



वार्षिक प्रतिवेदन 2025 ANNUAL REPORT

भा.कृ.अनु.प.- राष्ट्रीय मखाना अनुसंधान केंद्र,
दरभंगा 846005, बिहार

ICAR-National Research Centre for Makhana,
Darbhanga 846005, Bihar





वार्षिक प्रतिवेदन

ANNUAL REPORT

2025

भा.कृ.अनु.प.- राष्ट्रीय मखाना अनुसंधान केंद्र,
दरभंगा 846005, बिहार

**ICAR-National Research Centre for Makhana,
Darbhanga 846005, Bihar**

Annual Report 2025
ICAR-National Research Centre for Makhana, Darbhanga

Editorial Committee

Chairman

Dr Nachiket Kotwaliwale, Director

Chief Editor

Sh. Shailendra Mohan Raut

Editor

Dr Suryakant Bajirao Tarate

Cover Design

Sh. Shailendra Mohan Raut

Cover Page Photo

1. Makhana Field
2. Makhana Seed
3. Makhana Popping Machine
4. Makhana Pop

Published by

Director

ICAR-National Research Centre for Makhana, PO. - Basudeopur Farm, Near Delhi More,
Darbhanga 846005, Bihar

Citation

Annual Report 2025. (2026, March). ICAR-National Research Centre for Makhana, Darbhanga
846005, Bihar, India. 67 p.

Copyright

All rights are reserved. No portion of this Annual Report may be reproduced or transmitted in any form, whether by print, microfilm, or other methods, without prior written permission from the Director, ICAR NRC for Makhana, Darbhanga.

Disclaimer

This report is intended for informational purposes only. While efforts have been made to ensure its accuracy and timeliness, some parts of this report have been compiled as of 31.12.2025. It should not be regarded as legal advice or used as a basis for legal decisions.

Content

प्रस्तावना/Preface	i
कार्यकारी सारांश/Executive Summary	1
Introduction	7
Infrastructure	9
Staff Position	11
Budget	11
Research Highlight	12
Makhana	12
Water chestnut	22
Lotus	24
Natural Resource Management	27
Award and Recognition	36
Linkages & Collaboration	37
Human Resource Development and Capacity Building Programme	38
Training and Capacity Building	38
Seminar and Symposia	38
Training and Exposure Visit	40
Stakeholder Exposure Visit	46
<i>Viksit Krishi Sankalp Abhiyan (VKSA-2025)</i>	48
Event Organized	50
Prioritization, Monitoring and Evaluation Cell	61
Publication	61
Research Project	63
Personalia	64
ICAR-NRC for Makhana in the News	65



प्रस्तावना

भा.कृ.अनु.प-राष्ट्रीय मखाना अनुसंधान केंद्र (रा.म.अनु.कें.), दरभंगा की वार्षिक रिपोर्ट - 2025 प्रस्तुत करना मेरे लिए सौभाग्य की बात है, जो वर्ष 2025 के दौरान केंद्र की वैज्ञानिक गतिविधियों, आउटरीच कार्यक्रमों और महत्वपूर्ण उपलब्धियों पर प्रकाश डालती है। यह केंद्र विशेष रूप से मखाना (यूरियाल फेरॉक्स सैलिसब) और अन्य वाणिज्यिक जलीय फसलों जैसे कि सिंघाड़ा और कमल, में फसल पूर्व और बाद के मशीनीकरण, जर्मप्लाज्म संग्रह, वैराइटी डेवलपमेंट, कृषि प्रणाली मॉडल, कृषि-तकनीक, विविधीकरण और जलीय कृषिपर अनुसंधान करने के लिए काम कर रहा है। इसके अलावा, पूरे भारत में मखाना की खेती के माध्यम से तालाबों, झीलों, भूमि अवसादों, दलदलों और खाइयों जैसे स्थिर जल निकायों का प्रभावी उपयोग संभव है। यह केंद्र व्यावसायिक रूप से महत्वपूर्ण जलीय फसलों के सतत उत्पादन, प्रसंस्करण और मूल्यवर्धन के लिए अनुसंधान, प्रौद्योगिकी विकास और क्षमता निर्माण को आगे बढ़ाने में महत्वपूर्ण भूमिका निभा रहा है। मखाना उत्पादकों, विशेष रूप से छोटे और सीमांत किसानों और इसकी खेती और प्रसंस्करण में लगे पारंपरिक मछुआरा समुदायों की सामाजिक-आर्थिक स्थिति में सुधार के उद्देश्य से उपयुक्त कृषि प्रौद्योगिकियों को विकसित करने पर भी जोर दिया गया। वर्ष 2025 के दौरान, आईसीएआर-एनआरसी-एम, दरभंगा ने अनुसंधान, विस्तार और क्षमता निर्माण में प्रमुख परिणाम हासिल किए। उन्नत खेती प्रथाओं को बढ़ावा देने के लिए किसानों और हितधारकों को कुल 3.5 टन गुणवत्ता वाले बीज वितरित किए गए। संस्थान ने मखाना नर्सरी प्रबंधन और खेती के लिए प्रोटोकॉल विकसित किए, प्रमुख कीटों की पहचान की और उप-उत्पाद लक्षण वर्णन किया। इसके अलावा, सिंघाड़ा और कमल के लिए प्रसार प्रोटोकॉल, उनकी उपयुक्त बढ़ती परिस्थितियों पर अध्ययन के साथ-साथ सफलतापूर्वक विकसित किए गए थे। केंद्र ने रिमोट सेंसिंग तकनीकों का उपयोग करके उत्तर बिहार की प्राकृतिक संसाधन स्थिति, विशेष रूप से वर्षा पैटर्न का भी आकलन किया। वर्ष के दौरान, सहयोगात्मक अनुसंधान और विकास के लिए तीन समझौता ज्ञापनों पर हस्ताक्षर किए गए। 700 से अधिक किसानों और हितधारकों को विभिन्न प्रशिक्षण कार्यक्रमों और एक्सपोजर यात्राओं से लाभ हुआ, जबकि 400 से अधिक हितधारकों, अधिकारियों और किसानों ने संस्थान का दौरा किया। रा.म.अनु.कें. ने विकसित कृषि संकल्प अभियान में सक्रिय रूप से भाग लिया और कई बैठकों और विस्तार कार्यक्रमों के साथ-साथ कृषि चौपाल, किसान संवाद और राष्ट्रीय मखाना महोत्सव जैसे विभिन्न आउटरीच कार्यक्रमों का आयोजन किया। प्रभावी अनुसंधान और विस्तार के लिए केंद्र के बुनियादी ढांचे को बढ़ाने के लिए महत्वपूर्ण प्रयास किए गए। केंद्र के वैज्ञानिकों ने 20 वैज्ञानिक लेख प्रकाशित किए, जो संस्थान के मजबूत शोध आउटपुट को दर्शाते हैं। केंद्र ने प्रसंस्करण प्रथाओं और मशीनरी का विकास किया है और इन्हें किसानों और उद्यमियों द्वारा अपनाया जा रहा है। केंद्र ने महत्वपूर्ण इनपुट प्रदान करके राष्ट्रीय मखाना बोर्ड के निर्माण में सक्रिय भूमिका निभाई है और केंद्र और बिहार राज्य स्तर पर मखाना से संबंधित नीतियों को प्रभावित करने में भी मदद की है। मुझे विश्वास है कि अपने सभी हितधारकों की शुभकामनाओं के साथ, केंद्र मखाना आधारित जलीय कृषि-पारिस्थितिकी तंत्र के सतत विकास और कृषक समुदायों के कल्याण के लिए अनुसंधान, नवाचार, प्रौद्योगिकी हस्तांतरण और रणनीति विकास में उत्कृष्टता प्राप्त करेगा।

(डॉ. नचिकेत कोतवालीवाले)
निदेशक

Preface

It is my privilege to present the Annual Report - 2025 of ICAR– National Research Centre for Makhana (NRC-M), Darbhanga, which highlights the scientific activities, outreach programmes, and significant achievements of the Centre during the year 2025. This centre is exclusively working for conducting research on pre- and post-harvest mechanisation in Makhana (*Euryale ferox* Salisb.) and other commercial aquatic crops such as water chestnut and lotus, germplasm collection, varietal development, farming system models, agro-techniques, diversification, and aquaculture. Moreover, the effective use of stagnant water bodies like ponds, lakes, land depressions, swamps and ditches is possible through makhana cultivation throughout India. The Centre continues to play a pivotal role in advancing research, technology development, and capacity building for sustainable production, processing, and value-addition of commercially important aquatic crops. Also emphasised to generate appropriate agricultural technologies aimed at improving the socio-economic status of makhana growers, particularly the small and marginal farmers and the traditional fishing communities engaged in its cultivation and processing. During the year 2025, ICAR–NRC-M, Darbhanga, achieved major outcomes in research, extension, and capacity building. A total of 3.5 tonnes of quality seed was distributed to farmers and stakeholders to promote improved cultivation practices. The institute developed protocols for makhana nursery management and cultivation, identified major insect pests, and carried out by-product characterization. In addition, propagation protocols for water chestnut and lotus, along with studies on their suitable growing conditions, were successfully developed. The Centre also assessed the natural resource status of north Bihar, particularly rainfall patterns, using remote sensing techniques. During the year, three MoUs were signed for collaborative research and development. Over 700 farmers and stakeholders benefited from various training programmes and exposure visits, while more than 400 stakeholders, officers, and farmers visited the institute. NRC-M actively participated in the *Viksit Krishi Sankalp Abhiyan* and organized various outreach events such as *Krishi Chaupal*, *Kisan Samwad*, and the *Rashtriya Makhana Mahotsav*, along with several meetings and extension programmes. Significant efforts were made to enhance the Centre's infrastructure for effective research and extension. Scientists of the Centre published 20 scientific articles, reflecting the institute's strong research output. The centre has developed processing practices and machineries and these are being adopted by farmers and entrepreneurs. The center has played an active role in the creation of the National Makhana Board by providing important inputs and also helped in influencing makhana-related policies at the central and state levels of Bihar. I am confident that with good wishes of all its stakeholders, the Centre will attain excellence in research, innovation, technology transfer, and strategy development for the sustainable development of the Makhana-based aquatic agro-ecosystem and the welfare of farming communities.



