भाकृअनुप
ICAR

वार्षिक प्रतिवेदन
Annual Report

2024

भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र
ICAR-NATIONAL RESEARCH CENTRE ON LITCHI

मुशहरी प्रक्षेत्र, मुशहरी, मुजफ्फरपुर - 842 002 (बिहार)

Mushahari Farm, Mushahari, Muzaffarpur - 842 002 (Bihar)

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प्रस्तावना

लीची *(लीची चाइनेंसिस)*, जिसे "फलों की रानी" भी कहा जाता है, अपने आकर्षक रंग, सुगंधित खुशबू और अनोखे स्वाद के कारण पूरी दुनिया में पसंद की जाती है। भारत, जो दुनिया में लीची उत्पादन में दूसरा सबसे बड़ा देश है, वैश्विक लीची बाजार में एक महत्वपूर्ण भूमिका निभा सकता है। भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केंद्र, मुज़फ्फरपुर (बिहार) जिसकी स्थापना 2001 में हुई थी, देश में लीची मूल्य श्रृंखला से जुड़े विभिन्न हितधारकों की तकनीकी आवश्यकताओं और उनके अंतिम उपयोगकर्ता तक हस्तांतरण को पूरा कर रहा है।

वर्ष 2024 के दौरान, संस्थान में चल रही अनुसंधान परियोजनाओं को सुदृढ़ करने के साथ-साथ नए क्षेत्रों में अनुसंधान प्रारंभ करने में महत्वपूर्ण प्रगति की। जीनोम वाइड एसोसिएशन स्टडीज़ (GWAS) के माध्यम से विशेष गुणों से संबंधित आणविक मार्करों की पहचान, लीची स्टिंक बग के प्रबंधन के लिए व्यवहार संशोधित करने वाले रसायनों की संभावना की खोज, लीची फलों में कीटनाशक अवशेषों की निगरानी के लिए वास्तविक समय प्रणाली का विकास, फसल तुड़ाई के बाद प्रबंधन रणनीतियों का विकास, लंबी दूरी के परिवहन के दौरान वास्तविक समय अध्ययन, लीची के फलन व्यवहार को समझना और लीची-आधारित उत्पादन प्रणाली की पारिस्थितिकीय पदचिह्न मैपिंग जैसे नए क्षेत्रों में अनुसंधान कार्य शुरू किए गए। फलों के फटने का प्रबंधन और लीची की शेल्फ लाइफ बढ़ाने में प्रोत्साहनजनक परिणाम प्राप्त हुए हैं। यह आशा की जाती है कि ये नए अनुसंधान प्रयास भविष्य में लीची उत्पादकों को जिन प्रमुख और अब तक अनसुलझी चुनौतियों का सामना करना पड़ता है, उनके समाधान में सहायक सिद्ध होंगे।

मैं, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र की 2024 की वार्षिक प्रतिवेदन प्रस्तुत करते हुए गर्व महसूस करता हूँ। मैं इस केंद्र की प्रगति के लिए वैज्ञानिकों और कर्मचारियों की निष्ठा और कड़ी मेहनत को श्रेय देता हूँ। मैं, डॉ. हिमांशु पाठक, सचिव, कृषि अनुसन्धान एवं शिक्षा विभाग एवं महानिदेशक, भारतीय कृषि अनुसन्धान परिषद तथा डॉ. संजय कुमार सिंह, उप महानिदेशक (बागवानी विज्ञान), भारतीय कृषि अनुसन्धान परिषद का उनके निरंतर समर्थन और मार्गदर्शन के लिए धन्यवाद देता हूँ।

मार्च, 2025
मुज़फ्फरपुर

(बिकाश दास)
निदेशक

PREFACE

Litchi *(Litchi chinensis)*, also known as "Queen of fruits" is relished all over the world for its attractive colour, pleasant aroma and unique taste. India, being the second largest litchi producing country in the world can play very important role in global litchi market. The ICAR-NRC on Litchi, Muzaffarpur, since its establishment in 2001 has been addressing to the needs of different stakeholders in the litchi value chain of the country with respect to technology generation and their transfer to the end user.

During the year 2024, the institute could make significant progress with respect to strengthening on going research programme as well as initiating research in newer areas. Identification of trait specific molecular markers through Genome Wide Association Studies (GWAS), exploring the potential of behaviour modifying chemicals for the management of litchi stink bug, developing strategies for minimizing the pesticide residue status in litchi fruits through real time monitoring, developing post-harvest management strategies through real time long distance transportation studies, understanding the phenological behaviour of litchi and ecological foot print mapping of litchi based production system are some of the the new areas in which research work have been initiated. Encouraging results on management of fruit cracking and enhancing shelf life of litchi were obtained through the on-going programme. It is hoped that the new research initiatives will help in solving some of the major unsolved challenges faced by the litchi growers in future.

I am proud to present the Annual Report 2024 of ICAR-NRCL. I place on record the sincere work and dedication of scientists and staff of ICAR-NRCL for the progress of this Centre. I am thankful to Dr. Himanshu Pathak, Secretary DARE & DG, ICAR, and Dr. S. K. Singh, DDG (HS), ICAR for their constant support and guidance.

March, 2025
Muzaffarpur

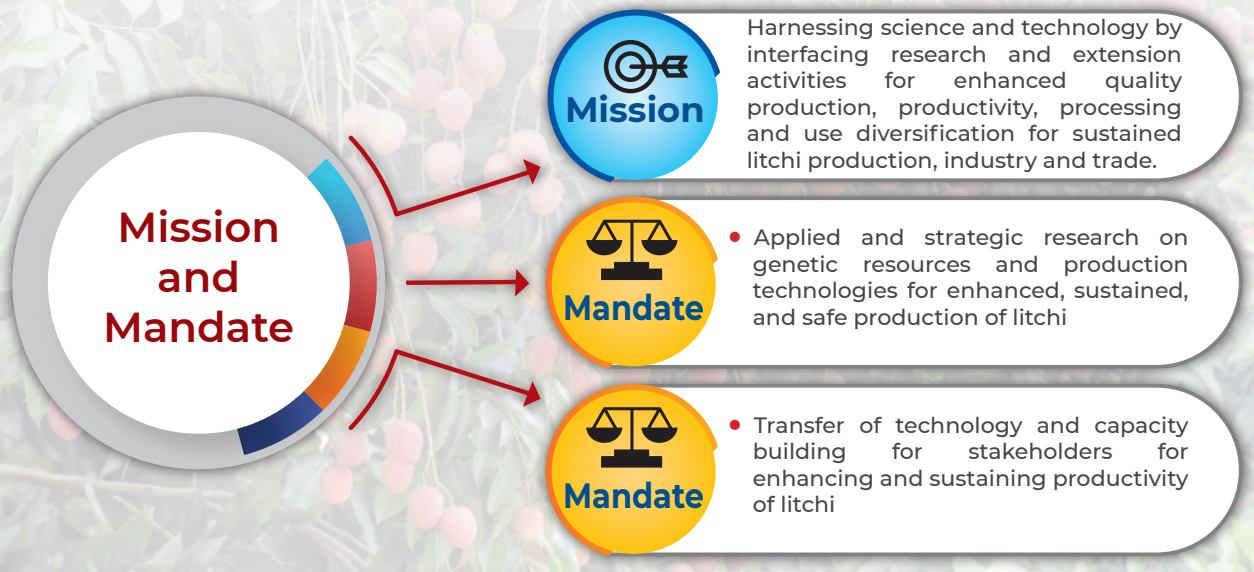
(Bikash Das)
Director

About the Centre

The ICAR-NRCL is the premier national institute for conducting research and development in litchi and provides leadership at national level. It also acts as a national repository for information on litchi production, processing, value addition, and provides consultancy services to end users.

Genesis and Growth

The ICAR-National Research Centre on Litchi (ICAR-NRCL) was established on 6th June, 2001 under the aegis of the Indian Council of Agricultural Research. With the lease deedhaving signed on 25th June, 2002 between the ICAR and Government of Bihar to transfer 100 acres of land to the Centre at Mushahari, Muzaffarpur, ICAR-NRCL began its journey. The Centre grew in strength and number in subsequent years as more scientists and staff were allotted from the Council. The Centre is constrained today by its scientific strength, but have all modern laboratories with core equipment, a sprawling farm and experimental area, and a buzzing campus. The Centre is located at Mushahari, on Muzaffarpur-Pusa Road at 26°5'87'' N latitude, 85°26'64'' E longitude at an elevation of 210 m. It is located at about eight km distance from Muzaffarpur railway station. The research farm of the Centre is spread over an area of 35 hectares.



Infrastructure Facilities

The research farm of the Centre has modern propagation structures, screen houses, glasshouses, irrigation networking and water sources. Modern analytical and diagnostic equipments like RT-PCR, GCMS, AAS, UV-VIS spectrophotometer, HPLC, CHNS analyzer, leaf area meter, portable photosynthesis system, horizontal electrophoresis unit, nitrogen analyzer, flame photometer, trinocular phase-contrast upright microscope, trinocular compound microscope, inverted phase contrast microscope, stereo binocular microscope, lyophilizer, bioformentor, ultracentrifuge, modified atmospheric packaging unit, hydro-cooling system, forced-air cooling system, litchi grading machine, plastic strip sealing and packaging machine, litchi peeling machine, cool storage chamber, bottle washing machine, litchi harvester cum pruner, power sprayer and mist chamber have been installed for different research and supportive activities.

Library

NRC on Litchi is endeavoring to create an excellent library at the center. The center has obtained 1906 books (300 in Hindi and 1606 in English), including the Encyclopaedia, Britannica and Wealth of India. Additionally, the center has subscribed to 15 Indian and 15 foreign magazines to support research activities. The Centre Institute has published technical folders in Hindi and English, extension folders, pamphlets, reports, information bulletins, technical bulletins, and extension bulletins. The Centre has subscribed to the Hindi journals Pratiyogita Darpan, Outlook, India Today, and Yojana. The library also preserves records of all other publications from the institute, as well as those from externally financed projects. All the books are accessible to scientists, farmers, workers, and students. The library is essential and beneficial for students participating in training programs at the institute.

Agricultural Knowledge Management Unit (AKMU)

The centre has an Agricultural Knowledge Management Unit to manage the knowledge database with software of international repute such as SAS, CAB abstracts, horticultural abstract, and other computing softwares. The centre has now installed server and LAN system for shared resources. Access to high speed internet is made available through the National Knowledge Network (NKN). The centre`s website (https://nrclitchi.icar.gov.in/) is regularly updated with the latest information and is visited by thousands of visitors from all over the world.

Research and Development Activities

ICAR-NRC on Litchi carries out its research and development programmes under six main thematic areas

1. Conservation, characterization, and utilization of genetic diversity for improvement of litchi
2. Development and refinement of integrated production technologies for improved productivity of litchi
3. Development and refinement of integrated crop protection technologies for improved productivity of litchi
4. Integrated postharvest management to reduce losses, improve marketing and product diversification
5. Litchi based farming system under changing climate scenario
6. Improving knowledge and skill of stakeholders for increasing production of litchi

The Centre regularly conducts training programmes and activities for transfer of technology to farmers and various stakeholders. Under the TSP and NEH component, the centre has laid out structured programmes for area expansion and technology dissemination in tribal belts and North Eastern hill regions of the country.

कार्यकारी सारांश

भा.कृ.अनु.प.–राष्ट्रीय लीची अनुसंधान केंद्र ने बहुविषयक कार्यक्रमों के अंतर्गत बुनियादी और अनुप्रयुक्त अनुसंधान में उल्लेखनीय प्रगति की है, जिसमें लीची के विभिन्न पहलुओं जैसे—जैविक संसाधन प्रबंधन और फसल सुधार, फसल उत्पादन, फसल संरक्षण तथा कटाई उपरांत प्रबंधन शामिल हैं। केंद्र ने विभिन्न हितधारकों के ज्ञान को बढ़ाने और उनके कौशल विकास के लिए प्रशिक्षण, जनसंपर्क कार्यक्रमों और प्रौद्योगिकी हस्तांतरण गतिविधियों का भी आयोजन किया। वर्ष 2024 के दौरान प्राप्त प्रमुख उपलब्धियों का संक्षिप्त सार यहां प्रस्तुत किया गया है।

अनुसंधान उपलब्धियाँ

फसल सुधार

- तीन श्रेष्ठ क्लोन की पहचान की गई, जिनमें NRCL-4 (फल फटने के प्रति प्रतिरोधी), NRCL-24 (बड़े फल वाला) और NRCL-91 (चिकन टंग जैसे बीज वाला) शामिल हैं, जिन्हें उत्कृष्ट बीजू पोधों के चयन से प्राप्त किया गया।
- कुल 1093 संकरण विभिन्न मातृ-पितृ संयोजनों से किए गए, जैसे कि शाही × चाइना, शाही × बेदाना, शाही × देहरारोज, शाही × क्वाई मे पिंक, शाही × लोंगिया, शाही × मंडरजी, चाइना × बेदाना और चाइना × शाही। इन संकरणों में से केवल 43 संकर प्राप्त हुए, जिनमें से मात्र 26 संकर पौधे नेट हाउस में जीवित रह सके।
- लोंगन के कुल 74 प्रविष्टियों का फल गुणवत्ता मापदंडों के आधार पर मूल्यांकन किया गया। औसत फल वजन (> 9 ग्राम) के आधार पर लोंगन प्रविष्टि Lg-14 और Lg-16 को अच्छा पाया गया।
- लीची के जननद्रव्यों में भिन्नता की जांच के लिए 32 नए ईएसटी आधारित एसएसआर प्राइमरों का उपयोग किया गया, जिनमें से 10 प्राइमरों ने 39 जीनोटाइप्स के बीच भिन्न प्रवर्धन पैटर्न प्रदर्शित किया।
- लीची की शाही किस्म में विविधता उत्पन्न करने के लिए एथिल मेथेनसाल्फोनेट (ईएमएस) के विभिन्न सांद्रणों (0.25%, 0.5%, 1.0%, 2.0%, 3.0%, 4.0% और 5.0%) का उपयोग किया गया। इनमें से केवल 0.25% EMS से उपचारित बीजों में ही अंकुरण प्राप्त हुआ।
- कोलचिसिन (0.1%, 0.2%, 0.3%, 0.4% और 0.5%) को भी म्यूटाजेन के रूप में लीची में म्यूटेशन/ पॉलीप्लॉयडी उत्पन्न करने के लिए उपयोग किया गया। कोलचिप्लॉइड्स में पौधे के रूपात्मक गुणों के संदर्भ में महत्वपूर्ण विविधताएं देखी गईं।
- लीची की दो वर्षीय हाफ-सिब्लिंग सीड्लिंग आबादी (68) का मूल्यांकन करने पर शाही किस्म में रूपात्मक (मॉर्फोलॉजिकल) लक्षणों में महत्वपूर्ण विविधता पाई गई।
- 43 लीची जिनोटाइप्स में फल गुणवत्ता लक्षणों का विश्लेषण किया गया और अध्ययन से पता चला कि लीची जर्मप्लाज्म में अध्ययन किए गए लक्षणों के लिए व्यापक और अधिक महत्वपूर्ण विविधता पाई गई।

फसल उत्पादन

- लीची के पेड़ों में गर्डलिंग करने के बाद माइकोराइजल कॉलोनाइजेशन और राइजोस्पीयर में सूक्ष्मजीव आबादी पर किए गए अध्ययन से पता चला कि पेड़ में गर्डलिंग समय के साथ माइकोराइजल कॉलोनाइजेशन को काफी कम कर देती है।
- लीची बाग में *इन-सिटू* माइकोराइज़ेशन से मिट्टी और पेड़ के पत्तों में मुख्य पोषक तत्व (N, P, K) और सूक्ष्म पोषक तत्व (S, Cu) दोनों के स्तरों पर सकारात्मक प्रभाव पड़ा, साथ ही मिट्टी की श्वसन प्रक्रिया के माध्यम से सूक्ष्मजीव गतिविधि भी बढ़ी।
- लीची के पत्ते के विभिन्न हिस्सों में पोषक तत्वों की स्थिति का मूल्यांकन करने के लिए, फूल आने से पहले की अवस्था में पत्ती का नमूना लिया गया। परिणामों से पता चला कि पत्ती के कुल नाइट्रोजन की मात्रा पहले जोड़े से चौथे जोड़े तक बढ़ती हुई प्रवृत्ति दिखाती है। पत्ती का कुल फास्फोरस पहले जोड़े से दूसरे जोड़े तक बढ़ा, इसके बाद तीसरे और चौथे जोड़े तक कम होता गया।
- लीची फल के उत्पादन और गुणवत्ता पर पौधे की संरचना के प्रभाव का मूल्यांकन किया गया, जिसमें अधिकतम उत्पादन (40.48 किलो/पेड़) उन पेड़ों में प्राप्त हुआ जिनकी छत्राकृति में 4 प्राथमिक शाखाएं और 4 द्वितीयक शाखाएं बनी हुई थीं।
- ड्रिप सिंचाई और मल्चिंग पर किए गए अध्ययन में पाया गया कि 100% ER पर सिंचाई के साथ 100

माइक्रोन वाले काले पॉलीथीन से मल्चिंग करने पर फल का उत्पादन (48.57 किग्रा/पौधा) और फल का वजन (22.83 ग्राम) दोनों में उल्लेखनीय वृद्धि हुई।

- फल लगने के 30 दिन बाद सफेद रंग के पॉलीप्रोपाइलीन बैग से बैगिंग; छत्रछाया के नीचे माइक्रो स्प्रिंकलर का उपयोग; फल लगने के 30 दिन बाद गुलाबी रंग के पॉलीप्रोपाइलीन बैग से बैगिंग; सैलिसिलिक एसिड का पत्तियों पर छिड़काव @ 50 ppm और समुद्री शैवाल अर्क (सागरिका लिक्विड @ 0.5%) का पत्तियों पर छिड़काव लीची की शाही किस्म में फल के फटने और जलने को कम करने में सबसे प्रभावी पाए गए।

फसल सुरक्षा

- पुष्पक्रम वेबर की जनसंख्या में अधिकतम कमी थियाक्लोप्रिड 21.7% SC + फिप्रोनिल और थियाक्लोप्रिड 21.7% SC + प्रोफेनोफॉस छिड़काव से हुई (क्रमशः 58.3% और 57.91%), जबकि थियाक्लोप्रिड 21.7% SC और बीटा साइलफ्यूथ्रिन 8.49% + इमिडाक्लोप्रिड 19.8% लीची में स्टिंक बग्स की जनसंख्या कम करने में अत्यंत प्रभावी रहे।
- स्टिंक बग्स के पाचन तंत्र की सूक्ष्मजीव समुदाय (मेटाजेनोमिक्स) विश्लेषण से पता चला कि सभी विकासात्मक चरणों में प्रोटियोबैक्टीरिया प्रमुख रूप से मौजूद रहते हैं, जबकि फर्मिक्यूट्स डी और बेक्टेरायडोटा विशेष रूप से दूसरे निंफल अवस्था में अधिक पाए जाते हैं।
- लीची स्टिंक बग की उपस्थिति पहली सतत मासिक सप्ताह (1st SMW) में शुरू हुई और फल कटाई तक जारी रही; लीची लूपर कॉम्प्लेक्स की अधिकतम जनसंख्या मार्च के दूसरे सप्ताह (10वें SMW) में पहुंची, वेबर की अधिकतम जनसंख्या मार्च के तीसरे सप्ताह (11वें SMW) में रही, स्केल की अधिकतम संख्या 19वें SMW में पहुंची, और पत्ती मोड़ने वाला कीड़ा *S. leucaspis* की अधिकतम उपस्थिति जुलाई के दूसरे सप्ताह (28वें SMW) में दर्ज की गई।
- एंटेना के इलेक्ट्रोफिजियोलॉजिकल अध्ययन से पता चला कि नर टे. *जवानिका* में एथिल एसीटेट, जेरानियोल, डेकानोल, अंडेकेन और β-कैरियोफाइलीन के प्रति संवेदनशीलता अधिक होती है।
- प्राकृतिक संक्रमण के क्षेत्रीय परिस्थितियों में फल ब्लाइट *अल्टरनेरिया अल्टरनेटा* रोग के खिलाफ फफूंदनाशी दवाओं के मूल्यांकन से पता चला कि अजॉक्सिस्ट्रोबिन 23% SC, डाइफेनकोनाजोल 25% EC, थायोफेनेट मेथिल 70% WP, कार्बेंडाजिम 50% WP और मेटिराम 55% + पिराक्लोस्ट्रोबिन 5% WG फल ब्लाइट रोग नियंत्रण में अधिक प्रभावी पाए गए।
- लीची फलों में कीटनाशक अवशेष विश्लेषण से पता चला कि अवशेष मुख्य रूप से फल की खाल में संकेंद्रित थे, जबकि फल के गूदा में अवशेष मात्रा निर्धारण सीमा से नीचे पाए गए, सिवाय कॉपर ऑक्सी क्लोराइड और कार्बेंडाजिम के।
- मेलिसोपलिनोलॉजिकल (मधुमक्खी परागण) अध्ययन से लीची बागानों में सापिंडेसियस और गैर-सापिंडेसियस स्रोतों सहित विभिन्न प्रकार के परागकणों की उपस्थिति पता चली, जो लीची बागानों में समृद्ध परागकण विविधता को दर्शाता है।

फसल कटाई उपरांत प्रबंधन और मूल्य संवर्धन

- फलों की तुड़ाई से पूर्व BS-01 के छिड़काव से फल सड़न में कमी देखी गई (28 ± 2ºC तापमान पर चौथे दिन और 4ºC पर 20वें दिन तक सड़न 0.0% रही)।
- तुड़ाई से पूर्व हाथीसूद अर्क, BS-01, और कल्चर फिल्ट्रेट (BS-01) के छिड़काव ने फल झड़ने, फटने और सड़ने की समस्या को कम करने में लगातार बेहतर प्रभाव दिखाया।
- लीची छिलके से जैव सक्रिय यौगिकों के सोनिकेशन (600 W, 5 मिनट, 50% एथेनॉल, 1:40 फीड-टू-सॉल्वेंट अनुपात) द्वारा निष्कर्षण से जैव सक्रिय तत्वों की प्राप्ति में सुधार हुआ, जिसमें छोटे कणों ने अधिक निष्कर्षण क्षमता (78.84 मि.ग्रा. GAE/ग्राम) दिखाई।
- सोनिकेशन लीची बीज से स्टार्च निष्कर्षण की सबसे उत्तम विधि पाई गई, जिसमें सामान्य स्टीपिंग, अम्लीय या क्षारीय स्टीपिंग की तुलना में 32.13% निष्कर्षण क्षमता प्राप्त हुई।
- लीची फलों के METWASH डिप से उपचारित करने पर शीतित परिस्थितियों में शेल्फ लाइफ 15 दिनों तक बढ़ गई, जिसमें केवल 20% विकिरण (discoloration) और 10% सड़न देखी गई, जबकि नियंत्रण (control) समूह में यह क्रमशः 100% था।

- लाह आधारित कोटिंग, 1 एथिलीन अवशोषक और 1 फ्रेश कार्ड के साथ पननेट में लीची फलों के परिवहन प्रयोग में पाया गया कि दिल्ली पहुंचने के बाद 90% फल विपणन योग्य रहे।
- पैकेजिंग प्रयोगों में यह पाया गया कि LDPE फिल्म का उपयोग करने पर सड़न (30%) और विकिरण (40%) सबसे कम था, जबकि बायोफिल्म और पॉलीथीन फिल्म में यह क्रमशः 80% तक पाया गया।

जलवायु अनुकूल खेती

- वर्ष 2023-24 के दौरान लीची की फेनोलॉजिकल प्रवृत्ति से पता चला कि पैनिकल निकलने की दर केवल 6.66% रही, जिसका प्रमुख कारण अक्टूबर (1.17 ºC अधिक) और नवंबर (1.84 ºC अधिक) में पिछले 10 वर्षों की औसत न्यूनतम तापमान से अधिक तापमान रहा, जिससे नवंबर माह में समय से पहले फ्लशिंग हो गई।
- लीची आधारित उत्पादन प्रणालियों के पारिस्थितिक पदचिह्न (Ecological Footprint) का अनुमान 3.6 टन/हेक्टेयर CO_2 समतुल्य उत्सर्जन के रूप में लगाया गया, जिसमें रासायनिक उर्वरकों के प्रयोग का सर्वाधिक योगदान पाया गया।

सहयोग और भागीदारी

- केंद्र विभिन्न संगठनों जैसे ICAR-IARI (झारखंड), ICAR-NISA (रांची), ICAR-CISH (लखनऊ) के साथ सहयोग में कार्य कर रहा है।

तकनीकी हस्तांतरण

- साल 2024 के दौरान 19 औपचारिक प्रशिक्षण कार्यक्रम आयोजित किए गए और विभिन्न प्रशिक्षण एवं विस्तार गतिविधियों के माध्यम से 2000 से अधिक हितधारकों को लाभान्वित किया गया।

गुणवत्तापूर्ण पौध वितरण

- राजस्थान, मध्य प्रदेश, त्रिपुरा, सिक्किम, पश्चिम बंगाल, ओडिशा, छत्तीसगढ़, अरुणाचल प्रदेश, उत्तराखंड, उत्तर प्रदेश, कर्नाटक और बिहार में किसानों तथा विभिन्न हितधारकों को कुल 21,552 लीची के पौधे वितरित/सप्लाई किए गए।

Executive Summary

ICAR-National Research Centre on Litchi has made commendable progress in basic and applied research under multi-disciplinary programme covering different aspects of litchi *viz.*, genetic resource management and crop improvement, crop production, crop protection and postharvest management. The Centre also conducted training, organized outreach programmes and transfer of technology activities to improve knowledge and to develop skills of different stakeholders. A concise summary of salient achievements during 2024 is presented here.

Research Accomplishments

Crop Improvement

- Three superior clones *viz.* NRCL-4 (resistant to cracking) while NRCL-24 (large fruit) and NRCL-91 (chicken tongue seeds) were identified from superior seedling selections.
- A total of 1093 crosses were made from different parental combinations *viz.* Shahi × China, Shahi × Bedana, Shahi × Dehrarose, Shahi × Kwai May Pink, Shahi × Longia, Shahi × Mandraji, China × Bedana and China × Shahi. Only 43 hybrids were recovered out of which only 26 hybrids seedlings survived in the net house.
- Seventy-four (74) accessions of longan were evaluated for fruit quality parameters. Based on average fruit weight (> 9 g), the longan accession Lg-14 and Lg-16 were found promising.
- Thirty-two novel EST based SSR primers were used for screening of the litchi genotypes and ten primers showed differential amplification pattern among the 39 genotypes.
- In order to create variability in litchi *cv.* Shahi different concentrations of EMS (0.25%, 0.5%, 1.0%, 2.0%, 3.0%, 4.0% and 5.0%) were tried. Seed germination was obtained only in case of seeds treated with 0.25% EMS.
- Colchicine (0.1%, 0.2%, 0.3%, 0.4% and 0.5%) was also used as a mutagen to induce mutation /polyploidy in litchi. Significant variations were observed in colchiploids with respect to the plant morphological parameters.
- Evaluation of two-year-old half-sib seedling population (68) of litchi *cv.* Shahi indicated significant variation for morphological characteristic.
- Fruit quality traits in the 43 litchi genotypes were analyzed and study showed that there was wider and more significant diversity for the studied traits in the litchi germplasm.

Crop Production

- Studies on mycorrhizal colonization and microbial populations in the rhizosphere of litchi trees treated with girdling revealed that tree girdling significantly reduces mycorrhizal colonization over time.
- *In-situ* mycorrhization in litchi orchard positively affected both macronutrient (N, P, K) and micronutrient (S, Cu) levels in the soil and tree leaves, as well as microbial activity in terms of soil respiration.
- To assess the nutrient status of litchi leaf at different positions of the leaflet, leaf sampling was done at the pre-flowering stage. Results showed that total nitrogen of the leaf sample followed the increasing trend from the first pair to the fourth pair. The total phosphorus of the leaf increased from the first pair to the second pair, then it decreased onward to the fourth pair of leaves.
- The effect of plant architecture on yield and quality of litchi fruits was evaluated and the higher yield (40.48 kg/tree) were recorded in canopy architecture retaining 4 primary branches and 4 secondary branches.

- Studies on drip irrigation and mulching indicated significantly higher fruit yield (48.57 kg/plant) and fruit weight (22.83 g) in irrigation at 100% ER + mulching with 100-micron black polyethylene.
- Bagging with white colour polypropylene bags 30 days after fruit set; use of under-canopy micro sprinkler; bagging with pink colour polypropylene bags 30 days after fruit set; foliar application of salicylic acid @ 50 ppm and foliar application of sea weed extract (Sagarika liquid @ 0.5%) were found to be most effective in minimizing the incidence of fruit cracking and scorching in litchi *cv.* Shahi.

Crop Protection

- The maximum reduction in flower webber population occurred with Thiachloprid 21.7% SC + Fipronil and Thiachloprid 21.7% SC + Profenophos spray (58.3% and 57.91% respectively), while, Thiachloprid 21.7 %SC, Beta cyfluthrin 8.49 % + Imidachloprid 19.8 % was highly effective in reducing the populations of stink bugs in litchi.
- The metagenomics analysis of gut bacteria of stink bugs revealed the dominance of *Proteobacteria* throughout all developmental stages, although Firmicutes D and Bacteroidota are particularly prominent in the second nymphal instar.
- The incidence of litchi stink bug first appeared in 1st SMW and lasted up to fruit harvesting; litchi looper complex attained a peak population during second week of March (10th SMW), webber attained a peak during 3rd week of March (11th SMW), scale, D. mangiferae peaked at 19th SMW, Leaf folder S. leucaspis incidence attained a peak population during 2nd week of July (28th SMW).
- Electrophysiological studies of antenna indicated that male *T. javanica* exhibited heightened sensitivity to ethyl acetate, geraniol, decanol, undecane, and β-caryophyllene.
- Evaluation of fungicides against fruit blight *(Alternaria alternata)* disease under natural infection field conditions indicated that Azoxystrobin 23% SC, Difenoconazole 25% EC, Thiophanate methyl 70% WP, Carbendazim 50% WP and Metiram 55%+ Pyraclostrobin 5% WG were observed to be more effective in controlling fruit blight disease.
- Pesticide residue analysis in litchi fruits showed that residues were mainly concentrated in the peel, while residues in the pulp were found below the limit of quantification, except for Copper oxychloride and Carbendazim.
- The melissopalynological studies revealed the presence of diverse types of pollen including Sapindaceous and non-Sapindaceous sources highlighting the rich pollen diversity available in litchi orchards.

Postharvest Management and Value addition

- Pre harvest spray of BS-01 was found to reduce fruit decay (0.0% decay at 4th day at 28 ± 2ºC and, 20th day of storage at 4^{o}C) compared to control.
- Pre harvest spray of Hathisud extract, BS-01, and Culture filtrate (BS-01) consistently demonstrated superior performance in reducing fruit drop, cracking, and fruit decay.
- Extraction of litchi peel bioactive compounds using sonication (600 W, 5 min, 50% ethanol, 1:40 feed-to-solvent) improved bioactive yield, with smaller particles showing higher extractability (78.84mg GAE/g).
- Sonication was found to be the best method for the extraction of starch from litchi seed with an extractability of 32.13% compared to normal steeping, acid or alkali steeping.
- METWASH dip of litchi fruits was found to increase the shelf life up to 15 days at refrigerated condition with only 20% discoloration and 10% decay compared to 100% in control.

- Transportation experiment of litchi fruit using lac based coating in punnet with 1 ethylene absorber and 1 fresh card showed 90% marketable fruits after reaching Delhi.
- Packaging experiments showed the lease decay (30%) and discoloration (40%) using LDPE film compared to 80% in biofilm and polyethylene film.

Climate resilient litchi farming

- Phenological behavior of litchi during 2023-24 suggest that panicle emergence was only 6.66% which was probably due to higher minimum temperature than the average of last 10 years during October (1.17^{0}C higher) and November (1.84^{0}C higher) leading to early flushing in November.
- Ecological footprint of litchi based production systems estimated a total emission of 3.6 t/ha CO_2 equivalent out of which the highest contribution was from application of chemical fertilizer.

Linkages and Collaborations

- The Centre is working on different aspects in close collaboration with other organizations (ICAR-IARI, Jharkhand, ICAR-NISA, Ranchi, Jharkhand, ICAR-CISH, Lucknow.

Transfer of Technology

- During the year 2024, 19 formal training programs were organized and more than 2000 stakeholders were benefitted through various training and extension activities.

Production and supply of quality planting materials

- A total of 21,552 litchi saplings were distributed to farmers /supplied to various stakeholders in Rajasthan, Madhya Pradesh, Tripura, Sikkim, West Bengal, Odisha, Chhattisgarh, Arunachal Pradesh, Uttarakhand, Uttar Pradesh, Karnataka and Bihar.

Contents

Research Accomplishments

1. Conservation, Characterization and Utilization of Genetic Diversity for Improvement of Litchi

1.1. Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization

Evaluation of superior seedling selections

Thirty-five clones of superior seedlings were evaluated for the fruit quality parameters. Among the 35 clones only 20 were in bearing stage. No sign of cracking and sun scorching was observed in NRCL-4 while NRCL-24 and NRCL-91 were found promising for higher fruit weight (> 25 g) and small seed size (chicken tongue seeds: 80%), respectively (Table 1).

1.2. Development of improved hybrids of litchi

In order to develop a dwarf, precocious, high yielding, regular bearer, cracking resistant variety, a total of 1093 crosses were made from different parental combinations *viz.* Shahi × China, Shahi × Bedana, Shahi × Dehrarose, Shahi × Kwai May Pink, Shahi × Longia, Shahi × Mandraji, China × Bedana and China × Shahi during March 2024. Only 43 fruits were harvested and fresh seeds extracted from these forty-three harvested fruits were sown in polyethylene bags and observed for germination. Only 26 hybrids seedlings survived and are being maintained in the net house (Table 2).

1.3. Characterization, evaluation and utilization of longan germplasm

Longan is emerging as a popular fruit due to the time of availability of fruits as well as sweet pulp of fruits having longer shelflife. Research work is being undertaken to identify a superior genotype of longan based on fruit quality and yield parameters. Seventy-four (74) accessions of longan were evaluated for fruit quality parameters. Significant variation in fruit physicochemical parameters was observed. Maximum variation was noted for fruit weight (2.90- 10.30 g) and aril recovery (44.74 – 77.78%) followed by seed weight (0.50- 1.90 g) and TSS (12.50- 28.90 oB) (Table 3). Based on average fruit weight (> 9 g), the longan accession Lg-14 and Lg-16 were found promising. Higher TSS (≥ 25 oB) was noted in Lg-12, Lg-64, Lg-13 and Lg-14 (Table 4).

Table: 1. Fruit quality parameters of promising clones.

Name of the Clone	Fruit weight (g)	Peel weight (g)	Pulp weight (g)	Seed weight (g)	Pulp recovery (%)	TSS (°B)	Chicken tongue seeds (%)	Cracking and sun burning (%)
NRCL-4	13.50	2.15	9.35	2.00	69.26	22.66	0	0.00
NRCL-24	25.20	3.20	17.30	4.70	68.65	22.10	0	28.6
NRCL-91	17.20	2.20	13.50	1.50	78.48	21.50	80	30.2

Plate-1. Profuse bearing in NRCL-4 free from cracking

Table: 2. Details of the surviving hybrid seedlings.

