N.V., Sharma, J., Shilpa, P., Roopa Sowjanya, P., Marathe, R.A. 2021, Outreach Programmes of ICAR-NRCP under SCSP and STC to disseminate pomegranate production technologies. Technical Bulletin No. NRCP/2021/2, ICAR-National Research Centre on Pomegranate, Solapur, p. 33.
6.	Singh NV, Shilpa P., Roopa Sowjanya P., Sharma J., Mallikarjun MH., Maity A., Gaikwad NN., Babu KD., Pokhare S., Manjunatha N. and Marathe RA, 2022, Promotion of ICAR-NRCP technologies under SCSP programme. Technical Bulletin No. NRCP/2022/1, ICAR-National Research Centre on Pomegranate, Solapur, p. 36.

S.No.	E-NEWSLETTER / E-PUBLICATIONS
1.	Mallikarjun, Rajiv Marathe and Dinkar Chaudhari 2021. Advisory for pomegranate shot hole borer management (September-2021)
2.	Mallikarjun, Rajiv Marathe and Dinkar Chaudhari 2021. Dalimb pikaavaril khod keed (Bhungera) vyavstapan (September-2021).
3.	Mallikarjun 2021. Fruit Piercing Moths Management Advisory August 2021.
4.	Jyotsana Sharma, Ashis Maity, N V Singh, Somnatha Pokhare, Mallikarjun and Dinkar Chaudhari, 2021. Bimonthly Pomegranate Advisory (English) for bearing orchards of April-May 2021.
5.	Jyotsana Sharma, Ashis Maity, N V Singh, Somnatha Pokhare, Mallikarjun and Dinkar Chaudhari, 2021. Annar fasal ki diwimasik salah (Hindi) for April-May 2021.
6.	Jyotsana Sharma, Ashis Maity, N V Singh, Somnatha Pokhare, Mallikarjun and Dinkar Chaudhari, 2021. Dalimba pikasatil salla (Marathi) for April-May 2021.
7.	Jyotsana Sharma, Ashis Maity, N V Singh, Somnatha Pokhare, Mallikarjun and Dinkar Chaudhari, 2021.Dalimbae beleyalli kandubaruv samasyegalige salahegalu (Kannada) for April-May 2021.
8.	Jyotsana Sharma, Ashis Maity, NV Singh Mallikarjun H. and Somnath S Pokhar 2021. Bimonthly Pomegranate Advisory for Bearing Orchards (English) June- July 2021.

9.	Jyotsana Sharma, Ashis Maity, NV Singh Mallikarjun H. and Somnath S Pokhar 2021. Annar fasal ki diwimasik salah (Hindi) for June- July 2021.
10.	Jyotsana Sharma, Ashis Maity, NV Singh Mallikarjun H. and Somnath S Pokhar 2021. Dalimba pikasatil salla (Marathi) for June- July 2021.
11.	Jyotsana Sharma, Ashis Maity, NV Singh Mallikarjun H. and Somnath S Pokhar 2021. Dalimbae beleyalli kandubaruv samasyegalige salahegalu (Kannada) June- July 2021.
12.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary2021. Bimonthly Pomegranate Advisory (English) for bearing orchards of August-September 2021.
13.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary 2021. Bimonthly Pomegranate Advisory (English) for bearing orchards of August-September 2021.
14.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary 2021. Annar fasal ki diwimasik salah (Hindi) August-September 2021.
15.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary 2021. Dalimba pikasatil salla (Marathi) August-September 2021.
16.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha, N., Somnath Pokhare and Dinkar Chaudhary 2021. Dalimbae beleyalli kandubaruv samasyegalige salahegalu (Kannada) August-September 2021.
17.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha N., Somnath Pokhare and Dinkar Chaudhary, 2021. Bimonthly Pomegranate Advisory (English) for bearing orchards of October-November 2021.
18.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha N., Somnath Pokhare and Dinkar Chaudhary, 2021. Dalimba pikasatil salla(Marathi) Oct-Nov2021
19.	Jyotsana Sharma, Ashis Maity, N V Singh, Mallikarjun, Manjunatha N., Somnath Pokhare and Dinkar Chaudhary, 2021. Dalimbae beleyalli kandubaruv samasyegalige salahegalu (Kannada) October-November 2021.
20.	Jyotsana Sharma, Ashis Maithy, N V Singh, Mallikarjun, Manjunatha N., Somnath Pokhare, 2021. Bimonthly Pomegranate Advisory for Bearing Orchards (English) Feb-Mar 2022.
21.	Jyotsana Sharma, Ashis Maithy, N V Singh, Mallikarjun, Manjunatha N., Somnath Pokhare, 2021. Dalimba pikasatil salla (Marathi) February-March 2022.