(Dr. Nachiket Kotwaliwale)

Director

कार्यकारी सारांश

भाकृअनुप- राष्ट्रीय मखाना अनुसंधान केंद्र (रा.म.अनु.कें.) दरभंगा, मखाना (*Euryale ferox* Salisb.) पर विशेष रूप से समर्पित विश्व का एकमात्र अनुसंधान केंद्र है। इसके कार्यक्षेत्र में कमल, सिंघाड़ा, मछली तथा अन्य जलीय फसलें भी शामिल हैं, जिनका पोषण, औषधीय, औद्योगिक और आर्थिक महत्व अधिक है। वर्ष 2025 के दौरान रा.म.अनु.कें. दरभंगा ने अपने अनुसंधान एवं विस्तार कार्यों के माध्यम से मखाना की उत्पादन एवं उत्पादकता में उल्लेखनीय वृद्धि की है, जिससे किसानों की आय बढ़ी है और खेती का क्षेत्र भी विस्तृत हुआ है। इससे मखाना को वैश्विक स्तर पर “सुपरफूड” के रूप में स्थापित करने में मदद मिली है। इसके अतिरिक्त संस्थान का उद्देश्य मखाना प्रसंस्करण और मूल्य संवर्धन के लिए किफायती एवं सरल तकनीकों का विकास करना है, ताकि भारत की वैश्विक नेतृत्व स्थिति को और मजबूत किया जा सके। रा.म.अनु.कें. किसानों की आय, आजीविका और बिहार सहित पूर्वी भारत की कृषि-आधारित अर्थव्यवस्था को सुदृढ़ करने के लिए प्रतिबद्ध है। साथ ही, यह राष्ट्रीय मखाना बोर्ड की स्थापना में भी महत्वपूर्ण भूमिका निभा रहा है।

मखाना

मखाना की खेती हेतु नर्सरी की तैयारी

वैज्ञानिक विधि से नर्सरी तैयार करने में हल चलाना, उर्वरक और जैविक खाद का प्रयोग अत्यंत महत्वपूर्ण है। खेत को पानी से भिगोया जाता है और नवंबर से दिसंबर के बीच 500 m² क्षेत्रफल वाली नर्सरी में 20 किलो स्वस्थ बीज बोए जाते हैं, जो एक हेक्टेयर क्षेत्र में रोपाई के लिए पर्याप्त होते हैं। इस दौरान पानी की गहराई नवंबर से मार्च तक 0.45 मीटर बनाए रखी जाती है। मखाना एक जलीय पौधा है जो बीज के माध्यम से फैलता है और इसके अंकुरण की दर 50% से 90% तक होती है। नर्सरी में तैयार पौधों को मार्च के पहले सप्ताह में मुख्य खेत में स्थानांतरित किया जाता है और पौधों तथा पंक्तियों के बीच 1.25 मीटर x 1.25 मीटर की दूरी पर रोपाई की जाती है।

मखाना की खेती के लिए मानक प्रोटोकॉल

मखाना की खेती के लिए मानक प्रोटोकॉल को पहचानकर और रूपरेखा तैयार की गई है, जिसमें मखाना फसल की उत्पादन क्षमता बढ़ाने के लिए मिट्टी के विभिन्न मानक, जल संबंधी पैरामीटर और बीज की विशेषताओं जैसे कई महत्वपूर्ण कारकों को शामिल किया गया है।

मखाना पौधे पर कीट प्रकोप

मखाना पौधे पर सबसे सामान्य कीट प्रकोप मखाना एफिड (*Rhopalosiphum nymphaeae*) का होता है। इसके आणविक पहचान और आनुवंशिक विविधता के अध्ययन से पता चला कि हैप्लोटाइप नेटवर्क में छह प्रकार (हैप्लोटाइप) पहचाने गए, जिनमें से अधिकांश का संबंध एक प्रमुख हैप्लोटाइप (H1) से था, जिसमें विभिन्न देशों से 14 नमूने शामिल थे। इसके अतिरिक्त, *R. nymphaeae* में आणविक वैरिएंट्स के आधार पर जनसंख्या संरचना के विश्लेषण से विभिन्न जनसंख्याओं के बीच महत्वपूर्ण आनुवंशिक भिन्नता पाई गई।

मखाना बीज का छिलका

मखाना बीज का छिलका, मखाना पॉपिंग प्रक्रिया का एक उप-उत्पाद है। इसका विभिन्न उपयोगों के लिए प्रसंस्करण किया जा सकता है। इसलिए, इसके पिसे हुए पाउडर का विश्लेषण किया गया, जिसमें पाया गया कि इसमें 99.66% जैविक पदार्थ मौजूद है। इसके विपरीत, अकार्बनिक तत्व (राख सामग्री के रूप में) बहुत कम, केवल 0.34% पाए गए। इसके अतिरिक्त, विश्लेषण से यह भी स्पष्ट हुआ कि जैविक कार्बन इसकी संरचना का प्रमुख भाग है, जो 57.81% है। ऊर्जा-विसरण एक्स-रे स्पेक्ट्रोस्कोपी (EDX) विश्लेषण में तत्वों की परमाणु प्रतिशत मात्रा इस प्रकार पाई गई: 97.76% कार्बन (C), 2.32% ऑक्सीजन (O), 0.42% लोह (Fe) और 0.15% जिंक (Zn)। TGA विश्लेषण से यह भी पता चला कि अध्ययन की गई तापमान सीमा के दौरान नमूने में कई चरणों में तापीय अपघटन की प्रक्रिया होती है।

रिमोट सेंसिंग डेटा द्वारा फसल क्षेत्र का आकलन

मखाना फसल क्षेत्र के आकलन के लिए Sentinel-2 रिमोट सेंसिंग उपग्रह के डेटा का उपयोग किया गया, जो मुख्य रूप से Sentinel-2 मल्टीस्पेक्ट्रल इंडस्ट्रमेंट (MSI) इमेजरी पर आधारित है। वर्ष 2024 और 2025 के दौरान फसल की मुख्य वृद्धि अवधि में उत्तर बिहार के प्रमुख मखाना उत्पादक जिलों से डेटा एकत्रित कर उसका विश्लेषण किया गया। सभी जिलों में मखाना फसल का

कुल क्षेत्रफल वर्ष 2024 में लगभग 31,325 हेक्टेयर और वर्ष 2025 में लगभग 37,879 हेक्टेयर आंका गया। इसके अलावा, मखाना के विभिन्न विकास चरणों (फेनोलॉजिकल स्टेज) के दौरान उसके समयानुसार स्पेक्ट्रल रिफ्लेक्टेंस व्यवहार का भी Sentinel-2 मल्टीस्पेक्ट्रल डेटा की सहायता से विश्लेषण किया गया।

सिंघाड़ा

सिंघाड़ा (जलफल) खेती का प्रसार प्रोटोकॉल

सिंघाड़ा (जलफल) की खेती एक उच्च आर्थिक महत्व वाली जलीय फसल के क्षेत्र विस्तार के लिए अत्यंत महत्वपूर्ण है। इसमें कई महत्वपूर्ण मानकों और प्रबंधन प्रथाओं की पहचान और उनका मात्रात्मक निर्धारण किया गया है, जैसे बीज की विशेषताएँ, खेती की विधियाँ, नर्सरी प्रबंधन, रोपण, पोषक तत्व प्रबंधन तथा कटाई की प्रक्रिया।

मिट्टी और जल गुणों के मानदंड

सिंघाड़े की उत्पादन क्षमता बढ़ाने के लिए जल और मिट्टी की गुणवत्ता बुनियादी मानदंड हैं। इसलिए, सिंघाड़ा की खेती के लिए पानी और मिट्टी की गुणवत्ता की आदर्श सीमा को विभिन्न उत्पादन स्तरों के आधार पर वर्गीकृत किया गया है, जिसमें कम उत्पादन से लेकर उच्च उत्पादन तक के मानदंड शामिल हैं।

कमल

कमल की खेती खेती का प्रसार प्रोटोकॉल

कमल के प्रसार के लिए बीज या राइजोम (जड़ गांठ) का उपयोग किया जाता है। इसके मुख्य चरणों में बीज का चयन, राइजोम का आकार, अंकुरण अवधि, पानी की गुणवत्ता और मिट्टी की गुणवत्ता शामिल हैं।

कमल पौधे की आकृतिक विशेषताएँ

राइजोम से शुरू होने वाले कमल के पौधे निष्क्रिय कंद से उगते हैं। राइजोम को टुकड़ों में काटें, सुनिश्चित करें कि प्रत्येक टुकड़े में कम से कम एक अंकुर हो। इन टुकड़ों को चौड़े, गोलाकार पात्र में लगाएँ, जिनमें जल निकासी के छेद न हों; चौकोर पात्र से बचें ताकि संवेदनशील बढ़ती नोक सुरक्षित रहे। प्रति पात्र केवल एक टुकड़ा लगाना चाहिए। पात्र को समृद्ध, दोमट मिट्टी से भरें और ऊपर पर पतली मटर जैसी कंकड़ की परत डालें, जिससे बढ़ती नोक लगभग 1.3 सेमी बाहर रहे। बर्तनों को गर्म और धूप वाली जगह पर रखें, जहाँ बढ़ती नोक पानी की सतह से 5–7.5 सेमी भीतर डूबा रहे, आदर्श तापमान 10–16°C हो। सही विधि अपनाने पर लगभग तीन हफ्तों में पहले पत्ते दिखाई देने लगते हैं।

प्राकृतिक संसाधन प्रबंधन

दरभंगा जिले का भूजल सर्वेक्षण

भूजल बिहार के ग्रामीण और शहरी क्षेत्रों में पीने के पानी एवं कृषि सिंचाई का मुख्य स्रोत है। अप्रैल-मई 2025 के दौरान दरभंगा जिले में किए गए क्षेत्रीय सर्वेक्षण में भूजल की गुणवत्ता का विश्लेषण किया गया। इसमें आर्सेनिक का स्तर 5 से 50 $\mu\text{g/L}$, कुल घुलित ठोस (TDS) 175 से 1010 mg/L , और विद्युत चालकता (EC) 340 से 2000 $\mu\text{S/cm}$ पाया गया। पानी में आर्सेनिक का स्तर WHO मानकों से अधिक था।