Sl. No.	Cross (♀ × ♂)	Code No.	Sl. No.	Cross (♀ × ♂)	Code No.
1.	Shahi × China	H-24-1	14.	China × Bedana	H-24-24
2.	Shahi × China	H-24-2	15.	China × Bedana	H-24-25
3.	Shahi × China	H-24-3	16.	China × Bedana	H-24-26
4.	Shahi × China	H-24-5	17.	China × Bedana	H-24-27
5.	Shahi × China	H-24-6	18.	China × Bedana	H-24-28
6.	Shahi × China	H-24-9	19.	China × Bedana	H-24-30
7.	Shahi × China	H-24-10	20.	China × Bedana	H-24-31
8.	Shahi × China	H-24-15	21.	China × Bedana	H-24-32
9.	Shahi × Bedana	H-24-16	22.	China × Shahi	H-24-33
10.	Shahi × Bedana	H-24-17	23.	China × Shahi	H-24-37
11.	Shahi × Dehrarose	H-24-19	24.	China × Shahi	H-24-39
12.	Shahi × Dehrarose	H-24-20	25.	China × Shahi	H-24-41
13.	China × Bedana	H-24-23	26.	China × Shahi	H-24-42

Table: 3. Descriptive statistics for fruit quality traits in 74 longan accessions.

Trait	Maximum	Minimum	Mean	Std. deviation	CV
Fruit weight (g)	10.30	2.90	6.02	1.27	21.02
Peel weight (g)	1.90	0.50	0.86	0.24	27.78
Pulp weight (g)	7.90	1.50	4.06	1.03	25.49
Seed weight (g)	1.90	0.50	1.10	0.24	22.17
Pulp recovery (%)	77.78	44.74	66.78	5.92	8.87
TSS (°B)	28.90	12.50	22.93	2.80	12.22
Acidity (%)	0.27	0.03	0.08	0.03	31.62
Ascorbic acid (mg/ 100 ml juice)	68.75	2.75	20.72	11.11	53.61

Table: 4. Variations in fruit quality parameters of the longan accessions.

Sl. No.	Accession No.	Fruit weight (g)	Peel weight (g)	Pulp weight(g)	Seed weight(g)	Pulp recovery (%)	TSS (◦B)	Acidity (%)	Ascorbic Acid (mg/100ml)
1	LG-1	5.15^{uvwxyz}	0.85^{jkl}	3.40^{uvwxy}	0.90^{klm}	$66.06^{pqrstuvwx}$	$22.82^{rstuvwxy}$	0.08^{cd}	8.52^{zABC}
2	LG-4	3.30^{G}	1.00^{ghi}	1.60^{F}	0.70^{no}	48.71^{E}	$23.05^{qrstuvwxy}$	0.25^{a}	8.80^{yzABC}
3	LG-11	3.70^{FG}	0.65^{nop}	2.25^{CDE}	0.80^{mn}	60.76^{ABC}	$23.32^{opqrstuvw}$	0.06^{de}	9.90^{xyzABC}
4	LG-12	5.00^{wxyzA}	1.05^{fgh}	2.65^{ABCD}	1.30^{cdef}	52.97^{D}	28.22^{a}	0.06^{de}	11.27^{xyzABC}
5	LG-13	6.85^{fghij}	1.05^{fgh}	$4.65^{ghijklm}$	1.15^{fghi}	$67.82^{ijklmnopqrstu}$	25.60^{cdef}	0.08^{cd}	$21.72^{klmnopqrs}$
6	LG-14	9.20^{a}	1.50^{b}	6.45^{a}	1.25^{defg}	$69.51^{fghijklmnopq}$	$22.50^{tuvwxyzA}$	0.06^{de}	7.97^{zABC}

Sl. No.	Accession No.	Fruit weight (g)	Peel weight (g)	Pulp weight(g)	Seed weight(g)	Pulp recovery (%)	TSS (°B)	Acidity (%)	Ascorbic Acid (mg/100ml)
7	LG-15	7.05^{efghi}	1.20^{cde}	4.70^{fghijkl}	1.15^{fghi}	66.68^{mnopqrstuvwx}	24.05^{ijklmnopqr}	0.08^{cd}	15.40^{pqrstuvwxyz}
8	LG-16	9.250^{a}	1.25^{cd}	6.65^{a}	1.35^{cde}	71.86^{bcdefghi}	23.70^{mnopqrstu}	0.06^{de}	10.17^{xyzABC}
9	LG-17	7.20^{cdefgh}	0.95^{hij}	5.15^{cdefg}	1.10^{ghij}	71.47^{cdefghij}	22.55^{tuvwxyz}	0.05^{e}	7.97^{zABC}
10	LG-18	4.75^{zABC}	0.70^{mno}	3.15^{xyzA}	0.90^{klm}	66.32^{nopqrstuvwx}	23.35^{opqrstuv}	0.06^{de}	8.80^{yzABC}
11	LG-19	6.70^{ghijk}	1.00^{ghi}	4.35^{jklmno}	1.35^{cde}	64.81^{rstuvwxyzA}	20.15^{D}	0.06^{de}	23.10^{jklmnop}
12	LG-20	5.40^{rstuvwx}	0.65^{nop}	3.85^{opqrstuv}	0.90^{klm}	71.34^{cdefghijk}	21.80^{yzABC}	0.08^{cd}	20.62^{mnopqrstu}
13	LG-21	5.40^{rstuvwx}	0.75^{lmn}	3.50^{tuvwx}	1.15^{fghi}	64.78^{stuvwxyzA}	25.11^{cdefghij}	0.05^{e}	21.72^{klmnopqrs}
14	LG-22	5.80^{nopqrs}	0.75^{lmn}	3.85^{opqrstuv}	1.20^{efgh}	66.23^{opqrstuvwx}	23.75^{klmnopqrstu}	0.06^{de}	23.10^{jklmnop}
15	LG-23	5.85^{nopqr}	0.70^{mno}	4.30^{klmnop}	0.85^{lmn}	73.44^{abcdef}	23.29^{pqrstuvw}	0.06^{de}	32.72^{cdefg}
16	LG-24	6.25^{klmn}	0.75^{lmn}	4.15^{mnopqr}	1.35^{cde}	66.39^{nopqrstuvwx}	21.92^{xyzABC}	0.08^{cd}	28.87^{efghijkl}
17	LG-25	5.65^{opqrstuv}	0.60^{opq}	4.20^{lmnopq}	0.85^{lmn}	74.33^{abcde}	22.58^{stuvwxyz}	0.08^{cd}	23.375^{ijklmno}
18	LG-26	7.25^{cdefg}	1.10^{efg}	4.60^{hijklm}	1.55^{b}	63.45^{vwxyzA}	22.29^{vwxyzA}	0.08^{cd}	23.10^{jklmnop}
19	LG-27	7.05^{efghi}	1.15^{def}	4.75^{fghijk}	1.15^{fghi}	67.38^{jklmnopqrstuvw}	21.90^{xyzABC}	0.06^{de}	34.65^{cde}
20	LG-28	5.90^{mnopqr}	0.95^{hij}	3.65^{rstuvwx}	1.30^{cdef}	61.82^{yzAB}	21.25^{zABCD}	0.06^{de}	20.62^{mnopqrstu}
21	LG-29	5.10^{vwxyz}	0.60^{opq}	3.15^{xyzA}	1.35^{cde}	61.76^{yzAB}	22.65^{stuvwxy}	0.06^{de}	33.82^{cdef}
22	LG-30	4.80^{yzABC}	0.60^{opq}	3.30^{wxyz}	0.90^{klm}	68.74^{ghijklmnopqrs}	21.82^{xyzABC}	0.06^{de}	28.87^{efghijkl}
23	LG-32	5.65^{opqrstuv}	1.00^{ghi}	3.70^{qrstuvw}	0.95^{jklm}	65.50^{qrstuvwxy}	23.12^{pqrstuvwxy}	0.06^{de}	17.60^{nopqrstuvwx}
24	LG-33	7.65^{cd}	1.00^{ghi}	5.50^{bcd}	1.15^{fghi}	71.87^{bcdefghi}	21.90^{xyzABC}	0.08^{cd}	19.52^{mnopqrstuvw}
25	LG-34	5.900^{mnopqr}	0.80^{klm}	3.90^{opqrstu}	1.20^{efgh}	66.09^{pqrstuvwx}	25.92^{bcde}	0.06^{de}	30.25^{efghij}
26	LG-35	3.85^{EFG}	0.55^{pq}	2.75^{ABC}	0.55^{o}	71.44^{cdefghij}	24.17^{hijklmnopq}	0.08^{cd}	22.82^{jklmnopq}
27	LG-37	6.25^{klmn}	0.55^{pq}	4.85^{efghij}	0.85^{lmn}	77.59^{a}	22.25^{vwxyzA}	0.08^{cd}	15.67^{opqrstuvwxyz}
28	LG-38	7.10^{defghi}	0.90^{ijk}	5.00^{defghi}	1.20^{efgh}	70.44^{efghijklmn}	23.15^{pqrstuvwx}	0.10^{bc}	11.55^{xyzABC}
29	LG-39	6.25^{klmn}	0.80^{klm}	4.30^{klmnop}	1.15^{fghi}	68.74^{ghijklmnopqrs}	23.65^{lmnopqrstu}	0.06^{de}	19.80^{mnopqrstuv}
30	LG-40	6.95^{efghij}	0.65^{nop}	5.05^{defgh}	1.25^{defg}	72.70^{bcdefg}	24.25^{ghijklmnopq}	0.06^{de}	7.15^{ABC}
31	LG-42	5.150^{uvwxyz}	0.70^{mno}	3.30^{wxyz}	1.15^{fghi}	64.07^{tuvwxyzA}	24.87^{defghijklm}	0.08^{cd}	15.12^{qrstuvwxyz}
32	LG-43	7.35^{cdef}	0.90^{ijk}	5.30^{cde}	1.15^{fghi}	72.09^{bcdefgh}	23.90^{jklmnopqrs}	0.11^{b}	20.62^{mnopqrstu}
33	LG-46	6.45^{jklm}	0.80^{klm}	4.55^{hijklmn}	1.10^{ghij}	70.37^{efghijklmno}	24.27^{fghijklmnopq}	0.10^{bc}	26.12^{fghijklm}
34	LG-48	5.45^{qrstuvw}	0.600 ^{opq}	3.65^{rstuvwx}	1.20^{efgh}	67.03^{lmnopqrstuvw}	26.37^{bc}	0.06^{de}	28.87^{efghijkl}
35	LG-49	6.90^{fghij}	0.80^{klm}	4.90^{efghi}	1.20^{efgh}	71.01^{defghijkl}	24.78^{efghijklmn}	0.08^{cd}	39.60^{bc}
36	LG-50	7.50^{cde}	1.10^{efg}	4.95^{efghi}	1.45^{bc}	66.04^{pqrstuvwx}	24.17^{hijklmnopq}	0.08^{cd}	24.47^{hijklmn}
37	LG-51	5.40^{rstuvwx}	0.50^{q}	3.80^{pqrstuv}	1.10^{ghij}	70.44^{efghijklmn}	25.52^{cdefg}	0.08^{cd}	25.57^{ghijklm}
38	LG-52	5.55^{pqrstuvw}	0.60^{opq}	3.85^{opqrstuv}	1.10^{ghij}	69.35^{fghijklmnopq}	26.07^{bcde}	0.06^{de}	14.85^{rstuvwxyzA}
39	LG-53	7.50^{cde}	0.65^{nop}	5.65^{bc}	1.20^{efgh}	75.32^{abc}	24.85^{defghijklmn}	0.08^{cd}	19.80^{mnopqrstuv}
40	LG-54	6.25^{klmn}	0.75^{lmn}	4.30^{klmnop}	1.20^{efgh}	68.82^{ghijklmnopqrs}	25.40^{cdefgh}	0.06^{de}	34.92^{cde}
41	LG-55	5.15^{uvwxyz}	0.60^{opq}	3.70^{qrstuvw}	0.85^{lmn}	71.89^{bcdefghi}	25.30^{cdefghi}	0.10^{bc}	31.35^{defgh}
42	LG-56	4.25^{CDEF}	0.60^{opq}	2.80^{zAB}	0.85^{lmn}	65.90^{pqrstuvwx}	23.79^{jklmnopqrstu}	0.06^{de}	38.50^{bcd}

Sl. No.	Accession No.	Fruit weight (g)	Peel weight (g)	Pulp weight(g)	Seed weight(g)	Pulp recovery (%)	TSS (°B)	Acidity (%)	Ascorbic Acid (mg/100ml)
43	LG-57	5.75^{nopqrst}	0.65^{nop}	3.90^{opqrstu}	1.20^{efgh}	67.19^{klmnopqrstuvw}	23.82^{jklmnopqrst}	0.08^{cd}	46.20^{b}
44	LG-58	7.25^{cdefg}	0.85^{jkl}	5.00^{defghi}	1.40^{bcd}	68.95^{ghijklmnopqr}	26.15^{bcd}	0.08^{cd}	30.52^{efghij}
45	LG-59	6.90^{fghij}	0.95^{hij}	4.90^{efghi}	1.05^{hijk}	71.01^{defghijkl}	24.40^{fghijklmnop}	0.06^{de}	29.15^{efghijk}
46	LG-60	6.65^{hijk}	0.70^{mno}	5.05^{defgh}	0.90^{klm}	75.93^{ab}	25.32^{cdefghi}	0.10^{bc}	31.07^{defghi}
47	LG-62	5.32^{stuvwxy}	0.87^{jk}	3.32^{wxy}	1.12^{ghi}	62.29^{yzAB}	22.36^{vwxyzA}	0.10^{c}	18.83^{nopqrstuvw}
48	LG-63	6.38^{00b}	1.25^{cd}	5.85^{b}	1.40^{bcd}	68.75^{ghijklmnopqrs}	23.62^{mnopqrstu}	0.06^{de}	26.12^{fghijklm}
49	LG-64	4.75^{zABC}	0.65^{nop}	3.15^{xyzA}	0.95^{jklm}	66.28^{opqrstuvwx}	27.12^{ab}	0.06^{de}	31.07^{defghi}
50	LG-65	4.25^{CDEF}	0.95^{hij}	2.15^{DE}	1.15^{fghi}	50.21^{DE}	24.50^{fghijklmno}	0.08^{cd}	22.27^{klmnopqr}
51	LG-66	5.80^{nopqrs}	0.60^{opq}	4.350^{jklmno}	0.85^{lmn}	75.00^{abcd}	24.97^{defghijkl}	0.10^{c}	14.30^{stuvwxyzAB}
52	LG-67	5.70^{nopqrstu}	0.65^{nop}	3.80^{pqrstuv}	1.25^{defg}	66.63^{mnopqrstuvwx}	24.50^{fghijklmno}	0.06^{de}	21.72^{klmnopqrs}
53	LG-68	5.25^{stuvwxyz}	0.65^{nop}	3.35^{vwxy}	1.25^{defg}	63.81^{uvwxyzA}	23.75^{klmnopqrstu}	0.08^{cd}	64.35^{a}
54	LG-69	5.35^{rstuvwxy}	0.75^{lmn}	3.80^{pqrstuv}	1.05^{hijk}	66.24^{opqrstuvwx}	25.07^{cdefghijk}	0.08^{cd}	34.65^{cde}
55	LG-70	4.45^{ABCD}	0.55^{pq}	2.95^{yzAB}	0.95^{jklm}	66.28^{opqrstuvwx}	24.50^{fghijklmno}	0.083^{cd}	22.27^{klmnopqr}
56	LG-71	3.85^{EFG}	1.00^{ghi}	2.05^{EF}	0.80^{mn}	53.00^{D}	20.30^{D}	0.10^{c}	16.5000^{opqrstuvwxy}
57	LG-87	6.05^{lmnop}	0.85^{jkl}	4.20^{lmnopq}	1.00^{ijkl}	69.96^{fghijklmnop}	22.47^{uvwxyzA}	0.08^{cd}	12.65^{vwxyzABC}
58	LG-91	5.20^{tuvwxyz}	1.05^{fgh}	3.30^{wxyz}	0.85^{lmn}	63.28^{wxyzAB}	20.65^{CD}	0.06^{de}	13.47^{tuvwxyzAB}
59	LG-95	4.35^{BCDE}	0.90^{ijk}	2.65^{ABCD}	0.80^{mn}	60.74^{ABC}	20.75^{BCD}	0.08^{cd}	21.72^{klmnopqrs}
60	LG-108	6.00^{mnopq}	0.85^{jkl}	4.05^{nopqrs}	1.10^{ghij}	67.52^{jklmnopqrstuv}	22.00^{wxyzAB}	0.10^{bc}	11.82^{wxyzABC}
61	LG-120	7.00^{efghij}	1.05^{fgh}	4.90^{efghi}	1.05^{hijk}	69.96^{fghijklmnop}	22.45^{uvwxyzA}	0.10^{bc}	11.00^{xyzABC}
62	LG-124	6.60^{ijkl}	0.95^{hij}	4.50^{jklmn}	1.15^{fghi}	68.13^{hijklmnopqrst}	20.45^{D}	0.06^{de}	13.47^{tuvwxyzAB}
63	LG-123	7.15^{defghi}	1.05^{fgh}	4.35^{jklmno}	1.75^{a}	60.83^{zABC}	23.32^{opqrstuvw}	0.08^{cd}	12.92^{uvwxyzABC}
64	LG-117	7.65^{cd}	1.05^{fgh}	4.80^{efghijk}	1.80^{a}	62.76^{xyzAB}	22.62^{stuvwxy}	0.06^{de}	13.47^{tuvwxyzAB}
65	LG-113	7.75^{c}	1.25^{cd}	5.30^{cde}	1.20^{efgh}	68.31^{hijklmnopqrs}	18.65^{E}	0.10^{bc}	14.30^{stuvwxyzAB}
66	LG-111	5.60^{pqrstuv}	0.85^{jkl}	3.80^{opqrstuv}	0.90^{klm}	68.70^{ghijklmnopqrs}	24.17^{hijklmnopq}	0.08^{cd}	21.17^{lmnopqrst}
67	LG-119	4.85^{xyzAB}	0.85^{jkl}	3.150^{xyzA}	0.85^{lmn}	64.96^{rstuvwxyz}	23.52^{nopqrstu}	0.08^{cd}	9.35^{yzABC}
68	LG-62	5.32^{stuvwxy}	0.87^{jk}	3.32^{wxy}	1.12^{ghi}	62.297^{yzAB}	22.36^{vwxyzA}	0.10^{c}	18.83^{nopqrstuvw}
69	LG-79	6.20^{klmno}	0.85^{jkl}	4.50^{ijklmn}	0.85^{lmn}	72.59^{bcdefg}	18.37^{E}	0.08^{cd}	11.27^{xyzABC}
70	LG-127	7.35^{cdef}	1.05^{fgh}	5.20^{cdef}	1.10^{ghij}	70.72^{efghijklm}	21.20^{ABCD}	0.08^{cd}	15.67^{opqrstuvwxyz}
71	LG-103	6.90^{fghij}	1.65^{a}	3.95^{opqrst}	1.30^{cdef}	57.34^{C}	12.97^{H}	0.06^{de}	5.22^{C}
72	LG-41	5.70^{nopqrstu}	1.00^{ghi}	3.85^{opqrstuv}	0.85^{lmn}	67.45^{jklmnopqrstuv}	14.72^{G}	0.08^{cd}	6.875^{BC}
73	LG-107	6.95^{efghij}	1.30^{c}	4.30^{klmnop}	1.35^{cde}	61.86^{yzAB}	14.15^{GH}	0.06^{de}	11.55^{xyzABC}
74	LG-148	4.10^{DEF}	0.80^{klm}	2.45^{BCDE}	0.85^{lmn}	59.25^{BC}	16.10^{F}	0.06^{de}	10.17^{xyzABC}
	SEM	0.20	0.048	0.19	0.06	1.48	0.47	0.006	2.77
	SED	0.28	0.067	0.27	0.09	2.10	0.67	0.009	3.91
	CV	5.75	9.625	8.36	10.00	3.85	3.62	13.80	23.16

Notes: *Superscript in small letters indicate significant difference at P < 0.05.*

1.4. Molecular characterization of litchi cultivars using microsatellite markers

Thirty-two novel EST based SSR primers were designed based on bioinformatic analyses for screening of the litchi genotypes using in-house developed perl script programme. Fresh genomic DNA was isolated from 39 varieties of litchi. The thermal profiling of the PCR protocol was calibrated with reference to the new set of primers. The polymorphism study revealed, out of 32 SSR based primers, ten of these were showing differential amplification pattern among the 39 genotypes. The parental polymorphism identified above can be used for varietal differentiation.

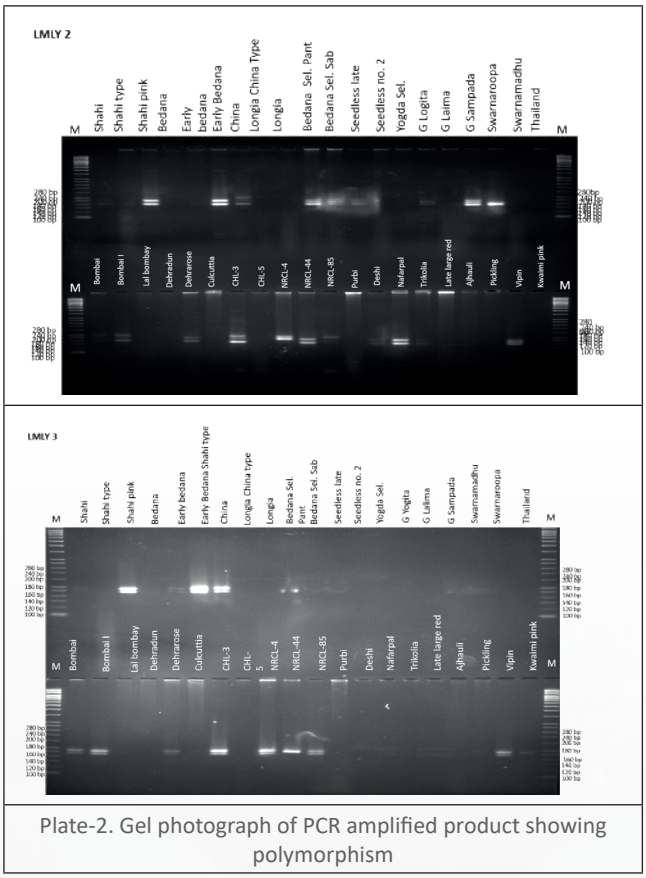


Plate-2. Gel photograph of PCR amplified product showing polymorphism

1.5. Mutation breeding for litchi improvement

EMS induced mutagenesis

Ethyl methane sulfonate (EMS) is a widely used chemical mutagen to induce genetic variations in crop plants and has gained popularity due to its effectiveness and ease of handling. In order to determine the optimal conditions for mutagenesis of litchi, fresh seeds (50 seeds per treatment) of *cv.* Shahi were treated with 0.25%, 0.5%, 1.0%, 2.0%, 3.0%, 4.0% and 5.0% (v/v) of EMS in May 2024. The treated seeds were incubated for 48 h at room temperature with gentle shaking, while untreated seeds were used as a control. The treated and untreated seeds (control) were then sown in the polyethylene bags and the germination was observed for 1 months with the results recorded. Based on the result (Table 5), it is apparent that none of the EMS treated seeds were able to germinate except seeds treated with 0.25% EMS. This suggests that concentration and duration of seed exposure to EMS could be decreased to induce mutation in litchi.

Colchicine induced mutagenesis

Colchicine is also used as a mutagen in the plant breeding technique, that can induce mutation / polyploidy in plants. It is widely used to make polyploid plants and works as a mitotic poison by introducing mutagenic effects. Fresh seeds (50 seeds per treatment) of litchi *cv.* Shahi were immersed for 48 h at room temperature in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% (w/v) solutions of colchicine (Hi-Media) dissolved in distilled water along with the untreated (control). The treated and untreated seeds (control) were sown in the polyethylene bags. Two months after sowing, the survivorship was measured by dividing the surviving plants by the total number of treated seeds. There was no consistent trend observed for concentrations of colchicine treatment on the survival rate of litchi seedlings (Table 6). Significant variations were observed in colchiploids with respect to the plant morphological parameters.

The results obtained in litchi prompted us to hypothesize that both EMS and colchicine under various concentration and soaking duration might be effective for induction of mutagenesis. Therefore, the effectiveness of the EMS and colchicine were examined in longan. In August, 2024, twenty-four seeds of longan for each treatment were soaked in different concentration of EMS (0.25%, 0.5%, 1.0%, 2.0%, 3.0%, 4.0% and 5.0%) and colchicine (0.1%, 0.2%, 0.3%, 0.4% and 0.5%) along with untreated (control) for 24 and 48 h. The treated and untreated seeds (control) were then sown in the polyethylene bags and the germination was observed for 1 months with the results recorded. Decline in germination percentage was observed with the increasing dose and exposure of the treatment. The germination was not observed when the seeds were treated with 0.5% or higher doses in both the treatments (Table 7). The findings of the experiment revealed that the concentration of EMS and colchicine should be maintained below 0.5% for mutagenesis in litchi and longan.

Table: 5. Effect of EMS concentration (%) on the germination percentage of litchi.

EMS concentration	0.25%	0.5%	1.0%	2.0%	3.0%	4.0%	5.0%	Control (untreated)
Germination (%)	4	0	0	0	0	0	0	42

Table: 6. Effect of colchicine treatments on the surviving seedling of litchi.

Colchicine concentration	0.1%	0.2%	0.3%	0.4%	0.5%	Control
Survival of seedling (%)	22	13	19	26	17	23

Table: 7. Effect of EMS and colchicine treatments on the germination (%) of longan.

Treatment	Concentration (%)	Germination (%)	
		After 24 hr	After 48 hr
EMS	0.25%	75.00	41.67
EMS	0.5%	8.33	0.00
EMS	1%	0.00	0.00
EMS	2%	0.00	0.00
EMS	3%	0.00	0.00
EMS	4%	0.00	0.00
EMS	5%	0.00	0.00
Colchicine	0.1%	87.50	62.50
Colchicine	0.2%	62.50	8.33
Colchicine	0.3%	16.67	4.17
Colchicine	0.4%	12.50	0.00
Colchicine	0.5%	0.00	0.00
Control	Untreated	45.83	54.17

Note: *24 seeds were used in each treatment and germinated seeds were counted one month after sowing.*

1.6. Creating variability in litchi (ICAR-AICRP on Fruits)

The half-sib seedling population of litchi *cv.* Shahi were raised in 2022 for widening the genetic base of litchi. Plant growth parameters of the populations consisting of 68 plants (2-year-old) were recorded. The plant height ranged between 41 cm to 212 cm while the canopy volume ranged between 0.06 to 8.84 m^3.

Plate-3. Field view of half sib seedling population of litchi *cv.* Shahi

1.7. Evaluation of small seeded litchi variety (ICAR-AICRP on Fruits)

This experiment was started in 2022 to evaluate the performance of small-seeded litchi varieties. Significant difference in plant growth was observed for litchi var. Swarna Madhu and Early Bedana (Table 8).

1.8. Mapping of gene(s)/QTLs for economically important traits in litchi through genome-wide association studies (GWAS)

A number of recent advances in genomic technologies have been used to investigate the genetic basis of variation in large germplasm sets by genome-wide association studies (GWAS). In recent years, GWAS has been a popular method used for identifying the associated markers or causal genes responsible for important traits.

Fruit quality traits namely fruit weight, peel weight, seed weight, pulp recovery, TSS, acidity and ascorbic acid in the 43 litchi genotypes were measured in 2024. Table 9 displays the descriptive statistics of the maximum, minimum, mean, standard deviations, and coefficient of variation (CV) for the studied traits. The study showed that there was wider and more significant diversity and also had high CV values in the studied traits in the litchi germplasm (Table 10).

Table: 8. Plant growth parameters of litchi varieties Swarna Madhu and Early Bedana.

	Plant height (cm)		Canopy volume (m^3)	
	Mean	SE	Mean	SE
Swarna Madhu	77.06	5.39	0.95	0.33
Early Bedana	66.00	1.15	0.55	0.00
T- value	2.59		1.22	
Sig. (2-tailed)	0.12		0.34	

Table: 9. Descriptive statistics for fruit quality traits in 43 litchi germplasm.

Trait	Maximum	Minimum	Mean	Std. deviation	CV
Fruit weight (g)	23.38	11.33	18.37	3.15	17.13
Peel weight (g)	4.17	1.47	2.91	0.62	21.39
Pulp weight (g)	18.07	6.60	12.53	3.02	24.12
Seed weight (g)	11.04	1.83	7.32	2.48	33.88
Pulp recovery (%)	82.61	54.98	67.66	7.60	11.23
TSS (°B)	20.97	16.25	18.65	1.10	5.88
Acidity (%)	0.76	0.22	0.44	0.14	32.33
Ascorbic acid (mg/ 100 ml juice)	73.98	13.48	27.32	11.22	41.07

Table: 10. Variations in fruit quality parameters of the studied litchi germplasm.

Sl. No.	Name of the Germplasm	Fruit weight (g)	Peel weight (g)	Pulp weight (g)	Seed weight (g)
1.	Shahi	19.73^{efg}	2.06^{qr}	15.00^{cdef}	6.66^{klm}
2.	China	16.20^{lmnopq}	$2.86^{ghijklm}$	9.93^{mnop}	$8.50^{bcdefghijk}$
3.	Bombai- II	$16.40^{klmnopq}$	$2.53^{klmnopq}$	10.80^{lmno}	$7.66^{efghijkl}$
4.	Dehrarose	21.46^{abcde}	2.46^{lmnopq}	15.60^{bcde}	$8.50^{bcdefghijk}$
5.	NRCL-87	14.49^{pq}	2.49^{lmnopq}	9.50^{nop}	6.25^{lm}
6.	NRCL-90	$17.25^{hijklmn}$	1.75^{rs}	14.25^{defgh}	3.12^{op}
7.	Gandaki Sampada	22.66^{ab}	3.46^{bcde}	18.06^{a}	2.83^{op}
8.	CHL-5	16.26^{lmnopq}	3.46^{bcde}	9.20^{op}	$9.00^{bcdefgh}$
9.	Ajhauli	19.20^{efghi}	2.46^{lmnopq}	13.60^{efghi}	$7.83^{defghijkl}$
10.	Bombal-1	$16.60^{jklmnopq}$	3.40^{bcdef}	9.13^{op}	10.16^{abc}
11.	CHL-7	21.46^{abcde}	$2.80^{hijklmn}$	15.33^{cde}	$8.33^{cdefghijk}$
12.	Thailand Selection	22.40^{abcd}	2.26^{opq}	16.66^{abc}	$8.66^{bcdefghij}$
13.	NRCL-85	15.00^{nopq}	2.33^{nopq}	9.86^{mnop}	7.00^{ijklm}
14.	Longia	11.75^{s}	2.33^{nopq}	8.08^{pq}	10.25^{abc}

Sl. No.	Name of the Germplasm	Fruit weight (g)	Peel weight (g)	Pulp weight (g)	Seed weight (g)
15.	Sarguja Selection-1	14.66^{opq}	2.60^{jklmnop}	9.06^{op}	7.50^{fghijkl}
16.	Shahi Type	14.26^{qr}	2.13^{pqr}	9.26^{op}	7.16^{hijklm}
17.	CHL-4	18.75^{ghijk}	3.25^{cdefgh}	12.00^{ijkl}	8.75^{bcdefghi}
18.	Green	19.46^{efgh}	3.06^{defghij}	12.26^{hijkl}	10.33^{ab}
19.	Trikolia	22.53^{abc}	3.00^{efghijk}	16.00^{bcd}	8.83^{bcdefghi}
20.	Gandaki Lalima	19.00^{fghij}	3.53^{bcd}	11.80^{ijklm}	9.16^{abcdefg}
21.	Rose Scented	21.33^{abcdef}	2.41^{mnopq}	15.58^{bcde}	8.33^{cdefghijk}
22.	CHL-3	17.00^{ijklmno}	3.33^{bcdefg}	9.80^{mnop}	9.66^{abcd}
23.	Bedana	20.20^{cdefg}	3.66^{bc}	15.33^{cde}	3.00^{op}
24.	Bedana (Shahi type)	23.38^{a}	2.55^{klmnopq}	16.73^{abc}	10.25^{abc}
25.	Late Large Red	18.46^{ghijkl}	2.20^{pqr}	13.20^{fghij}	7.66^{efghijkl}
26.	Bedana Selection (Pantnagar)	22.53^{abc}	3.46^{bcde}	17.46^{ab}	4.00^{no}
27.	Late Bedana-II	20.00^{defg}	3.66^{bc}	15.60^{bcde}	1.83^{p}
28.	Calcuttia Late	16.80^{ijklmnop}	3.80^{ab}	9.33^{op}	9.16^{abcdefg}
29.	Seedless Late	20.26^{bcdefg}	3.46^{bcde}	15.66^{bcd}	2.83^{op}
30.	Yogada Selection	16.00^{mnopq}	2.20^{pqr}	10.86^{klmno}	7.33^{ghijkl}
31.	Mandraji	19.00^{ghij}	3.66^{bc}	11.40^{jklmn}	9.83^{abc}
32.	Elaichi	22.80^{a}	3.06^{defghij}	16.60^{abc}	7.83^{defghijkl}
33.	Seedless No.2	19.73^{efg}	3.80^{ab}	12.86^{ghijk}	7.66^{efghijkl}
34.	Bombai	19.16^{efghi}	4.16^{a}	10.58^{lmno}	11.04^{a}
35.	Lal Bombay	23.00^{a}	2.93^{fghijkl}	16.60^{abc}	8.66^{bcdefghij}
36.	Deshi	16.60^{jklmnopq}	2.53^{klmnopq}	10.66^{lmno}	8.50^{bcdefghijk}
37.	Dehradun	17.86^{ghijklm}	2.93^{fghijkl}	11.46^{jklmn}	8.66^{bcdefghij}
38.	Nafarpal	19.86^{efg}	3.13^{defghi}	12.93^{ghij}	9.50^{abcde}
39.	Purbi	16.80^{ijklmnop}	3.73^{abc}	9.33^{op}	9.33^{abcdef}
40.	Kaselia	11.33^{s}	2.60^{jklmnop}	6.60^{q}	5.33^{mn}
41.	Kasaba	16.20^{lmnopq}	3.26^{cdefgh}	10.53^{lmno}	6.00^{lm}
42.	Piyaji	20.10^{defg}	2.70^{ijklmno}	14.70^{cdefg}	6.75^{jklm}
43.	Kwai Mi Pink	11.86^{rs}	1.46^{s}	9.66^{nop}	1.83^{p}
	LSD at 5%	2.41	0.49	2.03	1.97
	SEm±	0.85	0.17	0.72	0.70

Notes: Superscript in small letters indicate significant difference at P < 0.05.