22.	Somnath S. Pokhare, Manjunatha, N., Mallikarjun H., Jyotsana Sharma, Rajiv Marathe.2022. Integrated Nematode management in Pomegranate. Advisory for Delimb Mitra social media platform.
S.No.	**VIDEOS**
	ETV programs for Farmers
1.	**Technology video on SBH:** Shot Hole Borer (SHB) diagnosis and management in Pomegranate on 13.03.2022 by DD Pune.
2.	**Technology video on Khod Bhungera:** Dalimb pikaavaril pinhole borer (Khod Bhungera) Ekatmik vyavstapan, Krishi Vibhag Sangola on 26.03.2022 (Marathi) by state Dept. of Agriculture.

S.No.	NCBI data base
1.	Different loci (ITS (OK284541- OK284570), LSU (OL377934- OL377961, OL 958630-OL 958631) sequences of *Ceratocystis fimbriata* isolates (30) are submitted NCBI database
2.	Antibiotic resistance gene (*rpsL*) sequences of *Xanthomonas axonopodis pv. punicae* of 15 isolates were submitted to NCBI database with accession numbers (OK483036-OK483041, Ok416031- OK416035, OK 626267- OK626270)
3.	Different loci (ITS: OL662873-OL662884), LSU: OM073988-OM073999), NSU: OM 108305-OM 638736) and TEF) sequences of *Alternaria alternata* isolates (12) were submitted to NCBI database
4.	Sequenced ITS loci of *Colletotrichum* causing fruit rot in pomegranate and submitted to NCBI database with accession numbers (OM638721-OM638736)
5.	Sequences (LSU: OL440914, ITS: OL440915, NSU: OL440918) of collar rot of pomegranate pathogen were submitted to NCBI database
6.	Mallikarjun MH. 2022. Sequenced Euwallacea fornicatus isolate MH-SPR-001 cytochrome c oxidase subunit causing pomegranate wilting submitted to NCBI database with accession numbers (ON063908- ON063909).

Any Other: Not covered above

S.No.	Souvenir:
1.	Marathe R. A., Singh N. V., Roopa Sowjanya, Gaikwad N. N., Manjunath N. Shilpa P., Damale R. D., Jyotsana Sharma. 2021. International Webinar on Pomegranate:

	Ancient Fruit in Modern Horticulture, August 25-27, 2021, ICAR-NRCP and SARP, Solapur, Maharashtra, India, 205 p.

- **Crop Advisory**

S.No.	Crop Advisory
1.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (April- May 2021 in English). (https://nrcpomegranate.icar.gov.in/files/Advisory/92.pdf).
2.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (April- May 2021 in Hindi). (https://nrcpomegranate.icar.gov.in/files/Advisory/95.pdf).
3.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (April- May 2021 in Marathi). (https://nrcpomegranate.icar.gov.in/files/Advisory/93.pdf).
4.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (June-July 2021 in English). (https://nrcpomegranate.icar.gov.in/files/Advisory/97.pdf).
5.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (June-July 2021 in Hindi). (https://nrcpomegranate.icar.gov.in/files/Advisory/101.pdf).
6.	Dr. Jyotsana sharma, Dr. Ashis Maity, Dr. N V Singh, Dr. Somnath Pokhare, Dr. Mallikarjun and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (June-July 2021 in Marathi). (https://nrcpomegranate.icar.gov.in/files/Advisory/99.pdf). Dr. Jyotsana Sharma, Dr. Ashis Maithy, Dr. N V Singh, Dr. Mallikarjun, Dr. Manjunatha, N., Dr. Somanth Pokhare and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (August-September 2021 in English). (https://nrcpomegranate.icar.gov.in/files/Advisory/102.pdf).
7.	Dr. Jyotsana Sharma, Dr. Ashis Maithy, Dr. N V Singh, Dr. Mallikarjun, Dr. Manjunatha, N., Dr. Somanth Pokhare and Shri. Dinkar Chaudhari. Bimonthly