मुख्य मखाना उत्पादक जिलों में वर्षा

उत्तर बिहार के प्रमुख मखाना उत्पादक जलभूमि जिलों में वर्षा के स्थानिक और कालगत भिन्नताओं तथा दीर्घकालिक प्रवृत्तियों का अध्ययन 1901 से 2022 तक के पिछले वर्षा आंकड़ों के आधार पर किया गया। इस अध्ययन में वार्षिक और मौसमी वर्षा के लिए औसत, मानक विचलन (SD), वक्रता गुणांक (CS) और कुर्त्तोंसिस गुणांक (CK) जैसे सांख्यिकीय मानदंडों का मूल्यांकन किया गया। वार्षिक वर्षा के आंकड़े 1204.5 से 2162 मिमी के बीच औसत, 290.1 से 459.4 मिमी का मानक विचलन, -0.32 से 0.31 का वक्रता गुणांक और -0.4 से 1.17 का कुर्त्तोंसिस गुणांक दर्शाते हैं। वहीं, मानसून मौसमी वर्षा के आंकड़े 1004.49 से 2052.29 मिमी के औसत, 303.15 से 330.59 मिमी का मानक विचलन, 0.28 से 0.42 का वक्रता गुणांक और -0.18 से 0.37

का कुर्तौसिस गुणांक दिखाते हैं। इस विश्लेषण से स्पष्ट होता है कि इन जिलों में वर्षा की मात्रा समय और स्थान के अनुसार काफी भिन्न होती है, जो मखाना उत्पादन और जल संसाधन प्रबंधन पर महत्वपूर्ण प्रभाव डालती है।

भूमि सतह तापमान

1995 से 2024 तक प्रमुख मखाना उत्पादक जिलों में औसत वार्षिक भूमि सतह तापमान के विश्लेषण से महत्वपूर्ण भिन्नताएँ सामने आई हैं। Landsat उपग्रह इमेजरी का उपयोग करके किए गए इस अध्ययन में यह पाया गया कि LST में उतार-चढ़ाव मुख्य रूप से जलवायु में परिवर्तन, भूमि उपयोग में बदलाव और सतही जल निकायों की गतिशीलता से प्रभावित होते हैं। अध्ययन के अंतिम चरण (2018-2024) में विशेष रूप से तापमान में वृद्धि का रुझान देखा गया, जिसमें कटिहार में 2022 में 34.42°C और दरभंगा में 2023 में 35.72°C दर्ज किया गया। इस विश्लेषण का उद्देश्य तापमान में बदलाव को जल निकायों की स्थिति, उनके घटने या समाप्त होने तथा वर्षा के पैटर्न से जोड़कर उनके अंतर्संबंधों की जांच करना है।

सतही जल निकायों की गतिशीलता

मखाना मुख्य रूप से भारत के उत्तर बिहार के जलीय क्षेत्रों में उगाया जाता है, विशेष रूप से दरभंगा, मधुबनी, अररिया, मधेपुरा, सहारसा, सुपौल, पूर्णिया, किशनगंज और कटिहार जिलों में। इन जिलों में सतही जल निकायों की गतिशीलता का मूल्यांकन 1995 से 2024 तक के पोस्ट-मॉनसून मौसम के लिए रिमोट सेंसिंग आधारित जल सूचकांक का उपयोग करके किया गया। कटिहार में सबसे बड़ा सतही जल क्षेत्र पाया गया, जो 2022 में लगभग 47,000 हेक्टेयर तक पहुंच गया, जो विस्तृत बाढ़ मैदानों और स्थायी जल निकायों की उपलब्धता को दर्शाता है। इसके विपरीत, दरभंगा, सुपौल और सहारसा में जल निकायों में महत्वपूर्ण भिन्नता देखी गई, विशेष रूप से 1999, 2009 और 2020 जैसे बाढ़ वर्षों में। रिमोट सेंसिंग के माध्यम से जल निकायों की पहचान यह स्पष्ट करती है कि इस क्षेत्र में सतही जल की उपलब्धता में हाइड्रोलॉजिकल पैटर्न और भूदृश्य संरचना का महत्वपूर्ण योगदान है।

अन्य उपलब्धियाँ

रिपोर्ट किए गए वर्ष 2025 में, सहयोगी अनुसंधान और विकास के लिए तीन समझौता ज्ञापन (MoUs) पर हस्ताक्षर किए गए। वर्षों के दौरान लगभग 700 किसान और अन्य हितधारकों को विभिन्न प्रशिक्षण कार्यक्रमों और एक्सपोजर विजिट से लाभ प्राप्त हुआ, जबकि 400 से अधिक हितधारक, अधिकारी और किसान संस्थान का दौरा कर चुके हैं। रा.म.अनु.कें. ने विकसित कृषि संकल्प अभियान में सक्रिय भागीदारी की और कृषि चौपाल, किसान संवाद, राष्ट्रीय मखाना महोत्सव सहित कई आउटरीच कार्यक्रमों और बैठकों का आयोजन किया। इन प्रयासों के अलावा, प्रभावी अनुसंधान और विस्तार कार्यक्रमों को सक्षम बनाने के लिए केंद्र के बुनियादी ढांचे को भी सुदृढ़ किया गया। केंद्र के वैज्ञानिकों ने 20 वैज्ञानिक लेख प्रकाशित किए, जो संस्थान की मजबूत अनुसंधान क्षमता को दर्शाते हैं। इसके अतिरिक्त, केंद्र ने मखाना प्रसंस्करण की तकनीकें और मशीनरी विकसित की हैं, जिन्हें किसान और उद्यमी अपनाकर प्रयोग में ला रहे हैं।

EXECUTIVE SUMMARY

ICAR-National Research Centre for Makhana (NRC-M) is the only research centre in the world exclusively dedicated to makhana (*Euryale ferox* Salisb.) research. Also, its mandate has been to include research on lotus, water chestnut, fish, and other aquatic crops with potentially high nutritive, medicinal, industrial, and economic significance. During the reported year 2025, NRC-M, Darbhanga, through its research and extension activities, has made an immense contribution in improving the production and productivity of makhana, resulting in higher farm income and area expansion, leading to establishing makhana as a superfood in the global arena. It also aims to develop cost-effective, easily adaptable technologies for makhana processing and value addition to better leverage India's position as the world leader in makhana production and processing. The NRC-M, Darbhanga, remains committed to improving farmers' income and livelihoods, and the agri-based economy of Bihar, Eastern India, and beyond. Also, it's playing an important role in the creation of the National Makhana Board. A brief overview of key research achievements and technology transfer activities for the reported year is provided below.

Makhana

Nursery preparation for makhana cultivation

In preparing a scientific nursery for makhana, ploughing, application of fertilizer, and organic manures are crucial. The field is flooded, and 20 kg of healthy seeds are broadcast from November to December in a nursery of 500 m², which is adequate for transplanting in a one-hectare area, with water depth maintained at 0.45 meter from November to March. Makhana is an aquatic plant that propagates through seeds, achieving germination rates of 50% to 90%. The seedlings are transferred from the nursery plot to the pre-prepared main field in the first week of March and transplanted at a spacing of 1.25 m x 1.25 m plant-to-plant and row-to-row.

Standard Protocol for Makhana Cultivation

The standard protocol for the makhana cultivation has been identified and conceptualized, including several parameters of soil, water parameters, and seed characteristics to increase the yield potential of the makhana crop.

Infestation on the makhana plant

Makhana aphid is the most common infestation on the makhana plant. Molecular identification and genetic diversity study of the makhana aphid (*Rhopalosiphum nymphaeae*) reveals that the haplotype network identified six haplotypes, and many individuals belonged to a single dominant haplotype (H1), which included 14 accessions from different countries. Moreover, analysis of population structure using molecular variance in *R. nymphaeae* shows significant genetic differentiation among populations.

Makhana seed coat

The makhana seed coat is a by-product of makhana popping. It might be processed multiple uses; therefore, the grounded seed coat powder has been characterised, and it accounted for 99.66% of the organic matter. In contrast, the inorganic content, as measured by ash content, was relatively low, comprising only 0.34% of the seed coat's mass. Furthermore, the analysis shows that organic carbon constitutes a significant portion of the seed coat, accounting for

57.81%. The energy-dispersive X-ray spectroscopy (EDX) spectrum shows elemental atomic percentages of 97.76% C, 2.32% O, 0.42% Fe, and 0.15% Zn. The TGA analysis reveals multiple thermal degradation events occurring within the sample over the studied temperature range.

Crop area estimation using remote sensing data

The Sentinel-2 remote sensing satellite datasets, derived primarily from the Sentinel-2 Multispectral Instrument (MSI) imagery, were used to estimate makhana crop area. Data were collected and analysed for the major makhana-growing districts of North Bihar, India, during the main growth period of the crop for year 2024 and 2025. The total makhana crop area across all districts in the year 2024 and 2025 was estimated around 31,325 ha and 37,878.7 ha, respectively. The temporal spectral reflectance behaviour of Makhana was analysed using Sentinel-2 multispectral data for its major phenological stages.

Water chestnut

Propagation Protocol of Water Chestnut

The propagation protocol for the water chestnut cultivation is important for the expansion of the cultivation area under such high economic importance as an aquatic crop. Several important parameters and management practices are identified and quantified, such as seed characteristics, cultivation practices, including nursery management, plantation, nutrient management, and harvesting protocol.

Criteria of soil and water properties

The water and soil quality are the basic criteria for enhancing the production of water chestnut, and therefore, the optimum range of water and soil quality for the cultivation of water chestnut has been categorised from low productivity to high productivity.

Lotus

Propagation protocol for Lotus cultivation

For propagating lotus, either seeds or rhizomes are used. The key steps involve seed selection, rhizome size, germination period, water, and soil quality.

Morphological characteristics of the lotus plant

Lotus plants from rhizomes start with dormant tubers. Cut them into pieces, ensuring each section has at least one bud. Plant these pieces in wide, round pots without drainage holes; avoid square pots to protect the delicate growing tip. Only one piece should be planted per pot. Fill the pot with rich, loamy clay soil and add a thin layer of pea gravel on top, leaving about 1.3 cm of the growing tip exposed. Place the pots in a warm, sunny spot with the growing tip submerged 5 to 7.5 cm under the water's surface, ideally in temperatures between 10 and 16°C. If done correctly, the first leaves should appear in about three weeks.