Table: 10. Cont. Variations in fruit quality parameters of the studied litchi germplasm

Sl. No.	Name of the Germplasm	Pulp recovery (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/ 100 ml juice)
1.	Shahi	75.92^{cdefg}	17.87^{ghijkl}	0.45^{defghi}	21.45^{ijklm}
2.	China	61.33^{lmn}	18.86^{bcdefghi}	0.28^{lmn}	13.47^{n}
3.	Bombai- II	65.82^{kl}	16.25^{m}	0.68^{ab}	20.90^{jklm}
4.	Dehrarose	72.62^{ghi}	18.53^{bcdefghijk}	0.73^{a}	18.42^{mn}
5.	NRCL-87	65.54^{kl}	18.14^{cdefghijk}	0.30^{klmn}	19.98^{klm}

Sl. No.	Name of the Germplasm	Pulp recovery (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/ 100 ml juice)
6.	NRCL-90	82.60^{a}	18.46^{bcdefghijk}	0.35^{ghijklm}	25.85^{fghij}
7.	Gandaki Sampada	79.65^{abc}	18.52^{bcdefghijk}	0.27^{lmn}	23.65^{ghijklm}
8.	CHL-5	56.55^{op}	17.74^{hijklm}	0.33^{ijklmn}	24.93^{ghijk}
9.	Ajhauli	70.79^{hij}	18.22^{cdefghijk}	0.30^{klmn}	23.65^{ghijklm}
10.	Bombai-1	54.97^{p}	19.94^{ab}	0.37^{fghijklm}	28.05^{efgh}
11.	CHL-7	71.39^{ghij}	16.51^{lm}	0.36^{ghijklm}	22.18^{ijklm}
12.	Thailand Selection	74.50^{defgh}	18.44^{bcdefghijk}	0.41^{efghijkl}	24.38^{ghijkl}
13.	NRCL-85	65.76^{kl}	18.71^{bcdefghij}	0.26^{mn}	22.91^{hijklm}
14.	Longia	68.47^{ijk}	17.96^{efghijkl}	0.30^{klmn}	26.67^{efghi}
15.	Sarguja Selection-1	61.42^{lmn}	17.96^{efghijkl}	0.37^{fghijklm}	23.10^{hijklm}
16.	Shahi Type	65.04^{kl}	17.01^{klm}	0.46^{defghi}	21.08^{jklm}
17.	CHL-4	63.95^{klm}	19.11^{bcdefgh}	0.21^{n}	21.72^{ijklm}
18.	Green	63.17^{lm}	17.12^{klm}	0.75^{a}	23.46^{ghijklm}
19.	Trikolia	70.98^{hij}	17.26^{jklm}	0.63^{abc}	19.61^{lm}
20.	Gandaki Lalima	61.97^{lmn}	18.77^{bcdefghij}	0.68^{ab}	19.98^{klm}
21.	Rose Scented	72.93^{efghi}	19.96^{ab}	0.26^{mn}	23.83^{ghijkl}
22.	CHL-3	57.62^{nop}	17.94^{fghijkl}	0.67^{ab}	23.10^{hijklm}
23.	Bedana	75.78^{cdefg}	19.44^{abcdefg}	0.73^{a}	22.00^{ijklm}
24.	Bedana (Shahi type)	71.56^{ghij}	19.21^{bcdefgh}	0.43^{efghijk}	22.00^{ijklm}
25.	Late Large Red	71.37^{ghij}	19.10^{bcdefgh}	0.33^{ijklmn}	23.28^{ghijklm}
26.	Bedana Selection (Pantnagar)	77.48^{bcde}	19.42^{abcdefg}	0.31^{jklmn}	30.43^{def}
27.	Late Bedana-II	77.91^{bcd}	19.53^{abcde}	0.34^{hijklmn}	27.50^{efgh}
28.	Calcuttia Late	55.58^{op}	19.06^{bcdefgh}	0.39^{efghijklm}	26.58^{efghi}
29.	Seedless Late	77.22^{bcdef}	19.56^{abcd}	0.42^{efghijk}	25.39^{fghij}
30.	Yogada Selection	67.80^{ijk}	17.35^{ijklm}	0.49^{defg}	28.41^{efg}
31.	Mandraji	59.78^{mno}	19.23^{bcdefgh}	0.41^{efghijkl}	31.71^{de}
32.	Elaichi	72.83^{fghi}	18.01^{defghijkl}	0.47^{defgh}	25.85^{fghij}
33.	Seedless No.2	65.10^{kl}	20.83^{a}	0.37^{fghijklm}	21.26^{jklm}
34.	Bombai	55.27^{op}	18.81^{bcdefghij}	0.73^{a}	23.65^{ghijklm}
35.	Lal Bombay	72.05^{ghij}	19.46^{abcdef}	0.43^{efghijk}	24.93^{ghijk}
36.	Deshi	64.02^{klm}	17.13^{klm}	0.58^{bcd}	28.41^{efg}
37.	Dehradun	63.91^{klm}	18.83^{cdefghij}	0.51^{cdef}	31.71^{de}
38.	Nafarpal	65.19^{kl}	19.59^{abc}	0.33^{ijklmn}	30.61^{def}
39.	Purbi	55.67^{op}	19.46^{abcdef}	0.41^{efghijkl}	37.58^{bc}
40.	Kaselia	57.73^{nop}	20.83^{a}	0.37^{fghijklm}	41.98^{b}
41.	Kasaba	65.10^{kl}	17.88^{ghijkl}	0.44^{defghij}	35.38^{cd}
42.	Piyaji	73.18^{efgh}	18.90^{bcdefghi}	0.38^{fghijklm}	73.97^{a}
43.	Kwai Mi Pink	81.45^{ab}	20.97^{a}	0.52^{cde}	69.66^{a}
LSD at 5%		4.594	1.576	0.134	5.232
SEm±		1.633	0.560	0.048	1.860

Notes: *Superscript in small letters indicate significant difference at P < 0.05.*

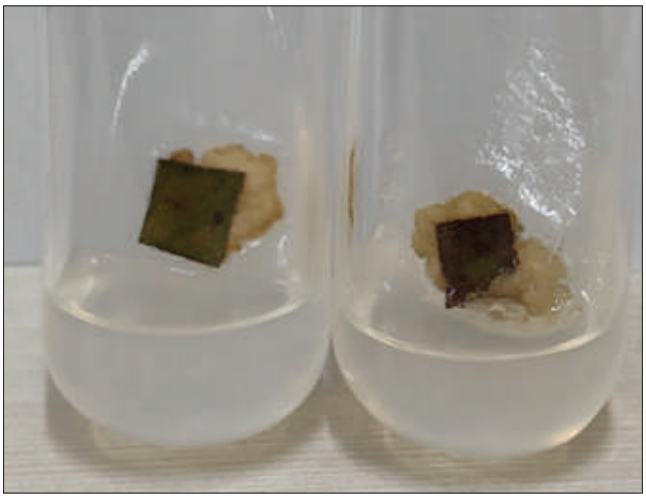
1.9. Standardization of tissue culture techniques for propagation and multiplication of litchi

With the objective of standardization of tissue culture techniques for propagation of litchi, tissue culture experiment was set up using leaf as plant explant material. The MS medium was precisely formulated with 1 mg/L of 6-benzylaminopurine (6-BAP), 1.5 mg/L of 2,4-dichlorophenoxyacetic acid (2,4-D), and 250 mg/L each of citric acid and ascorbic acid. Mature leaves were immersed in a 1.5% sodium hypochlorite solution for 15 minutes. Under aseptic conditions, leaf explants were immersed in liquid MS medium containing 250 mg/L each of citric acid and ascorbic acid for one hour to prevent browning. The test tubes were transferred to a tissue culture growth chamber, maintaining a temperature of 25°C ± 2°C with a photoperiod of 16 hours of light and 8 hours of darkness (TCE-1, 2). After a brief incubation period, it was evident that a significant portion of the test tubes had become contaminated by fungi. In TCE-3, a modification was implemented by substituting sodium hypochlorite sterilant with 0.1% $HgCl_2$. Among the 126 test tubes utilized, only 8 exhibited callus formation, while the remaining tubes were contaminated by fungi. Subsequently, in TCE-4, an antibacterial compound, cefixim, and an antifungal compound, fluconazole, were introduced while maintaining the same components as TCE-3. Following one month of incubation (276 test tubes), no callus growth was observed, and neither fungal nor bacterial contamination was detected. In TCE-5, due to inhibited callus growth, the use of antibacterial and antifungal compounds was omitted while retaining all other components from the previous experiment. Despite incubating 210 tubes, the rate of callus formation remained unchanged, and a majority of the test tubes became contaminated by fungi. In Tissue Culture Experiment-6, an additional sterilant was introduced. Explants underwent a dual sterilization process: first treated with 1.5% sodium hypochlorite for 5 minutes followed by triple rinsing with double-distilled water, then sterilized with 0.1% $HgCl_2$ for 15 minutes and again washed thrice with double-distilled water. This alteration resulted in significant callus formation, with callus observed in 76 out of 120 test tubes, while fungal contamination was notably reduced (Table 11).

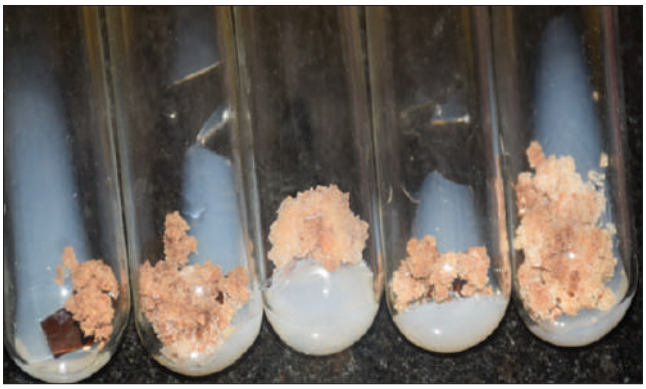
Table: 11. Details on the callus formation in different experiments.

Experiment	No. of test tubes	No. of callus formed	No. of fungal contamination	No growth/ No contamination	Callus formation (%)
TCE-1	92	0	77	15	0
TCE-2	106	0	95	11	0
TCE-3	126	8	84	34	6.34
TCE-4	276	0	0	276	0
TCE-5	210	17	167	26	8.09
TCE-6	120	76	13	31	63.33

Note: TCE-1: sterilant - 1.5% Sodium Hypochlorite (15 min), explants were immersed in liquid MS medium containing 250 mg/L each of citric acid and ascorbic acid for one hour to prevent browning, Solid MS media having 1 mg/L of 6-benzylaminopurine (6-BAP), 1.5 mg/L of 2,4-dichlorophenoxyacetic acid (2,4-D), and incubation in MS media containing 250 mg/L each of citric acid and ascorbic acid, TCE-2: sterilant - 1.5% Sodium Hypochlorite (20 min) + TCE-1, TCE-3: sterilant - 0.1% $HgCl_2$ (15 min) + TCE-1, TCE-4: sterilant - 0.1% $HgCl_2$ (15 min), antifungal (fluconazole) & antibacterial (cefixim) explants + TCE-1, TCE-5: sterilant - 0.1% $HgCl_2$ (15 min), TCE-1 and TCE-6: sterilant - 1.5% sodium hypochlorite for 5 minutes followed by triple rinsing with double-distilled water, then sterilized with 0.1% $HgCl_2$ for 15 minutes and again washed thrice with double-distilled water; + TCE-1



Early callus



Late callus

Plate-4. Callus formation in different treatments

2. Development and Refinement of Integrated Production Technologies for Improved Productivity of Litchi

2.1. Investigation on mycorrhizal association and role of bio-fertilizers for sustainable production of litchi

The trial is being undertaken to study the effect of biofertilizer application in litchi *cv.* 'Shahi'. The treatments comprised of combinations of AMF (Arbuscular mycorrhizal fungi), AZ *(Azotobacter chroococcum)*, TR *(Trichioderma viride)*, BM *(Bacillus megatarium)* and RDF (Recommended dose of fertilizer) which were compared to untreated control trees.

Effect of tree girdling on mycorrhizal colonization and other rhizosphere microbes

The experiment aimed to assess the effect of tree girdling on mycorrhizal colonization and microbial populations in the rhizosphere of litchi trees. Conducted in a two-factor randomized block design (RBD) at the NRCL farm in 2023, six trees with similar age, height, and canopy size were selected-three trees were girdled, and three were left non-girdled as controls. Girdling was performed on 11th September 2023, and observations were taken at intervals (before girdling, 15 days after girdling, and monthly thereafter). The treatments involved analysing AMF root colonization and microbial populations using serial dilution and CO_2 respiration methods. The experiment examined the effect of tree girdling on mycorrhizal colonization and rhizosphere microbes in litchi roots over time (0 days, 3 months, and 6 months). Results showed that non-girdled trees had consistently higher arbuscular mycorrhizal fungi (AMF) colonization percentages compared to girdled trees. At the beginning (0 days), AMF colonization in non-girdled trees was 54%, compared to 46.3% in girdled ones. Three months after girdling, AMF colonization in non-girdled trees remained stable at 53.2%, whereas in girdled trees, it dropped to 22.8%. After six months, non-girdled trees showed the highest total colonization at 63.5%, while girdled trees reached only 24.8%. The findings suggest that tree girdling significantly reduces mycorrhizal colonization over time, which could negatively affect nutrient uptake and overall plant health. Non-girdled trees maintained higher colonization levels, indicating better microbial support in the rhizosphere, potentially enhancing tree resilience and growth. While girdling may be useful for assured flowering and fruiting in girdled branches, it can negatively affect beneficial soil organisms critical for nutrient uptake and tree health.

Dynamics of population of other microbes (*Trichoderma spp.*, phosphate-solubilizing bacteria, and *Azotobacter spp.*) over an 8-month period in rhizosphere of girdled and non-girdled trees at NRCL Farm. In girdled trees, a sharp decline in all microbial populations was observed, with Trichoderma spp. dropping from 57.6 to 1.9 cfu $\times 10^2$/10g of soil, PSB from 56.3 to 1.7 cfu $\times 10^3$/10g, and *Azotobacter spp.* from 18.9 to 1.6 cfu $\times 10^3$/10g. In contrast, non-girdled trees maintained much higher microbial populations, with only slight decreases over time. For instance, *Trichoderma spp.* remained stable, declining modestly from 63.0 to 44.6 cfu $\times 10^2$/10g, while PSB and *Azotobacter spp.* showed similar resilience, maintaining high counts throughout the 8 months. Thus results highlight that girdling significantly disrupts the microbial balance in the rhizosphere, leading to a drastic decline in beneficial microbes such as *Trichoderma spp.*, PSB, and *Azotobacter spp.*

Table: 12. AMF colonization (%) of fine roots of litchi, 2023-24.

	0 D				3 M				6 M			
	A	V	A+V	Total	A	V	A+V	Total	A	V	A+V	Total
Girdled	32.3 (28.4-36.2)	10.7 (9.6-13.4)	3.3 (3.0-3.6)	46.3	16.6 (10.3-19.6)	4.3 (3.1-9.9)	1.9 (1.3-2.3)	22.8	16.6 (13.0-24.0)	7.9 (7.2-10.0)	0.3 (0.0-0.6)	24.8
Non-girdled	34.0 (32.1-36.6)	14.7 (10.4-16.0)	5.3 (3.9-6.3)	54.0	36.0 (30.9-39.3)	10.6 (9.0-12.3)	6.6 (3.6-6.9)	53.2	40.3 (34.1-43.9)	13.9 (10.4-17.0)	9.3 (5.0-10.6)	63.5

***0 D** = Before Girdling* ***3 M** = 3 Months after girdling* ***6 M** = 6 months after girdling*

Value in parenthesis is range* ***A = Arbuscular colonization* ***V** = Vesicular colonization*

Table: 13. Dynamics of microbial population in rhizosphere of girdled and non-girdled trees at NRCL Farm during 2023-24.

Treatment (T)	Time duration interval (D)									
	Before girdling	15 DAG	1 Month	2 Month	3 Month	4 Month	5 Month	6 Month	7 Month	8 Month
Trichoderma spp. (cfu×10^2/10 g of soil)										
Girdled	57.6	49.0	41.7	38.3	26.0	20.3	16.6	11.3	6.4	1.9
Non-girdled	63.0	69.3	67.0	63.3	57.6	55.9	52.3	50.0	48.9	44.6
	T			D			T×D			
LSD (p≤0.05)	1.71			3.21			5.04			
SEm (±)	0.61			1.20			2.11			
Phosphate Solubilising Bacteria (cfu ×10^3/10 g of soil)										
Girdled	56.3	46.0	39.9	34.0	26.0	21.6	18.1	7.6	6.2	1.7
Non-girdled	54.0	47.3	50.4	48.3	42.7	40.3	44.7	39.0	44.4	43.0
	T			D			T×D			
LSD (p≤0.05)	1.31			3.12			4.23			
SEm (±)	0.46			1.11			1.61			
Azotobacter spp. (cfu ×10^3/10 g of soil)										
Girdled	18.9	16.0	12.7	11.3	8.1	6.0	4.2	2.1	2.0	1.6
Non-girdled	19.6	17.7	15.0	14.7	15.0	15.7	16.0	15.3	14.4	16.4
	T			D			T×D			
LSD (p≤0.05)	1.20			2.73			3.16			
SEm (±)	0.31			1.04			1.33			

T=Treatment D=Duration (Time interval) DAG= Days after girdling cfu= Colony forming unit

Effect of *in-situ* mycorrhization on nutrient availability and microbial activity in litchi tree rhizosphere

The symbiotic relationship between finger millet or ragi *(Eleusine coracana),* mycorrhizal fungi, and litchi trees fosters a sustainable approach to improving tree vigour and orchard productivity. In this background, *In-situ* mycorrhization experiment was carried out in litchi orchard. Mycorrhizal culture was applied @10 kg per acre and finger millet (a host plant for multiplication of AMF) was sown in the orchard. Microbial population, as reflected by soil CO_2 flux and soil nutrient availability was monitored. The result showed that *in-situ* mycorrhization positively affected both macronutrient (N, P, K) and micronutrient (S, Cu) levels in the soil and tree leaves, as well as microbial activity in terms of soil respiration.

i). Soil macro-nutrient nontent (N, P, K): The *in-situ* mycorrhization led to a noticeable increase in available nitrogen (N), available phosphorus (P), and available potassium (K) levels in the rhizospheric soil. N increased by up to 8.9%, P by 66.6%, and K by 41.3% in treated soils, while the control showed a slight decline in all three nutrients (Table 14).

ii). Content of of available micronutrient in the soil (S, Zn, Cu, Fe): Sulphur (S) content increased by 30% in some cases, and copper (Cu) levels saw a moderate increase (up to 14.52%). Zinc (Zn) and iron (Fe) levels either slightly decreased or showed only minor changes. The control also showed slight reductions in Zn, Cu, and Fe levels (Table 15).

iii). Leaf Nutrient Content (N, P, K): Nitrogen (N) and phosphorus (P) content in the leaves improved slightly after mycorrhization, with P increasing by up to 30%. Potassium (K) content exhibited small declines of up to 2.17%, while the control showed a more significant K reduction of 6% (Table 16).

iv). Microbial Activity (Soil Respiration): The microbial activity, as indicated by soil respiration rates, increased in all the sampled tree rhizosphere soil, with improvements ranging from 2.52% to 11.76%. The control tree, however, saw a significant decrease of 13.89% in microbial activity (Table 17).

These changes indicate enhanced nutrient availability and microbial functioning, contributing to better soil health and nutrient uptake by litchi trees. In the control tree rhizosphere, on the other hand, either stagnation or decline in nutrient levels and microbial activity was recorded.

Table: 14. Effect of *in-situ* mycorrhization on available N, P and K in rhizospheric soil.

Soil Samples	16-07-24 (Initial)			16-09-24 (Final)			Change (%)		
	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)	Avail. N	Avail. P_2O_5	Avail. K_2O
1	267.01	10.78	117.210	274.03	17.96	165.62	2.6	66.6	41.3
2	275.35	13.94	169.413	285.04	19.85	212.887	3.5	42.4	25.7
3	250.32	15.61	188.038	272.60	18.17	217.676	8.9	16.4	15.8
4	272.04	18.12	210.801	284.42	20.44	244.773	4.6	12.8	16.1
5	278.20	15.78	176.267	286.63	19.52	216.727	3.0	23.7	23.0
6	267.40	14.81	212.257	282.33	21.64	215.87	5.6	46.1	1.7
Control	251.30	11.17	123.710	247.46	10.82	118.32	-1.5	-3.1	-4.4

Table: 15. Effect of *in-situ* mycorrhization on available micronutrient content in rhizospheric soil of litchi trees.

Soil Samples	16-07-24 (Initial)				16-09-24 (Final)				Change (%)			
	S (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	S (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	S	Zn	Cu	Fe
1	0.10	8.96	5.11	92.10	0.13	8.88	5.31	74.50	30.00	-0.89	3.91	-19.11
2	0.14	9.98	7.01	89.70	0.15	9.10	6.45	81.40	7.14	-8.82	-7.99	-9.25
3	0.09	8.87	6.20	89.60	0.11	8.30	7.10	72.91	22.22	-6.43	14.52	-18.63
Control	0.12	9.27	6.03	90.14	0.12	8.70	6.23	80.43	0.00	-6.15	3.32	-10.77

Table: 16. Effect of in-situ mycorrhization on N, P and K content of leaves of litchi trees.

Leaf Samples	16-07-24 (Initial)*			16-09-24 (Final)*			Change (%)		
	N %	P %	K %	N %	P %	K %	N %	P %	K %
1	1.37	0.23	1.00	1.37	0.23	0.94	0.71	17.39	-1.06
2	1.40	0.23	0.94	1.41	0.27	0.93	4.23	30.00	-2.17
3	1.42	0.20	0.92	1.48	0.26	0.90	-3.73	4.76	2.17
Control	1.34	0.21	0.92	1.29	0.22	0.94	0.00	0.00	-6.00

**Dry weight basis*

Table: 17. Effect of *in-situ* mycorrhization on microbial activity measured as soil respiration values.

Soil Samples	Soil Respiration Rate grams (CO_2) m^{-2} hr^{-1}		% Change
	16-07-24 (Initial)	16-09-24 (after Mycorrhization)	
1	1.43	1.54	7.69
2	1.17	1.20	2.56
3	1.19	1.22	2.52
4	0.67	0.69	2.99
5	0.70	0.74	5.71
6	0.34	0.38	11.76
Control	0.72	0.62	-13.89

2.2. Integrated soil health management for quality litchi production

An experiment was conducted with organic and inorganic treatments to determine the best treatment combination for sustainable litchi production while maintaining soil health. Soil samples were sampled and analysed for different nutrient parameters. Results (Table 18) revealed that available nitrogen was highest in treatment T1 due to the effect of a higher fertiliser nitrogen dose and enhanced microbial activity of free-living nitrogen-fixing azotobacter. All the treatments concerning available nitrogen were found to be significantly higher over the control. Soil available phosphorus was observed to be highest in T_4 treatment due to the addition of phosphorus fertiliser and high organic input, which enhanced higher phosphorus-solubilising bacteria activity. All the treatments except T_7 were observed to be significantly higher over control, while T_7 was at par with control. Soil available potassium was observed to be highest under the treatment T_4 due to high potassium fertiliser input and high organic matter addition, enhancing microbial activity. All treatments resulted in significant increase in available potassium over the control. Litchi fruit yield per tree was highest under treatment T_4 as a combined effect of organic + inorganic dose. Among all the treatments, T_2 treatment was more sustainable and eco-friendly as it utilised a lower input fertiliser dose (half phosphorus and half potassium) compared to T_4, while the yield of both the treatments were at par.

2.3. Standardizing leaf sampling technique in litchi for Alluvial plain of Bihar

Monthly leaf samples of Litchi *cv.* Shahi were collected from July 2023 to June 2024 and processed as per the standard protocol. The analysed data (Table 19) of total nitrogen revealed that the highest nitrogen (1.89%) was observed in March, while the lowest (1.16%) was observed in August. It was observed that after January, there was a gradual increase and attained a peak in March and decreased thereafter. Leaf total phosphorus was found to be highest (0.29%) in the month of August and the lowest in March (0.13%). The P% decreased gradually, December onwards up to March (lowest), and then increased. The analysed leaf total K% was found to be lowest in the month of October

and highest in May. From the Jan, K% gradually increased, and the peak (highest) was observed in March, then decreased. From January to April total K% remained almost stable and peaked in May, thereafter decreased. Total Sulphur in litchi leaf was found to be highest in October (0.155%) and lowest (0.085%) in April. Two peaks were observed in month of October and March. Leaf Zn content was observed to be highest in November, while lowest in February. Litchi leaf copper content was observed to be highest in the month of March and lowest in October. Leaf Iron content was found to be highest (112 ppm) in July while lowest in February (60.05 ppm).

Table: 18. Soil nutrient status and fruit yield under different treatment.

Treatment	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Yield (kg/ plant)
T_1 : (1000:550:1000)+ FYM 35 kg + ATP	347.41	18.1	155.75	49.16
T_2 : (500:275:500)+ FYM 70 kg + ATP	315.23	15.52	121.59	46.66
T_3 : (1000:550:1000)	337.21	19.22	147.89	42.08
T_4 : (500:550:1000)+ FYM 70 kg + ATP	324.53	24.1	171.31	56.51
T_5 : (500:550:1000)+FYM35kg+ATP	287.95	20.43	157.81	39.91
T_6 : (FYM70 kg+ATP)	274.3	13.37	114.8	35.4
T_7 : (FYM35 kg+ATP)	272.21	8.71	105.21	29.12
T_8 : Control	228.45	7.1	92.94	25.4
C.D.	10.11	2.29	1.29	10.91
SE(m) ±	3.39	0.71	0.41	3.88

*(**T:** treatments, Biofertilizers, **A:** Azotobacter, **T:** Trichoderma and **P:** Phosphorus-solubilising bacteria, applied @ 100 g each per tree)*

Table: 19. Nutrient content in litchi leaves at monthly intervals.

Month	N (%)	P (%)	K (%)	S (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)
Jul-23	1.29	0.26	0.99	0.14	8.41	4.40	112.05
Aug-23	1.16	0.29	0.98	0.11	9.88	7.53	88.80
Sep-23	1.21	0.28	0.95	0.13	9.32	4.83	88.65
Oct-23	1.29	0.28	0.90	0.15	9.98	1.96	88.85
Nov-23	1.24	0.21	1.01	0.11	10.80	3.73	75.30
Dec-23	1.41	0.22	1.06	0.10	8.33	3.83	61.50
Jan-24	1.26	0.22	0.97	0.09	7.86	3.53	68.05
Feb-24	1.39	0.20	1.03	0.09	7.12	4.23	60.05
Mar-24	1.89	0.12	0.97	0.11	7.79	16.80	93.40
Apr-24	1.18	0.23	0.97	0.08	9.62	8.60	73.10
May-24	1.35	0.22	1.17	0.08	8.55	6.50	67.75
Jun-24	1.42	0.21	1.00	0.09	8.54	3.93	75.40
C.D.	0.01	0.006	0.008	0.007	0.48	0.87	4.48
SE(m) ±	0.005	0.002	0.003	0.002	0.16	0.29	1.51

To assess the nutrient status of litchi leaf at different positions (Table 20) of the leaflet, leaf sampling was done at the pre-flowering stage, and samples were processed as per standard protocol. The total nitrogen of the leaf sample followed the increasing trend from the first pair to the fourth pair. The total phosphorus of the leaf increased from the first pair to the second pair, then it decreased onward to the fourth pair of leaves. Litchi leaf total potassium data revealed that it increased from the first to the third pair and then decreased to the fourth pair. Litchi leaf S% remained the same from the first pair leaf to the second pair, and thereafter it increased gradually till the fourth pair. Leaf Zn initially decreased sharply from the first pair leaf to the second pair leaf, and then it gradually increased till the fourth pair. The leaf Fe content ppm showed a trend of decreasing from the first to the fourth pair. Copper content in litchi leaf initially it decreased from the first to the second leaf pair, then increased in the third pair, and finally Cu% decreased in the fourth leaf pair.

2.4. Nutrient management in Litchi (Litchi chinensis Sonn.) orchard using Diagnosis and Recommendation Integrated System (DRIS)

Nutrient status of the Litchi orchards of Bihar

A nutritional survey of litchi orchards was conducted in the most productive zone of Bihar, *viz.* Muzaffarpur, East Champaran, Vaishali, Samastipur and Sitamarhi. The samples of leaf and soil were collected from 33 litchi orchards and analysed as per standard protocol. Leaf N% ranged between 1.41% to 2.17% while the mean value was 1.76%. Nitrogen % was found low, high and uptimum categories in 39.4%, 21.2% and 39.4% of the orchards (Table 21). Total P % ranged between 0.11% to 0.36% with mean value of 0.20%. 45.5% of the orchards were onserved to be in low phosphorus category. The leaf potassium content ranged between 1.08 to 2.14% with a mean value of 1.5%. Only 18.2% of the orchards were recorded under low potassium category. The sulphur content of leaf samples ranged between 0.054 to 0.163% and 69.9% of the orchards were recorded under 'low' category. The Zn in litchi leaf ranged between 6.49 to 40.77 ppm, while 84.8% orchards were recorded under low category. The Cu in litchi leaf ranged between 0.40 to 10.30 ppm while 75.8% of the orchards were recorded under low category. The Fe content ranged between 158 ppm to 304.2 ppm, and all surveyed orchards, Fe was observed in the high category of nutritional status.

2.5. Development of plant canopy architecture in litchi (ICAR-AICRP on Fruits)

The effect of plant architecture on yield and quality of litchi fruits was evaluated under different branching combinations comprising 2, 3 and 4 primary branches each retaining 2, 3 and 4 secondary branches. The maximum plant height (4.32 m) and canopy volume (334.53 m^3) was measured in T_8. The maximum fruit weight (21.81 g) was recorded in T_7 whereas, number of fruits/tree (1926.00) and yield (40.48 kg/tree) were recorded with the treatment T_9 (Table 22).

2.6. Irrigation scheduling in litchi (ICAR-AICRP on Fruits)

The trial consists of irrigation at 50% ER, 75% ER, 100% ER and control (calendar schedule). It was laid out to determine the optimum irrigation requirement in litchi. The effect of different drip irrigation treatments and mulching was assessed and it was found that all mulching treatment gave higher yield than non-mulched treatments and control. Significantly higher fruit yield (48.57 kg/plant) and fruit weight (22.83 g) was recorded in T3 (100% ER + M) (Table 23). The soil moisture content under different treatments was also measured using the Profile probe and it was found that mulched treatments retained maximum moisture during the fruiting season (Fig. 1.).

Table: 20. Nutrient content in litchi leaves at different leaf pair position.

Leaf pair	N (%)	P (%)	K (%)	S (%)	Zn (ppm)	Fe (ppm)	Cu (ppm)
First pair	1.44	0.13	0.91	0.10	10.40	117.50	7.00
Second pair	1.57	0.14	0.93	0.10	6.19	96.30	4.05
Third pair	1.56	0.13	1.01	0.16	7.19	93.25	6.25
Fourth pair	1.61	0.11	0.93	0.17	7.89	94.45	2.60
C.D. at 5%	0.01	0.01	0.01	0.01	0.30	7.33	1.08
SE(m) ±	0.003	0.002	0.00	0.003	0.08	2.08	0.31

Table: 21. Litchi leaf nutrient status into low, optimum and high of surveyed orchard.

Nutrients	Low nutrient status (%)	Optimum nutrient status (%)	High nutrient status (%)
N%	39.4	39.4	21.2
P%	45.5	30.3	24.2
K%	18.2	75.8	6.1
S%	69.9	33.3	0.0
Zn ppm	84.8	3.0	12.1
Fe ppm	0.0	0.0	100.0
Cu ppm	75.8	24.2	0.0

Table: 22. Effect of canopy architecture on growth, yield and fruit quality of litchi in 2024

Treatment		Plant height (m)	Canopy volume (m^3)	TCSA (cm^2)	Light interception in (lux)	No. of fruit / tree	Yield (kg/tree)	Fruit weight (g)
T_1	P_2S_2	3.42	220.83	254.14	4047.5	1628.00	32.46	19.96
T_2	P_2S_3	3.61	264.14	263.72	2410.0	1867.75	38.81	20.78
T_3	P_2S_4	3.67	280.87	250.21	3397.5	1841.75	37.29	20.23
T_4	P_3S_2	3.58	251.48	245.22	3242.5	1671.75	33.91	20.29
T_5	P_3S_3	3.64	271.41	269.36	2787.5	1615.25	34.91	21.61
T_6	P_3S_4	3.08	181.06	228.40	4247.5	1619.50	34.17	21.09
T_7	P_4S_2	3.43	253.48	255.22	2590.0	1722.00	37.55	21.81
T_8	P_4S_3	4.32	334.53	271.38	1305.0	1807.50	37.55	20.79
T_9	P_4S_4	4.14	317.98	264.86	1365.0	1926.00	40.48	21.02
T_{10}	Control	3.65	273.01	292.22	3090.0	1804.25	34.67	19.22
LSD		0.51	88.14	59.75	183.18	183.18	2.64	1.16
SE(m)		0.17	30.37	20.59	63.13	63.13	0.91	0.40
C.V.		9.75	22.93	15.87	44.32	44.32	5.04	3.89

Table: 23. Effect of irrigation treatments on growth, yield and fruit quality of litchi *cv.* Shahi.

Treatment		Plant height (m)	Canopy volume (m^3)	Yield (kg/tree)	Fruit weight (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/ 100 ml juice)
T_1	M_1I_1	5.10^{ab}	532.24^{ab}	42.12^{bc}	19.66^{bc}	20.06^{a}	0.70^{b}	40.33^{a}
T_2	M_1I_2	5.01^{ab}	467.32^{ab}	43.01^{b}	21.46^{ab}	19.56^{a}	0.94^{ab}	42.16^{a}
T_3	M_1I_3	5.30^{a}	580.30^{a}	48.57^{a}	22.83^{a}	19.50^{a}	1.17^{ab}	40.33^{a}
T_4	M_2I_1	4.96^{ab}	462.85^{ab}	38.48^{d}	20.00^{bc}	19.43^{a}	1.34a	33.00^{a}
T_5	M_2I_2	4.93^{ab}	383.57^{b}	39.12^{cd}	20.93^{ab}	19.00^{a}	1.0^{ab}	45.83^{a}
T_6	M_2I_3	5.01^{ab}	420.49^{ab}	42.08^{bc}	22.26^{ab}	20.40^{a}	0.94^{ab}	29.33^{a}
T_7	Control	4.75^{b}	415.24^{ab}	38.26^{d}	19.00^{c}	19.73^{a}	1.20^{ab}	27.50^{a}
LSD		0.50	183.63	3.15	2.72	1.78	0.52	21.49
SE(m)		0.16	59.59	1.02	0.88	0.57	0.17	6.97
C.V.		5.68	22.15	4.18	7.37	5.10	28.20	32.71

Notes: *Superscript in small letters indicate significant difference at P < 0.05.*

Plate-4. Field view of canopy architecture in litchi

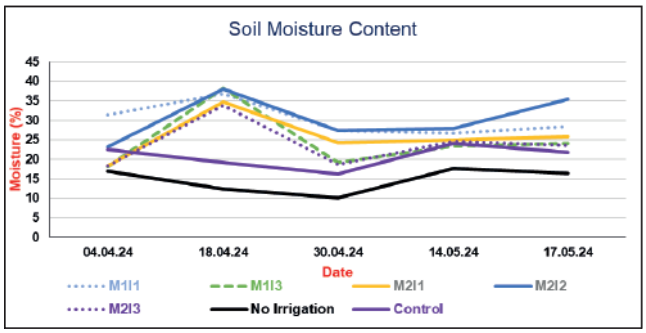


Fig. 1. Effect of irrigation treatments on soil moisture content during fruiting season 2024

2.7. Management of fruit cracking in Litchi

Fruit cracking is a major physiological disorder that adversely affects litchi production and quality. The cracking of litchi fruit is a significant issue for the Shahi cultivar. Several horticultural practices, including the application of growth promoters, micronutrients, balanced water supply, and mulching, have been suggested to manage fruit cracking in different fruit crops. With increasing severity of summer temperature during the last few years, there is a need for identification of newer options for minimizing the incidence of fruit cracking. Keeping in mind the positive effects of nutrients, PGRs and bagging, the experiment is being undertaken to elucidate their impact on fruit cracking in litchi *cv.* Shahi during the 2024 production cycle.