	Pomegranate Advisory for Bearing Orchards (August-September 2021 in Hindi). (https://nrcpomegranate.icar.gov.in/files/Advisory/105.pdf).
8.	Dr. Jyotsana Sharma, Dr. Ashis Maithy, Dr. N V Singh, Dr. Mallikarjun, Dr. Manjunatha, N., Dr. Somanth Pokhare and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (August-September 2021 in Hindi). (https://nrcpomegranate.icar.gov.in/files/Advisory/103.pdf).
9.	Dr. Jyotsana Sharma, Dr. Ashis Maithy, Dr. N V Singh, Dr. Mallikarjun, Dr. Manjunatha N., Dr. Somanth Pokhare and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (October-November 2021 in English). (https://nrcpomegranate.icar.gov.in/files/Advisory/109.pdf).
10.	Dr. Jyotsana Sharma, Dr. Ashis Maithy, Dr. N V Singh, Dr. Mallikarjun, Dr. Manjunatha N., Dr. Somanth Pokhare and Shri. Dinkar Chaudhari. Bimonthly Pomegranate Advisory for Bearing Orchards (October-November 2021 in Marathi). (https://nrcpomegranate.icar.gov.in/files/Advisory/112.pdf).

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Awards and Recognition

AWARDS

S.No.	Name of Scientist	Name of award	Year of award	Awarding organization
		Fellowship/ Associateship/Young Scientist/ other awards		
1.	Dr. R.A. Marathe	Fellow of Society for Advancement of Research on Pomegranate – 2020	2021	Society for Advancement of Research on Pomegranate (SARP), Solapur
2.	Dr. R.A. Marathe	Fellow of Indian Society for Arid Horticulture, Bikaner, Rajasthan. (FISAH-2021)	2021	Indian Society for Arid Horticulture, Bikaner
3.	Dr. K. Dhinesh Babu	Fellow of Society for Advancement of Research on Pomegranate - 2020	2021	Society for Advancement of Research on Pomegranate (SARP), Solapur
4	Dr. K. Dhinesh Babu	Fellow of Indian Society for Arid Horticulture, Bikaner, Rajasthan. (FISAH-2021)	2021	Indian Society for Arid Horticulture, Bikaner
5	Dr. K. Dhinesh Babu	Life Time Achievement Award in Fruit Science	2021	Society for Development and Advancement of Agricultural Technologies (SDAAT), Meerut
6	Dr. Ashis Maity	SARP Associateship-2020	2021	Society for Advance Research in Pomegranate (SARP), Solapur
7	Dr. Mallikarjun	Young Scientist Award-	2021	Society for Advancement of

	M.H	2020		Research on Pomegranate (SARP) Solapur
8	Dr. Gaikwad Nilesh N.	SARP Associateship-2020	2020	Society for Advancement of Research on Pomegranate, Solapur
9	Dr. Gaikwad Nilesh N.	Best Scientist of the year award 2020-21	2020-21	ICAR-NRCP, Solapur
10	Dr. N.V. Singh	Fellowship of the Society for Advancement of Research on Pomegranate-2021	2021	Society for Advancement of Research on Pomegranate, Solapur
11.	Dr. N.V. Singh	Fellowship of the Confederation of Horticulture Associations of India-2021 (FCHAI)	2021	Confederation of Horticulture Association of India (CHAI), New Delhi
12.	Dr. P. G. Patil	SARP Associateship Award-2021	2021	Society for Advancement of Research on Pomegranate, ICAR-NRCP, Solapur
13.	Dr. P. G. Patil	NESA Eminent Scientist Award -2021	2021	National Environmental Science Academy, New Delhi
14.	Dr. P. G. Patil	Excellence in Research Award -2021	2021	Society for Scientific development in Agriculture and Technology, UP
15.	Dr. P. G. Patil	Best research publication of the Year 2020-21 Award	2021	ICAR-National Research Centre on Pomegranate, Solapur
16.	Dr. Shilpa	Young Scientist Award-	2021-22	Society for Advancement of