Natural Resource Management

Groundwater survey of Darbhanga district

Groundwater is the main source of drinking and irrigation water in Bihar's rural and urban areas. Field surveys in Darbhanga district during April-May 2025 analyzed groundwater

quality, reported arsenic levels from 5 to 50 µg/L, TDS from 175 to 1010 mg/L, and EC from 340 to 2000 µS/cm. Arsenic levels in water exceeded WHO limits.

Rainfall in the major makhana growing districts

The spatio-temporal variability and long-term trends of rainfall across the major makhana-growing wetland districts of north Bihar were investigated using past rainfall data spanning from 1901 to 2022. The statistical parameters of rainfall, including mean, standard deviation (SD), coefficient of skewness (CS), and coefficient of kurtosis (CK), were assessed for annual and seasonal rainfall across the districts. The mean rainfall, SD, CS, and CK for the annual scale vary from 1204.5 to 2162 mm, 290.1 to 459.4 mm, -0.32 to 0.31, and -0.4 to 1.17, respectively. Monsoon seasonal rainfall mean, SD, CS, and CK vary from 1004.49 to 2052.29 mm, 330.59 to 303.15 mm, 0.28 to 0.42, and -0.18 to 0.37.

land surface temperature (LST)

The analysis of mean annual land surface temperature (LST) across major makhana-growing districts from 1995 to 2024 reveals significant variations. Using Landsat satellite imagery, the study highlighted fluctuations in LST influenced by climatic variability, land use changes, and surface water dynamics. A notable warming trend emerged in the latter part of the study (2018-2024), with Katihar reaching 34.42°C in 2022 and Darbhanga 35.72°C in 2023. This analysis aims to correlate temperature changes with water body fluctuations or even loss of water bodies and rainfall patterns to explore their interconnections.

Dynamics of surface water bodies

Makhana is primarily cultivated in the wetland areas of North Bihar, India, particularly in the districts of Darbhanga, Madhubani, Araria, Madhepura, Saharsa, Supaul, Purnea, Kishanganj, and Katihar. The dynamics of surface water bodies in these districts were assessed using remote sensing-based water indices for the post-monsoon season from 1995 to 2024. Katihar had the largest surface water area, peaking at about 47,000 ha in 2022, indicating availability of extensive floodplains and permanent water bodies. In contrast, Darbhanga, Supaul, and Saharsa showed significant variability, particularly during flood years like 1999, 2009, and 2020. The identification of water bodies through remote sensing highlights the importance of hydrological patterns and landscape configuration in determining surface water availability in the region.

Other achievements

In the reported year (2025), three Memoranda of Understanding (MoUs) were signed for conducting collaborative research and development. Over the years around 700 farmers and stakeholders benefited from various training programmes and exposure visits, while more than 400 stakeholders, officers, and farmers visited the institute. NRC-M actively participated in the *Viksit Krishi Sankalp Abhiyan* and organized various outreach events such as *Krishi Chaupal*, *Kisan Samwad*, and the *Rashtriya Makhana Mahotsav*, along with several meetings and extension programmes. In addition to these significant efforts were also made to enhance the Centre's infrastructure for initiating effective research and extension. Scientists of the Centre published 20 scientific articles, reflecting the institute's strong research output. The centre has developed processing practices, machineries, and these are being adopted by farmers and entrepreneurs.



INTRODUCTION

ICAR-National Research Centre for Makhana (NRC-M) was established in Darbhanga on 28th February 2002, considering the historical, cultural and economic significance of makhana in the Mithila Region of Bihar. To date, it is regarded as the only Research Centre in the world exclusively dedicated to makhana research. Its mandate was, however, expanded in 2023 to include research on lotus, water chestnut, fish and other aquatic crops with potentially high nutritive, medicinal, industrial and economic significance. During over two decades of its existence, NRC-M, Darbhanga, through its research and extension activities, has made an immense contribution in improving production, productivity of makhana, resulting in higher farm income, and area expansion, leading to establishing makhana as a superfood in the global arena. With a strong multidisciplinary team of scientists, newly acquired state-of-the-art scientific equipment, and research facilities/infrastructure, the NRC-M, Darbhanga, envisions further accelerating its research and extension activities for nationwide expansion of makhana cultivation. It also aims to develop cost-effective, easily adaptable technologies for makhana processing and value addition to better leverage India's position as the world leader in makhana production and processing. The NRC-M, Darbhanga, remains committed to improving farmers' income and livelihoods, and the agri-based economy of Bihar, Eastern India and beyond, through its demand-driven research and outreach activities. The major achievements are:

- ❖ The first ever improved variety of makhana “*Swarna Vaidehi*” was developed by NRC-M Darbhanga in the year 2013, with a production potential of 2.8-3.0 t/ha, almost double that obtained from conventional cultivation till then.
- ❖ The NRC-M, Darbhanga, initiated a field system for makhana cultivation requiring less water (30-45 cm water depth), nearly doubling productivity compared to traditional pond methods. Introducing makhana into this system has driven its quick spread to new areas and farmers.
- ❖ Makhana cultivation in cropping system mode was developed by NRC-M, Darbhanga, which allowed cultivation of as many as three crops in a year on the same piece of land, improving cropping intensity, land productivity and farm income.
- ❖ A system of makhana-cum-fish farming was also initiated. Vacant Space System for fish-cum-makhana cultivation and periphyton-based fish-cum-makhana cultivation was developed by the Centre.
- ❖ A package of practices for makhana cultivation, including nutrient management and crop protection measures, was developed by NRC-M, Darbhanga.
- ❖ The NRC-M Darbhanga has trained thousands of farmers and entrepreneurs in makhana cultivation, processing, value addition and marketing, which have yielded revolutionary results in terms of improving makhana productivity, farm income and makhana-based industries in north Bihar and beyond.
- ❖ In the past five years, the area under makhana cultivation in Bihar has increased from 13000-15000 ha to around 40,000 ha. Now the crop is being cultivated in many states other than Bihar, such as Chhattisgarh, Madhya Pradesh, Uttar Pradesh, West Bengal, Assam, Odisha, and Manipur.
- ❖ Two improved varieties of water chestnut, namely *Swarna Harit* and *Swarna Lohit*, have also been developed by the Centre.
- ❖ Research on lotus has also been initiated to explore its nutritional, medicinal, industrial and economic values.

VISION

To improve the livelihoods of all stakeholders in makhana and other aquatic crops through the application of appropriate mechanisation, production practices, biological improvements, standardisation, and management systems while ensuring health, nutritional security, and environmental sustainability.

OBJECTIVE

- ❖ To develop technologies for efficient management of land, water, human resources and other inputs through appropriate mechanisation and biological practices for improving productivity and human comfort in the production of makhana and other aquatic crops and integrate it with aquaculture.
- ❖ To provide technological solutions for post-production handling, processing, storage, packaging, and innovative product development from makhana, other aquatic crops and aquaculture.
- ❖ To develop entrepreneurship, agri-business, and impart training for capacity building of all stakeholders.

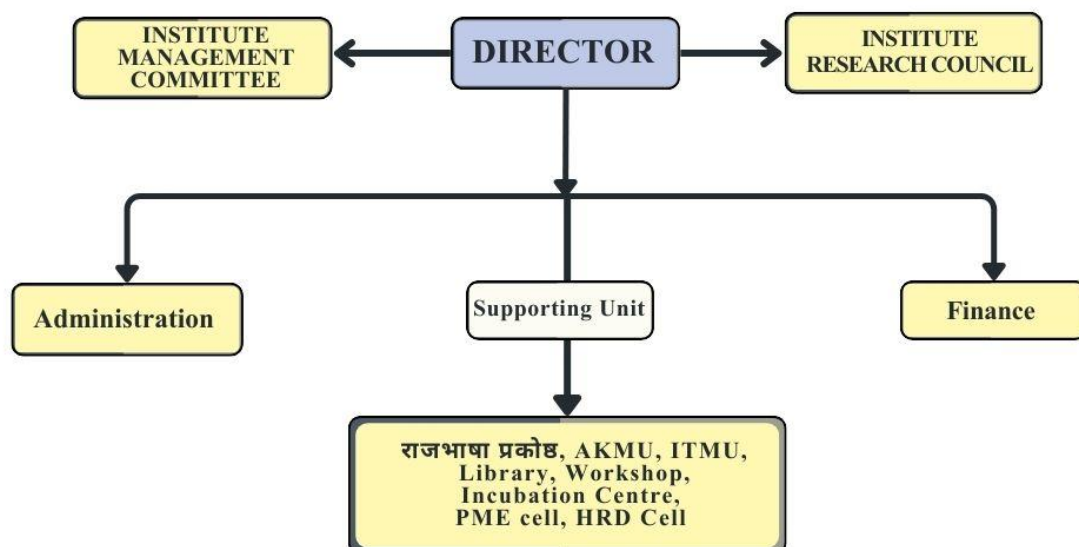
MANDATE

Basic and strategic research for production, post-production and value-addition of makhana and other aquatic crops, including aquaculture



Institute building at ICAR-NRCM Darbhanga

ICAR- NATIONAL RESEARCH CENTRE FOR MAKHANA, DARBHANGA



Organogram of ICAR NRC for Makhana, Darbhanga

Infrastructure

Makhana Processing Unit

Makhana processing unit provides demonstration and hands-on training for trainees and incubators, and facilitates makhana processing services for other makhana growers and entrepreneurs. This unit is well-equipped with different machines. The makhana seed washer is a motor-operated cylindrical unit with an internal mat layer that provides friction to remove dirt and membranes from seeds, using continuous water flow and handling 120–180 kg of seeds per hour. The makhana seed dryer, whether sun-dried or cabinet-dried, reduces seed moisture from about 41% to 30% using hot-air convection, with a batch capacity of 15–20 kg. The raw makhana seed grader segregates dried seeds into different size fractions using oscillating screens to ensure uniform roasting, with a capacity of 200–250 kg/h. The primary roasting machine roasts graded seeds in a rotating, heated pan using LPG burners, preparing them for popping through controlled roasting and tempering, with a capacity of 8–10 kg per batch. The secondary roasting-cum-popping machine performs final roasting and popping using a thermic oil-heated cylinder and centrifugal popping unit, producing 25–30 kg roasted seeds per hour. The popped makhana grader separates popped seeds into different commercial grades based on size using concentric cylindrical screens, ensuring quality-based marketing. The form, fill and seal machine automatically packs fixed quantities of makhana pops into pouches for retail marketing, while the coating machine uniformly applies edible oil and flavours to roasted makhana, enhancing taste and consumer acceptability.