Bagging was performed in litchi bunches 30 days after fruit set. The nutrients and bio regulators were applied during the first week of May and the under canopy micro-sprinkler was operated for 1 hrs. (11.00 AM to 12.00 PM) daily for two weeks (10th May to 25th May). Different treatments significantly reduced the fruit cracking and scorching percentage in litchi *cv.* Shahi. The minimum fruit cracking (0.00 %) was recorded in case of Bagging with white colour polypropylene bags 30 days after fruit set. Similarly, the scorching percentage was also significantly reduced by different treatments as compared to the control. As evident in the Fig. 2. the treatments Bagging with white colour polypropylene bags 30 days after fruit set; use of under-canopy micro sprinkler; Bagging with pink colour polypropylene bags 30 days after fruit set; foliar application of salicylic acid @ 50 ppm and foliar application of sea weed extract (Sagarika liquid @ 0.5%) were found to be most effective in minimizing the incidence of fruit cracking and scorching in litchi.

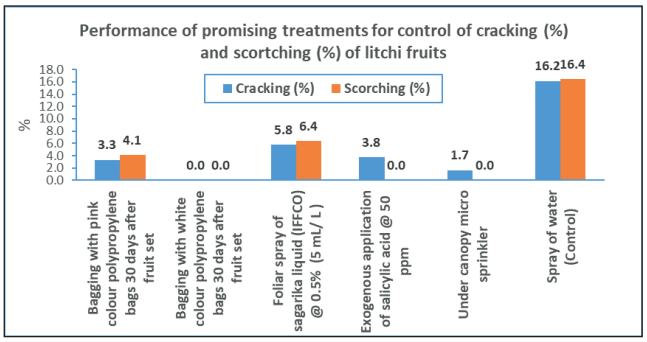


Fig. 2. Effect of different treatments on fruit cracking and scorching of Litchi *cv.* Shahi

3. Development and refinement of integrated crop protection technologies for improved productivity of litchi

3.1. Investigation and management of pre-harvest diseases of litchi

Disease incidence and severity of leaf, panicle and fruit blight

Blights disease caused by *Alternaria alternata* is a significant disease of litchi affecting it at multiple stages- beginning with leaf blight in nursery plants, and later progressing to panicle and fruit blight- ultimately reducing plant vigour, flowering, and fruit yield. The incidence and severity of leaf blight disease in nursery plants in 2024 were recorded on monthly basis. The mean disease incidence (DI) between July to October was higher and ranged from 17.56-32.48 %. The mean percent of infected leaves (IL) was noted to be from 25.3 to 52.6 %. Additionally, the percent of disease severity index (PDI) ranged from 38.67 to 65.39. The peak time period for the development of blight disease was found to be from July to September, and disease incidence and severity was lower during November to January. As the litchi crop matures, *Alternaria alternata* continues to pose a serious threat by

causing panicle and fruit blight, which can severely impact flowering, fruit set, and overall marketable yield. During 2024, similar observations to previous year (2023) were recorded for having higher panicle blight incidence in farmer's field as compared to NRCL farm. The five selected orchards (I-V) at NRCL farm revealed different range of mean incidence of panicle blight and noted to be 54.0% (range 32.0-71.9%), 62.8% (range 41.8-75.4%), 62.6% (range 55.6-66.8%), 77.9% (range 74.5-80.5%) and 58.6% (range 48.7-65.8%), respectively. The data on mean percent distribution of trees in different levels of panicle blights showed that trees in ≤ 20%, 21–40%, 41–60%, 61–80% and > 80% blighted panicles in surveyed orchards were 82.9-91.7, 8.3-17.0, 0, 0 and 0%, respectively. These findings showed that the maximum numbers of trees at NRCL farm were having less than 20% blighted panicles.

On the other hand, the five selected orchards (I-V) at farmers' orchard in Muzaffarpur, Bihar revealed different range of mean incidence of panicle blight and noted to be 72.26% (range 55.5-89.5%), 73.2% (range 61.8-88.6%), 71.8% (range 52.6-91.2%), 82.4% (range 72.7-92.5%) and 86.4% (range 78.2-86.4%), respectively. The data on mean percent distribution of trees in different levels of panicle blights showed that trees in ≤ 20%, 21–40%, 41–60%, 61–80% and > 80% blighted panicles in surveyed orchards were 88.6-93.6, 6.4-11.5, 0, 0 and 0%, respectively. These findings showed that the maximum numbers of trees at NRCL farm were having less than 20% blighted panicles. In another survey of the cultivar 'China' at NRCL experimental farm and farmers' field, incidence of fruit blight was also recorded. The mean disease incidence of fruit blight on trees in farmers' orchard in Muzaffarpur, Bihar during June 2024 varied from 15.8 to 26.7% while the range was 4.9-31.4%.

Table: 24. Disease incidence and severity of panicle blight during 2024 season.

Orchard No.	NRCL farm					Mean	Farmer's Orchard					Mean
	I	II	III	IV	V		I	II	III	IV	V	
Disease incidence (%)												
10-04-2024	32.0	41.8	55.6	74.5	48.7	50.5	55.5	61.8	52.6	72.7	78.2	64.2
20-04-2024	58.2	71.3	65.5	78.9	61.3	67.0	71.8	69.2	71.7	81.9	85.3	75.9
30-04-2024	71.9	75.4	66.8	80.5	65.8	72.1	89.5	88.6	91.2	92.5	95.6	91.5
Mean	54.0	62.8	62.6	77.9	58.6	63.2	72.3	73.2	71.8	82.4	86.4	77.2
Percent distribution of trees in different level of blighted panicles												
<20%												
10-04-2024	91.8	89.2	91.5	92.7	97.0	92.4	94.2	91.5	90.7	95.3	99.5	94.2
20-04-2024	85.5	82.8	87.2	91.5	91.0	87.6	92.1	90.2	88.1	89.4	91.4	90.3
30-04-2024	71.6	78.0	82.6	88.4	87.0	81.5	89.8	85.4	86.8	85.5	90.0	87.5
Mean	82.9	83.3	87.1	90.9	91.7	87.2	92.0	89.0	88.5	90.1	93.6	90.7
21-40%												
10-04-2024	8.2	10.8	5.5	1.3	3.0	7.6	5.8	8.5	9.3	4.7	0.5	5.8
20-04-2024	14.5	17.2	12.8	8.5	9.0	12.4	7.9	9.8	11.9	10.6	9.6	9.8
30-04-2024	28.4	22.0	17.4	11.6	13.0	18.5	10.2	14.6	13.2	14.5	10.0	12.5
Mean	17.0	16.7	12.9	9.1	8.3	12.8	7.9	10.9	11.5	9.9	6.4	9.3
41-60%												
10-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
20-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
30-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0
61-80%												
10-04-2024	0	0	0	0	0	0	0	0	0	0	0	0

Orchard No.	NRCL farm					Mean	Farmer's Orchard					Mean
	I	II	III	IV	V		I	II	III	IV	V	
20-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
30-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0
>80%												
10-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
20-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
30-04-2024	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Plate-5. Panicle blight symptoms on a litchi tree

Evaluation of fungicides for management of *Alternaria* disease of litchi

Ten different fungicides were evaluated against fruit blight *(Alternaria alternata)* disease under natural infection field conditions. Results showed that the disease incidence of fruit blight was 0.3-7.0% in fungicidal treatments as against 10.0% in control trees of orchard at NRCL experimental farm. Amongst the ten selected fungicides, only five namely Azoxystrobin 23% SC, Difenoconazole 25% EC, Thiophanate methyl 70% WP, Carbendazim 50% WP and Metiram 55%+ Pyraclostrobin 5% WG were observed to be more effective in controlling fruit blight disease. Cost benefit ratio (C:B ratio) for recommended fungicides were found to be 1:3.93 to 1:4.91 for thiophanate methyl, 1:2.77 to 1:3.46 for difenoconazole, and 1:2.32 to 1:2.90 for azoxystrobin.

3.2. Investigation and management of insect-pest complex of litchi

Effects of different insecticides on incidence of flower webber *(Dudua aprobola)* and stink bug *(Tessarotoma javanica)*

The study represents the efficacy of different combination of insecticides on stink bug and

flower webber populations. The insecticides combination: Lambda cyhalothrin 5% EC (1.5 ml/lit) + Chlorofenapyr (1.0 ml/lit), Lambda cyhalothrin 5% EC (1.5 ml/lit) + Dimethoate 30 EC (1.5 ml/lit), Thiachloprid 21.7% SC (0.5 ml/lit) + Fipronil (1.0 ml/lit) and Thiachloprid 21.7% SC (0.5 ml/lit) + Profenophos (1.5 ml/lit) were used for application at before-flower-open stage and immediately after fruit set, respectively, and their mortality per cent on flower Webber and stink bug population were recorded. The highest % reduction in webbed panicles of 72.41%, 79.31%, 93.10%, 94.82% and 96.55% was observed in Lambda cyhalothrin 5% EC + Dimethoate 30 EC at 24 hr, 48 hr, 72 hr, 1 week and 2 weeks after spray, respectively, followed by Thiachloprid 21.7% SC + Fipronil, Lambda cyhalothrin 5% EC (1.5 ml/lit) + Chlorofenapyr (1.0 ml/lit) and Thiachloprid 21.7% SC (0.5 ml/lit) + Profenophos (1.5 ml/lit) at before-flower-open stage (Table 26).

After the first spray, the maximum per cent reduction occurred with Thiachloprid 21.7% SC + Fipronil and Thiachloprid 21.7% SC + Profenophos at 24 hr after spray, 58.3% and 57.91%, respectively.

Table: 25. Effect of spray application of different fungicides on fruit blight, anthracnose cracking and sunburn in litchi.

Product used	Fungicide	Dose		Fruit Blight	Anthracnose (%)	Cracking (%)	Sunburn (%)
		Active ingredient (%)	Formulation (mL or g/L)				
Amistar	Azoxystrobin 23% SC	0.023	1.0	0.50	1.00	8.00	6.50
Amistar top	Azoxystrobin 18.2% w/w+ Difenoconazole 11.4% w/w SC	0.0182 + 0.0114	1.0	4.50	1.50	7.00	6.00
Battle ship	Azoxystrobin 11.5 + Mancozeb 30.0% WP	0.0115+ 0.030	1.0	5.00	2.50	9.00	8.00
Nativo	Tebuconazole 50% +Trifloxystrobin 25% WG	0.015+ 0.0075	0.3	4.00	1.00	6.00	7.00
Score	Difenoconazole 25% EC	0.025	1.0	0.50	1.50	4.00	6.50
Roko	Thiophanate methyl 70% WP	0.140	2.0	0.50	1.50	3.80	3.00
Cabrio Top 60 % WG	Metiram 55%+ Pyraclostrobin 5% WG	0.0825 + 0.0075	1.5	2.50	2.00	8.00	7.00
Indofil M-45	Mancozeb 75% W.P.	0.150	2.0	4.00	1.80	7.50	4.50
Saaf	Carbendazim 12% +Mancozeb 63% WP	0.024+ 0.126	2.0	6.50	4.80	3.00	6.50
Blitox	Copper oxychloride 50% WP	0.10	2.0	7.00	2.20	9.00	8.00
Bavistin	Carbendazim 50% WP	0.10	2.0	0.3	0.5	3.5	2.5
Control	Water spray	-	-	10.00	9.80	10.00	7.20
LSD		-	-	0.84	0.43	1.82	1.41
SE(m)±				0.28	0.17	0.66	0.47

Table: 26. Efficacy of different insecticide on flower webber population at application of 20 days and 10 days before harvesting.

Treatments	% reduction in webber population	
	24 hrs after spray (20 days before harvest)	24 hrs after spray (10 days before harvest)
Thiachloprid 21.7 %SC	22.22 ± 0.45 ^{d}	16.67 ± 1.67 ^{g}
Spinosad 45 %SC	66.67 ± 1.98 ^{a}	71.43 ± 3.90 ^{b}
Emamectin benzoate 5 % SG	66.67 ± 2.15 ^{a}	66.67 ± 2.76 ^{c}
Lambda cyhalothrin 5 % EC	20.00 ± 1.87 ^{d}	75.00 ± 3.54 ^{b}
Novaluron 10 % EC	25.00 ± 2.56 ^{d}	83.33 ± 4.67 ^{a}
Spinetoram 11.7 % SC	40.00 ± 3.45 ^{c}	37.50 ± 3.41 ^{f}
Broflanilide 20 % SC	50.00 ± 2.56 ^{b}	40.00 ± 2.43 ^{e}
Tetraniliprole 18.18 SC	42.85 ± 1.78 ^{b}	50.00 ± 1.78 ^{d}
Thiamethoxam 12.6 % + Beta cyhalothrin 9.5 %	60.00 ± 3.57 ^{a}	60.00 ± 2.56 ^{c}
Beta cyfluthrin 8.49 % + Imidachloprid 19.8 %	71.42 ± 4.15 ^{a}	83.33 ± 3.71 ^{a}
Emamectin benzoate + Lufenuron	14.29 ± 3.89 ^{d}	75.00 ± 2.78 ^{b}
F-value	674.04	304.073
P-value	< 0.05	< 0.05
LSD	7.95	7.21

Table: 27. Efficacy of different insecticide on stink bug population (spray at 20 days and 10 before harvesting).

Treatments	% Reduction in stink bug population	
	24 Hrs after spray (20 days before harvest)	24 Hrs after spray (10 days before harvest)
Thiachloprid 21.7 %SC	90.90 ± 2.56 ^{a}	83.24 ± 2.43 ^{b}
Spinosad 45 %SC	13.33 ± 3.21 ^{f}	18.18 ± 1.45 ^{d}
Emamectin benzoate 5 % SG	22.22 ± 2.21 ^{e}	25.00 ± 1.21 ^{c}
Lambda cyhalothrin 5 % EC	85.71 ± 3.21 ^{b}	91.66 ± 1.45 ^{a}
Novaluron 10 % EC	12.50 ± 2.21 ^{f}	23.07 ± 1.25 ^{c}
Spinetoram 11.7 % SC	30.00 ± 2.21 ^{d}	26.66 ± 1.43 ^{c}
Broflanilide 20 % SC	42.85 ± 2.22 ^{c}	18.18 ± 1.67 ^{d}
Tetraniliprole 18.18 SC	80.00 ± 3.21 ^{b}	82.35 ± 1.76 ^{b}
Thiamethoxam 12.6 % + Beta cyhalothrin 9.5 %	80.00 ± 1.14 ^{b}	84.61 ± 1.34 ^{b}
Beta cyfluthrin 8.49 % + Imidachloprid 19.8 %	98.78 ± 1.76 ^{a}	93.33 ± 1.32 ^{a}
Emamectin benzoate + Lufenuron	20.00 ± 1.45 ^{e}	21.42 ± 1.66 ^{c}
F-value	346.90	356.94
P-value	< 0.05	< 0.05
LSD	6.90	6.16

Metagenome analysis of different bacterias associated with diverse developmental stages of litchi stink bug

Specimens of the litchi stink bug *(Tessaratoma javanica)* were collected from litchi trees at the ICAR-NRC on litchi in Mushahari, Muzaffarpur, Bihar, India, during 2023. The processed samples were sent for metagenomics analysis of 16s RNA (V3-V4) region. The predominant bacterial phyla associated with *T. javanica* were Proteobacteria, Firmicutes, Bacteroidetes, Actinobacteria, Patescibacteria and Nitrospirota (Fig. 3). The dominance of Proteibacteria was more in 1st, 4th instar and adult female, while, Firmicutes are dominant in 3rd and 5th nymphal instar of *T. javanica*. While, among different classes of bacterial communities, Gammapropteobacteria dominated the *T. javanica* gut followed by Bacilli, Alphaproteobacteria and Bacteriodia. Gammaproteobacteria dominated the gut of 1st, 4th nymphal instar and adult female, while, in 3rd, 4th, and 5th nymphal instar the Bacilli were found to be dominated the microbial ecosystem of *T. javanica* gut (Fig. 4).

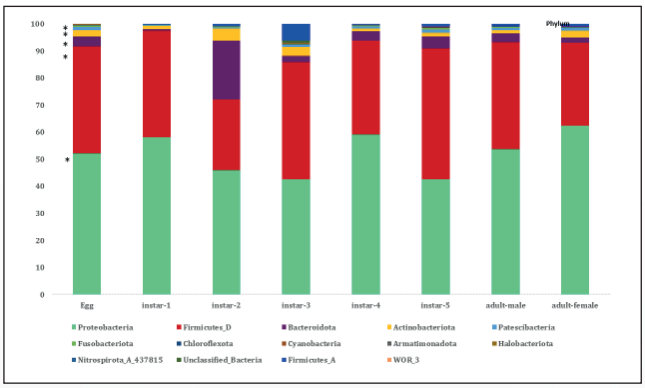


Fig. 3. The predominant bacterial phyla associated with *T. javanica*

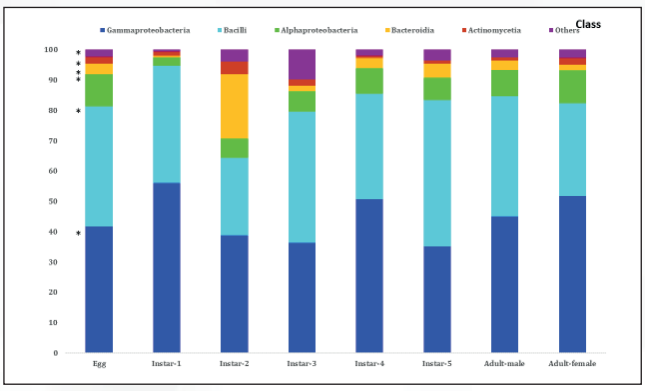


Fig. 4. The predominant bacterial classesassociated with *T. javanica*

The comparative analysis of bacterial communities associated with different developmental stages of the litchi stink bug *(T. javanica)* are particularly noteworthy when examining the differences between the egg, nymphal instars, and adult stages, as well as between male and female adults. The bacterial community composition in egg stage of *T. javanica* indicates a focus on foundational metabolic processes necessary for early development. While, the Bacterial communities are highly active in fatty acid and amino acid biosynthesis in diverse nymphal stages, reflecting the increased nutritional demands during rapid growth phases (Fig. 5). Characterization of the bacterial community phyla of litchi stink bug *(T. javanica)* using modular bipartite matrix analysis illustrates the modular organization of the microbial community by showing the interactions between several bacterial phyla and stink bug development. Significant emphasis is placed on phyla such as Proteobacteria, Firmicutes, and Bacteroidetes, demonstrating their widespread presence and interactions across several stages of pest life. The dominance of Proteobacteria is observed throughout all developmental stages, although Firmicutes D and Bacteroidota are particularly prominent in the second nymphal instar of the litchi stink bug, *T. javanica*.

Fig. 5. Functional profiling of different bacteria associated with female of litchi stink bug

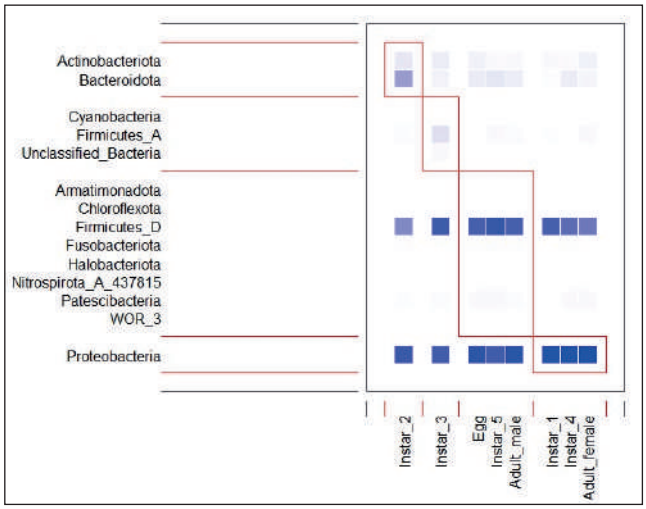


Fig. 6. Modular bipartite network of bacterial phyla associated with different developmental stages of stink bug

3.3. Understanding spatio-temporal changes in host-pests interactions and population dynamics of litchi under changing climate scenarios

Seasonal incidence of insect pest of litchi in relation to weather parameters.

Litchi stink bug, *Tessaratoma javanica:* The incidence of Litchi stink bug, *Tessaratoma javanica* first appeared in 1st SMW and lasted up to fruit harvesting (Fig. 7). The incidence of looper started from 1st week of January (1st SMW) with 1.2 larvae per plant and attained a peak population (14.2 larvae/plant) during second week of March (10th SMW) (Fig. 8). The incidence of Webber started from 1st week of January (1st SMW) with 5.2 larvae per 120 panicles per plant and attained a peak population (69.4 larvae/120 panicles/plant) during 3rd week of March (11th SMW) (Fig. 9). The incidence of scale, Drosicha mangiferae first appeared in 4th week of April and lasted up to fruit setting (Fig. 10). It was observed that, the scale insects population increased gradually and population was observed at 19th SMW. Thereafter, pest population declining till 20th SMW. Leaf folder *Statherotis leucaspis* incidence was started from 2nd week of May (19th SMW) with 18.2 larvae per 80 panicles per plant and attained a peak population (64.6 larvae/80 panicles/plant) during 2nd week of July (28th SMW) (Fig. 11). Ash weevil, Myllocerus sp. incidence started from 3rd week of April (16th SMW) with 0.97 weevil per plant and attained a peak population (4.69 weevil/plant) during 2nd week of May (19th SMW). Afterwards, a declining trend in population was observed 1st week of June (22th SMW). After 22th SMW, no further incidence of ash weevil was recorded (Fig. 12). The Red weevil, *Apoderus blandus* incidence was first observed in last week of June (26th SMW) with 0.4 adult per plant (Fig. 13).

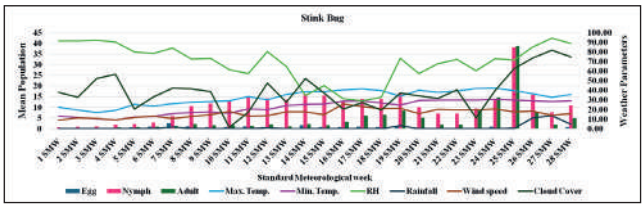


Fig. 7. Seasonal incidence of litchi stink bug, *Tessarotoma javanica*

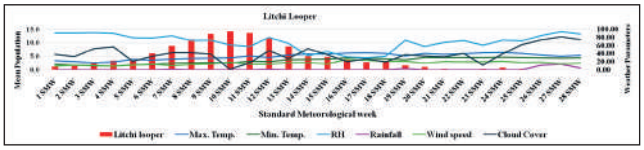


Fig. 8. Seasonal incidence of Litchi loopers

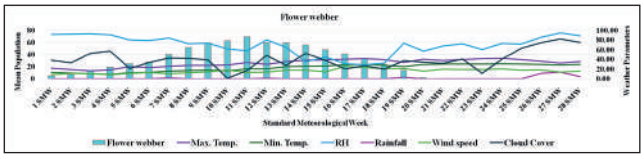


Fig. 9. Seasonal incidence of Flower webber, *Stherotis leucaspis*

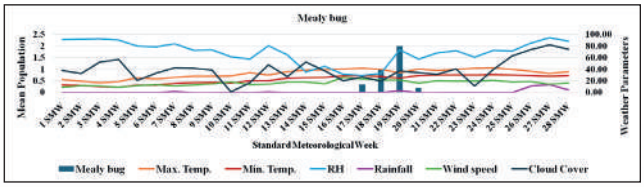


Fig. 10. Seasonal incidence of scale, *Drosicha mangiferae*

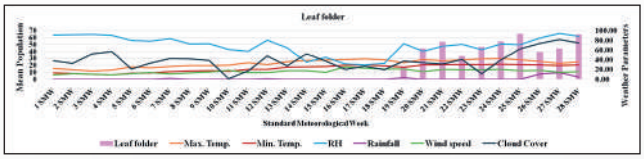


Fig. 11. Seasonal incidence of leaf folder, *Dudua aprobola*

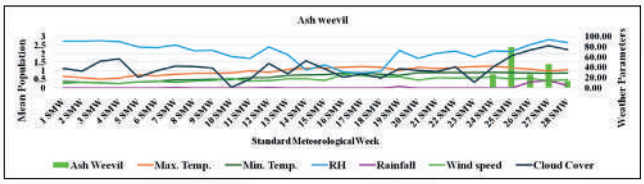


Fig. 12. Seasonal incidence of ash weevil, *Myllocerus sp*

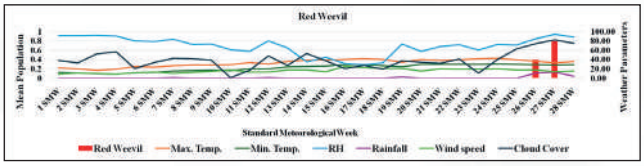


Fig. 13. Seasonal incidence of red weevil, *Apoderus blandus* in litchi

Alpha diversity of light trap collected insects from litchi orchard, ICAR-NRCL

In the study area, species richness (number of species), abundance (number of individuals) and various otherindices were used to assess species diversity. The value of alpha diversity indices *viz.* Simpson's index (0.97 & 0.96 in for *Dudua aprobola,* dung beetles and *Conopomorpha sinensis,* respectively) and dominance (highest for *Creatonotus gangis,* respectively) showed high species richness of *D.aprobola* and *C. sinensis* in the study area.The value of the Shannon index (3.56, 3.50 and 3.47 for *D. aprobola* and *C. sinensis, Perixera illepidaria* respectively) and Pielou's evenness (0.92, 0.87 and 0.87, respectively) indicates a more equitable distribution of species within a community. Several other alpha diversity indices were calculated and are presented in Table 28.

Table: 28. Diversity indices in insect biodiversity analysis in Litchi orchard.

Doiversity indices	Dung Bettle	Garden Bettle	Whirling bettle	White grub	*Dudua aprobola*	*Stathero-tisleu-caspis*	*Conopo-morpha sinensis*	*Chlume-tiatrans-versa*	*Crea-tonotos-gangis*	*Perixera illepi-daria*	*Hypo-sidrata-laca*
Taxa_S	33.00	33.00	28.00	24.00	38.00	34.00	38.00	27.00	12.00	37.00	19.00
Individuals	160.00	127.00	121.00	7.00	275.00	48.00	126.00		7.00	50.00	2.00
Dominance_D		0.05	0.05		0.03				0.23		
Simpson_1-D		0.95			0.97				0.77		
Shannon_H		3.15			3.56				1.89		
Evenness_e^H/S	0.78				0.92				0.55		
Brillouin					3.03					1.82	0.29
Menhinick					2.23				3.54		6.78
Margalef	6.31		5.63				7.65				25.97
Equitability_J					0.98				0.76		0.93
Fisher_alpha	12.04			0.00				145.90	0.00		0.00
Berger-Parker			0.09						0.43	0.04	
Chao-1	33.00	33.00	28.00	24.00	38.00	34.00	38.00		12.00		19.00

3.4. Exploring the potential of behaviour modifying chemicals for the management of litchi stink bug

The electrophysiological responses of the litchi stink bug, *Tessarotoma javanica,* have been studied in relation to various volatile compounds associated with litchi plants. The tested volatiles included a range of substances such as β-caryophyllene, tridecane, undecane, tetradecane, pentadecane, nonanal, decanal, sabinene, limonene, linalool, geraniol, terpinolene, α-terpineol, p-cymene, nerol, beta-myrcene, 1-octanol, ethyl acetate, dimethyl disulfide, dimethyl trisulfide, ethanol, and β-pinene. Electrophysiological measurements indicated that male *T. javanica* exhibited heightened sensitivity to ethyl acetate, geraniol, decanol, undecane, and β-caryophyllene. Conversely, female *T. javanica* showed a stronger response to ethyl acetate, nonalol, linalool, α-terpineol, and β-caryophyllene. These findings suggest significant differences in how each sex perceives host plant volatiles (Fig. 14). Further investigation is warranted to explore the behavioral responses of *T. javanica* to these volatile compounds as well as to plant-based repellents and pheromones. Future research will involve testing both attractants and repellents in controlled environments and field settings to evaluate their effectiveness against stink bug populations (Fig. 15).

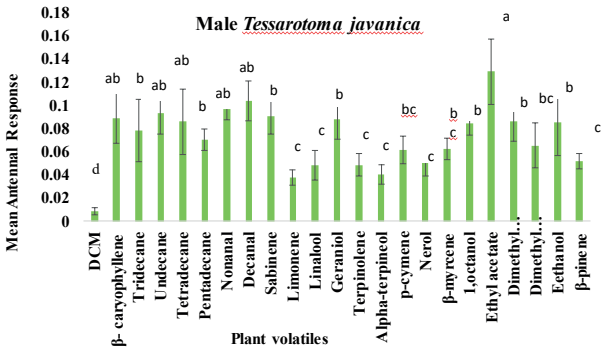


Fig. 14. Mean Antennal Response of male stink bug antenna to different plant volatiles

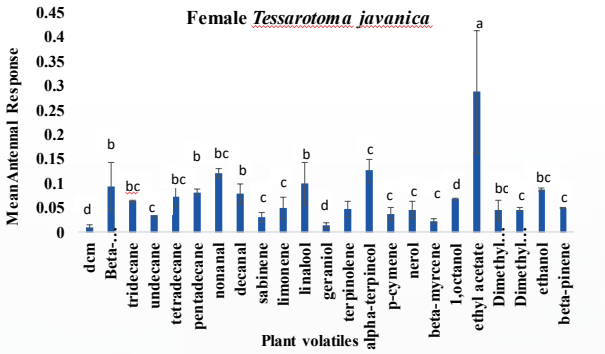


Fig. 15. Mean Antennal Response of female stink bug antenna to different plant volatiles

3.5. Analysis of pesticide residue status in litchi fruits

This study determined the pesticide residues in litchi fruits collected from experimental plots of the National Research Centre on Litchi (NRCL), farmers' field, and local market of Muzaffarpur by NRCL during 2024. The samples of litchi fruits form NRCL experimental plots were collected at 15, 10, and 5 days before harvest. The pesticide residue analysis was carried out at the National Referral Laboratory, ICAR-NRCG, using a validated LC-MS/MS and GC-MS/MS method, which provided a limit of quantification (LOQ) of 0.01 mg/kg for pesticide residues in litchi pulp as well as peel. The limit of detection (LOD) of

pesticide residues was 0.003 mg/kg for litchi pulp as well as peel. Pesticide residue analysis in litchi fruits showed that residues were mainly concentrated in the peel, while residues in the pulp were found below the limit of quantification, except for Copper oxychloride (1.100-2.542 mg/kg) and Carbendazim (0.017-0.028 mg/kg), which were detected. Among the tested insecticides, Novaluron, Thiacloprid, and Lambda cyhalothrin showed measurable residues in litchi peel (Table 29), with concentrations rising when sprayed at 5 days before harvest. Other compounds, including Spinosad, Emamectin benzoate, Flubendiamide, and the control, had negligible or undetectable residues throughout the sampling period. Further, in pulp of litchi fruits, the residual concentration of insecticides was found below the limit of quantification.

Copper oxychloride resulted in the highest and most rapidly increasing residue levels in litchi peel as harvest approached, followed by Difenoconazole, Carbendazim, and Azoxystrobin. Thiophanate Methyl was only detectable at 5 days before harvest (Table 30). The control samples showed no detectable residues. Further, the litchi pulp was found to have residues below the limit of quantification except Copper oxychloride and Carbendazim. Residues of Carbendazim, Clothianidin, and Thiamethoxam were detected in the range of 0.026-0.444 mg/kg in litchi peel of farmers' samples. Similarly, residues of Carbendazim, Difenoconazole, and Imidacloprid were found in the range of 0.055-0.706 mg/kg in litchi peel of market samples. Pesticide residues in litchi pulp of all farmers' and market samples were below the limit of quantification.

A study was conducted to identify the diverse pollen sources collected by honeybees in litchi orchard by installing pollen traps during the flowering period. Results revealed the presence of diverse types of pollen including Sapindaceous and non-Sapindaceous sources highlighting that the rich pollen diversity available in litchi orchards. By identifying the pollen sources present in litchi orchard, the research could offer useful insights to beekeepers and farmers, improving honey production methods, guaranteeing quality benchmarks, and supporting sustainable farming practices.

16SrRNA (V3-V4) Metagenome profiling of Litchi honey using Illumina MiSeq profiling

The hypothesis of a 16S rRNA (V3–V4) metagenomic profiling study of Litchi honey using Illumina MiSeq would likely center on characterizing its unique microbial community (Fig. 16 and 17) and its implications for honey quality, safety, or bioactive properties. Based on analogous studies in the search results, such a study might propose that Litchi honey harbors a distinct bacterial composition influenced by floral source, environmental factors, or processing methods, which could affect its nutritional, antimicrobial, or spoilage-related traits. This type of study would provide a foundation for understanding how microbial communities shape Litchi honey's functional attributes, informing both agricultural practices and food industry standards.

Table: 29. Insecticide residues in litchi peel and pulp.

	Average residues in litchi peel (mg/kg)			Average residues in litchi pulp (mg/kg)		
Duration between date of spray and sampling date	15 days	10 days	5 days	15 days	10 days	5 days
T1 (Thiacloprid)	0.24	0.42	0.91	BLQ	BLQ	BLQ
T2 (Spinosad)	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
T3 (Emamectin benzoate)	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
T4 (Lambda cyhalothrin)	0.12	0.25	0.47	BLQ	BLQ	BLQ
T5 (Novaluron)	0.51	0.98	1.37	BLQ	BLQ	BLQ
T6 (Spinetoram)	BLQ	BLQ	0.09	BLQ	BLQ	BLQ
T7 (Flubendiamide)	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
T8 (Control)	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ

Table: 30. Fungicides residue in litchi peel and pulp.