	Parashuram	2020		Research on Pomegranate (SARP), Solapur
17.	Dr. Shilpa Parashuram	Young Scientist Award-2021	2021-22	Environment and Social Development Association (ESDA), New Delhi
18.	Mr. Rahul Damale	Young Scientist Award-2021	2021	Society for Scientific Development in Agriculture & Technology (SSDAT), Meerut, India
		Best poster awards		
1.	K. Dhinesh Babu, N.V. Singh, R. Chandra, A. Maity, J. Sharma, V.T. Jadhav, R.K. Pal, R.A. Marathe, Shilpa P., N. Gaikwad, P.G. Patil, R. Dhamale, S.H. Jalikop, B.N.S. Murthy, P.S. Kumar and P.L. Saroj	Best Poster Award	2021	Indian Academy of Horticultural Science (IAHS)
2.	K. Dhinesh Babu, N.V. Singh, R. Chandra, A. Maity, J. Sharma, V.T. Jadhav, R.K. Pal, R.A. Marathe, Shilpa, P., N. Gaikwad, P.G. Patil, R. Damale, S.H. Jalikop, B.N.S. Murthy and P.S. Kumar	Best Poster Award	2021	Society for Advancement of Research on Pomegranate (SARP)
3.	Gaikwad N.N., Kadam A., Giri,	Best poster presentation	25-27th August	ICAR-NRCP, Solapur

	N.A. and Suryavanshi S.K	Award	2021	
4.	K. D. Babu, NV Singh, R. Chandra, A.Maity, J Sharma, VT Jadhav, RK Pal, RA Marathe, Shilpa P, N.Gaikwad, PG Patil, R Damale, SH Jalkiop, BNS Murthy & PS Kumar.	Solapur Lal : A bio-fortified HYV of pomegranate, International Webinar on Pomegranate : Ancient fruit in Modern Horticulture,	2021	NRCP & SARP, Aug 25-27, 2021.
5.	K. D. Babu, NV Singh, R. Chandra, A.Maity, J Sharma, VT Jadhav, RK Pal, RA Marathe, Shilpa P, N.Gaikwad, PG Patil, R Damale, SH Jalkiop, BNS Murthy & PS Kumar, PL Saroj.	Solapur Lal: A bio-fortified HYV of pomegranate for nutrition & livelihood. 9th Indian Horticulture Congress-2021: Horticulture for Health, Livelihoods and Economy,	2021	IAHS, CSUA&T, Kanpur, Nov 18-21,2021
6.	Manjunatha N	*In-vitro* evaluation of endophytes against fungal pathogens of pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture, 25^{th} -27^{th} August, 2021	2021	SARP, Solapur
7.	Mallikarjun M.H	Best Poster Award	2021	Society for Advancement of Research on Pomegranate (SARP) Solapur
8.	NV Singh, Shweta Bute, AS Shinde,	Best Poster Award-Strategies to manage	2021	ICAR-NRCP & ICAR-CIAH and SARP,

	DM Mudewadikar, Shilpa Parashuram, Roopa Sowjanya P, PG Patil and RA Marathe	phenolic browning for efficient *in vitro* culture establishment in pomegranate cv. Bhagwa. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture		Solapur August 25-27, 2021.
9.	Unnati Salutgi, NV Singh, VR Sangnure, Shilpa Parashuram, Roopa Sowjanya P., PG Patil, VA Gargade and RA Marathe	Best Poster Award-. 2021. Standardizing micropropagation protocol and genetic fidelity testing of micropropagated clones of pomegranate cv. Super Bhagwa. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organized by ICAR-NRCP, Solapur; ICAR-CIAH and SARP, Solapur August 25-27, 2021.	2021	ICAR-NRCP & SARP
10.	Raghavendra Gunnaiah, Dattatraya Hegde Radhika, M. Nandan, Pushpa Doddaraju, Pavan Dumble, Girigowda Manjunatha and Nripendra Singh.	Best Poster Award-2021. Genome-wide analysis of resistance gene analogues (RGAs) in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH and SARP, Solapur August 25-27, 2021.	2021	ICAR-NRCP & SARP
11.	Prakash G. Patil, Shivani M. Jamma, Singh N. V., Manjunatha N.,	Best Poster Award-2021. Hybridity and heterozygosity analysis of putative F1s using	2021	ICAR-NRCP & SARP