Makhana Processing Unit at NRCM Darbhanga

Library

The library of ICAR–NRC-M, Darbhanga, serves as an important knowledge resource centre, supporting the Institute's research, education, and extension activities. It houses a collection of journals, reports, extension folders, leaflets, and reference materials on makhana books, post-harvest management, medicinal plants, organic farming, plant breeding, a dictionary, Hindi sahitya, agriculture, natural resource management, and allied sciences. The library provides access to print resources, including books, journals, reports, and institutional publications, thereby facilitating the dissemination of scientific information to researchers, students, and staff.



Library Facility at NRC-M Darbhanga

Agricultural Knowledge Management Unit (AKMU)

AKMU provides essential support in IT-related management and software solutions for the institute. The unit is equipped with licensed Microsoft Office software and the ESET Total Security Suite for Business Anti-Virus, deployed through the institute's server and network systems. AKMU assists scientists and staff with reliable internet connectivity and the smooth

functioning of the biometric attendance system. In addition, the unit is responsible for providing, monitoring, and maintaining the institute's Wi-Fi network and landline telephone services, ensuring uninterrupted communication and digital operations.

STAFF POSITION (AS ON 31ST DEC 2025)

Category	Sanctioned strength	Filled	Vacant
*Director	1	1	0
*Scientific	10	8	2
Administrative	8	0	8
Technical	10	3	7
Total	29	12	17

*Staff position proposed with the council

Budget

ICAR-NRCM, Darbhanga and ICAR-CIPHET, Ludhiana have a common budget.



RESEARCH HIGHLIGHTS

Makhana

Project title: Participatory Seed Production of Makhana, Water chestnut and Lotus

Nursery preparation for makhana cultivation

Under this scientific method of makhana nursery preparation technology, the field is well prepared by two to three deep ploughings; however, before ploughing, for the proper nourishment of seedlings, fertilizers 100 kg/ha, 60 kg/ha, 40 kg/ha, respectively, of N, P and K, in combination with 20 t/ha compost, are applied. Prior to puddling, the soil is treated with cakes of neem/mahua/karanj @ 0.8-1.0 t/ha. These cakes help in keeping the soil-borne diseases away from the rhizosphere of plants. The field is filled with water up to a height of 0.45 m, and the seeds are broadcast in the months of November and December. An amount of 20 kg of healthy seed is broadcast uniformly in the entire nursery plot. For transplanting in a one-hectare area, an area of 500 m² is sufficient for raising the nursery. The water level of 0.45 m height is maintained throughout the growing period of seedlings, i.e., from November to March. The seedlings are transferred from the nursery plot to the already prepared main field in the first week of March and transplanted at a spacing of 1.25 m x 1.25 m plant-to-plant and row-to-row.

Physiological activities

This deep-water macrophyte is an absolutely seed-propagated plant. Makhana tends to grow in dense beds that totally cover the water's surface, thus shading native submerged species, which in due course of time died and decomposed underneath the leaves of makhana plants. The ecosystem impacts of this species are not entirely negative. The germination percentage varies from 50 to 90. The germination of the makhana seed is of a hypogeal type. Upon germination, the cotyledons and hypocotyls of the seeds remain in the soil. It does not bear a stem, but the rootstalks are short, thick and fibrous, comprising 3 to 5 clusters, each consisting of about 15 rootlets. The roots are thick and long (40-50 cm), fleshy and fibrous in nature and have several air pockets. The plant has rhizomatous stems. The petioles are prickly and deep green or pink. The contribution of different parts of a mature plant in biomass production is depicted in Table 1.

Table 1: Distribution of plant biomass (on fresh weight basis) of ten germplasms of makhana at the time of harvesting

Sr. No.	Total plant wt. (kg)	Leaf wt. (kg)	Petiole wt. (kg)	Root wt. (kg)	Flower wt. (kg)	Pedicel wt. (kg)	Fruit wt. (kg)	Fruit stalk (kg)
01	14.140	8.700	1.970	2.020	0.061	0.102	0.900	0.515
02	14.287	9.561	2.100	1.310	0.080	0.136	0.800	0.400
03	7.150	4.436	1.000	0.575	0.021	0.035	0.335	0.165
04	5.500	3.415	0.612	0.785	0.027	0.050	0.450	0.215
05	7.640	4.887	0.991	1.066	0.320	0.062	0.525	0.213
06	10.230	6.650	1.438	1.590	0.050	0.091	0.615	0.370
07	12.300	8.120	1.650	1.445	0.049	0.086	0.720	0.360
08	12.000	7.300	1.685	1.441	0.062	0.096	0.585	0.285
09	9.835	6.885	1.258	1.172	0.045	0.087	0.720	0.335

10	11.215	7.525	1.467	1.590	0.057	0.075	0.672	0.369
Total %		60-70	12-15	6-15	0.4-0.5	0.6-0.9	4-6	2.13

The plant produces about 8-9 alternate leaves. Young leaves are sinuate to sagittate in shape, while the mature ones are circular. The gigantic prickly floating leaves are orbicular in shape (diameter: 0.50-1.70 m), floating, corrugated adaxial surface green in colour and deep purple beneath, supported by stout, porous and prickly ribs, floating in nature and born on a 0.30-1.5 m long petiole. The number of thorns on fully developed leaves ranges from 200 to 640. The thorns are positioned at 45 to 60° angles as stout, hooked prickles on the joints of the dorsal veins. Some researchers have reported that cell proliferation completes in leaves themselves, during initial growth stages, they are developing under water and expand rapidly while coming up to the water surface. The leaf development stages have a strong association with the expression of genes associated with cell development, energy transport and photosynthetic metabolism. The competition for space faced by developing and expanding leaves favours adaptive evolution. This adaptive evolution is mediated by gene sub-functionalization, assigning separate functions to paralogs after duplication. The genome evolution of makhana plants is mediated through polyploidization. Besides leaves, petioles, sepals and the outer surface of fruits are also covered with semi-delicate bent prickles having a length range from 0.4 to 1.5 cm. The fleshy 20 to 50 cm long roots are the only parts of this plant that are thornless. Flowering starts in the second week of April when the average air temperatures are 30 °C and the photo period is 12.60 h. Most flowers appear in the first week of May. Flowering, fruiting and fruit maturation aspects have been dealt with in detail under the flowering heads explained under traditional methods of makhana cultivation.



Fig. 1. Report on germination of makhana seeds soaked under fresh & sweet tap water at room temperature (The germination % =75).

Seed Standard Protocol of Makhana

The seed standard protocol has been developed to increase the yield potential of the makhana crop. The details of the seed standard are given below:

Table 2: Details of the seed standard

Sr.. No.	Parameters	Characteristics
Optimum soil properties		
01.	Most suitable climate	Sub-tropical
02.	Depth of the water level	0.45 m (field condition); 1 to 1.5 m (pond condition)
03.	Soil type	Humus-rich clayey, silty/sandy clay loam (heavy soil with high organic matter content and water holding capacity)
04.	Soil reaction (pH)	6.00-7.50
05.	EC (dS/m)	<1.0
06.	Org. C (%)	>0.75
07.	Available N (kg/ha)	> 400
08.	Available P ₂ O ₅ (kg/ha)	>25
09.	Available K ₂ O (kg/ha)	>150
10.	Secondary and micronutrients	Adequate quantity
Water		
01.	pH	7.1-8.2
02.	Transparency (cm)	40-50
03.	Optimum water temperature	18-25°C
04.	Optimum air temperature	18-22 °C
05.	Optimum suitable depth of field	1.5-2.0 ft (45 -60 cm)
06.	Optimum suitable depth of pond	4.0 – 6.0 ft (120-180 cm)
07.	Electrical conductivity	232-338 µS/cm (micron Siemen per cm)
08.	Total Dissolved Salts (TDS)	148-216 ppm
09.	Dissolved Oxygen	5-6 ppm
10.	BOD	< 2.0
11.	Total alkalinity	60-300 ppm
12.	Hardness	60-80 ppm (≤200 ppm)
13.	Nitrite	0.0-0.1 ppm
14.	Chlorine (Cl)	≤200 ppm
15.	Total Phosphorus	0.05-0.4 ppm
16.	Plankton (ml/50 L)	2.0 ml
Seed		
01.	Avg. size of makhana seed	0.8 to 1.2 cm
02.	Avg. weight of makhana seed	0.8 to 1.2 g
04.	Spacing of seed sowing	1.25 m
05.	Germination percentage	90%
06.	Fruit diameter	7 to 8 cm
07.	Number of fruits per plant	10 to 16
08.	Number of seed packets per fruit	8 to 13
09.	Avg. number of seeds per fruit	40 to 70

10.	Weight of 100 seeds (Seed Index)	80 to 120 g
11.	Seed yield per plant	450 to 700 g
12.	In an old pond	Seed sowing is favoured method/approach
13.	In the new pond	Transplanting is an effective cultivation method
14.	Application rate of seed sowing in ponds	60 kg/ha
15.	For getting better sprouting of the seed	Seeds should be kept in a wet jute bag under shade for one week. Water should be sprinkled intermittently
16.	Transplanting of seedlings	Should be completed by the end of March
17.	Roots contain 3 to 5 lumps/groups/bundles	Each group contains 15 radish-type rootlets.
18.	In the month of April, when the temperature reaches around 30°C, flowering starts.	Fruiting starts from mid-May.
19.	The minimum standing water level to be maintained in old ponds.	1 m

Molecular identification and genetic diversity of makhana aphid (*Rhopalosiphum nymphaeae*)

Molecular identification:

The COI gene sequences of aphids infesting makhana, water chestnut, blue water lily, four-leaf clover and red water lily (Fig. 2 & 3) subjected to homology search in NCBI BLAST resulted in 100% similarity to *Rhopalosiphum nymphaeae* sequences and confirmed the same aphid species infesting all the aquatic crops under investigation. Barcode sequences which were obtained in the study, showed nine mutation sites and nine singleton variable sites. The total nucleotide composition found were: A 35.83%, T 41.01%, G 9.11% and C 14.02 % in the sequences, showed high AT content. Generally, insect mitochondrial genome is AT rich and has been reported in many insects like Brown planthopper and moths etc.