	Average residues in litchi peel (mg/kg)			Average residues in litchi pulp (mg/kg)		
Duration between date of spray and sampling date	15 days	10 days	5 days	15 days	10 days	5 days
T1 (Thiophanate Methyl)	BLQ	BLQ	0.18	BLQ	BLQ	BLQ
T2 (Difenoconazole)	0.43	0.72	1.04	BLQ	BLQ	BLQ
T3 (Azoxystrobin)	0.15	0.43	0.53	BLQ	BLQ	BLQ
T4 (Copper oxychloride)	1.74	2.36	3.58	1.1	1.48	2.54
T5 (Carbendazim)	0.28	0.52	0.94	BLQ	BLQ	0.02
T6 (Control)	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ

3.6. Enhancing the livelihood of litchi farmers through beekeeping and assessing the agrochemicals in honey (National Bee Board)

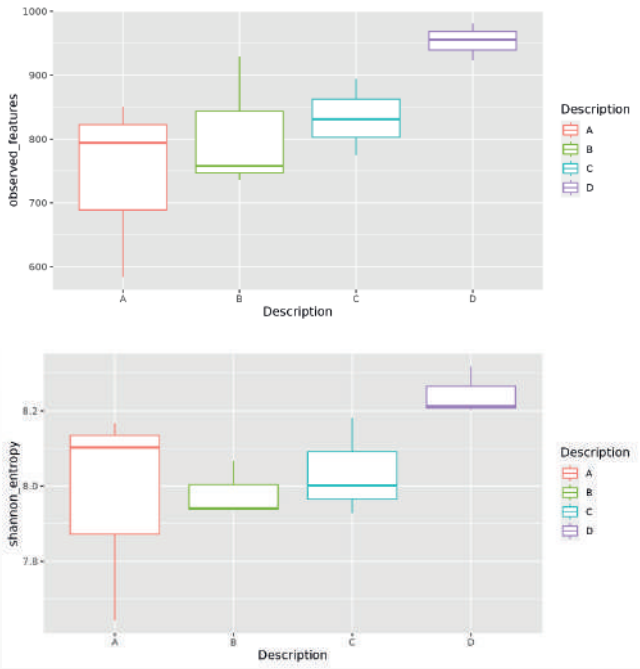


Fig. 16. Diversity indices of 4 different litchi honey samples

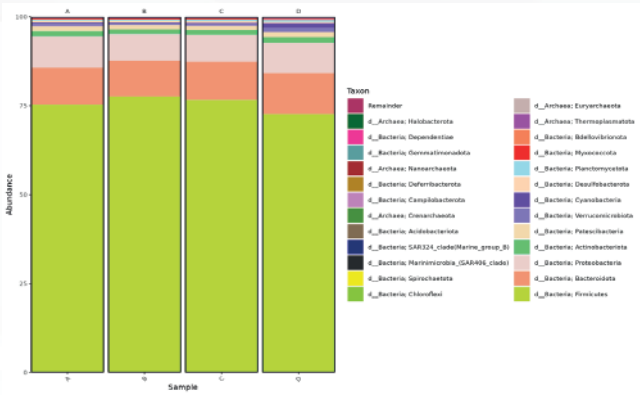


Fig. 17. Relative abundance of top 25 dominant bacterial phylum

4. Integrated Postharvest Management to Reduce Losses, Improve Marketing and Product Diversification

4.1. Investigation and management of post-harvest losses in litchi

Effect of different pre-harvest treatments on shelf life of litchi fruits

The *Bacillus subtilis* strain (NRCL BS-01), previously isolated from the surface of litchi fruits at the NRCL farm, was utilized in this study. The strain was maintained in the lab and prepared for application. The bacterial (BS-01) spray formulation was supplemented with trehalose. The trees were treated with a spray solution containing BS-01 at a concentration of 5 ml/L, applied 48 hours (2 days) before harvest. The spray solution had a bacterial concentration of 10^6 cfu/ml. In the control, trees were sprayed with water instead of the bacterial solution. Two ethnomedicinal plants, Guma *(Leucas aspera)* and Indian heliotrope *(Heliotropium indicum)*, were selected to assess their effects on the shelf life of litchi fruits. The upper parts of the plants, including leaves, were collected, chopped into small pieces, and soaked overnight in water (250 g/L of water). The mixture was then filtered to obtain an aqueous extract, which was stored as a stock solution. From this stock, the plant extracts were prepared at a concentration of 30 ml/L and sprayed on the trees two days before harvest. Four different chemicals namely methionine, salicylic acid, 1-MCP and nisin were evaluated for their effect on the shelf life of litchi fruits. All the chemicals were sprayed at their optimized dose *viz.*, methionine 0.1 g/L, salicylic acid 0.5 g/L, 1-MCP 4 mg/L and nisin 30 mg/L to the respective trees 48 hrs before harvest. Fruits were harvested from each treatment after two days of spraying and stored in

aerated polythene bags. The fruits were maintained at two different temperatures i.e. at 28 ± 2°C and 4 °C. Different parameters such as fruit decay, browning and colour were assayed at different interval of time and compared with control. Additionally, biochemical assays such as content of anthocyanin, TSS, total phenols, and enzyme activity *viz.* PAL, POD and PPO were analyzed in all the treated litchi fruits. This experiment was conducted for three consecutive years 2022, 2023 and 2024 seasons. Therefore, comparative results are presented.

Plate-6. Guma *(Leucas aspera)*, and Indian heliotrope *(Heliotropium indicum)*

Fruit decay was marginally lower at cold storage condition (4°C) as compared to storage of fruits at 28 ± 2°C. The best treatment with respect to fruit decay was BS-01 followed by methionine, salicylic acid, 1-MCP, guma extract, Nisin, hathisud extract compared to control. Mean percent fruit decay in BS-01 treated fruits was found to be 0.0 at 4th day of storage at temperature of 28 ± 2°C and, at 20th day of storage at 4°C. The percentage of fruit decay was observed to be 7.8 and 9.2 in BS-01 treated fruits as compared to 76.7 and 94.0 in control fruits on 6th day of storage at temperature of 28 ± 2°C, in year 2023 and 2024, respectively. Mean percentage of browning of fruit was 0.00 in BS-01 treated fruits on 2nd day of storage at temperature of 28 ± 2°C and at 20th day of storage at 4°C. TA decreased with increase in storage time but rate of TA decrease was slightly lower in BS-01 treated fruits as compared to the control fruits. Analysis of all the seven treated litchi samples demonstrated almost comparable values compared to the control. However, during the prolonged storage period, the TSS values were reduce and reached up to 15.48 in case of salicylic sprayed litchi samples (Fig. 18A-C).

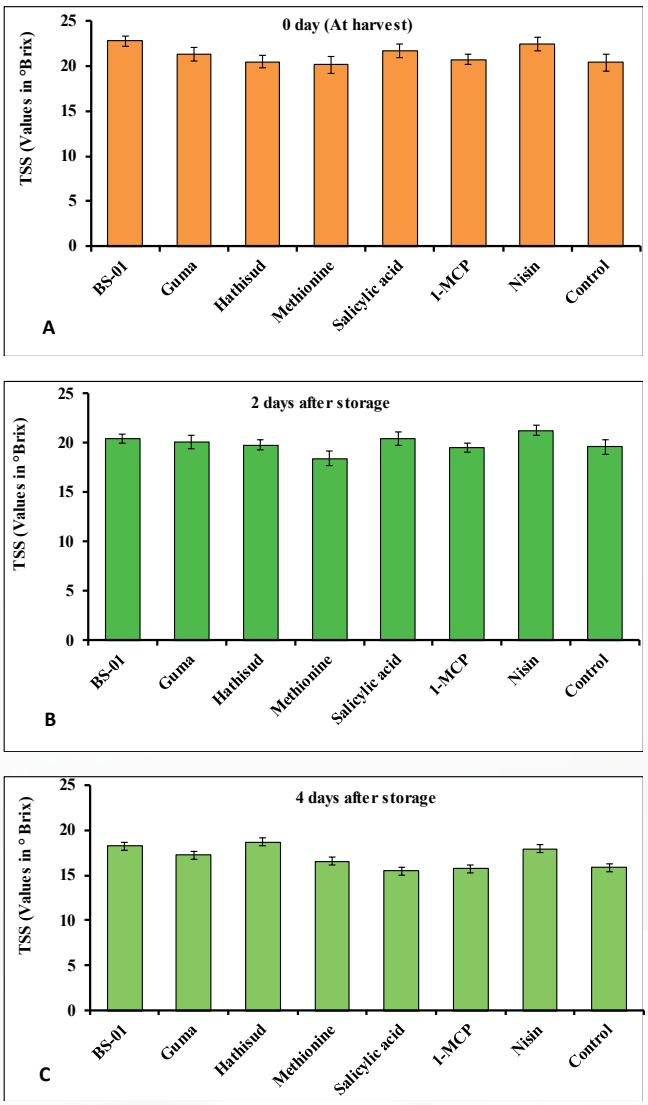


Fig. 18A-C. TSS of the litchi fruits under various treatments stored at ambient conditions

The total anthocyanin content in freshly harvested litchi pericarp was estimated using standard method. The results revealed that the anthocyanin content in litchi samples treated with 1-MCP and Bacillus (BS-01) was slightly higher than the control and

other treatments at the time of harvest (Day 0). Anthocyanin levels in all the samples decreased over the course of storage for 2 and 4 days when compared to the control (Fig. 16A-C). However, there was lesser decrease in BS-01 and 1-MCP treatments.

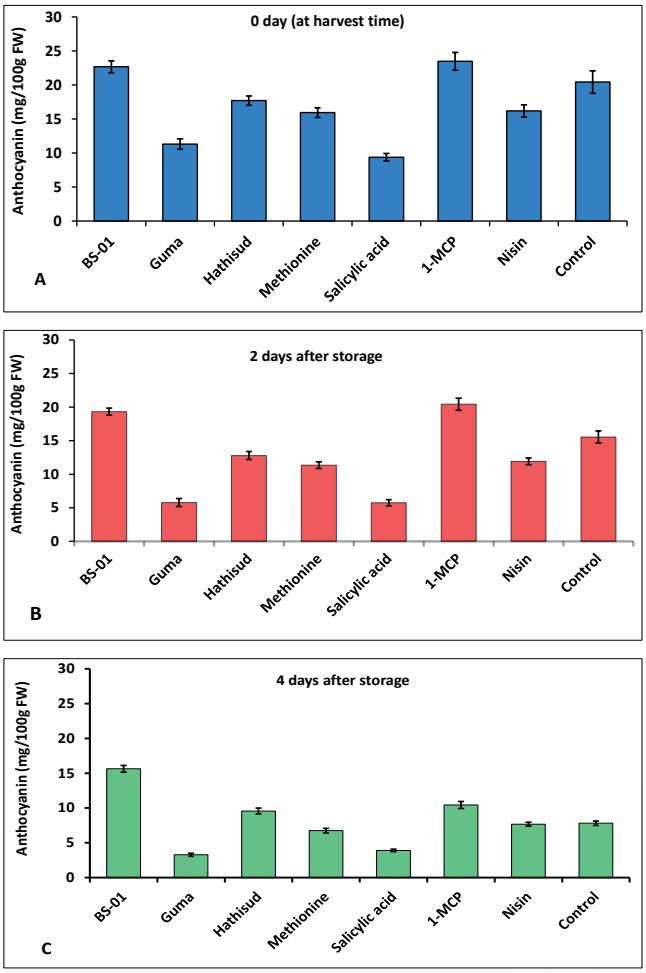
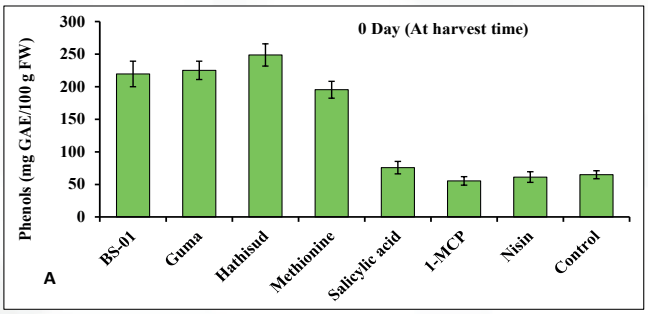


Fig. 19A-C. Anthocyanin content of the litchi fruits under various treatments stored at ambient conditions

The total phenol content was found to be significantly higher in litchi samples treated with ethno-medicinal plant extracts compared to other treatments, such as salicylic acid, 1-MCP, nisin, and the control. Specifically, the BS-01 and methionine spray treatments also exhibited elevated levels of phenolics in the litchi samples compared to the control (Fig. 20A-C).



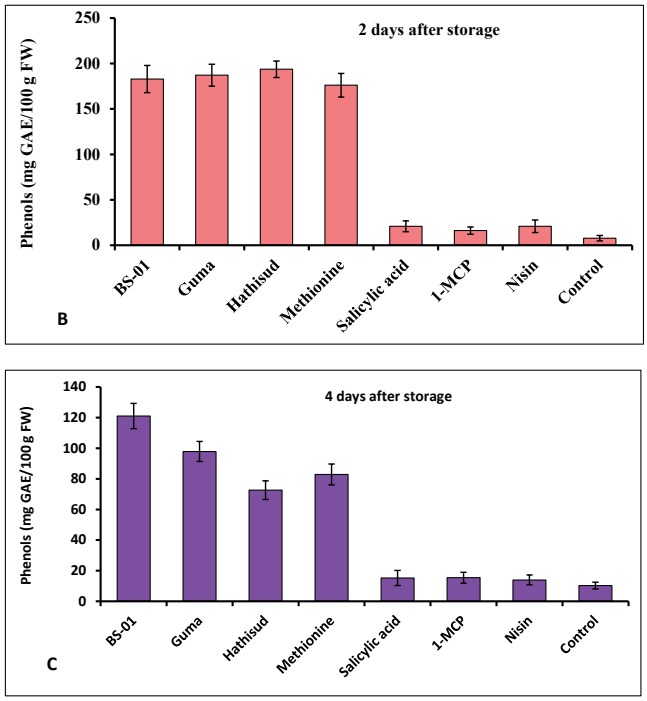


Fig. 20A-C. Total phenolic content of the litchi samples with seven different treatments performed in rejuvenation block on harvested day and after 2 & 4 days of storage at 25°C

The increased phenolic content in litchi fruits treated with ethno-medicinal plants and certain other treatments, such as BS-01 and methionine, is particularly significant in relation to enhancing post-harvest shelf life. Phenolic compounds are known to play a crucial role in delaying fruit senescence and reducing oxidative stress, which can lead to improved fruit quality and extended storage life. Higher phenolic content in these treated litchi fruits suggests enhanced antioxidant activity, which could help mitigate post-harvest deterioration, maintain nutritional quality, and reduce susceptibility to microbial spoilage. Thus, these treatments show potential for practical application in improving the post-harvest longevity of litchi fruits, making them more viable for commercial distribution and storage.

The browning of the litchi pericarp is driven by enzymes such as POD and PPO, which degrade anthocyanins by catalyzing the oxidation of phenolic compounds. In this study, the activities of both POD and PPO increased during storage at 25°C, from day 0 to day 4 (Fig. 21A-C). However, the rate of POD activity was notably higher in control fruits compared to those treated with BS-01 and other treatments. Conversely, PAL activity decreased over

the storage period, with a sharper decline observed in BS-01 treated fruits compared to the control. These findings conclusively demonstrate that a pre-harvest spray of *Bacillus subtilis* (NRCL BS-01) 48 hours before harvest significantly enhanced the shelf-life and quality of litchi fruits.

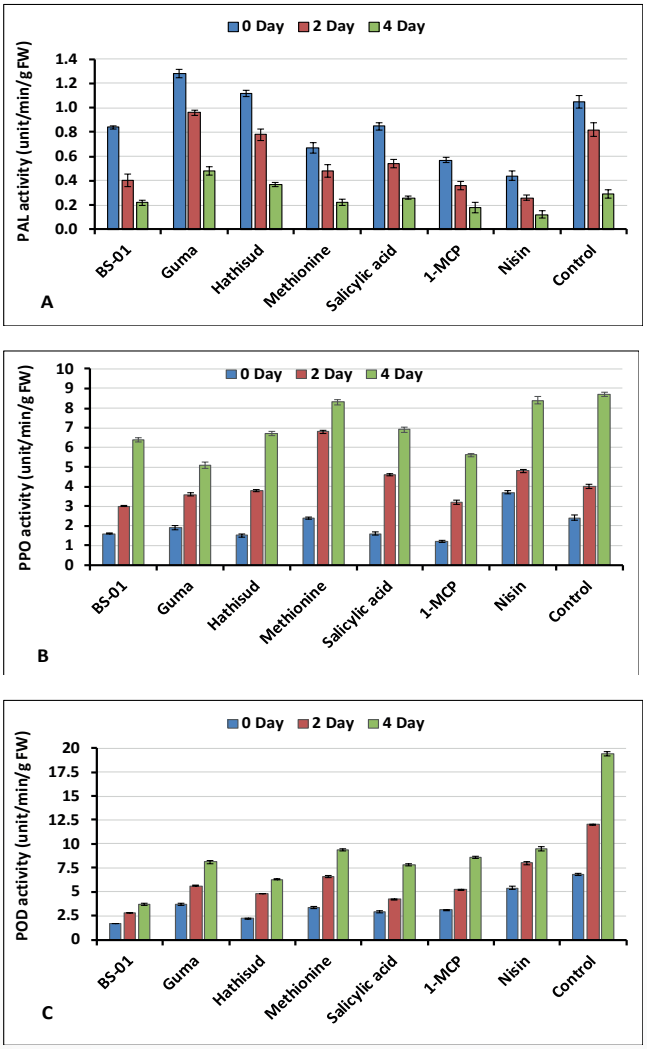


Fig. 21A-C. PAL/POD/PPO activities of the litchi samples with seven different treatments performed in rejuvenation block on harvested day and after 2 & 4 days of storage at 25°C

Effect of different treatments on fruit decay of litchi fruits

Harvested fruits were stored at ambient condition in perforated polybags and fruit decay (%) was recorded at 2-days interval up to 6th day of storage. The results indicated that pre-harvest treatments with *Bacillus subtilis* BS-01 significantly reduced post-harvest fruit decay of litchi fruits, with only 31.1% decay after 6 days at 25°C (Fig. 22). In contrast, untreated control fruits exhibited complete decay (100%), while other treatments showed varying levels of decay, with Nisin leading to the highest decay rate at 91.9%. These findings prove efficacy of *Bacillus subtilis* BS-01 as an effective treatment for extending the shelf life of litchi fruits during ambient storage. By reducing decay rates, this approach could improve marketability and reduce waste, addressing a critical challenge in the post-harvest management of litchi.

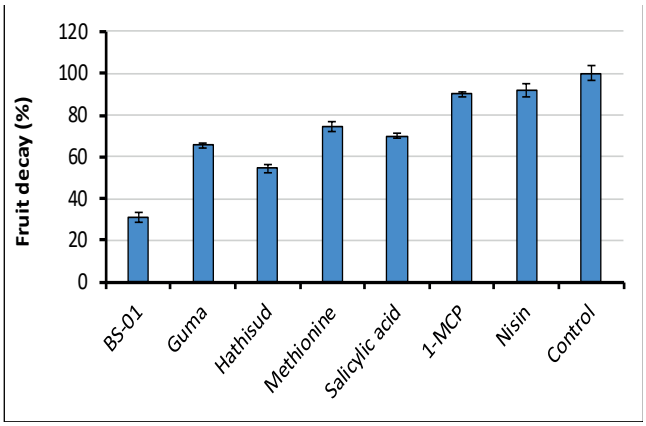


Fig. 22. Effect of different pre-harvest spray treatments on fruit decay of litchi fruits

Results showed that pre-harvest spray of *Bacillus subtilis* (BS-01) exhibited the lowest browning index (0.86) after 6 days of storage at ambient conditions (25°C), followed by Guma (1.36) and Hathisud (1.33) (Fig. 23). The control group showed the highest browning index (2.80), indicating severe browning, while 1-MCP (1.68) and Methionine (1.60) treatments also resulted in moderate browning. The results thus suggest that the use of *Bacillus subtilis* (BS-01) can significantly delay browning and potentially extend the shelf life of litchi fruits during ambient storage. In contrast, the untreated control and treatments like 1-MCP and Methionine showed higher browning, indicating reduced effectiveness in prolonging shelf life under similar conditions.

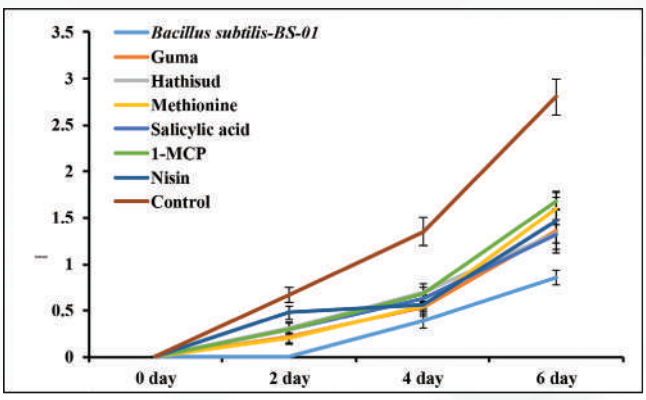


Fig. 23: Effect of different pre-harvest spray treatments on browning index of litchi fruits over storage period of 6 days at ambient condition (25°C)

4.2. Effect of application of biostimulants, microbes and microbial products on fruit drop, pest and disease incidence and fruit quality of litchi

In the 2024 season, an experiment was conducted to evaluate the effects of various treatments on the 'Shahi' litchi. These treatments included *Bacillus subtilis* (NRCL BS-01) and its culture filtrate, extracts from ethno-medicinal plants such as Guma and Hathisud, along with organic products like Humic acid, Seaweed extract, and 'Ambition'. The aim of the experiment was to assess the impact of these treatments on key biochemical parameters, including total Soluble Solids (TSS), total phenols, anthocyanin content, and enzyme activities like Phenylalanine Ammonia-Lyase (PAL), Peroxidase (POD), and Polyphenol Oxidase (PPO). Additionally, the experiment evaluated fruit quality parameters, such as sunburn, fruit decay, and pest and disease incidence. The treatments were applied as foliar sprays at three critical stages of fruit development: before flowering, after fruit set, and during the color break stage. The evaluation of various pre-harvest treatments on the TSS of 'Shahi' litchi showed that Culture filtrates (BS-01 and *Trichoderma viride* T-01) were the most effective, starting with the highest TSS values (24.18° Brix for BS-01) and maintaining higher levels after 6 days (17.36° Brix for BS-01, 18.67° Brix for T-01). Guma and Hathisud showed a noticeable drop in TSS, from around 19 °Brix at harvest to 15 °Brix by day 6. The results show the potential of culture filtrate as pre harvest spray for Shelf life of litchi (Fig. 24).

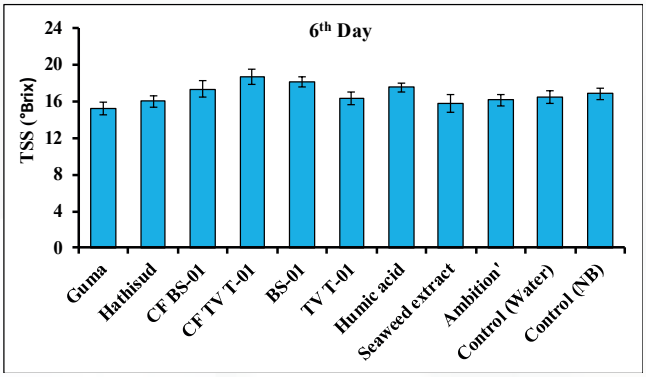


Fig. 24. Effect of different treatments on TSS of fruits stored at 25°C

The effect of different treatments on the anthocyanin content of litchi fruits stored at ambient conditions (25^{0}C) was evaluated over 6 days. The BS-01 exhibited the highest anthocyanin content throughout storage, starting at 21.34 mg/100 g on day zero and retaining 11.41 mg/100 g by day 6, indicating superior anthocyanin retention. Humic acid and Ambition also performed well, with humic acid starting at 20.63 mg/100 g and retaining 10.18 mg/100g by day 6, while Ambition retained 6.14 mg/100 g. Culture filtrates (BS-01 and T-01) showed moderate retention, with CF BS-01 retaining 7.13 mg/100g and CF TV T-01 retaining 3.74 mg/100g by day 6. In summary, BS-01, Humic acid, and Ambition were the most effective in preserving anthocyanin content, while the plant extracts and control treatments showed significant degradation during storage (Fig. 25).

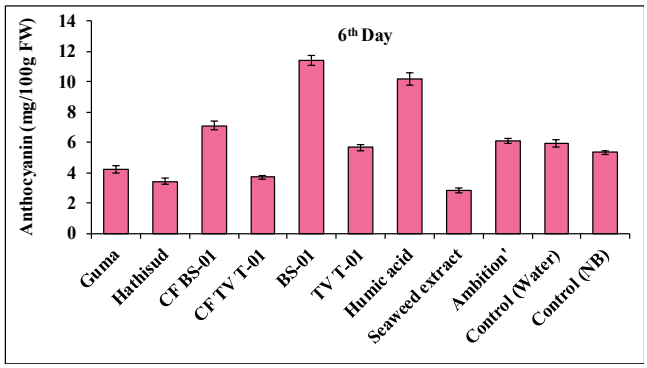


Fig. 25. Effect of different treatments on Anthocyanin content of litchi fruits stored at 25°C

The total phenol content in the freshly harvested litchi pulp/juice was estimated and results showed that Guma and culture filtrate of T-01 had the highest initial phenolic content (145 mg GAE/100g and 134 mg GAE/100g, respectively) and retained the most phenolics by day 6 (36.8 mg and 43.2 mg, respectively). Hathisud, Humic acid, and 'Ambition' showed significant phenolic loss, with Ambition retaining the lowest content (2.2 mg by day 6). BS-01 and *Trichoderma viride* T-01 treatments maintained moderate phenolic levels during storage compared to the other treatments.

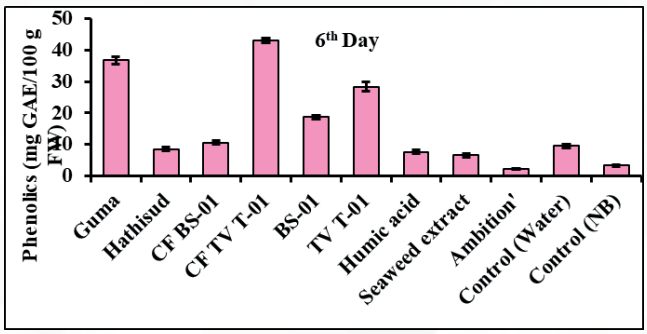
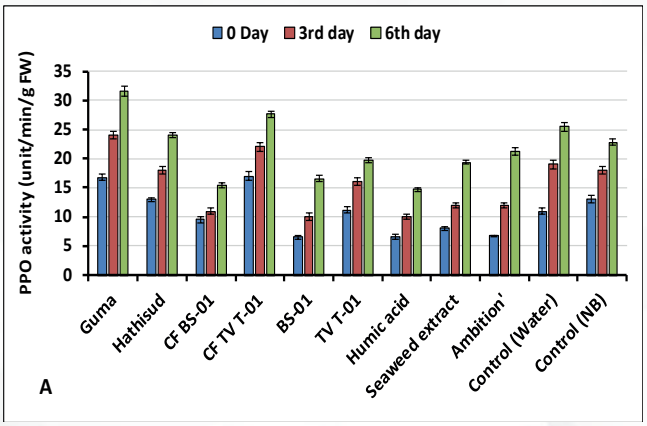
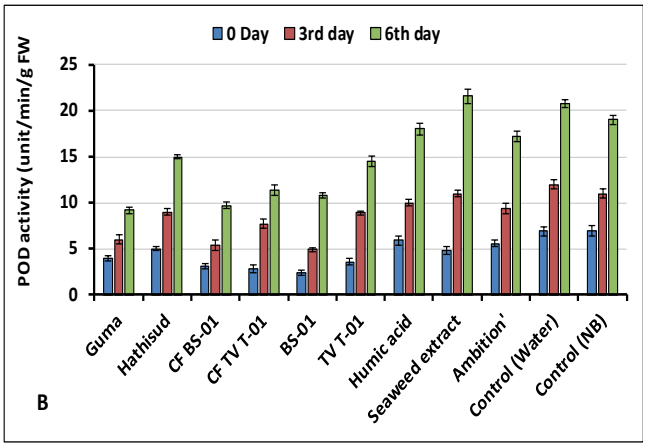


Fig. 26. Effect of different treatments on total phenolic content of litchi fruits stored at 25°C

The lowest PPO activity was observed in the BS-01 and Humic acid treatments throughout the storage period, indicating better retention of fruit quality. Control (Water) and Guma treatments showed the highest PPO activity, suggesting quicker degradation of fruit quality. Culture filtrate of (CF) of BS-01 and Seaweed extract treatments showed moderate increases in PPO activity, indicating a balanced effect on shelf life. Thus, Treatments like BS-01, Humic acid, and CF BS-01 demonstrated a slower increase in PPO activity, which suggests better control over enzymatic browning, thus potentially prolonging the shelf life of litchi fruits during ambient storage. BS-01 and CF BS-01 treatments consistently showed the lowest POD activity, indicating better retention of fruit quality. Control (Water), Control (NB), and Seaweed extract exhibited the highest increase in POD activity, reflecting faster degradation of fruit quality. Humic acid and Ambition' treatments had moderate increases in POD activity, suggesting a balanced effect on shelf life. Thus, Lower POD activity in treatments like BS-01 and CF BS-01 suggests reduced oxidative stress, which may help prolong the shelf life of litchi fruits by minimizing browning. PAL activity was noted to be decreasing trend with the enhancement in the storage period of litchi at 25°C. Treatments BS-01 and CF BS-01 exhibited significantly higher initial PAL activity, which gradually decreased over time, indicating strong activation of defense mechanisms early on. Control (Water), Control (NB), and Guma treatments had the lowest PAL activity, showing minimal defense responses and suggesting quicker degradation. Thus, higher initial PAL activity in treatments like BS-01 and CF BS-01 may contribute to a stronger defense against oxidative stress and browning, helping to prolong the shelf life of litchi fruits by reducing enzymatic browning over time.





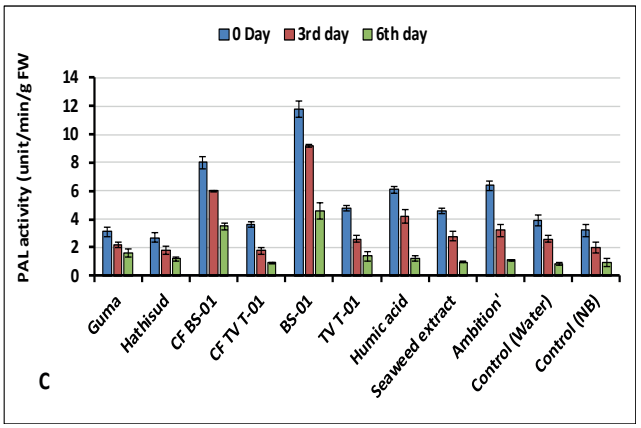


Fig. 27A-C. Effect of different treatments on PPO/ POD/PAL enzyme activities of litchi fruits stored at 25°C

Effect on fruit drop, pest and disease incidence, and fruit quality of litchi

Significantly lowest fruit drop was observed in Hathisud extract (2.9%) followed by Seaweed extract (4.6%), and BS-01 (8.7%), whereas Ambition (19.4%) and Guma (17.3%) had the highest fruit drop percentage which was statistically at par with control (15.6 %) (Table 30). Extracts of Guma and Hathisud exhibited lower sunburn percentages (5% and 4%, respectively) compared to Control treatments (9%). BS-01 (3.5%) and Culture filtrate (BS-01) (4.5%) marginally minimized fruit cracking compared to control. Fruit borer incidence were low even in control so results are not significant. Guma extract and BS-01 treatments showed less fruit blight (3.5%), compared to Control (Water) (6.8%) and Ambition (5.5%). Culture filtrate (BS-01) (41.6%) and BS-01 (45%) showed the lowest fruit decay percentages compared to control treatment (100%), based on cumulative fruit decay value observed upto 6th day of storage.

Table: 31. Effect of different pre-harvest treatments on fruit drop, pest and disease incidence, and fruit quality of litchi.

Treatments	Fruit drop (%)	Sunburn (%)	Cracking (%)	Fruit borer infestations (%)	Fruit blight (%)	Fruit decay* (%)
Guma	17.3	5.0	6.0	2.0	3.5	55.0
Hathisud	2.9	4.0	5.0	2.5	4.0	65.0
Culture filtrate (BS-01)	9.3	6.0	4.5	1.5	4.5	41.6
Culture filtrate (T-01)	12.0	8.0	7.0	1.0	6.0	60.0
BS-01	8.7	5.0	3.5	1.0	3.5	45.0
T-01	15.2	9.0	6.0	1.1	5.8	93.3
Humic acid	10.7	7.5	5.0	2.0	4.5	45.0
Seaweed extract	4.6	8.6	9.0	2.0	6.4	96.0
Ambition	19.4	8.0	8.5	1.5	5.5	90.0
Control (Water)	16.7	9.0	8.0	2.0	6.8	100.0
Control (NB medium)	15.6	10.0	7.5	2.0	5.2	100.0
LSD (p=0.05)	3.74	2.2	1.96	NS	0.66	4.00
SE(m)±	0.13	0.10	0.66	-	0.22	1.35

Cumulative value upto 6th day of storage

Thus, results indicate that pre-harvest treatments significantly affect various quality parameters of litchi fruits. Hathisud, BS-01, and Culture filtrate (BS-01) consistently demonstrated superior performance in reducing fruit drop, cracking, and fruit decay, making them effective treatments for improving the post-harvest quality and shelf life of litchi. In particular, the low fruit decay rates observed with BS-01 and its culture filtrate suggest their potential for extending shelf life, thus minimizing post-harvest losses and improving marketability.

In-vitro test for the safety of *Bacillus subtilis*-*sprayed* litchi fruits

The experiment was conducted with the objective of assessing the safety of litchi fruits for human consumption after a pre-harvest spray of *Bacillus subtilis* (BS-01). The study involved analyzing the presence of *B. subtilis* cells on the peel, pulp, and seed surface under in-vitro conditions by plating tissue samples onto nutrient agar (NA) plates. For this experiment, trees bearing litchi fruits were sprayed with *Bacillus subtilis* (BS-01) at a concentration of 1×10^7 CFU/ml, 48 hours prior to harvesting. The treated fruits were then brought to the laboratory, and tissue samples from the pericarp (peel), pulp, and seed, both pre-spray and post-harvest, were plated on NA plates to observe colony formation. In addition, a sample study involved washing three fruits in 100 ml distilled water, after which 0.1 ml of the washing solution was plated onto NA plates. The results revealed a significant difference in the Bacillus subtilis cell count between the sprayed and control fruits. On the day of harvest, the *Bacillus subtilis* cell count on the sprayed fruit surface was approximately 12,550 times higher than on control fruits (11.3×10^6 cells per fruit compared to 600 cells in the control). This confirmed that the pre-harvest spray effectively deposited *Bacillus subtilis* cells on the fruit surface. Importantly, no bacterial colonies developed on NA plates when bits of pulp were plated, indicating the absence of *Bacillus subtilis* in the fruit pulp. Thus, the study demonstrates that *Bacillus subtilis* successfully adheres to the surface of litchi fruits after being sprayed pre-harvest, without penetrating the pulp. These findings suggest that *Bacillus subtilis* application is likely safe for human consumption, as the bacteria remain localized on the fruit's outer surface and do not contaminate the edible portion. The significance of this study lies in the potential of *Bacillus subtilis* to reduce post-harvest losses while simultaneously ensuring food safety.