	Dhinesh Babu K. and Marathe R. A.	genome-wide SSR markers in pomegranate. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH and SARP, Solapur August 25-27, 2021.		
12.	Roopa Sowjanya P., Kiran Gudaghe, Vipul R Sangnure, Singh N. V., Ajinkya Mandave, Shilpa Parashuram, Sharma J. and Marathe R. A.	Best Poster Award-2021. Standardization of SRAP markers for assessing pomegranate (*Punica granatum* L.) genetic diversity. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture	2021	ICAR-NRCP, Solapur; ICAR-CIAH and SARP, Solapur August 25-27, 2021
13.	Shilpa P, Babu KD, Singh NV, Gaikwad, NN, Roopa Sowjanya, P., Kade KR, Jadhav D. C. and Sharma J.	Best Poster Award for the poster on DUS Characterization of New candidate varieties of Pomegranate, in International webinar on Pomegranate: Ancient Fruit in Modern Horticulture. during 25-27th Aug, 2021	2021	ICAR-NRCP & SARP
14.	Dr. Somnath S. Pokhare	Best poster award 'In-vitro bio-efficacy of bactronol against fungal pathogens of pomegranate' in the international webinar on Pomegranate: Ancient Fruit in Modern Horticulture	2021	SARP, Solapur

Best oral presentation awards				
1.	Ashis Maity	Best oral presentation award	2021	Society for Advancement of Research on Pomegranate (SARP)
2.	Ashis Maity	Best oral presentation award	2021	Hi-Tech Horticulture Society and Prerna Foundation
3.	Dr. Namrata Giri	Best oral presentation award	18-20August 2021	ICAR-IARI, New Delhi.
4.	Gaikwad N.N., Giri, N.A. and Marathe, R.A. 2021.	Best Invited oral presentation paper Value Added products and dietary supplements from pomegranate in International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 158.	2021	SARP and ICAR-NRCP Solapur, (M.S)
5.	Gaikwad N.N., Kadam A., Giri, N.A. and Suryavanshi S.K. 2021.	Best poster presentation Award. Foam mat drying of pomegranate juice using whey protein isolate and carboxy methyl cellulose in International webinar on Pomegranate ancient fruit in modern horticulture, ICAR-NRCP, Solpaur, 25-27th August 2021 p. 167.	2021	SARP and ICAR-NRCP Solapur, (M.S)
6.	Singh, N.V., Sharma, J., Maity, A., Manjunatha, N.,	Best Oral Award -2021. Bio-priming and innovative propagation	2021	ICAR-NRCP & SARP Solapur, (M.S)

	Parashuram, S., Patil, P.G., Marathe, R.A. 2021.	techniques for climate smart pomegranate production. In: International Webinar on Pomegranate: Ancient Fruit in Modern Horticulture organised by ICAR-NRCP, Solapur; ICAR-CIAH and SARP, Solapur August 25-27, 2021.		
7.	Dr. P. G. Patil	Best invited oral presentation award for the topic entitled ‘Genomics Assisted Breeding for accelerated crop improvement in pomegranate’ presented in International Webinar on ‘*Pomegranate: Ancient fruit in modern horticulture* ‘.	2021	SARP, ICAR-NRCP, Solapur, (M.S)
8.	Shilpa P., Roopa Sowjanya P., Singh N. V., Patil, P. G., Babu, K. D., Sharma, J. and Marathe, R. A.	Best invited oral presentation entitled “promising germplasm resources for pomegranate improvement	2021-22	Jointly by ICAR-NRCP, Solapur; ICAR-CIAH, Rajasthan and SARP, Solapur.