Fig. 2. Water lily aphid, *R. nymphaeae* collected from different host plants. A. Makhana, *Euryale ferox*, B. Water chestnut, *Trapa natans*, C. Blue water lily, *Nymphaea nouchali*, D. Four leaf clover, *Marsilea quadrifolia*, E. Red water lily, *Nymphaea rubra*

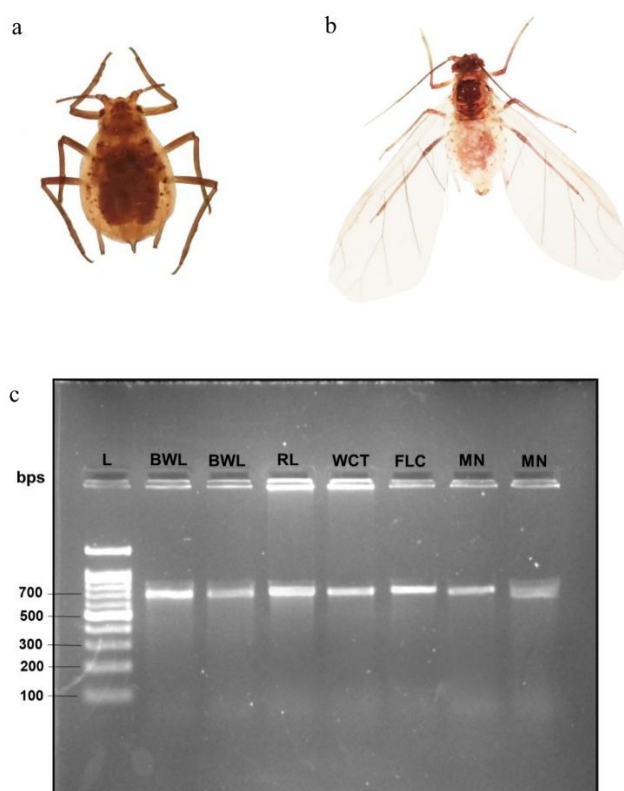


Fig. 3. a) & b) Nymph and Adult of Water lily aphid, *R. nymphaeae* under stereozoom microscope. c) PCR product of Water lily aphid, *R. nymphaeae* collected from following host plants. L: Molecular ladder, BWL: Blue water lily; RL: Red lily; WCT: Water chestnut; MN: Makhana

Haplotype network and genetic diversity in the aphid population

Haplotype analysis identified a total of six haplotypes. Many individuals belonged to a single dominant haplotype (H1), which included 14 accessions from four countries: USA, India, Canada, and China. The remaining haplotypes, H2 (Canada), H3 (China), H4 (China), and H5 (Lithuania) were each represented by a single accession, while H6 (Lithuania) comprised four accessions (Fig. 4). For genetic diversity analysis, the populations were grouped into three categories: the Indian population, the rest of the world population, and the combined dataset. No segregating sites were observed within the Indian population of *R. nymphaeae*, which was entirely represented by a single haplotype. In contrast, 10 segregating sites were detected in the global population (excluding India). The average number of nucleotide differences (K) for the total population was 1.225, and nucleotide diversity (π) was estimated at 0.00229, indicating low genetic variation. Despite this, a moderate haplotype diversity (Hd) of 0.580 was recorded. Neutrality tests, including Tajima's D, Fu and Li's D, Fu and Li's F, and Fu's Fs, all yielded negative but statistically non-significant values ($0.10 > p > 0.05$), suggesting no strong evidence of selection.

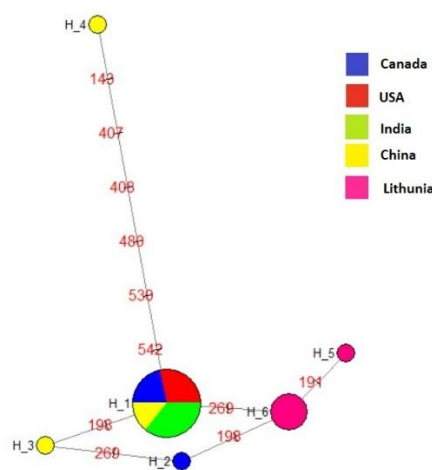


Fig. 4. Haplotype network of *R. nymphaeae* population. The cross lines represent the mutated positions, and different colour represents different countries

Phylogenetic Analysis

A total of 28 sequences were used for phylogenetic tree construction, including five sequences generated in the present study and 23 retrieved from GenBank. A neighbor-joining (NJ) tree was constructed using MEGA 11 software, employing the Kimura 2-parameter model (Kimura, 1980) to calculate genetic distances, with bootstrap support set at 2000 replicates (Fig. 5). The resulting tree had a total branch length of 0.3345, and the average pairwise genetic distance was 0.0245. The intraspecific genetic divergence within the Indian population was found to be 0.000, indicating no genetic variation among Indian samples. The highest genetic divergence (0.032) was observed between populations from Australia and France. The NJ tree revealed that samples from various countries generally clustered together. Indian samples from different host plants grouped closely with those from China, Canada, and the USA, mirroring the clustering pattern observed in the haplotype network. In contrast, the Lithuanian population formed a separate cluster along with one sample from Australia.

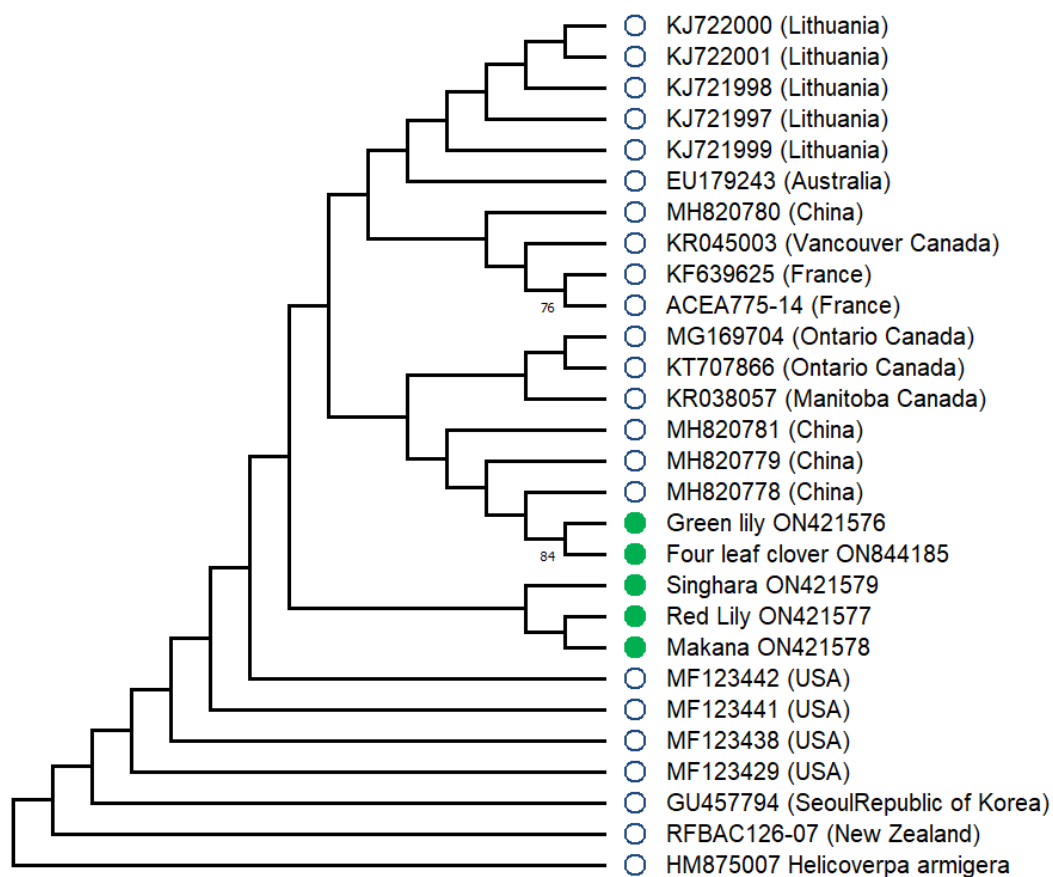


Fig. 5. The neighbour joining phylogenetic relationship of *R. nymphaeae* based on 27 COI sequences all over the world. (Green colour circles indicate *R. nymphaeae* sequences generated from current study (Indian population) and uncoloured circles from rest of world population. *Helicoverpa armigera* used as an outgroup in the study).

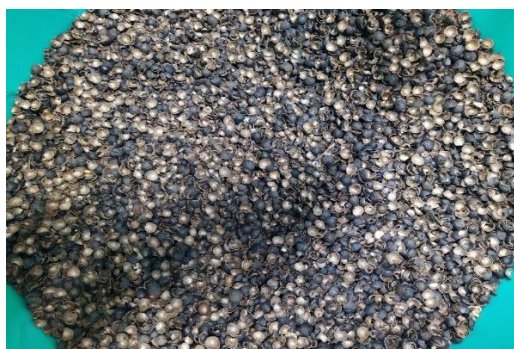
Population structure

The analysis of molecular variance (AMOVA) for *R. nymphaeae* populations revealed significant genetic differentiation among populations ($p < 0.05$), using the Kimura 2-parameter model with 1000 bootstrap replicates. The overall F_{ST} value was 0.24560, indicating moderate genetic differentiation. AMOVA results based on 22 sequences showed that 75.44% of the genetic variation existed within populations from five different countries, while 15.14% of the variation was attributed to differences among countries. When grouped into two categories, Indian population vs. the rest the variation among these groups accounted for 9.4 %.

Project title: Performance of Activated Carbon from Makhana (*Euryale ferox* Salisbury) seed coat for Removal of Arsenic in Water

Preparation of makhana seed coat (MSC) powder

The seed coat of *Euryale ferox* Salisbury is collected from the makhana pop processing Unit, NRCM, Darbhanga. The seed coat was used as a raw material and ground to a powder (100-200 μm) for the preparation of an adsorbent (Fig. 6).