Monitoring progressive pH change on the surface of *Bacillus subtilis* (BS-01) treated fruits

To explore whether *Bacillus subtilis* colonization lowers the surface pH of litchi fruits and enhances post-harvest shelf life, an experiment was conducted. The hypothesis was that *Bacillus subtilis* colonization on the fruit surface, following a pre-harvest spray, may lead to a progressive decrease in pH. To test this, pH changes on the surface of litchi fruits treated with *Bacillus subtilis* were monitored over a storage period of 0, 2, 4, and 6 days at ambient temperature (25°C). The results were compared with untreated control fruits. pH readings were obtained by gently rubbing the fruit surface with a sterile cotton swab dipped in distilled water, dissolving the swab in a small volume of water (5 ml), and measuring the pH using a calibrated pH meter. A progressive decrease in surface pH was observed in the *Bacillus subtilis*-treated fruits compared to the control over the 6-day storage period. The initial pH of the fruit pericarp was recorded at 5.52 before spraying. Over time, the pH gradually decreased, reaching 4.51 on the 6th day of storage. The control fruits, on the other hand, showed a relatively stable pH with minor fluctuations over the same period. The range of pH values in the treated fruits was from 5.52 (Day 0) to 4.51 (Day 6). This study provides valuable insights into the potential of Bacillus subtilis as a biocontrol agent in post-harvest management of litchi fruits. The reduction in surface pH observed in treated fruits suggests a possible mechanism through which Bacillus subtilis enhances shelf life by inhibiting the growth of spoilage organisms.

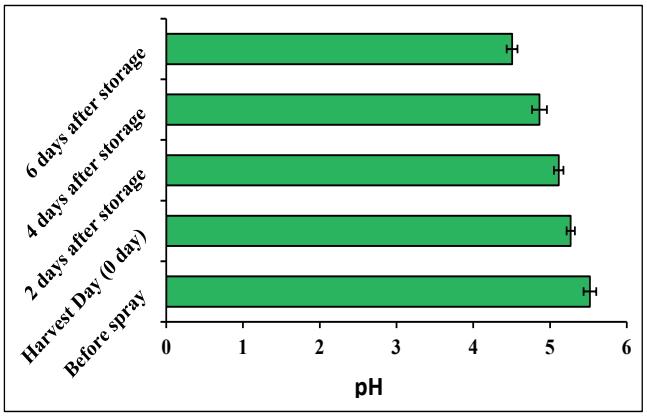


Fig. 28. Progressive pH values of the Bacillus subtilis (BS-01) treated fruits over a storage period 6 days at ambient temperature (25°C)

4.3. Post-harvest management and by-product utilization of litchi fruit

Utilization of litchi peel and seed for high value commercial product

Litchi pericarp and seed were sun-dried (<10% moisture), ground, and sieved into >355 µm, 250–355 µm, and <250 µm fractions for extraction. Sonication (600 W, 5 min, 50% ethanol, 1:40 feed-to-solvent) improved bioactive yield, with smaller particles showing higher extractability. Different solvents (water, methanol, ethanol, and their 50% mixtures) were tested at 40°C for 30 min. Aqueous solvents enhanced extraction, with ethanol preferred for safety. Optimization (600 W, 15 min, 655 RPM, desirability 0.947) confirmed sonication power and time as key factors.

Table: 32. Effect of particle size on extractability of litchi peel bioactive compounds.

Particle Size	TPC (mg GAE/g)	TFC (mg QE/g)	FRAP (mg TE/g)	DPPH (mg GAEAC/g)	TCT (mg CE/g)
>355 µm	56.73±2.25 ^{c}	42.86±0.73 ^{c}	78.77± 1.47^{b}	16.04±0.10 ^{c}	47.24±0.03 ^{b}
250-355 µm	73.29±0.63^{b}	49.01±0.35 ^{b}	85.97±0.80 ^{a}	20.58±0.06 ^{b}	75.64±0.06 ^{a}
<250 µm	78.84±1.22^{a}	54.83±1.12 ^{a}	88.30±0.06 ^{a}	23.19±0.00 ^{a}	86.46±0.10 ^{a}

Table: 33. Effect of solvent concentration on extractability of litchi peel bioactive compounds.

Solvent Concentration	TPC (mg GAE/g)	TFC (mg QE/g)	FRAP (mg TE/g)
Water	76.02±1.11 ^{b}	40.41±0.53 ^{c}	61.19±1.82 ^{b}
Ethanol	39.67±0.82^{d}	20.40±0.44^{c}	42.19±1.08 ^{d}
Methanol	69.17±1.19 ^{c}	31.35±0.77 ^{d}	54.46±1.18 ^{c}
Aq. Ethanol (50%)	84.32±2.25 ^{a}	92.40±5.22 ^{a}	89.02±0.87 ^{a}
Aq. Methanol (50%)	84.84±0.96^{a}	75.30±5.13 ^{b}	89.15±0.67 ^{a}

Starch extraction from litchi seed

Litchi seed starch was extracted using normal steeping (0.16% sodium bisulfite), alkali steeping (0.5% NaOH), acid steeping (2% acetic acid), and ultrasonication. Five grams of <250 µm seed powder was mixed with 100 ml water, processed, filtered, settled for 12 h, and dried at 40°C. Ultrasonication yielded the highest starch and amylose content, making it suitable for biodegradable films (Table 34). Acid and alkali steeping improved recovery over normal steeping. Moisture content (<10%) and water activity (<0.6) ensured stability. Longan seeds had higher starch and amylose than litchi.

METWASH is a product developed at ICAR-CISH, Lucknow. Firstly, 2 kg of fruits were dipped in sodium hypochlorite solution for 5 min and then their surface was dried and trials were conducted using 0.5 to 2% concentration pf metwash. After dipping, the surface of fruits was dried properly and then they were kept in punnet boxes made of PET and stored at refrigerated condition and the readings were taken at every 5 days' interval. METWASH formulations were effective in shelf-life enhancement of litchi at refrigerated conditions. Hot water (50^{0}C) dip treatment followed by METWASH dip degraded color of litchi after 15 days of refrigerated storage.

Table: 34. Effect of different extraction method on different properties of starch and their yield

Sample	Litchi seed starch			
	Amylose content	Starch Yield	Moisture content	Water activity
Normal Steeping	21.50	31.42	9.12	0.35
Alkali Steeping	13.95	30.44	9.23	0.36
Acid Steeping	21.99	30.23	9.21	0.35
Ultrasonication	22.87	32.13	9.01	0.33

Effect of METWASH (MW) (Organo peptides and lipid formulation) on shelf life of litchi fruit

Table: 35. Effect of METWASH treatment on discoloration and decay percentage of litchi.

Treatments	(%) Discoloration	(%) Decay
T0	100	0
T1	90	10
T2	100	20
T3	100	0
T4	80	10
T5	80	20
T6	80	10
T7	20	10
T8	60	10
T9	100	15

Effect of Lac based formulation on the shelf life of litchi

Lac based formulations were taken from ICAR-National Institute of Secondary Agriculture (NISA). Freshly harvested litchi fruits were kept in air-conditioned room for 2 h for precooling. The precooled litchi was dipped in 5% sodium hypochlorite solution for 1 min then after surface drying in open air, the samples were dipped in different formulations. 1 L of solution was used for 4 kg of litchi. The experimental results showed that T7 (NISA 03 (70:30 dilutions with water)) and T9 (NISA 04 (50:50 dilutions with water)) treatments showed least colour change and loss in weight. The decay and discoloration percentage were also found least in these samples. There was degradation of litchi flavor in treatments without dilution. In case of NISA 7, the flavor was not degraded after 5 days. The lac-based coating showed positive effect on shelf life of litchi even after 5 days under ambient conditions.

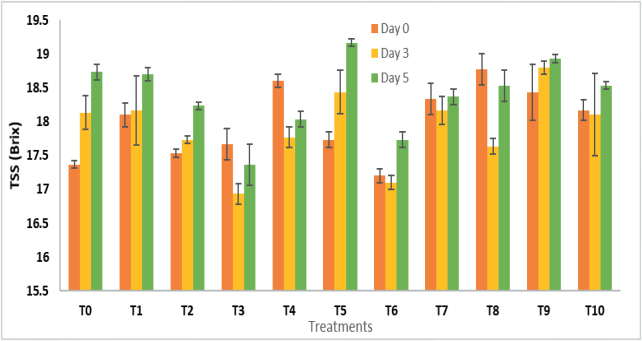


Fig. 29. Variation in total soluble solid of the sample with treatments and duration of storage

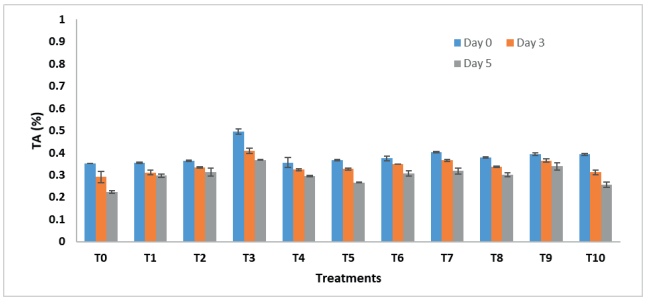


Fig. 30. Variation in titratable acidity of the sample with treatments and duration of storage

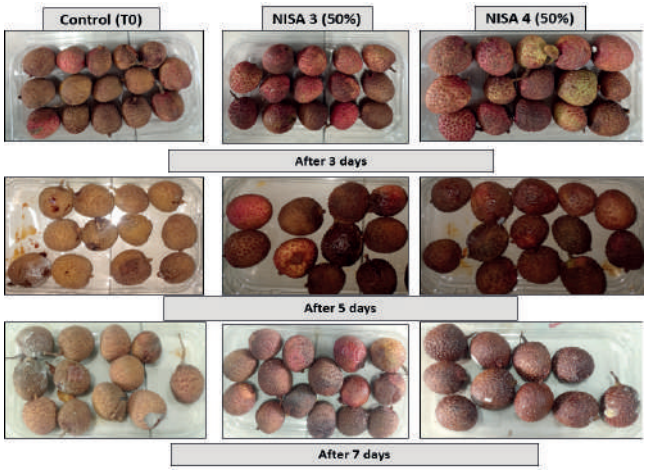


Fig. 31. Variation in Lac based formulation treated samples with storage

4.4. Development of packaging protocol for the long-distance transport of litchi

Fresh litchi fruits were transported to Azadpur Mandi, Delhi with different packaging and coating treatments. Transportation of litchi was carried out in CFB boxes (Table 37). In each box 10 kg of fruit was taken. The transportation condition was very harsh to mimic the extreme condition of transport. The temperature reached upto 50^0C occasionally during transportation. It was observed that litchi fruits under traditional packing with leaves and bunches exhibited longer shelf life than that under plastic packaging or with the addition of oxygen absorber or ethylene absorber. The lac-based coating resulted in lowest decay and discoloration along with more than 90% marketable fruits.

Table: 36. Variation in physiologic loss in weight (PLW) and total colour difference (DEL E).

Treatments	PLW (%) Day 3	PLW (%) Day 5	Δ E (Day 3)	Δ E (Day 5)
T0	13.07	23.84	4.25	12.89
T1	8.51	17.02	5.40	15.02
T2	5.65	14.34	6.61	11.79
T3	3.82	9.78	6.76	10.99
T4	5.09	12.00	9.66	15.63
T5	4.87	13.65	5.43	12.90
T6	4.00	10.66	6.24	12.50
T7	2.64	9.05	2.60	6.95
T8	2.85	11.42	3.17	7.73
T9	4.08	10.61	2.28	6.70
T10	8.00	13.45	6.44	12.17

Table: 37. Effect of different treatments on shelflife of litchi aafter long distant transport.

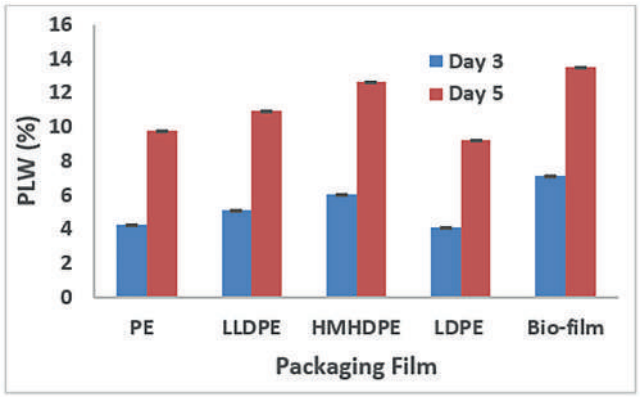
Treatment	Details of the treatment	% Marketable fruits	% decay fruits	TSS (°B)	Acidity (%)
T1	Traditional packing (with leaves) in 7 Ply CFB with holes (5%)	76	6	21	0.384
T2	Treatment 1 with 2 Fresh cards (FC) and 2 EA (Holes closed)	54	5	18	0.384
T3	Litchi packed in 2 LDPE pouches with 5 kg each (1FC, 5 OA, 1 EO, 5 SG each) (holes closed)	7	80	18	0.512
T4	Litchi packed in 2 LDPE pouches with 5 kg each (5 OA, 5 SG each) (holes closed)	10	6	15	0.512
T5	Litchi packed in Perforated LLDPE Pouches	3	87	17	0.384
T6	Litchi packed in LLDPE Pouches with 10 OA, 10 SG each	5	74	18	0.256
T7	Litchi packed in Perforated LLDPE Pouches with 10 OA, 10 SG, 2 EA, 2 FC each	22	30	18	0.512
T8	Litchi packed in Perforated LLDPE Pouches with 10 SG each	30	44	18	0.256
T9	Litchi in 5 HMHDPE pouches with 4 SG each	3	15	18	0.896
T10	Precooled litchi in traditional packaging	66	5	18	0.256
T11	Perforated LLDPE pouches with leaves as cushioning material	5	84	15	0.896
T12	Litchi in 5 HMHDPE pouches with 4 SG and 1 FC each	4	61	20	0.896
T13	Litchi in 5 HMHDPE pouches with 4 SG, 1 EA and 1 FC each	21	45	18	0.256
T14	Litchi packed in Punnet boxes coated with NISA 7	79	4	18	0.384
T15	Litchi packed in Punnet boxes coated with NISA 7 and 1 EA and 1 FC each	90	3	18	0.384
T16	Litchi packed in Punnet boxes coated with NISA 9	50	6	21	0.256
T17	Litchi packed in Punnet boxes coated with NISA 9 and 1 EA and 1 FC each	75	10	18	0.256

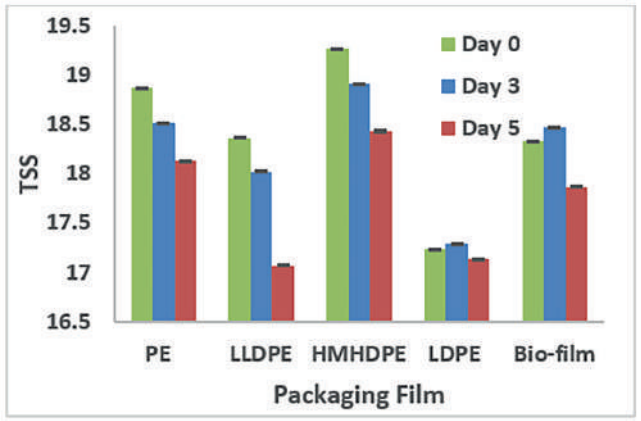
***FC:** Fresh cards; **OA:** Oxygen absorber; **EA:** Ethylene absorber; **SG:** Silica Gel*

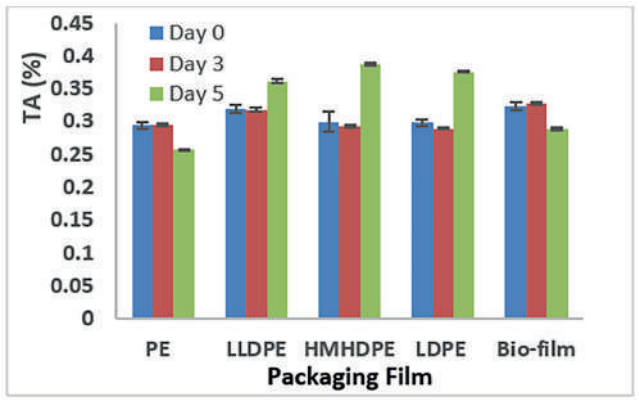
4.5. Shelf-life enhancement and value addition of litchi through various post-harvest intervention (RKVY)

Effect of packaging on shelf life of litchi

Freshly harvested Shahi litchi from ICAR-NRCL was precooled from 31±2°C to 27±2°C under an air conditioner and stored in PE, LDPE, LLDPE, HMHDPE, and biofilm at 40±5°C. After 3 and 5 days, LDPE showed the least weight loss, minimal TSS and acidity variation, and under 30% decay, while biofilm exceeded 80% decay. Discoloration remained below 40% in LDPE but surpassed 80% in PE (Fig. 32).







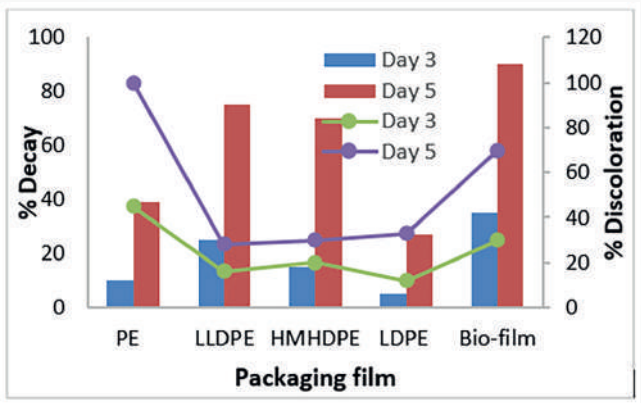


Fig. 32. Effect of packaging film on various storage parameters of litchi

Study on variation of respiration rate of litchi with different storage temperature

Fresh litchi (500 g) was sealed in glass jars with a septum and stored at 4, 25, and 35°C with 0–3 oxygen absorbers. Respiration rate was highest at 35°C and decreased with temperature, but calibration issues affected accuracy. After 15 days at 4°C and 7 days at 25°C and 35°C, discoloration and decay were lowest with three absorbers, showing their positive effect on shelf life (Table 38).

Table: 38. Effect of storage temperature and oxygen absorber on decay and discoloration of litchi.

Samples kept at 4 ^{0}C (Reading after 15 days)		
Sample	**% Discoloration**	**% Decay**
Without Oxygen absorber	33.84	31.53
With 1 Oxygen absorber	25.71	21.57
With 2 Oxygen absorber	14.28	11.42
With 3 Oxygen absorber	0	6.66
Samples kept at 25 ^{0}C (Reading after 7 days)		
Without Oxygen absorber	41.66	33.33
With 1 Oxygen absorber	20	24.76
With 2 Oxygen absorber	14.28	18.22
With 3 Oxygen absorber	12.33	16.5
Samples kept at 35 ^{0}C (Reading after 7 days)		
Without Oxygen absorber	53.84	61.53
With 1 Oxygen absorber	35.71	38.56
With 2 Oxygen absorber	24.28	32.62
With 3 Oxygen absorber	13.33	20.66

Effect of CMC and chitosan coating on shelf life of litchi

Litchi fruits were dipped in NaOCl (1% w/v) for 1 min, then CMC (1.0–2% w/v) for 30 s, dried for 30 min, followed by chitosan (0.5–1.5% w/v) for 30 s, and stored in PET boxes at 35–45°C. Coatings significantly influenced PLW, pH, TSS, acidity, colour, and vitamin C. Maximum PLW (5.66%) and colour index (44.30) were in $NaOCl_2$-treated fruits, while minimum PLW (3.20%) and colour index (36.34) were in 2% CMC + 1.5% chitosan (T9), which also maintained TSS and acidity best (Fig. 33).

Fig. 33. Effect of coating at different storage duration

Preparation of litchi fiber powder

The fibers were dried at three different temperatures (55, 65, 75°C) till the moisture content of the samples fell below 10%. The dried fibers were analyzed for their moisture content, water activity and sensory attributes. The water activity of all the three powdered samples was found below 0.45 which ensures its suitability against the microbial contamination. The colour, flavour and aroma were best for 65°C dried powder. The samples dried at 55°C took more than 24 h and their colour degradation was more compared to 65°C sample (Fig. 36).

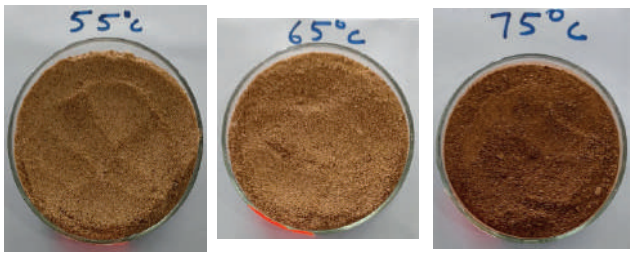


Fig. 36. Litchi fiber dried at different drying tempartures

5. Litchi based farming system under changing climate scenario

5.1. Understanding temporal variation in fruit maturity behavior in litchi growing in Bihar

The study is being undertaken to develop a better understanding on effect of climatic variability on phenological behavior of litchi. The phenological data were collected from adult trees (16 years old) of 'Shahi' *cv.* of litchi. Five healthy trees were randomly selected, and four branches from each tree were tagged (30 tag per tree) and were studied. In addition, all trees in the orchard were monitored to ascertain the predominant developmental stage (Table 39). Observations were recorded during several growing seasons at a frequency depending on the stage, ranging from two to three times per week to once every 15 days. Results revealed (Fig. 37) that during 2023-24, panicle emergence was only 6.66% which was probably due to higher minimum temperature than the average of last 10 years during October (1.17^{0}C higher) and November (1.84^{0}C higher) leading to early flushing in November. The total degree days during shoot development stage of second flush was recorded as 172.81 days. The average duration during which the shoots were exposed to minimum temperature of <12^{0}C (identified as one of the critical parameter for suitability of litchi) was 56.9 days. The duration between stage 119 (all leaves change from light green to dark green) to stage 502 (Panicle axis begins to elongate) was recorded as 151.2 days.

Table: 39. Description of the phenological stages of litchi.

1. Principal growth stage 0: bud development	
010	Dormancy: foliar buds are completely closed and covered by brownish scales, sharp-pointed
011	Foliar buds start to swell and open
013	End of leaf bud swelling: brownish scales are slightly separated; light-green buds emerge
017	Beginning of bud burst: green leaf tips start to become visible
019	Bud burst: green shoot tips are clearly visible
2. Principal growth stage 1: leaf development	
110	First leaves separate: green scales open slightly; leaves begin to emerge
111	First leaves visible: first leaves unfold and spread away from the shoot
113	More leaves unfold: leaves appear red; petioles become visible
115	First leaves fully expand: leaves colour change from red to light green
117	All leaves unfold and expand completely
119	Leaves mature: all leaves change from light green to dark green
3. Principal growth stage 3: shoot development	
311	Beginning of shoot growth: axes of the developing shoots become visible and are approximately 10% of the final length.
313	Shoots are about 30% of the final length.
315	Shoots are about 50% of the final length.
317	Shoots are about 70% of the final length.
319	Shoots are about 90% of the final length
4. Principal growth stage 5: inflorescence emergence	
500	Inflorescence buds are completely closed and covered with brownish scales
501	Beginning of bud swelling: scales begin to separate
502	Panicle axis begins to elongate: leaves are visible in the principal axis.
503	"Whitish millet" stage: inflorescence primordium becomes visible; panicle development begins
505	Flowers are visibly separated: secondary axes begin to elongate
507	Secondary axes elongate: flower buds are swollen.
509	End of panicle development: secondary axes are fully grown; most flowers with petals form a hollow ball, and the corolla changes from green to white
5. Principal growth stage 6: flowering	
610	First flowers open.
611	Beginning of flowering: 10% of the panicle flowers open
613	Early flowering: 30% of the panicle flowers open.
615	Full flowering: more than 50% of the panicle flowers open
617	Flower fading: The majority of petals fall off or dry out
619	End of flowering: All petals have fallen off or dried out; fruit is set.
620	Barren panicle
621	Panicle has dried out or fallen off completely

6. Principal growth stage 7: fruit development	
700	Fruit set: two conjoined fruits
701	Beginning of ovary growth: first physiological fruit falls.
702	One of the conjoined fruits grows
703	Fruit is about 30% of the final size. Second physiological fruit falls
705	Fruit is about 50% of the final size
707	Fruit is about 70% of the final size
709	Fruit is at standard cultivar size: fruit appears plump and light green
7. Principal growth stage 8: fruit maturity	
800	Physiological maturity: green fruit is fully developed with a creamy pericarp.
801	Colour break stage: pericarpcolour changes from light green to red
805	Advanced ripening: increased intensity of the cultivarspecific red colour
809	Fruit colour fully developed: fruit is ripe for consumption, with correct firmness and typical taste; fruit senescence begins

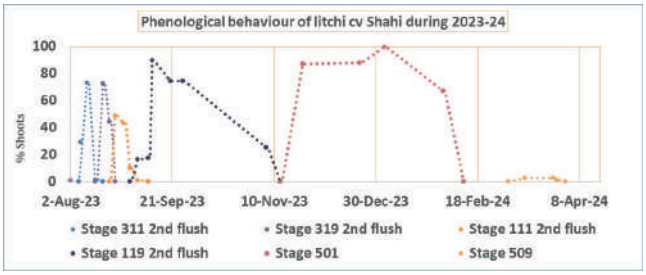


Fig. 37. Chronological progression of principal growth stages of litchi cv. Shahi

5.2. Ecological foot printing of litchi production in India

The study is being undertaken with the objective of developing recommendation for ptimizing ecological footprint of litchi based production systems in different parts of India. During 2023-24, efforts were made to document the structure, composition and practices of litchi based farming systems prevailing in farmer's fields of Bihar. The average holding size was found to be 0.70 ha with cropping intensity of 128.08%. The average value of Simpson's Crop diversification index was 0.67. The average net income was found to be Rs 1.41 lakh per ha in which % contribution of litchi and cereals was found to be 28.23% and 41.91%. Estimation of total greenhouse gas emission from litchi cultivation indicated a total emission of 3.6 t/ha CO2 equivalent out of which the highest contribution was from application of chemical fertilizer (28%) (Fig. 38).

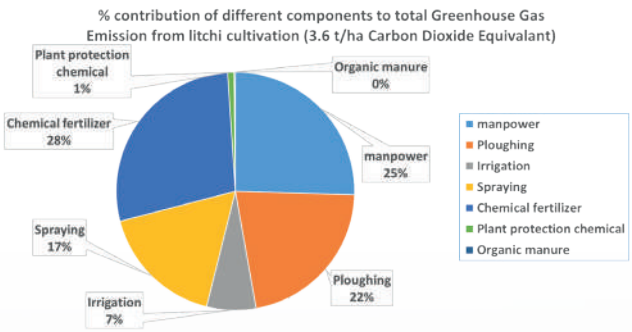


Fig. 38. Per cent contribution of different component to total gas emission

6. Improving knowledge and skill of stakeholders for increasing production of litchi

6.1. Technological upscaling among tribal farmers (TSP)

Under the Tribal Sub-Plan (TSP) project during 2024–25, a comprehensive initiative was undertaken for the promotion of litchi cultivation and farmer capacity building in the tribal regions. With active support from Krishi Vigyan Kendra (KVK), Tirap, Arunachal Pradesh, 2,000 planting materials of the elite litchi cultivar 'Shahi' were supplied and distributed to local farmers. A hybrid-mode training programme was also organized at KVK Tirap, benefiting approximately 50 tribal farmers. During the training, participants were sensitized to scientific litchi cultivation practices and were also provided

with seed kits and small agricultural tools to aid in on-farm adoption. This initiative is of strategic importance as it contributes significantly to area expansion under high-value litchi cultivation in tribal regions, where such crops have traditionally been underutilized. By introducing improved planting materials and conducting targeted trainings, the project plays a crucial role in upgrading farmers' technical knowledge, enhancing crop productivity, and supporting sustainable livelihood opportunities.

The activities were carried out within a modest budget allocation of ₹5.00 lakh for the financial year 2024–25. Further, 1142 saplings of litchi have also been booked for farmers in Jharkhand, which are currently undergoing hardening. These will be distributed in the upcoming rainy season through KVK, Gumla, or in collaboration with the NGO, 'PRADAN'. This coordinated approach ensures a wider geographical impact and sustained efforts towards diversified horticultural development among tribal farming communities.

Plate-7. Training cum input distribution Programme at KVK, Tirap, Arunachal Pradesh

6.2 Technological upscaling among Scheduled Caste farmers

Table: 40. Details of the activities carried out under SCSP project.

Sl. No.	Details of the activities
1.	1000 chicks of poultry (Vanraj) and poultry feed were distributed among 50 farmers
2.	2000 saplings of Litchi cv. Shahi and China were distributed to 120 farmers of different villages *i.e.* Chhajan, Sakra, Kishunpur, Ram Nagar and Paigambarpur
3.	Wheat (2000 kg) (DBW 187), lentil (500 kg) (IPL-220), and potato (4800 kg) (Kufri Himani, Kufri Jyoti, Kufri Khyati, Kufri Lalit and Kufri Neelkanth) seeds for the purpose of technological demonstration within the SC-SP programme
4.	Exposure visit and technology demonstration of SC farmers was organised under SC-SP to ICAR-RCER, Patna

Plate-8. Distribution of litchi saplings to the SC farmers at KVK, Turki

Plate-9. Poultry chicks and feed were distributed to the farmers at KVK, Turki

Transfer of Technology and Outreach Activities

Dissemination of technologies have been done through organizing training, demonstration, field day, Kisan Gosthis, lectures, showcasing NRCL's technologies in agriculture/farmers fair and interaction with stakeholders. The details of formal training and other programmes pertaining to transfer technology and human resource development activities are summarized below.

1. Training programmes/field days organized

Sl. No.	Title of the training	Date	Number of participants	Sponsoring agency	Coordinators
1.	लीची में प्रसंस्करण एवं मूल्य संवर्धन	7-9 फरवरी 2024	20	BAMETI, Govt. of Bihar	डॉ. सुनील कुमार
2.	रोजगार सृजन हेतु लीची में पौधशाला प्रबंधन	12-14 फरवरी 2024	20	BAMETI, Govt. of Bihar	डॉ. सुनील कुमार
3.	लीची में उन्नत बागवानी एवं इसका प्रबंधन	18-22 मार्च 2024	20	BAMETI, Govt. of Bihar	डॉ. प्रभात कुमार डॉ. सुनील कुमार
4.	लीची के पुराने बागो का जीर्णोधार और इसका प्रबंधन	26-28 मार्च 2024	20	BAMETI, Govt. of Bihar	डॉ. प्रभात कुमार
5.	लीची की खेती, पैकेजिंग एवं प्रसंसकरण	29-31 मार्च 2024	20	RKVY	ई. अंकित कुमार
6.	8th EDP (Entrepreneurship Development Program)	18-21 June 2024	21	ICAR-NRC on Litchi	Er. Ankit Kumar Dr. Sunil Kumar
7.	उद्यमिता विकास हेतु लीची में पौधशाला प्रबंधन	10-12 जुलाई 2024	25	BAMETI, Govt. of Bihar	डॉ. इप्सिता सामल
8.	Extension for Horticulture Technologies	10 -12 July 2024	25	MANAGE	Dr. Bhagya Vijayan
9.	लीची में छत्रक प्रबंधन पर उधमिता विकास कार्यक्रम	18-19 जुलाई 2024	20	Self Sponsored	डॉ. सुनील कुमार
10.	लीची में प्रसंस्करण एवं मूल्य संवर्धन	21-23 अगस्त 2024	32	BAMETI, Govt. of Bihar	डॉ. भाग्या विजयन
11.	जलवायु परिवर्तन के संबंध में लीची में एकीकृत कीट प्रबंधन	18-20 सितम्बर 2024	20	BAMETI, Govt. of Bihar	डॉ. विनोद कुमार डॉ. इप्सिता सामल
12.	लीची के पुराने एवं अनुत्पादक बागों का जीर्णोद्धार	14-16 अक्टूबर 2024	20	BAMETI, Govt. of Bihar	डॉ. सुनील कुमार डॉ. प्रभात कुमार
13.	लीची मे तुड़ाई उपरांत प्रसंस्करण एवं मूल्य संवर्धन	21-23 अक्टूबर 2024	20	RKVY	ई. अंकित कुमार डॉ. सुनील कुमार
16.	लीची बाग में एकीकृत पोषक तत्व प्रबंधन	20-22 नवम्बर 2024	23	BAMETI, Govt. of Bihar	डॉ. प्रभात कुमार डॉ. अभय कुमार
17.	लीची में तुड़ाई उपरांत प्रसंस्करण और प्रबंधन के माध्यम से उद्यमिता विकास	11-13 दिसंबर 2024	35	RKVY	ई. अंकित कुमार डॉ. सुनील कुमार

Sl. No.	Title of the training	Date	Number of participants	Sponsoring agency	Coordinators
18.	मूल्यवर्धित लीची उत्पाद के माध्यम से उद्यमिता विकास	18-20 दिसंबर 2024	25	BAMETI, Govt. of Bihar	ई. अंकित कुमार डॉ. सुनील कुमार
19.	लीची के बागों में उत्तम कृषि क्रियाएँ एवं प्रबंधन	26-28 दिसंबर 2024	25	BAMETI, Govt. of Bihar	डॉ. इप्सिता सामल

2. Institute Seminar / webinars organized

The talk series for the students and other litchi stakholders has been started, in which scientists from different fields were invited to interact.

Sl. No.	Title of Lecture	Date	Resource person
1.	Climate Proofing of Agriculture in a Participatory Approach: A Success Story in Tribal Areas.	28th October 2024	Dr. Bikash Das
2.	Modified and controlled atmosphere packaging of fruit products	3rd December 2024	Er. Ankit Kumar
3.	An insight into the host-pathogen interaction of necrotrophic fungal pathogens and its implications to disease management	18th April 2024	Dr. Vinod Kumar
4.	Intercropping in Litchi orchards for higher income generation	5th November 2024	Dr. Amarendra Kumar Principal scientist, ICAR-ATARI, Patna

Plate-10. Dr. Bikash Das delivering seminar on Climate Proofing of Agriculture in a Participatory Approach: A Success Story in Tribal Areas.

3. Monthly Stakeholders' Interface Meetings organized

The institute organizes Farmer-scientists interface meet at monthly interval in which litchi growers/ traders, processors participate in the deliberations on seasonal issues on litchi with scientists of the institute and representatives from Govt. of Bihar. During the year a total of eight number of monthly farmer scientist interface meetings were held at the centre in which more than 600 stakeholders participated.