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Budget Estimate

Table 1: Financial outlay in 2021-22

Head of account	Rupees (in lakhs)	
	2021-22	
	Govt. Grant	
	RE	**Expenditure**
(A) Recurring		
Establishment charge	458.61	458.59
T.A.	5.60	5.60
Other charges	292.05	292.04
Total A	756.26	756.23
(B) Non-recurring		
Equipment	73.81	73.81

Minor works	18.91	18.91
Library	0.00	0.00
Furniture	2.50	2.50
Information technology	8.01	8.01
Total B	103.23	103.23
(C) Loan & advances	0.00	0.00
(D) Pension	0.00	0.00
(E) Vehicles & vessels	2.27	2.27
Grand total (A+B+C+D)	**861.76**	**861.73**

Table 2: Revenue receipt in 2021-22

S. No.	Items	Amount (Rs.)
1.	Income from farm produce	1566131.00
2.	Income from royalty and publications	23838.00
3.	Income from other sources	565166.00
4.	Interest on loans and advances	9438.00
5.	Interest earned on short term deposits	213220.00
6.	Recovery of loans and advances	356510.00
7.	Training programs	390000.00
8.	Analytical testing fee	11896.00
9.	License fee/ Guest house	70504.00
	Total revenue receipt	**3206703.00**

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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	16	6
Technical	6	6	0
Administrative	11	5	6
Supporting	2	2	0
Total	42	30	12

PERSONNEL

RMP
Dr. R.A. Marathe
Director

Scientific staff	**Technical staff**	**Administrative staff**
Dr. Jyotsana Sharma,	Sh. D.T. Chaudhari	Sh. R.B. Rai
Principal Scientist (Plant Pathology)	Technical Officer	AAO
Dr. P.S. Shirgure	Sh. Yuvaraj Shinde	Sh. V.A. Shinde
Principal Scientist (Land and Water Management Engg.)	Technical Officer	Finance & Account Officer (FAO)
Dr. K. Dhinesh Babu	Sh. Bhausaheb Naikwadi	Sh. Kiran Khatmode
Principal Scientist (Hort.-Fruit Science)	Sr.Technical Assistant	UDC
Dr. Ashis Maity	Sh. Vijay Lokhande	Sh. A.S. Babar
Senior Scientist (Soil Science-Pedology)	Technical Assistant	LDC

Dr. N.V. Singh	Sh. Mahadev Gogaon	Sh. Vipin Dagar
Senior Scientist (Fruit Science)	Senior Technician	LDC
Dr. Prakash G. Patil	Sh. Govind Salunke	**Supporting staff**
Senior Scientist (Plant Biotechnology)	Senior Technician	
Dr. N.N. Gaikwad		Sh. Shailesh Bayas
Senior Scientist (Agrl. Structures and Process Engg.)		SSS
Dr. Shilpa P.		Sh. Vishal Gangane
Scientist (Genetics & Plant Breeding)		SSS
Dr. Mallikarjun		
Scientist (Agrl. Entomology)		
Dr. Roopa Sowajanya P.		
Scientist (Genetics & Plant Breeding)		
Dr. Somnath Pokhare, Scientist (Nematology)		
Dr. Manjunatha, Scientist (Plant Pathology)		
Dr. Namrata Ankhush Giri,		
Scientist (Food Technology)		
Mr. Rahul Damale, Scientist (Biochemistry)		
Dr. Pinky Raigond, Senior Scientist		
(Plant Physiology)		
Mr. Chandrakant Awachare, Scientist,		
(Fruit Science)		

JOINING:

Dr. Pinky Raigond, Senior Scientist (Plant Physiology) joined ICAR-NRCP, Solapur on

04.10.2021 due to transfer from ICAR-Central Potato Research Institute, Shimla.

Dr. Chandrakant Awachare, Scientist (Fruit Science) joined ICAR-NRCP, Solapur on 04.10.2021 due to transfer from Central Horticultural Experiment Station, Chettalli, ICAR-IIHR, Bengaluru.

Mr. Bhausaheb V Naikwadi, Sr. Technical Assistant (T-4) joined ICAR-NRCP, Solapur on 24.02.2021 due to transfer from ICAR-Central Institute for Cotton Research, Nagpur.

PROMOTION

Mr. Bhausaheb V Naikwadi, Technical Assistant promoted to Sr. Technical Assistant wef. 23.02.2020.

RELIEVING

Nil

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हर कदम, हर डगर
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ICAR-National Research Centre on Pomegranate

Solapur - 413 255 (M.S.)

T- (0217) 2354330, 2350074; Fax - (0217) 2353533

Email - nrcpomegranate@gmail.com

nrcpomegranate.icar.gov.in