Makhana seed coat



Makhana seed coat (MSC) powder

Fig. 6 Preparation of biomaterial for activated carbon from the makhana seed coat

Characterization of the makhana seed coat

Makhana seed coat (MSC) primarily comprises organic matter, accounting for 99.66% of its composition. In contrast, the inorganic content, as measured by ash content, was relatively low, comprising only 0.34% of the seed coat's mass. Furthermore, the analysis showed that organic carbon constitutes a significant portion of the seed coat, accounting for 57.81%. These findings highlight the predominantly organic nature of the makhana seed coat, suggesting its potential as a valuable source of carbon-rich compounds. Such characterization data are crucial for understanding the material's properties and exploring its applications in various fields, including pollutant-remediating technology.

Table 3: Proximate composition of MSC

Sr. No.	Parameter	Quantity
1.	Ash	0.34%
2.	Organic matter	99.66%
3.	Organic carbon	57.81%
4.	Bulk density	0.36 g/cm ³
5.	pH	6.8

Microstructure analysis and element mapping

The surface morphology of the makhana seed coat powder was analyzed by scanning electron microscopy (SEM) at different magnifications. Fig. 7 shows SEM micrographs at 200x magnification, revealing a fine structure with small, narrow pores. The energy-dispersive X-ray spectroscopy (EDX) spectrum shows elemental atomic percentages of 97.76% C, 2.32% O, 0.42% Fe, and 0.15% Zn (Fig. 8).

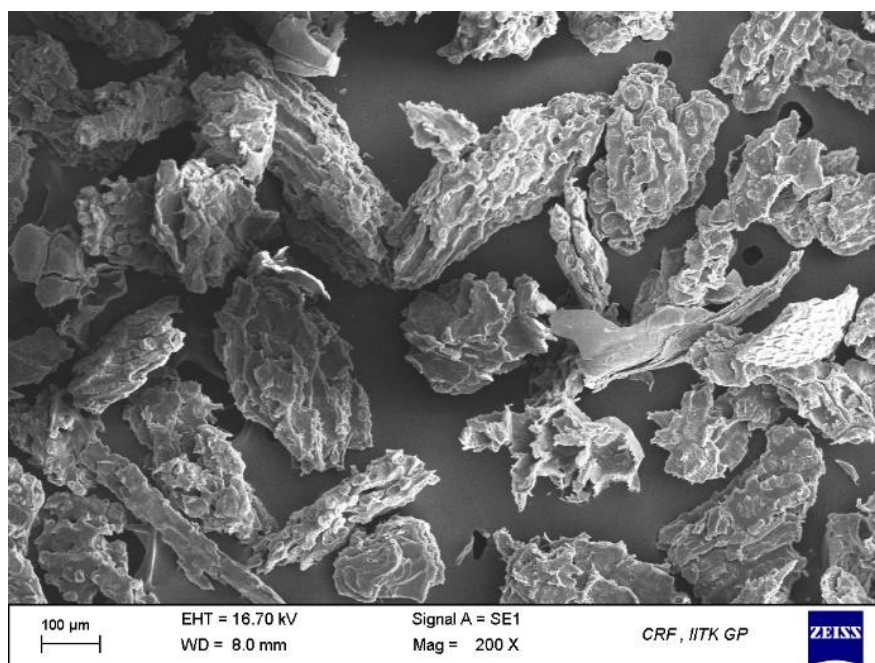
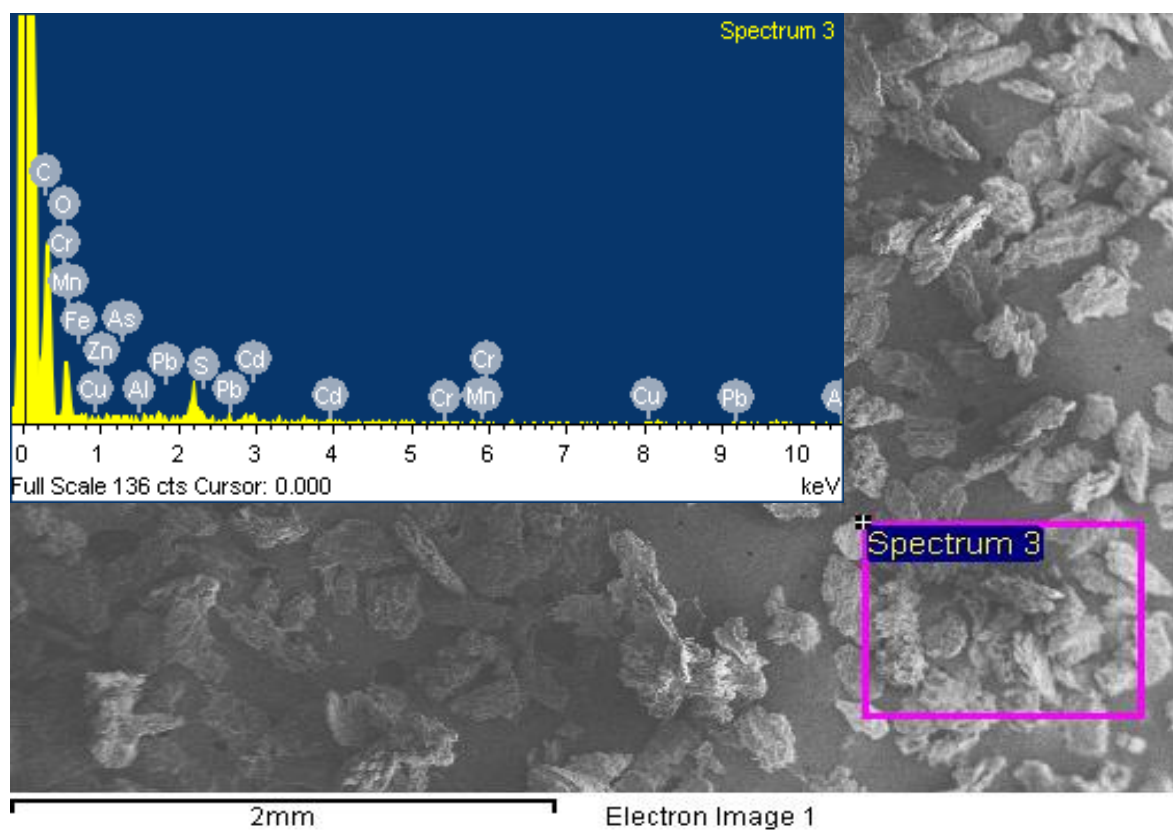


Fig. 7. Microstructure of the MSC powder by scanning electron microscope



Element	Weight%	Atomic%
C	97.13	97.76
O	3.08	2.32
Mn	0.02	ND
Fe	ND	0.42
Zn	0.84	0.15

Fig. 8. Microstructure and element mapping of the makhana seed powder by scanning electron microscope and EDX (ND: Not Detected)

Thermal characterization of MSC

Thermogravimetric analyses/Differential Thermal analysis (TGA/DTA) play a crucial role in preparing activated carbon by providing valuable insights into organic precursors' thermal behaviour, decomposition pathways, and activation parameters (Fig. 9). The TGA curve shows a weight-loss step from 23°C to 250°C. This step corresponds to a weight loss of 0.186 mg or 8.696% of the initial sample mass. The negative weight loss indicates that material is being lost from the sample during this thermal event. Possible reasons for this weight loss include dehydration and some low-molecular-weight volatile compounds. Another step showed significant weight loss in the TGA curve between 250°C and 400°C. This step results in a weight loss of 1.392 mg, corresponding to 65% of the initial sample mass. The substantial weight loss suggests a more pronounced thermal decomposition or volatilization process occurring within this temperature range. The third weight loss step starts at 400°C and ends at 515°C. This step results in a weight loss of 0.550 mg or 25.713% of the initial sample mass. The observed weight loss indicates further decomposition or volatilization of components within the sample at higher temperatures. Overall, the TGA analysis reveals multiple thermal degradation events occurring within the sample over the studied temperature range. Each weight loss step provides insights into the composition and thermal stability of the material, aiding in its characterization and understanding its behaviour under elevated temperatures.

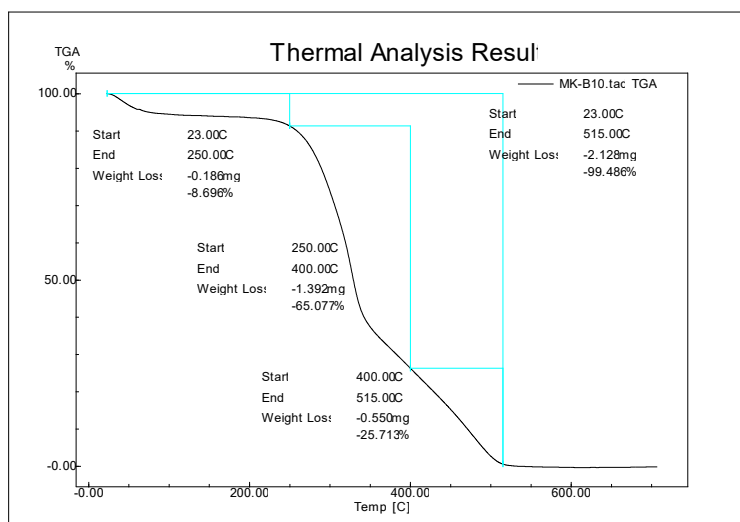


Fig. 9 Thermogravimetric analyses analysis of MSC

Water chestnut

Project title: Participatory Seed Production of Makhana, Water Chestnut and Lotus

Propagation Protocol of Water chestnut (*Trapa natans*)