4. Participation in Farmers' Fairs / Exhibitions

Sl. No.	Programme	Venue	Date	Participants
1.	Agricultural Mechanization cum Product Fair	Mushahari, Muzaffaripur	29-30 January 2024	Dr. Bhagya Vijayan Dr. J. P. Verma Mr. A. P. Pandey
2.	Regional Agricultural Fair	ICAR-IIVR, Varanasi	03-05 February 2024	Dr. Ramashish Kumar Mr. Rohit Kumar
3.	पूर्बी क्षेत्रीय किसान मेला	Krishi Vigyan Kendra, Khunti	03-05 February 2024	Dr. Bikash Das Dr. J. P. Verma Mr. Dharmendra Kumar
4.	किसान मेला	Krishi Vigyan Kendra, Piprakothi	10-12 February 2024	Mrs.Upagya Sah Mr. Alok Kumar Dr. J. P. Verma Mr. Ramesh Kumar
5.	किसान मेला- 2024	Bihar Agricultural University, Sabour, Bhagalpur	17-19 February 2024	Dr. J. P. Verma Mr. Ramesh Kumar
6.	Tribal farmers conference, conservation and improvement of tribal farming system		21-23 February 2024	Dr. Bikash Das Dr. J. P. Verma Mr. A. P. Pandey
7.	Kisan Mela-2024	Dr. RPCAU, Pusa, Samastipur	24-25 February 2024	Dr. Bikash Das Dr. Vinod Kumar Dr. Sunil Kumar Dr. J. P. Verma Mr. A. P. Pandey
8.	Kisan Mela-2024	Krishi Vigyan Kendra, Madhubani	9 March 2024	Dr. J. P. Verma, Mr. Ramesh Kumar
9.	Dairy Fair and Agricultural Exhibition	ICAR-IARI, Jharkhand	9-10 March 2024	Mr. Ajay Kr. Rajak Mr. Rohit Kumar
10.	Conference on seed spices and allied crops and Institue Industrial meet .	ICAR- NRC on Seed Spices, Ajmer	13-15 March 2024	Dr. J. P. Verma Mr. A. P. Pandey
11.	Agricultural Mechanization cum Product Fair	Mushahari, Muzaffaripur	27-28 July 2024	Mr. Dharmdev Bharti Mr. Chaman Kumar Mr. Akhand Pratap Pandey

Human Resource Development

1. Participation of Scientist Staff in Training/ Conference/ Seminar/ Symposia/ Workshop / Meeting

Sl. No.	Title	Venue and date	Participant(s)
1.	SRIJAN workshop	NASC, Pusa, New Delhi 17-19 January 2024	Dr. Bhagya Vijayan
2.	XI Group Discussion of ICAR- All India Coordinated Research Project on Fruits	NAU, Navsari (Gujarat) 22-25 January 2024	Dr. Bikash Das Dr. Sunil Kumar
3.	Exporters-Growers Business Meet (EGBM-2024)	ICAR-CISH, Lucknow 14 April 2024	Er. Ankit Kumar
4.	Online training on Business Opportunities for Farmers Producer Organization	MANAGE, Hyderbad 14 -18 May 2024	Dr. Bhagya Vijayan
5.	Training programme on pesticides residue analysis in fruits and vegetables" and demonstration of sampling techniques for pesticide residues in fruits and vegetables and aflatoxins in peanuts	ICAR-NRCG, Pune 28-29 May 2024	Dr. Ipsita Samal
6.	Litchi Diversity Show-2024	Dr. RPCAU, Pusa, Samastipur 30 May 2024	Dr. Bikash Das Dr. Sunil Kumar
7.	Brainstorming Session on "Litchi Research and Development: Navigating Challenges and future Goals"	ICAR-NRCL, Muzaffarpur 6 June 2024	Dr. Vinod Kumar Dr. Abhay Kumar Dr. Prabhat Kumar Dr. Bhagya Vijayan Dr. Sunil Kumar Er. Ankit Kumar Dr. Ipsita Samal
8.	XXXIII Annual Group Meeting of AICRP on Biological Control of Crop Pests	Dr. YSPUH&F, Nauni, Solan, 13-14 June 2024	Dr. Ipsita Samal
	Online training programme on "Python"	ICAR-IASRI, New Delhi 2-8 August 2024	Dr. Prabhat Kumar
9.	Online training on Climate Smart Agriculture Technologies	6 -8 August 2024	Dr. Bhagya Vijayan
10.	Online training on Use of Artificial Intelligence (AI) in Agriculture Sector	September 2024	Dr. Bhagya Vijayan
	Online training on Participatory Extension approaches for climate Risk management	ICAR- CRIDA and MANAGE, Hyderabad 17-19 September 2024	Dr. Prabhat Kumar
11.	Lotus (*Nelumbo nucifera*)-Aquatic plant with nutraceutical properties	ICAR-NRC on Makhana, Darbhanga 17 October 2024	Er. Ankit Kumar
12.	Online training on Drones in Agriculture	MANAGE, Hyderabad 10-12 December 2024	Dr. Bhagya Vijayan
13.	2nd National Conference and Webinar On Farmers Orientation Towards Climate Change and Upgradation to Sustainability (FOCUS) (Hybrid Mode)	GAPS, Dhanbad 23-24 December 2024	Dr. Abhay Kumar

Events Organized

24th Foundation Day 2024

The ICAR-National Research Centre on Litchi, Muzaffarpur, celebrated its 24th Foundation Day on 6th June 2024 with great enthusiasm and scholarly engagement. Dr. Sanjay Kumar Singh, DDG (Horticultural Science), ICAR, graced the occasion as Chief Guest. On this **Brainstorming Session on *"Litchi Research and Development: Challenges and Future Goals"* was also organized. In this programme,** Dr. Abhijit Kar (ICAR-NISA), Dr. Anup Das (ICAR-RCER), Dr. Anjani Kumar (ICAR-ATARI) and Dr. K.G. Mandal (ICAR-MGIFRI), **Dr. H.S. Singh** (Principal Scientist & Head, Crop Protection Division, ICAR-CISH, Lucknow) and **Dr. Jaipal S. Choudhary** (Senior Scientist, ICAR-RCER, Ranchi) delivered insightful addresses focusing on technology adoption and marketing strategies for horticultural produce.

Plate-11. Dr. Sanjay Kumar Singh, DDG (Horticultural Science), ICAR addressing the gathering on the occasion

Plate-12. Dr. Vinod Kumar, Principal Scientist, ICAR-NRCL, presenting during Session I of the Brainstorming Session 2024

हिंदी कार्यशाला, संगोष्ठी एवं प्रश्नमंच प्रतियोगिता का आयोजन

भा.कृ.अनु.प.- राष्ट्रीय लीची अनुसंधान केंद्र, मुशहरी, मुजफ्फरपुर ने दिनांक 27 जून 2024 को नराकास, मुजफ्फरपुर के तत्वावधान में हिंदी कार्यशाला, संगोष्ठी एवं प्रश्नमंच प्रतियोगिता का आयोजन किया। कार्यक्रम के मुख्य अतिथि श्री शैलेन्द्र प्रसाद, अध्यक्ष, नगर राजभाषा कार्यान्वयन समिति, मुजफ्फरपुर एवं उप-महा प्रबंधक बैंक ऑफ़ इंडिया, मुजफ्फरपुर थे। कार्यक्रम के शुरुआत में डॉ बिकाश दास, निदेशक एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केंद्र, मुशहरी, मुजफ्फरपुर ने सभी का स्वागत किया एवं उपस्थित कर्मियों को हिंदी का ज्यादा से ज्यादा से प्रयोग करने का निर्देश दिया। मुख्य अतिथि, श्री शैलेन्द्र प्रसाद , ने हिंदी में शत प्रतिशत कार्य करने के लिए सभी को आग्रह किया। कार्यशाला में श्री अनुप कुमार तिवारी, सदस्य सचिव, नराकास, मुजफ्फरपुर ने कार्यक्रम को आगे बढ़ाया एवं हिंदी के प्रयोग से सम्बंधित निति एवं नियमों (राजभाषा अधिनियम 1976) के बारे में सबको अवगत कराया। श्री रीतेश सुरभि, प्रबंधक, भारतीय स्टेट बैंक, ने राजभाषा नीति नियम पर व्याख्यान दिया एवं संविधान सभा में हिंदी के बारे में टिका टिपण्णी पर एक सुन्दर फिल्म का भी चित्रण किया गया। कार्यक्रम की अगली कड़ी में, श्री हेमन्त कुमार, प्रबंधक, सेंट्रल बैंक ऑफ़ इंडिया, ने "राजभाषा एवं तकनीक; कृत्रिम बुधिमत्ता" पर व्याख्यान दिया। संस्थान के राजभाषा अधिकारी, डा. सुनील कुमार ने भी हिंदी के अधिक से अधिक उपयोग पर जोर देते हुए सभी को संबोधित किया। संगोष्टी में विभिन्न राजभाषा अधिकारीयों के द्वारा हिंदी के प्रयोग को बढ़ाने के लिए विस्तृत चर्चा की गई। तत्पश्चात, एक प्रश्नमंच प्रतियोगिता का आयोजन किया गया जिसमें 40 प्रतिभागियों ने भाग लिया एवं विजेता (प्रथम, द्वितीय एवं तृतीय) को पुरस्कृत किया गया। कार्यक्रम के अंत में डॉ सुनील कुमार, राजभाषा अधिकारी एवं वैज्ञानिक ने धन्यवाद् ज्ञापन प्रस्तुत किया।

Plate-13. डॉ. बिकास दास, निदेशक, मुख्य अतिथि, श्री शैलेन्द्र प्रसाद, अध्यक्ष, नराकास, मुजफ्फरपुर का स्वागत करते हुए

Plate-14. हिंदी कार्यशाला में भाग लेने वाले प्रतिभागी

'हिन्दी चेतना मास' का आयोजन

सरकारी काम काज में राजभाषा हिन्दी के प्रति जागरूकता तथा उसके उत्तरोत्तर प्रयोग में गति लाने के उद्देश्य से राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर में 14 सितंबर से 14 अक्टूबर 2024 के दौरान 'हिन्दी चेतना मास' मनाया गया। इस अवसर पर हिंदी से सम्बंधित विभिन्न प्रतियोगिताओं (प्रश्नोत्तरी, हिंदी अनुवाद, हिंदी टंकण, श्रुत लेखन, सुलेखन, निबंध, वाद-विवाद) का आयोजन भी किया गया था। समापन समारोह के दोरान विजेता प्रतिभागियों को प्रमाण- पत्र सहित पुरुस्कृत किया गया।

Plate-15. संस्थान के कर्मचारी हिन्दी चेतना मास के शुभारम्भ पर हिंदी का अधिकाधिक प्रयोग करने हेतु प्रतिज्ञा लेते हुए

Plate-16. हिन्दी चेतना मास–2024 का समापन समारोह एवं पुरस्कार वितरण

Swachha Bharat Mission

Swachha Bharat Mission fortnight Swachhta Pakhwada from 17 Sept to 1 Oct 2024, Organised Gandhi Jayanti Swachha Bharat Diwas on 2nd Oct 2024 and Swachhta Pakhwada 16-31 December 2024: Swachhta mission was organized at NRCL during this various activity like shramdaan, cleanliness drive, plantation in local area were done. Apart from this Kishan diwas was also celebrated at farmer's field, mass awareness about cleanliness was spread, recycling of the waste material (best out of waste), knowledge of vermin-composting was spread.

Vigilance Awareness Week 2024

In line with the directions of the Central Vigilance Commission (CVC), ICAR-NRCL observed Vigilance Awareness Week from 28th October to 3rd November 2024 with the theme of "Culture of integrity for nations prosperity, सत्यनिष्ठा की संस्कृति से राष्ट्र की समृद्धि". The week began with administering of the Integrity Pledge to all the staff by the Director, Dr. Bikash Das. He also briefed about the focus area "Culture of integrity for nations prosperity". In the Workshop that followed, he emphasized on following the office ethics, protocols, guidelines and conduct rules to maintain the Institute's integrity. The banners and posters highlighting the year's theme of Vigilance Week were displayed at main entrance of the campus as well as office premises of NRCL at prominent place. Vigilance Officer, Dr Vinod Kumar motivated all the employees to also sign the e-pledge. Dr Kumar, apprised all the staff that Vigilance Awareness Week is one of the Participative Vigilance initiatives of the CVC in the fight against corruption. It is an awareness building and outreach measure which aims to bring together all the stakeholders. It is observed to create greater sensitivity about the need for ethics and transparency in governance and public

administration. As a prelude to Vigilance Awareness Week 2023, the Central Vigilance Commission (CVC) had desired that all organizations may undertake a three-month campaign (16th August 2024-15th November 2024) with Preventive Vigilance measures as focus areas. Accordingly, NRCL also undertaken campaign and a report was submitted to the Council by the Vigilance Officer.

Plate-17. A glimpse of Vigilance Awareness Celebration 2024

Plate-18. Shri I. B. Kumar delivering a lecture in Vigilance Awareness Week-2024

The 17th Research Advisory Meeting

The 17th Research Advisory Meeting of ICAR-National Research Centre on Litchi, Muzaffarpur was held on 30th September, 2024 under the Chairmanship of Dr. B.C. Deka, honourable Vice Chancellor, Assam Agricultural University, Jorhat. The meeting brought together an expert panel comprising Dr. Abraham Verghese (Former Director, ICAR-NBAIR), Dr. P.K. Ray (Former Head, Dept. of Horticulture, RPCAU), Dr. K.V. Bhat (Former Head, Genomic Resources, ICAR-NBPGR), Dr. Vivek Kumar and Sh. Vikrant Kumar Upadhyay (Non-official members), Assistant Director General (Fruit & Plantation Crops), Dr. Bikash Das (Director, ICAR-NRCL), and Dr. Vinod Kumar (Member Secretary and Principal Scientist, ICAR-NRCL). Notably, Dr. C.K. Narayana and Dr. B.S. Dwivedi were absent due to unavoidable circumstances, with Dr. Narayana officially retiring on the same day. The RAC began with a field visit to observe ongoing research trials, followed by formal presentations and discussions on research achievements and action-taken reports from the previous meeting.

During the meeting, the Committee provided several strategic recommendations for advancing litchi research. Key proposals included initiating a long-term (25–30 years) experiment to assess climate change impact on litchi yield, studying temporal variation in flowering and fruit maturity across locations to extend market availability, and collecting germplasm of important sapindaceous fruits such as longan, alupag, rambutan, pulasan, and ackee from nurseries to diversify the genetic base. Emphasis was also laid on standardizing protocols for organic litchi farming, regeneration, and grafting techniques. Advanced biotechnological approaches were recommended, such as exploiting SNP-based genomic differences for precision breeding and understanding detoxification mechanisms in pests using metagenomics. The committee also called for the development of a predictive model for pest outbreaks using weather parameters, preparing a block-wise soil fertility map, repeating pesticide residue analysis, and setting up a quarantine facility to monitor invasive pests and diseases. Additional suggestions included creating a post-harvest management bulletin, testing natural fungal bioagents like *Metarhizium anisopliae* and *Beauveria bassiana*, and exploring coating materials to extend fruit shelf life. The members unanimously praised ICAR-NRCL's contributions over the past two decades and called for enhanced manpower and funding support. Finally, the Director, ICAR-NRCL expressed gratitude to the members for their valuable inputs during the day's discussions. The meeting concluded with vote of thanks proposed by Dr. Sunil Kumar, Scientist, Fruit Science.

Plate-19. Scientists and staffs of the Centre with 17th RAC

Plate-20. Dr. Bikash Das, Director, ICAR-NRCL, with RAC members during field visit

Soil Day

Soil day was celebrated on 5th of Dec 2024 with the school children at local government High School at Mushahari, Muzaffarpur. During this day lecture was delivered about soil and its importance for soil health. During this programme quiz and completion on soil day was also prize was distributed among children. In this programme about 110 people participated including students, teachers and staff.

Kisan Diwas (Farmer's Day)

Celebration of **Kisan Diwas** was organized 23 Dec 2024 in village Nawada, Block Mushahari, Muzaffarpur. On this occasion Director Dr. Bikas Das was chief guest along with other Scientist Dr. Prabhat Kumar, Dr. Ipsita Samal and others addressed around 70 farmers who participated and interacted about their problems about litchi orchard management and the problems were resolved. The meaasge of swachhta was spread and cleanliness drive was also organized.

23rd IRC Meeting

The 23rd Institute Research Council (IRC) meeting of the of ICAR-NRCL, Muzaffarpur, was held on 30th Decmeber 2024 in the Committee room of the Institute under the chairmanship of Dr. Bikash Das, Director, ICAR-NRCL. Dr. Sunil Kumar, In-Charge PME Cell and Member Secretary, IRC, welcomed the Chairman and all the members to the 23rd IRC meeting. The gathering paid tribute and expreessed their deep sorrow after the sad demise of the former Indian Prime Minister, Dr. Manmohan Singh. In his opening remarks, Dr. Bikash Das, Director & Chairman, IRC, emphasised that the scientist should attract more externally funded projects and explore new avenues for technology transfer by working in close association with the stakeholders. He also emphasised that the institute should work on the entire supply chain of the Litchi. He also highlighted the importance of good quality publication in high rated Journals. The research projects of the institute are carried out under 5 broad core-areas and the progress of the research work under different core areas were presented by the respective Scientists. During the deliberation, 20 institute funded projects, 4 externally funded projects, 9 AICRP trials were discussed. Two new project proposals and three observational trials were also presented before the Council for approval. The IRC, reviewed the progress of each project and suggested future course of action.

Plate-21. A glimpse of 23rd Institute Research Council meeting of the Institute

Ongoing Research Projects

A. Institute funded

Sl. No.	Project title	Principal Investigator	Co-PIs
1. Conservation, characterization, and utilization of genetic diversity for improvement of litchi			
1.	Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization	Dr. Abhay Kumar	Dr. Sunil Kumar Dr. Vinod Kumar Dr. Ipsita Samal Er. Ankit Kumar
2.	Development of improved cultivars in litchi	Dr. Abhay Kumar	Dr. Sunil Kumar
3.	Characterization, evaluation and utilization of longan germplasm	Dr. Abhay Kumar	Dr. Sunil Kumar
4.	Molecular Finger-printing in litchi cultivars through microsatellite markers	Dr. Abhay Kumar	Dr. Sunil Kumar
5.	Mutation breeding for litchi improvement	Dr. Sunil Kumar	Dr. Abhay Kumar
6.	Mapping of gene(s)/QTLs for economically important traits in litchi through genome-wide association studies (GWAS)	Dr. Sunil Kumar	Dr. Abhay Kumar Dr. M. K. Dhakar Dr. K. U. Tribhuvan Dr. D. S. Bisht
2. Development and refinement of integrated production technologies for improved productivity of litchi			
7.	Investigation on mycorrhizal association and role of bio-fertilizers for sustainable production of litchi	Dr. Vinod Kumar	Dr. Prabhat Kumar
8.	Integrated soil health management for quality litchi production	Dr. Prabhat Kumar	Dr. Vinod Kumar
9.	Nutrient management in Litchi orchard using Diagnosis and Recommendation Integrated System	Dr. Prabhat Kumar	—
10.	Effect of Seasonal variation on leaf nutrient dynamics of litchi cultivar and Standardizing Litchi leaf sampling Technique for Alluvial plain of Bihar	Dr. Prabhat Kumar	—
11.	Effect of enriched biochar on soil properties and fruit yield in litchi orchard	Dr. Prabhat Kumar	—
3. Development and refinement of integrated crop protection technologies for improved productivity of litchi			
12.	Investigation and management of pre-harvest diseases of litchi	Dr. Vinod Kumar	Dr. Abhay Kumar
13.	Investigation and management of insect-pest complex of litchi	Dr. Ipsita Samal	Dr. Vinod Kumar Dr. J. S. Chaudhary
14.	Understanding spatio-temporal variation changes in host pest interaction	Dr. Ipsita Samal	Dr. Vinod Kumar Dr. Bhagya Vijayan Dr. Pratheepa M Dr. J. S. Chaudhary

Sl. No.	Project title	Principal Investigator	Co-PIs
15.	Exploring the potential of behaviour chemicals for the managment of litchi stink bug	Dr. Ipsita Samal	Dr. Vinod Kumar Dr. K. Subaharan Dr. J. S. Chaudhary
4. Integrated Postharvest Management to Reduce Losses, Improve Marketing and Product Diversification			
16.	Investigation and management of postharvest losses in litchi	Dr. Vinod Kumar	-
17.	Postharvest management with respect to pericarp browning and fruit decay	Er. Ankit Kumar	Dr. Vinod Kumar
18.	Post harvest management and by-product utilization of litchi fruit	Er. Ankit Kumar	Dr. Sunil Kumar Dr. Bhagya Vijayan Dr. S. K. S. Yadav Dr. Alok Gupta
5. Improving knowledge and skill of stakeholders for increasing production of litchi			
19.	Socio-Economic Impact assessment of ICAR-NRCL technologies among litchi growers in India	Dr. Bhagya Vijayan	Dr. Sunil Kumar
20.	Ecological footprinting of litchi production in India	Dr. Bhagya Vijayan	Dr. Bikash Das Er. Ankit Kumar
6. Long term activities			
21.	Tribal Sub-Plan	Dr. Vinod Kumar	Dr. Bhagya Vijayan
22.	Scheduled Caste Sub Plan	Dr. Bhagya Vijayan	Dr. Sunil Kumar Dr. Ipsita samal
7. Pilot projects/observational trials			
23.	Management of fruit cracking in Litchi	Dr. Sunil Kumar	Dr. Bikash Das Er. Ankit Kumar Dr. Ashok Dhakad
24.	Scheduling of flood irrigation on litchi	Dr. Sunil Kumar	Dr. Bikash Das Dr. Ashok Dhakad
25.	Natural farming in litchi	Dr. Sunil Kumar	Dr. Bikash Das Dr. Ashok Dhakad
26.	Conservation horticulture in litchi	Dr. Sunil Kumar	Dr. Bikash Das Dr. Ashok Dhakad

B. Externally Funded

Sl. No.	Project title	Principal Investigator	Co-PIs	Funding agency
1.	Developing national repository and facilities for DUS testing in Litchi	Dr. Abhay Kumar	Dr. Sunil Kumar	PPV&FRA
2.	National Agricultural Innovation project-Component II	Dr. Bhagya Vijayan	Dr. Vinod Kumar Dr. Abhay Kumar Dr. Prabhat Kumar Dr. Sunil Kumar Er. Ankit Kumar	NAIF

Sl. No.	Project title	Principal Investigator	Co-PIs	Funding agency
3.	Participatory Development of Litchi based Climate Resilient Farming systems in Bihar	Dr. Bhagya Vijayan	Er. Ankit Kumar Dr. Bikash Das	RKVY
4.	Shelf-life Enhancement and Value Addition of Litchi through various Post-harvest Intervention	Er. Ankit Kumar	Dr. Bhagya Vijayan Dr. Sunil Kumar	RKVY
5.	Enhancing the livelihood of litchi farmers through beekeeping and assessing the agrochemicals in honey	Dr. Ipsita Samal	Er. Ankit Kumar Dr. Sunil Kumar	NBB

C. Trials under ICAR-AICRPs:

Sl. No.	Title of the trial	Principal Investigator	Co-PIs
ICAR-AICRP on Fruits			
1.	Creating variability in litchi (1.3.2.L.)	Dr. Sunil Kumar	Dr. Bikash Das
2.	Evaluation of small seeded litchi variety (MLT-1) (1.3.3.L.)	Dr. Sunil Kumar	Dr. Bikash Das
3.	Development of plant canopy architecture in litchi (2.3.5.L.)	Dr. Sunil Kumar	-
4.	Irrigation scheduling in litchi (3.3.3.L.)	Dr. Sunil Kumar	-
5.	Assessment of phenology in litchi grown under varying climatic conditions (4.3.7.L.)	Dr. Sunil Kumar	Dr. Bikash Das
6.	Using paclobutrazol and micronutrient application as a tool for productivity and fruit quality improvement of litchi under subtropical conditions (4.3.8.L.)	Dr. Sunil Kumar	-
7.	Survey for new and emerging inscet pests and their natural enemies in litchi (5.3.1.L.)	Dr. Ipsita Samal	-
8.	Crop phenology based bio-intensive pest management module for litchi pest complex (5.3.5.L.)	Dr. Ipsita Samal	-
ICAR- AICRP on Biocontrol			
9.	Bio intensive pest management of Litchi fruit borer, *Conopomorpha sinensis* in litchi	Dr. Ipsita Samal	-

List of Publications

Research Papers

1. Ali, A., Das, B., Dhakar, M.K. *et al.* (2024). Enhancing soil health and fruit yield through *Tephrosia* biomass mulching in rainfed guava (*Psidium guajava* L.) orchards. *Scientific Reports,* 14: 13913.
2. Bhoi, T. K., Dhillon, M. K., Singh, N., Samal, I., Watts, A., Rao, M. and Bhattacharya, R. C. (2024). Phenology and morphological traits of wild crucifers impacting host selection and population build up by mustard aphid [*Lipaphis erysimi* (Kaltenbach)]. *Genetic Resources and Crop Evolution*, 1-19.
3. Gujjala, L. K. S., Kundu, D., Dutta, D., Kumar, A., Bal, M., Kumar, A. and Vo, D. V. N. (2024). Advances in ionic liquids: Synthesis, environmental remediation and reusability. *Journal of Molecular Liquids*, 396, 123896.
4. Jhorar, P., Choudhary, R., Jinger, D., Samal, I., Paramesh, V., Kumar, D., ... and Singh, S. (2024). Foliar Application of Silicon Influences Crop Productivity, Dry Matter Accumulation, Water Use Efficiency, Lodging Score, and Aphid Density in Wheat (*Triticum aestivum* L.). *Communications in Soil Science and Plant Analysis*, 55(19): 2894-2908.
5. Lal, N. and Kumar, A. (2024). Panicle and fruit characteristics influenced by plant age in litchi *cv.* Rose scented. *Bangladesh Journal of Botany.* 53(2): 279-285.
6. Lal, N., Kumar, A. and Pandey, S. D. (2024). Assessing the genetic diversity and character association of yield components in litchi (*Litchi chinensis* Sonn.). *Bangladesh Journal of Botany.* 53(3): 465-473.
7. Lal, N., Kumar, A., Marboh, E. S., Gupta, A. K., Pandey, S. D. and Nath, V. (2024). Effect of temperature and duration of storage on seed germination in litchi (*Litchi chinensis* Sonn.). *National Academy Science Letters.* 1-3.
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13. Rout, R. K., Kumar, A. and Rao, P. S. (2024). A Comparative Assessment of drying kinetics, energy consumption, mathematical modeling, and multivariate analysis of indian borage (*Plectranthus amboinicus*) Leaves. *Journal of Food Process Engineering*, 47(5): e14630.

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3. Singhal, V., Jinger, D., Rathore, A. C., Pal, R., Samal, I., Bhoi, T. K., Paramesh, V., Fahad, S., Jaremko, L., Abdelsalam, N. R. and Jaremko, M. (2024). COVID-19, deforestation, and green economy. *Frontiers in Forests and Global Change*, 6: 1305779.

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Jatav, H., S., Rajput, V. D., Samal, I. and Bhoi, T. K. (2024). Multitrophic Interactions for Sustainable Agroforestry: Harnessing the Power of Beneficial Insects and Ecological Dynamics. CRC Press.

Jatav, H., S., Rajput, V. D., Samal, I. and Bhoi, T. K. (2024). Agroforestry and Climate Change Mitigation: Harnessing Mutitropic Interactions for Sustainable Plant Protection and Ecosystem Resilience. CRC Press.

Kumar, S. and Yadav, A. (2024). Treasure of Fruit Science (7th Edition). New Vishal Publication.

Book chapters

Bhoi, T. K., Samal, I., Mahanta, D. K., Komal, J., Khan, M. A. and Jatav, H. S. (2024). Influence of Biochar on Soil Insect Dynamics and Infestation. In *Sustainable Use of Biochar-From Basics to Advances*. IntechOpen.

Bhoi, T. K., Samal, I., Mahanta, D. K., Komal, J., Majhi, P. K. and Bhatnagar, S. (2024). Genetic Engineering and Genome Editing Approaches for Identification and Sustainable Management of Insect Pests Under Forest Dynamics. In *Biotechnological Approaches for Sustaining Forest Trees and Their Products*. Singapore: Springer Nature Singapore. 385-423.

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Samal, I., Bhoi, T. K., Mahanta, D. K. and Komal, J. (2024). Agroforestry as an Effective Tool for Pest Management in the Era of Climate Change. In *Agroforestry Solutions for Climate Change and Environmental Restoration*. Singapore: Springer Nature Singapore. 221-244.

Samal, I., Bhoi, T. K., Mahanta, D. K. and Komal, J. (2024). Alternative natural options of synthesized agrochemicals. In *Bioremediation of Emerging Contaminants from Soils*. Elsevier. 387-419.

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Extension Folder

1. कुमार विनोद, कुमार सुनील, सामल इप्सिता, कुमार प्रभात (2024). लीची बाग प्रबंधन की मासिक कार्य योज़ना. रा.ली. अनु.के.-प्रसार पुस्तिका-15, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, पेज 06.
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1. Happy Kumari, Madhur Jyoti, Ansh Raj, Ajay Kumar, Ipsita Samal (2024). Biology of litchi stink bug (*Tessertoma javanica*) on Shahi cultivar of litchi in Muzaffarpur, Bihar, India in National conference on Modern agriculture: Innovation and Sustainability for a Resilient Future organized at Chaudhary Charan Singh University, Meerut, UP from 3-4 December 2024.
2. Madhur Jyoti, Happy Kumari, Ansh Raj, Ajay Kumar, Ipsita Samal. (2024). Seasonal prevalence and meterological influence on insect pest Dynamics in litchi (China cultivar) Orchard on bihar, India in National conference on Modern agriculture: Innovation and Sustainability for a Resilient Future organized at Chaudhary Charan Singh University, Meerut, UP from 3-4 December 2024.

Technical and popular articles

1. Das, B., Vijayan, B., Kumar, S. and Dhakar, M. K. (2024). Strategies for improving farmers' livelihood in Bihar through horticulture development. *Indian Farming Digest,* 3(1), 12-15.
2. Samal, I and Kumar, V. (2024). Asian weaver ants, *Oecophylla smaragdina* (Fabricius, 1775) (Hymenoptera: Formicidae): A natural solution for orchard pest management. *Indian Entomologist* 5(2): 65-71.

तकनीकी एवं लोकप्रिय लेख

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2. कुमार विनोद (2024). बदलते मौसम पेटर्न से अनुकूलन: लीची की चुनौतियाँ और समाधान. वज्जिकंगन, नराकास राजभाषा पत्रिका, मुजफ्फरपुर, बिहार, 20-23.
3. कुमार विनोद, सामल इप्सिता, कुमार लोकेश एवं साह उपज्ञा (2024). फसलों की सहनशीलता बढ़ाने के लिए पौधों पर आधारित जैव-जीवनाशक और जैव-प्रोत्साहक. लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, 10(1): 12-16.
4. सामल इप्सिता एवं कुमार विनोद (2024). बागों में एशियाई बुनकर चींटी (ओइकोफिला स्मारगडीना): लाभकारी अभिभावक या अवांछित मेहमान? लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, 10(1): 9-11.
5. साकरे प्रियका, महापात्र अर्चन, जॉन हिमा एवं विजयन भाग्या (2024). खाद्य उद्योग में इन्टरनटे ऑफ थिंग्स टेक्नोलॉजी का उत्तम समन्वय, लाक्षा, 16(1): 11.
6. कुमार अभय, सिंह प्रतिभा, कुमार सुनील, विजयन भाग्या, बिशी सुजीत कुमार एवं कुमार अंकित (2024). उद्यानिकी आनुवंशिक संपदा का संरक्षण: ग्रामीण भारत के विकास की दिशा में एक कदम, लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, 10(1): 30-35.
7. कुमार अभय, सिंह प्रतिभा, बिशी सुजीत कुमार, कुमार सुनील एवं कुमार प्रभात (2024). शहरी खाद्य उत्पादन में क्रांतिकारी बदलाव: वर्टिकल फार्मिंग (ऊर्ध्वाधर खेती) का उदय, लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, 10(1): 36-39.
8. कुमार अंकित, कुमार राहुल, कुकड़े ऋतु एवं प्रकाश रवि (2024). लीची के भंडारण अवधि के विस्तार के लिए रणनीतियाँ, प्रसंस्करण प्रगति, 8(1): 1-8.
9. सामल इप्सिता एवं कुमार विनोद (2024). एशियाई बुनकर चींटी (ओइकोफिला स्मारगडीना): बाग कीट प्रबंधन के लिए एक प्राकृतिक समाधान. बागवानी- राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय बागवानी अनुसंधान संस्थान, बेंगलुरु,कर्नाटक, (13): 62-65.
10. कविता, कुमार विनोद एवं कुमारी संगीता (2024). बीज प्राइमिंग: अंकुरण गुणता एवं उत्पादकता बढ़ाने की कारगर तकनीक, लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, वर्ष 10(1): 19-21.
11. कुमार प्रभात, प्रसाद शिव शंकर, कुमार राम, कुमार अभय, मीना राम भवन, कुमार रामाशीष एवं कुमार सोमेश (2024). बायोचार का महत्व: मृदा स्वास्थ्य और सतत कृषि के लिए, लीचिमा राजभाषा पत्रिका, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, वर्ष 10(1): 49-51.
12. कुमार प्रभात, प्रसाद शिव शंकर, कुमार राम, कुमार अभय, मीना राम भवन, कुमार रामाशीष एवं कुमार सोमेश (2024). भारतीय कृषि पर जलवायु परिवर्तन का प्रभाव, भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र, मुजफ्फरपुर, बिहार, वर्ष 10(1): 52-55.

Peer Recognition

Dr. Vinod Kumar

- Editor in the journal "*Indian Phytopathology*" published by Indian Phytopathological Society, New Delhi (Springer).
- Editor in the Journal "Pharmaceutical and Biomedical Sciences: An International Journal (PBIJ)"- a Quarterly peer-reviewed and refereed open access journal (http://airccse.com/pbij/index.html).
- Editor in the Journal "Journal of Crop Research and Fertilizers" - an Open Access peer reviewed journal published by Clerisy Publishers, Sunnyvale, USA (http://clerisyonlinepublishers.org/journals/journal-of-crop-research-and-fertilizers/jhome.php).
- Editor in the Journal "SCREA Journal of Agriculture", Science Research Association (http://www.scirea.org/).
- Associate Editor in "*International Journal of Agriculture Sciences",* Bioinfo Publications, Pune, India (https://bioinfopublication.org).
- Reviewer in National and International Journals: During 2024, reviewed paper for the four journals *viz., Journal of Crop Research and Fertilizers, Crop Protection, Indian Phytopathology* and *International Journal of Agriculture Sciences.*
- Appointed as external examiner for evaluation of answer sheets of Written Comprehensive Examination of PG Programmes {M.Sc. (Ag.) & Ph. D} in Plant Pathology at DRPCAU, Pusa, Bihar.
- Appointed as external examiner for evaluation of M. Sc. and Ph. D. thesis of students in Plant Pathology at DRPCAU, Pusa, Bihar.

Dr. Abhay Kumar

- Reviewer in National and International Journals: reviewed paper for four journals *viz., Crop Breeding & Applied Biotechnology*, *3Biotech*, *Erwerbs-Obstbau* and *International Journal of Agriculture Sciences*.
- Appointment for setting of Question paper for end term examination for BTech (Biotech) BBT 323 course at Bihar Agricultural University, Sabour, Bhagalpur.

Dr. Bhagya Vijayan

- Reviewer in National and International Journals:' During 2024 reviewed research papers for two journals *viz The Indian Research Journal of Agricultural Extension and Asian Journal of Agricultural Extension , Economis and Sociology.*

Dr. Sunil Kumar

- Delivered a TV talk on "*Litchi Ka Samsamyik Prabandhan*" (लीची का समसामयिक प्रबंधन). The program was broadcasted on 03rd June, 2024 at 02.00 PM in *Khet Khalian* by DD Bihar (DDK), Patna.
- Editor in the Journal *International Journal of Food Science and Agriculture.*
- Reviewer in National and International Journals: Reviewed paper for *Indian Journal of Horticulture, and Scientia Horticulturae.*
- संपादक, लीचिमा, राजभाषा पत्रिका, 2024.
- Convener of the Session -III on Nutrient & Water Management in GD XI of ICAR-AICRP on Fruits held at Navsari Agricultural University, Navsari (Gujarat) from 22nd to 25th January, 2024.
- Co-organizing Secretary of the "***Litchi Diversity Show-2024***" organized by Dr. RPCAU, Pusa, Samastipur in collaboration with ICAR- National Research Centre on Litchi, Muzaffarpur (Bihar) on 30th May 2024 at Dr. RPCAU, Pusa, Samastipur (Bihar).
- Convener of the Brainstorming Sessions held on the occasion of 24th Foundation Day (6th June 2024) of ICAR- NRC on Litchi, Muzaffarpur (Bihar).

- Member of the judging committee for evaluation of exhibits displayed in Horticulture Show, 2024 at RPCAU, Pusa, Samastipur on 24th February, 2024.
- Member of the judging committee for evaluation of exhibits displayed in "प्रमंडल स्तरीय उधान प्रदर्शनी तिरूहत प्रमंडल,राष्ट्रीय लीची अनुसंधान केंद्र, मुजफ्फरपुर (बिहार) on 10th March 2024.
- Associate faculty at ICAR-IARI, Jharkhand. Taught Courses *viz.* Subtropical and Temperate Fruit Production (FSC 502), Breeding of Fruit Crops (FSC 504), Tropical Fruit Production (FSC 501), Propagation and Nursery Management of Fruit Crops (FSC 503) and Minor Fruit Production (FSC 513) to the M.Sc. students of ICAR-IARI, Jharkhand.

Er. Ankit Kumar

- Cordinated the summer internship of 3 students from RPCAU Pusa during 01.07.2024 to 31.07.2024.

Dr. Ipsita Samal

- Reviewer in National and International Journals: During 2023, reviewed paper for the two journals *viz Frontiers in Agronomy and South African Journal of Botany.*
- Convenor in 24th foundation day celebration and Brainstorming on "Litchi research and Development: Navigating challenges and future goals" on 6th June, 2024 at ICAR-National Research Centre on Litchi, Mushahari, Muzaffarpur, Bihar.
- Convenor in Second International Conference on Biological Control: Biocontrol Contributions to One Health organised by Society for Biocontrol Advancement & ICAR–National Bureau of Agricultural Insect Resources, Bengaluru, India from 25th –28th February, 2025.

Member of Advisory Committee of Students

Sl. No.	Advisory Committee	Name of the Scientist	Name of the student	Degree	University/College	Year
1.	Chairman	Dr Bikash Das	Mageshwari D.	M.Sc.(Fruit Science)	ICAR- Indian Agricultural Research Institute, Hazaribag (Jharkhand)	2023-2025
2.	Chairman	Dr. Sunil Kumar	Nanneboyina Srikanth	M.Sc.(Fruit Science)	ICAR- Indian Agricultural Research Institute, Hazaribag (Jharkhand)	2023-2025
3.	Co-Chairman	Dr. Sunil Kumar	Mageshwari D.	M.Sc.(Fruit Science)	ICAR- Indian Agricultural Research Institute, Hazaribag (Jharkhand)	2023-2025
4.	Co-Advisor	Dr. Sunil Kumar	Jyoti Kumari	M.Sc. (Hort.) Fruit Science	College of Agriculture, IGKV, Raipur (C.G.)	2023-2025
5.	Member	Dr. Sunil Kumar	Happy Kumari	M.Sc. (Ag.) Entomology	Ch. Charan Singh University, Meerut	2023-2025
6.	Chairman	Dr. Ipsita Samal	Happy Kumari	M.Sc. (Ag.) Entomology	Ch. Charan Singh University, Meerut	2023-2025
7.	Chairman	Dr. Ipsita Samal	Madhur Jyoti	M.Sc. (Ag.) Entomology	Ch. Charan Singh University, Meerut	2023-2025

Awards and Honours

Dr. Abhay Kumar

- Young Scientist Award at 2nd National Conference and Webinar On Farmers Orientation Towards Climate Change and Upgradation to Sustainability (FOCUS) held at Dhanbad, Jharkhand 23-24 December, 2024.

Compilation, Editing and Documentation

Sl. No.	Title	Year of publication	Scientist involved
1.	ICAR-NRCL Annual Report 2023	2024	Dr. Sunil Kumar Dr. Ipsita Samal Er. Ankit Kumar
2.	EFC Memorandum (2021-2026) Prepared and revised time to time	2024	Dr. Vinod Kumar
3.	Technology and Publication Repository(Database), KRISHI (Knowledge BasedResources Information Systems Hub forInnovations in Agriculture)	2024	Dr. Vinod Kumar
4.	Web content and news updates for NRCLWebsite	2024	Dr. Sunil Kumar
5.	Research Report - 2024 of ICAR-All India coordinated Research Project on Fruits	2024	Dr. Bikash Das Dr. Sunil Kumar
6.	Annual Report - 2023 of ICAR-All India Coordinated Research Project on Fruits	2024	Dr. Bikash Das Dr. Sunil Kumar
7.	ICAR Institute Ranking Proforma 2024	2024	Dr. Abhay Kumar Dr. Vinod Kumar
8.	23rd IRC Proceedings, and Action Taken Report	2024	Dr. Sunil Kumar
9.	Compilation of Rajbhasa Hindi Patrika (Litchima) Vol 10	2024	Dr. Sunil Kumar

Personnel

	S. N.	Name	Designation
RMP	1.	Dr. Bikash Das	Director
Scientific	2.	Dr. Vinod Kumar	Pr. Scientist (Plant Pathology)
	3.	Dr. Abhay Kumar	Sr. Scientist (Biotechnology)
	4.	Dr. Prabhat Kumar	Scientist (Soil Science)
	5.	Dr. Sunil Kumar	Scientist (Fruit Science)
	6.	Dr. Bhagya Vijayan	Scientist (Ag. Extension)
	7.	Er. Ankit Kumar	Scientist (AS&PE)
	8.	Dr. Ipsita Samal	Scientist (Ag. Entomology)
Administration	9.	Sh. Shubham Sinha	AO
	10.	Sh. Kush Baghla	F&AO
	11.	Sh. Dileep Kumar	AAO
	12.	Sh. Akchhay Kumar Yadav	Assistant
	13.	Sh. Avinash Kumar Kashyap	Assistant
	14.	Sh. Sawan Kumar	UDC (Sr. Clerk)
	15.	Sh. Pawan Kumar	UDC (Sr. Clerk)
	16.	Ms. Ekta	LDC (Jr. Clerk)
	17.	Sh. Ritesh Kumar	LDC (Jr. Clerk)
Technical	18.	Sh. Ashok Dhakad	STO (T-6) (Cat-III)
	19.	Dr. Ramashish Kumar	STA, T-4 (F/F) (Cat-II)
	20.	Ms. Upagya Sah	STA, T-4 (F/F) (Cat-II)
	21.	Sh. Ajay Kumar Rajak	Sr. Technician, T-2 (F/F) (Cat-I)
	22.	Sh. Somesh Kumar	Sr. Technician, T-2 (F/F) (Cat-I)
	23.	Sh. Lokesh Kumar	Sr. Technician, T-2 (L/T) (Cat-I)
	24.	Sh. Dharmendra Kumar	Technician, T-1 (F/F) (Cat-I)
Supporting	25.	Ms. Sunita Devi	SSS
	26.	Sh. Shankar Ram	SSS

Recruitment, Promotion and Transfer

New entry during the year 2024:

- Shri Shubham Sinha joined to the post of Administrative Officer, ICAR-NRC on Litchi, Muzaffarpur on 25.04.2024.
- Shri Kush Baghla joined to the post of Finance & Accounts Officer, ICAR-NRC on Litchi, Muzaffarpur on 06.05.2024.

Relieving / Superannuation during the year 2024:

- Dr. Jai Prakash Verma, STA relieved from this Centre on 13th June, 2024 to join duty at ICAR-IISR, Lucknow on inter institutional transfer posting.

Budget Utilization and Revenue Generation

Financial Statement 2024-25

Sl. No.	Head-wise break up	RE 2024-25 (Rs. In lakh)	Release (Rs. In lakh)	Expenditure (Rs. In lakh)
(A). Recurring:				
a.	Establishment (including pension)	323.42	323.42	322.73
b.	T.A.	11.47	11.47	11.47
c.	Contingency	237.53	237.53	237.53
d.	HRD	1	1	0.66
e.	Loans and advances	5	5	.50
	Total (A)	578.42	578.42	572.89
(B). Non-Recurring:				
a.	Equipment	54	54	52.12
b.	Works (Minor)	0	0	0
c.	Furniture & Fixture	3	3	1.60
d.	I.T.	2	2	3.18
e.	Vehicle	0	0	0
f.	Live Stock	0	0	0
g.	Land	0	0	0
	Total (B)	59	59	56.90
Grand Total (A+B)		**637.42**	**637.42**	**632.59**

Resource generation 2024-25

Items	Rs. (In lakh)
Sale of farm produce	11.22
Interest earned on short term deposits	0.32
Income generated from internal resources (including recovery of loans and advances)	29.36
Miscellaneous receipts	13.19
Total	**50.19**

Receipts and Expenditure Statement of Externally Funded Projects 2024-25

Externally funded Projects	Opening Balance (Rs. In lakh)	Receipt (Rs. In lakh)	Expenditure (Rs. In lakh)
AICRP-F (ICAR)	0.00	11.25	11.24
NAIF (ICAR)	0.11	4.00	3.68
DUS (PPV&FRA)	0.40	6.71	7.11
RFS (Seed & Plant)	69.58	26.46	18.17
RFS (Post Harvest Lab)	14.92	12.28	3.67

Important Committees

Research Advisory Committee (RAC)

Chiarman	Dr. B. C. Deka, Vice Chancellor, AAU, Jorhat
Members	Dr. A. Verghese, Former Director, ICAR-NBAIR, Bengaluru Dr. P. K. Ray, Former Head, Horticulture, RAU, Pusa Dr. B. S. Dwivedi, Director, ICAR-NBSSLUP, Nagpur Dr. C. K. Narayan, Principal Scientist, ICAR-IHR, Bengaluru Dr. K.V. Bhat, Former PS, ICAR-NBPGR, New Delhi
Members (Non-Official)	Sh. Vivek Kumar, Muzaffarpur Sh. Vikrant Kumar Upadhyay, Dhanbad
Members *(Ex-officio)*	Dr. Bikash Das, Director, ICAR- NRC on Litchi, Muzaffarpur Dr. V. B. Patel, ADG (Fruits & Plantation Crops), ICAR- New Delhi
Member Secretary	Dr. Vinod Kumar, Pr. Scientist, ICAR- NRC on Litchi, Muzaffarpur

Institute Management Committee (IMC)

Chiarman	Dr. Bikash Das, Director, ICAR- NRC on Litchi, Muzaffarpur
Members	Dr. A. K. Dubey, Pr. Scientist, ICAR-IARI, New Delhi Dr. A. K. Mall, Pr. Scientist, ICAR-IISR Regional Station, Motipur Dr. R. K. Laxman, Pr. Scientist, ICAR-IIHR, Bangalore Dr. V. B. Patel, ADG (Fruits & Plantation Crops), ICAR- New Delhi Sh. Rajat Das, Finanace & Account Officer, ICAR- RCER, Patna
Members (Non-Official)	Sh. Vivek Kumar, Muzaffarpur Sh. Vikrant Kumar Upadhyay, Dhanbad
Members *(Ex-officio)*	Director Horticulture, Directorate of Horticulture, Department of Agriculture, Bihar Director Horticulture, Directorate of Horticulture, Department of Agriculture, Jharkhand Vice Chancellor, Birsa Agricultural University, Ranchi
Member Secretary	Sh. Shubham Sinha, Administrative Officer, ICAR- NRC on Litchi, Muzaffarpur

Institute Research Council (IRC)

Chiarman	Dr. Bikash Das, Director, ICAR- NRC on Litchi, Muzaffarpur
Members	Dr. Vinod Kumar, Pr. Scientist (Plant Pathology) Dr. Abhay Kumar, Sr. Scientist (Agri. Biotechnology) Dr. Prabhat Kumar, Scientist (Sr. Scale) (Soil Science) Dr. Bhagya Vijayan, Scientist (Agri. Extension) Dr. Sunil Kumar, Scientist (Fruit Science) Er. Ankit Kumar, Scientist (Agri. Structure & Process Engg.) Dr. Ipsita Samal, Scientist (Agri. Entomology)
Member Secretary	Dr. Sunil Kumar, Scientist (Fruit Science)

Nodal Officers and Responsibilities

Sl. No.	Nodal Officers	Responsibilities
1.	Dr. Vinod Kumar	Vigilance Officer, EFC, Liaison Officer (Reservation Roster), KRISHI Portal, TSP
2.	Dr. Abhay Kumar	ARMS, PIMS-ICAR, PMS, HRD Cell

Sl. No.	Nodal Officers	Responsibilities
3.	Dr. Prabhat Kumar	Swachha Bharat Abhiyan
4.	Dr. Bhagya Vijayan	PME (Upto 04.09.24), SCSP Project
5.	Dr. Sunil Kumar	PME (after 04.09.24), Rajbhasha Implementation
6.	Er. Ankit Kumar	ITMU, Academic
7.	Dr. Ipsita Samal	SCSP Project, Library, Institute Seminar
8.	Sh. Dileep Kumar	e-Office, e-HRMS 2.0, SPARROW

Other Institutional Committees

Sl. No.	Name and Composition of the Committee	
1.	**Priority Setting, Monitoring and Evaluation Cell**	
	Dr. Bhagya Vijayan, Scientist	In-charge
	Dr. Sunil Kumar, Scientist	Alternate In-charge
	Dr. Ipsita Samal, Scientist	Member
	Er. Ankit Kumar, Scientist	Member
	Ms. Upagya Sah, STA-T-4	Member Secretary
2.	**Farm Management and Advisory Committee (FMAC)**	
	Dr. Sunil Kumar, Scientist	Chairman
	Dr Ipsita Samal, Scientist	Member
	Mr Ajay Kumar Rajak, T-1	Member
	Mr Dharmender Kumar, T-1	Member
	Dr Ashok Dhakad, STO	Member Secretary & Farm In-charge
3	**Store & Purchase Advisory Committee (SPAC)/ Local Purchase Committee (LPC)**	
	Dr. Sunil Kumar, Scientist	Chairman
	Er. Ankit Kumar, Scientist	Co-chairman
	Dr. Ashok Dhakad, STO	Member
	Finance and Accounts Officer	Member
	Administrative Officer	Member Secretary

Sl. No.	Name and Composition of the Committee	
4.	**Works & Estate Committee**	
	Dr. Abhay Kumar, Senior Scientist	Chairman
	Dr. Prabhat Kumar, Scientist (SS)	Co-chairman
	Dr. Ashok Dhakad, STO	Member and Alternate Estate Officer
	Finance and Accounts Officer	Member
	Administrative Officer	Member Secretary and Estate Officer
5.	**Price Fixation Committee**	
	Dr. Sunil Kumar, Scientist	Chairman
	Dr. Ashok Dhakad	Co-chairman
	Finance and Accounts Officer	Member
	Administrative Officer	Member Secretary
6.	**Proprietary item cum Technical Evaluation Committee**	
	Dr. Abhay Kumar, Sr. Scientist	Chairman
	Dr. Prabhat Kumar, Scientist(SS)	Co-chairman
	Dr. Sunil Kumar, Scientist	Member
	Er. Ankit Kumar, Scientist	Member Secretary
7.	**Transfer of Technology Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Dr. Sunil Kumar, Scientist	Co-chairman
	Ms. Upagya Sah, TA-T-3	Member
	Mr. Somesh Kumar, T-1	Member
	Mr. Lokesh Kumar, T-1	Member
	Mr. Dharmender Kumar, T-1	Member
	Dr. Ashok Dhakar, STO	Member Secretary
8.	**Publication Committee**	
	Dr. Sunil Kumar, Scientist	Chairman
	Dr. Ipsita Samal, Scientist	Member
	Er. Ankit Kumar, Scientist	Member
	Ms. Upagya Sah, STA-T-4	Member Secretary

Sl. No.	Name and Composition of the Committee	
9.	**Institute Technology Management Unit**	
	Director, ICAR-NRCL	Chairman
	Dr. Vinod Kumar, Pr. Scientist	Co-chairman
	Dr. Abhay Kumar, Sr. Scientist	Member
	Dr. Prabhat Kumar, Scientist(SS)	Member
	Dr. Sunil Kumar, Scientist	Member
	Er. Ankit Kumar, Scientist	Member
	Dr. Bhagya Vijayan, Scientist	Member Secretary
10.	**Institute Variety Release Committee**	
	Director, ICAR-NRCL	Chairman
	Dr. Vinod Kumar, Pr. Scientist	Co-chairman
	Dr. Abhay Kumar, Sr. Scientist	Member
	Dr. Sunil Kumar, Scientist	Member Secretary
11.	**Corpus Fund Committee**	
	Director, ICAR-NRCL	Chairman
	Dr. Prabhat Kumar, Scientist(SS)	Co-chairman
	Dr. Sunil Kumar, Scientist	Member
	Er. Ankit Kumar, Scientist	Member
	Finance and Accounts Officer	Member
	Administrative Officer	Member Secretary
12.	**12.a. Agriculture Knowledge Management Unit (AKMU)**	
	Dr. Sunil Kumar, Scientist	In-charge
	Dr Ankit Kumar, Scientist	Alternate In-charge
	Finance and Accounts Officer	Member
	Mr. Pawan Kumar, UDC	Member Secretary
	12.b. Institute Server facility	
	Finanace & Accounts Officer	In-charge
	Mr Dileep Kumar, AAO	Alternate In-charge

Sl. No.	Name and Composition of the Committee	
13.	**राजभाषा कार्यान्वयन समिति (Official Language):**	
	Director, ICAR-NRCL	Chairman
	Dr. Prabhat Kumar, Scientist (SS)	Member
	Dr. Bhagya Vijayan, Scientist	Member
	Dr. Sunil Kumar, Scientist	Member & *Raajbhasha Adhikaari*
	Administrative Officer	Member Secretary
14.	**House Allotment Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Dr. Sunil Kumar, Scientist	Co-chairman
	Dr. Ashok Dhakad, STO	Member
	IJSC Secretary (Staff side)	Member
	Administrative Officer	Member Secretary
15.	**ISO Management Committee**	
	Dr. Prabhat Kumar, Scientist(SS)	In-charge
	Dr.Sunil Kumar, Scientist	Member
	Dr. Ipsita Samal, Scientist	Member
	Assistant Administrative Officer	Member Secretary
16.	**Institute Seminar Committee**	
	Dr. Ipsita Samal, Scientist	In-charge
	Er. Ankit Kumar, Scientist	Alternate-In-charge
17.	**Human Resource Development**	
	Dr. Abhay Kumar, Sr. Scientist	In-charge
	Dr. Ashok Dhakad, STO	Alternate In-charge
	Assistant Administrative Officer	Member Secretary
18.	**Library**	
	Dr. Ipsita Samal, Scientist	In-charge
	Er. Ankit Kumar, Scientist	Alternate In-charge

Sl. No.	Name and Composition of the Committee	
19.	**Monthly Staff Meeting**	
	Dr. Ashok Dhakad, STO	Coordinator
	Mrs Upagya Sah, TA-T-3	Member Secretary
20.	**Post-harvest Laboratory and Handling Facility**	
	Er. Ankit Kumar, Scientist	In-charge
	Dr. Sunil Kumar, Scientist	Alternate In-charge
	Adminstrative Officer	Member
	Finance and Accounts Officer	Member
	Ms. Upagya Sah, TA-T-3	Technical support and Member Secretary
21.	**Plant Pathology Laboratory**	
	Dr. Vinod Kumar, Pr. Scientist	In-charge
	Dr. Abhay Kumar, Sr. Scientist	Alternate In-charge
	Dr. Ipsita Samal, Scientist	Member
	Mr. Lokesh Kumar, T-1	Technical support
22.	**Biocontrol Laboratory**	
	Dr. Vinod Kumar, Pr. Scientist	In-charge
	Dr. Abhay Kumar, Sr. Scientist	Alternate In-charge
	Mr. Lokesh Kumar	Technical support
23.	**Entomology Laboratory**	
	Dr. Ipsita Samal, Scientist	In-charge
	Dr. Vinod Kumar, Scientist	Alternate In-charge
	Mr. Shankar Ram, SSS	Skilled Supporting Staff (MTS)
24.	**Soil Science Laboratory**	
	Dr. Prabhat Kumar, Scientist (SS)	In-charge
	Dr. Abhay Kumar, Sr. Scientist	Alternate In-charge
	Dr. Sunil Kumar, Scientist	Member
	Dr. Ramasish Kumar, STA-T-4	Technical support

Sl. No.	Name and Composition of the Committee	
25.	**Biotechnology Laboratory**	
	Dr. Abhay Kumar, Sr. SCientist	In-charge
	Dr. Sunil Kumar, Scientist	Alternate In-charge
26.	**Central Laboratory Facility**	
	Dr. Prabhat Kumar, Scientist(SS)	In-charge
	Dr. Abhay Kumar, Sr. Scientist	Alternate In-charge
	Dr. Sunil Kumar, Scientist	Member
	Mr. Somesh Kumar, T-1	Technical support
27.	**Crop Production Laboratory**	
	Dr. Sunil Kumar, Scientist	In-charge
	Dr. Prabhat Kumar, Scientist(SS)	Alternate In-charge
28.	**Agrometeorology unit**	
	Dr. Prabhat Kumar, Scientist(SS)	In-charge
	Dr. Ipsita Samal, Scientist	Alternate In-charge
29.	**Photography unit**	
	Dr. Bhagya Vijayan, Scientist	In-charge
	Dr. Sunil Kumar, Scientist	Alternate In-charge
	Dr. Ashok Dhakad, STO	Member
30.	**Plant Multiplication Unit**	
	Dr. Ashok Dhakad, STO	In-Charge
	Mr Ajay Rajak	Alternate In-charge
	Mr. Dharmendra Kumar, T-1	Member
31.	**Sports Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Dr. Sunil Kumar, Scientist	Co-Chairman
	Dr. Ashok Dhakad, STO	Member
	Administrative Officer	Member
	Finance & Accounts Officer	Member Secretary

Sl. No.	Name and Composition of the Committee	
32.	**Cultural Committee**	
	Dr. Prabhat Kumar, Scientist (SS)	Chairman
	Er. Ankit Kumar, Scientist	Co-chairman
	Ms. Upagya Sah, TA-T-3	Member
	Mr. Somesh Kumar, T-1	Member
	Mr. Lokesh Kumar, T-1	Member
	Administrative Officer	Member
	Finance and Accounts Officer	Member Secretary
33.	**Ward & Watch (Security)**	
	Dr. Sunil Kumar, Scientist	Member
	Er. Ankit Kumar, Scientist	Member
	Dr. Ashok Dhakad, STO	Chairman
	Administrative Officer	Member Secretary
	Mr. AK Yadav, Assistant	Member
	Mr. Avinash Kumar Kashyap, Assistant	Member
	Dr. Ramashish Kumar, STA	Member
	Mr. Sawan Kumar, UDC	Member
	Mr. Pawan Kumar, UDC	Member
34.	**Women Complaint Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Dr. Meenu Kumari, Scientist, ICAR-RCER FSRCHPR, Ranchi	Member from other ICAR institute
	Administrativer Officer	Member Secretary
	Ms. Upagya Sah, STA-T-4	Member
	Ms. Sudha Devi, Representative of NGO	Third Party representative
	Ms. Ekta, LDC	Member
	Ms. Sunita Devi, SSS	Member

Sl. No.	Name and Composition of the Committee	
35.	**Staff Grievance Redressal Cell**	
	Director, ICAR-NRCL	Chairman
	Dr. Vinod Kumar, Pr. Scientist	Co-chairman
	Dr. Prabhat Kumar, Scientist(SS)	Member
	Dr. Ashok Dhakad, STO	Member
	Ms. Sunita Devi, SSS	Member
	Administrative Officer	Member Secretary
36.	**Press and Media Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Er. Ankit Kumar, Scientist	Co-chairman
	Ms. Upagya Sah, TA-T-3	Member
	Mr. Somesh Kumar, T-1	Member Secretary
37.	**Staff Welfare Committee**	
	Dr. Bhagya Vijayan, Scientist	Chairman and Welfare Officer
	Finance & Accounts Officer(I)	Member
	Ms. Upagya Sah, Scientist	Member
	Administrative Officer	Member Secretary
	Mr. Ritesh Kumar, Scientist	Joint Secretary and Cashier
38.	**Academic Cell**	
	Dr. Bhagya Vijayan, Scientist	Chairman
	Dr. Sunil Kumar, Scientist	Co-chairman
	Dr. Ipsita Samal, Scientist	Member
	Er. Ankit Kumar, Scientist	Member Secretary

ICAR-NRCL in Media

'जलवायु परिवर्तन ने लीची की खेती पर भी डाला प्रभाव'

मुशहरी, हिसं। राष्ट्रीय लीची अनुसंधान केंद्र मुशहरी में बामेती, पटना द्वारा प्रायोजित लीची में

■ लीची अनुसंधान केंद्र में प्रशिक्षण का समापन

आयोजन • लीची में कीट प्रबंधन विषय पर प्रशिक्षण का समापन

लीची उत्पादन को बढ़ावा देने के लिए कीट प्रबंधन महत्वपूर्ण

भास्कर न्यूज | मुजफ्फरपुर

समापन शिविर में शामिल लीची अनुसंधान केंद्र के वैज्ञानिक।

'लीची उत्पादों से रोजगार के नए अवसर प्राप्त कर सकते'

प्रमाण पत्र देते राष्ट्रीय लीची अनुसंधान केंद्र के वैज्ञानिक।

लीची के उत्पादन म उपयोगी उपकरण की दी जानकारी

प्रशिक्षणार्थियों को प्रमाण पत्र देते केन्द्र के वैज्ञानिक।

भास्कर न्यूज | मुजफ्फरपुर

राष्ट्रीय लीची अनुसंधान केंद्र के तत्वावधान में लीची के पुराने और बताया। लीची उत्पादन में उपयोगी आधुनिक उपकरण और जैविक विधियों के उपयोग के बारे में भी जानकारी दी। प्रशिक्षण में मुजफ्फरपुर से एटीम रोशनी

युवाओं को प्रशिक्षण देकर स्वरोजगार को किया प्रेरित

प्रशिक्षणार्थी को प्रमाण पत्र देते कृषि वैज्ञानिक।

भास्कर न्यूज | मुशहरी

राष्ट्रीय लीची अनुसंधान केंद्र में किसानों को दिया गया प्रशिक्षण

पुराने बागों से भी बेहतर लाभ संभव

The Sentinel

of this land, for its people

NABARD-sponsored visit empowers farmers with modern techniques

A CORRESPONDENT

BISWANATH CHARIALI, March 31: In a recent development, a group of 25 litchi farmers affiliated with Agrigarh Producer Company Limited, promoted by Assam Agricultural University (AAU) under the Central Sector Scheme (CSS) with the support of NABARD, participated in a 3-day capacity-building programme titled "Agri-Entrepreneurship through Improved Litchi Cultivation" at the ICAR-National Research Centre on Litchi (NRCL) in Muzaffarpur, Bihar. This initiative, organised by NABARD, aimed to equip farmers with advanced knowledge and skills in modern litchi cultivation and management techniques. The visit was facilitated under the Farm Sector Promotion Fund (FSPF) in collaboration with the Centre for Development Action and Appropriate Technology (CADAT) in Biswanath Chariali.

The Assam Tribune

NABARD prog empowers litchi farmers to improve productivity

CORRESPONDENT

दैनिक भास्कर मुजफ्फरपुर 07-06-2024

2रां स्थापना दिवस : लीची अनुसंधान केंद्र में जुटे वैज्ञानिकों ने कहा-रिसर्च से मिल रहा फायदा

लीची की खेती अगर तकनीक आधारित हो तो फलों की गुणवत्ता भी बेहतर होगी : उपनिदेशक उद्यान

वैशाली, मुजफ्फरपुर, सीतामढ़ी सहित उत्तर स्थानों के 50 किसानों ने लाभ लिया

लीची को रोजगार सृजन का आधार बनाएं

लीची अनुसंधान केंद्र ने मनाया 24वां स्थापना दिवस

विकसित भारत बनाने में किसानों की भूमिका महत्वपूर्ण

नींबू पानी में रखने से लीची की लालिमा रहेगी बरकरार

सलाह

फल का सही उपयोग कर आमदनी बढ़ाएं किसान

पहल | मुजफ्फरपुर जिले में 25 हजार से अधिक हैं लीची किसान, 15 हजार हेक्टेयर में है लीची के बाग, 18 जुलाई से पहले बैच का शुरू होगा प्रशिक्षण

मुशहरी अनुसंधान केंद्र मजदूरों को देगा लीची तुड़ाई का प्रशिक्षण

मुजफ्फरपुर, हिन्दुस्तान प्रतिनिधि।

■ पहली बार प्रशिक्षण दिया जाएगा, जिले के दो लाख से अधिक मजदूरों को मिलेगा इसका लाभ

■ प्रशिक्षित मजदूर लीची तुड़ाई के बाद बगानों की कटाई-छंटाई और प्रबंधन का करेंगे कार्य

फलों की गुणवत्तापूर्ण रोपण सामग्री की बढ़ रही मांग : निदेशक

मुजफ्फरपुर/मुशहरी। राष्ट्रीय लीची अनुसंधान केंद्र मुशहरी में लीची की गुणवत्तापूर्ण रोपण सामग्री पौध उत्पादन विषय पर प्रशिक्षण शिविर का शुक्रवार को समापन हो गया। प्रशिक्षण में आठ जिलों के किसान व तकनीकी प्रबंधक एवं प्रखंड सहायक ने भाग लिया। निदेशक डॉ. विकास दास ने बताया कि लीची एवं अं गुणवत्तापूर्ण रोपण सा प्रतिदिन बढ़ती जा रं गुणवत्तापूर्ण रोपण

उत्पादन विषय पर राष्ट्रीय लीची अनुसंधान केंद्र मुशहरी में आयोजित

लीची में कीटों से बचाव के उपाय बताए

मुशहरी| लीची बाग में प्रबंधन व प्रसंस्करण विषय पर प्रशिक्षण मेहसी के तारापाकर गांव में हुआ। राष्ट्रीय लीची

8 दैनिक जागरण मुजफ्फरपुर, 21 सितंबर, 2024

मुजफ्फरपुर आसपास जागरण

एकीकृत कीट प्रबंधन के महत्व पर विशेष ध्यान देने की जरूरत

राष्ट्रीय लीची अनुसंधान केंद्र में तीन दिवसीय प्रशिक्षण संपन्न

लीची उत्पादों के प्रसंस्करण और विपणन में रोजगार के नये अवसर

प्रतिनिधि, मुशहरी

राष्ट्रीय लीची अनुसंधान केंद्र में प्रशिक्षण कार्यक्रम के समापन पर उपस्थित वैज्ञानिक.

राष्ट्रीय लीची अनुसंधान केंद्र, मुशहरी में शुक्रवार को राष्ट्रीय कृषि विकास योजना, पटना के सहयोग से "लीची तुड़ाई उपरांत प्रसंस्करण और प्रबंधन के माध्यम से उद्यमिता विकास' विषय पर आयोजित तीन दिवसीय प्रशिक्षण कार्यक्रम का समापन किया गया. यह प्रशिक्षण 11 से 13 दिसंबर, 2024 तक चला. बिहार के पांच जिलों मुजफ्फरपुर, सीतामढ़ी, वैशाली, पूर्वी चंपारण और समस्तीपुर के कुल 38 प्रगतिशील किसानों ने भाग लिया. कार्यक्रम के दौरान प्रशिक्षण समन्वयक डॉ अंकित कुमार ने लीची प्रसंस्कृत उत्पादों जैसे लीची स्क्वैश, आरटीएस, और लीची रसगुल्ला के निर्माण की विधियों एवं उनके घरेलू और व्यावसायिक मांग के बारे में विस्तृत जानकारी दी. इस कार्यक्रम में सकरा से प्रगतिशील किसान सौनू निगम कुमार, पूर्वी चम्पारण से मुक्ति नाथ, अरविन्द कुमार, मो फिरोज, मो नेयाज, मीनापुर से राज किशोर प्रसाद और नंद किशोर प्रसाद, गायघाट से सुभाष कुमार, शैलेन्द्र कुमार सिंह, मुरौल से दीपक कुमार, विमल कुमार, सकरा से सिंकु कुमारी, खुशबू कुमारी, शम्भा कुमारी, बन्दरा से ऋचा प्रिया, समस्तीपुर से राम करण पंडित, संतोष पंडित, गौतम कुमार, अशोक कुमार पंडित, तृप्ति कुमारी, कटरा से अंकित कुमार, सीतामढ़ी से राहुल कुमार, वैशाली से निशांत कुमार, कांटी से दीपक कुमार, कटरा से अभिनन्दन कुमार, विकास कुमार, औराई से सुधीर कुमार, मुशहरी से चंदन कुमार, हसखेली से चंदन कुमार, औराई से विक्की कुमार आदि लोगों ने भाग लिया समापन समारोह के अवसर पर केंद्र के प्रधान वैज्ञानिक डॉ विनोद कुमार ने कहा कि लीची उत्पादों के प्रसंस्करण और विपणन के माध्यम से किसान स्वरोजगार की दिशा में नए अवसर प्राप्त कर सकते हैं. कार्यक्रम में वरिष्ठ वैज्ञानिक डॉ अभय कुमार, डॉ प्रभात कुमार, डॉ इप्सिता साहल, ई. अंकित कुमार, प्रोजेक्ट असिस्टेंट श्याम पंडित, चमण कुमार एवं धर्मदेव भारती उपस्थित रहे.

लीची से प्रसंस्कृत पेय पदार्थ तैयार कर आय दोगुनी कर सकते : उपनिदेशक

लीची अनुसंधान केंद्र में उद्यमिता विकास विषय पर प्रशिक्षण का हुआ समापन

भास्कर न्यूज | मुशहरी

संबोधित करते बामेती पटना के उपनिदेशक।

राष्ट्रीय लीची अनुसंधान केंद्र के तत्वावधान में उद्यमिता विकास विषय पर तीन दिवसीय प्रशिक्षण कार्यक्रम का समापन हुआ। प्रशिक्षण में राज्य के दस जिलों- सीतामढ़ी, वैशाली, मधुबनी, बेगूसराय, पूर्वी चंपारण, मुजफ्फरपुर, समस्तीपुर, गोपालगंज, सिवान और सारण जिलों से 20 प्रगतिशील किसान एवं प्रखंड तकनीकी प्रबंधक एवं स्वरोजगार के क्षेत्र में भी कदम संबोधित करते हुए कहा कि लीची बढ़ा सकते हैं। बताया कि हाल के से प्रसंस्कृत उत्पाद बनाने की


मूल्यवर्धित लीची उत्पाद के माध्यम
से उद्यमिता विकास
18-20 दिसम्बर, 2024


लीची में प्रसंस्करण एवं मूल्य संवर्धन


भाकृअनुप-राष्ट्रीय लीची अनुसंधान केन्द्र
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उद्यमिता विकास हेतु लीची में पौधशाला प्रबंधन


स्वच्छ भारत अभियान

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