- It is a true annual, aquatic, floating-leaved plant that dies back at the end of each growing season. It overwinters by seed alone.
- It has very high germination success. Its germination does not seem to be inhibited by temperature or by exposure to shade.
- Water chestnut requires full sun, standing fresh waters, and nutrient-rich soft, muddy bottom/substrate.
- Water chestnut grows in waters 0.3 to 3.6 m deep.
- Traditionally, it is grown in naturally formed high organic matter-rich ponds/ditches where seed sowing is not required, since leftover seeds of previous crops serve as planting materials for subsequent crops.
- However, its cultivation in new water bodies (ponds) requires an addition of FYM (N 0.75%, P₂O₅ 0.20% and K₂O 0.5%) at the rate of 15 t/ha followed by two to three wet ploughings of the field afterwards the fields must be filled with 0.45 m depth of water.
- Completely matured seed of previous year is stored under water before planting in March of the following year. The seed rate is 70 kg/ha.
- Following seed germination, lateral roots grow down from the hypocotyl to anchor the young seedlings.
- The adventitious roots that develop at the nodes of the main stem and its branches contain photosynthetic pigments, particularly chlorophyll, and perform both photosynthesis and the absorption of nutrients.
- Seeds germinate in the spring, with each seed producing 10 to 15 rosettes, with each rosette capable of producing up to 20 seeds.
- For vegetative propagation, the bundle of three rootlets taken out from nursery plots is planted at one point, and another bundle of three rootlets is planted at a distance of 3 m, and the row-to-row distance should also be kept 3 m.
- The transplanting of saplings is done in the months of June and July in agricultural fields.
- The onset of flowering takes place in the months of September and October
- Pollination apparently occurs in the air; however, the pollen vector is unknown.
- Self-pollination possibly occurs before the flower opens.
- After pollination, the flower stalks droop downward beneath the water surface to facilitate fruit formation.
- Fruiting starts in the month of October and continues up to December.
- Overwintering of populations is accomplished through the mature, greenish brown seeds sinking to the bottom, where they can remain viable in the sediment for up to 12 years.
- Old nuts, black in colour, will float and are not viable.
- The harvesting of fruit in the pond is done with the help of a wooden boat in the months of November & December.
- Water chestnut has little nutritional or habitat value to fish or waterfowl.
- Its rapid and abundant growth can also out-compete native aquatic vegetation



Fig. 10. Water chestnut growing in an aquatic habitat



Fig. 11. One whorl of leaves of the water chestnut plant



Fig. 12. White coloured Water chestnut flower

Prepared suitability criteria of soil and water properties for the cultivation of water chestnut

Table 4: Suitability criteria of soil and water properties for the cultivation of water chestnut

Sr. No.	Parameters	Unproductive	Less productive	Highly productive
Water				
01.	pH	< 6.0	6.0 – 6.5	6.5 – 8.2
02.	Total alkalinity (ppm)	< 30	30 - 90	> 90
03.	Inorganic nitrogen (ppm)	< 0.1	0.1 – 0.5	0.5 – 1.5
04.	Orthophosphate (ppm)	< 0.05	0.05 – 0.2	0.2 – 1.0
05.	Dissolved oxygen (ppm)	< 2.0	2.0 – 6.0	6.0 – 9.0
Soil				

01.	pH	< 6.0	6.0 – 7.0	7.0 – 8.0
02.	EC (dS/m)	< 2.0	2.0 – 3.0	3.0 – 4.0
02.	Organic carbon (%)	< 0.3	0.3 – 0.5	> 0.5
02.	Available N (kg/ha)	< 250	250- 300	>300
03.	Available P (kg/ha)	< 10	10 - 20	>20
04.	Available K (kg/ha)	< 100	100 - 250	>250
05.	Available Fe (µg/g d.w.)	< 10	10 -20	> 20
06.	Available Mn (µg/g d.w.)	< 4	4 - 6	> 6
07.	Available Cu (µg/g d.w.)	< 0.5	0.5 – 0.7	> 0.7
08.	Available Zn (µg/g d.w.)	<0.2	0.2 – 0.5	> 0.5

d.w.: dry weight

Lotus

Project: Participatory Seed Production of Makhana, Water Chestnut and Lotus

Propagation protocol of Lotus (*Nelumbo nucifera*)

Propagating *N. nucifera* by seeds or rhizome is a rather straightforward task, as long as a few important steps are followed:

- First, it is crucial to use viable seeds. The easiest way to determine the viability of seeds is to throw them in a cup of water. Retain the seeds that sink and discard the seeds that float; floating seeds have poorly developed or rotten embryos.
- The hard seed coats must be scarified to allow the seeds to imbibe water. The simplest approach is to scratch off one or both pointed ends of the ellipsoidal seed coat using medium-grade sandpaper.
- The seeds should not be scratched too deeply, so that the creamy-white inner embryos do not get exposed.
- The seed gets swollen after absorbing the water.
- For better results, it is important to change the water daily as you wait for seeds to germinate. However, the water in the plastic pot can be changed after 3 to 4 days of experimentation.
- In about four days, the embryo begins to sprout out of the seed coat.
- Plant the seeds in water no longer than 30 cm, taking extra care to make sure seeds are fully covered with fertile soil.
- The seedlings grow rapidly, and in four months, the diameter of the leaves reaches up to about 20 cm.
- The completely ripened (matured) viable seeds look brownish-black.

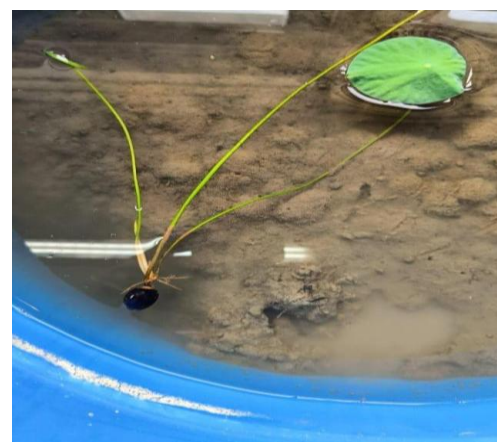
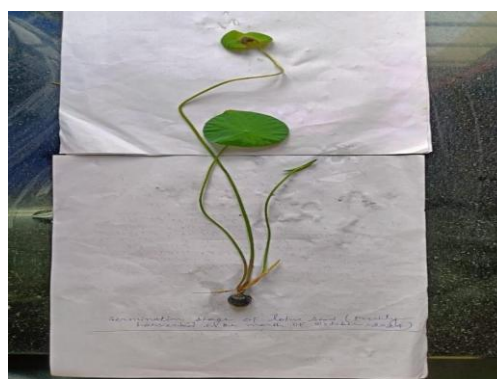
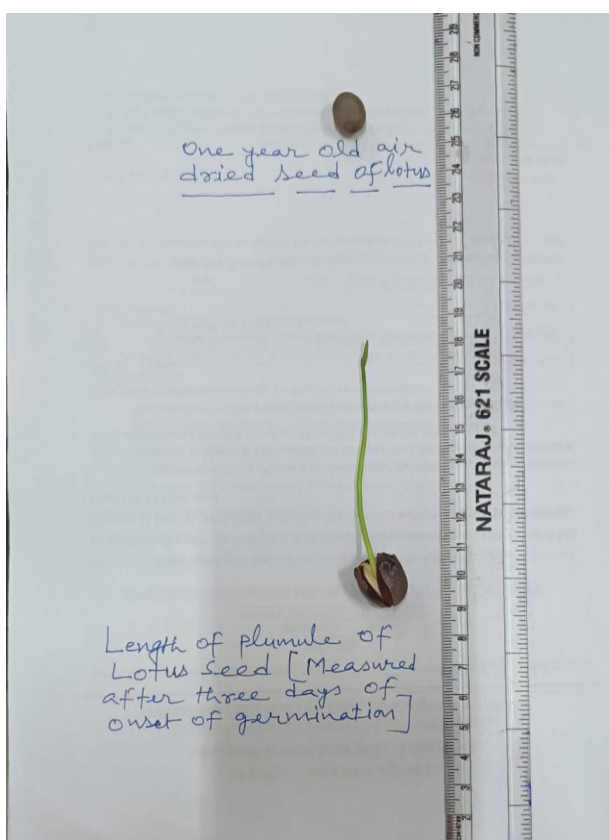
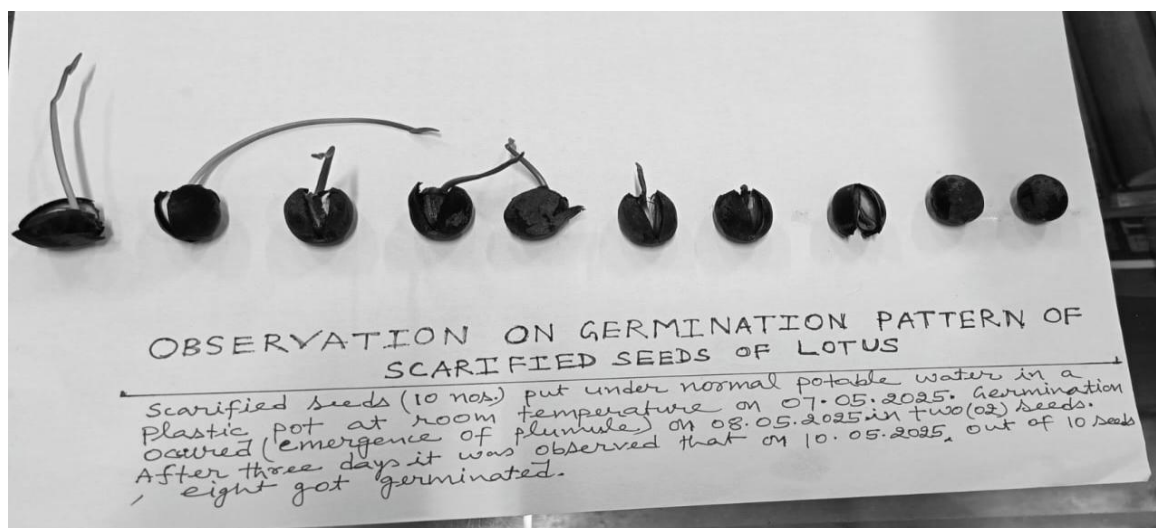


Fig. 13. Propagation of the Lotus study at the experimental laboratory of NRC-M, Darbhanga

Morphological characteristics of a fully grown lotus plant

- Floating leaves circular, of variable size (30-50 cm broad), with petioles attached at mid-understand (Fig. 13).
- Petioles up to 50 cm long, attached to the mid-underneath, rough, stiff.
- Flowers 15 – 20 cm wide when fully open, solitary, white on stiff peduncles up to 1 m long, sepals and petals up to 25 cm or more, the outer sepals green, stamens yellow and numerous.
- Receptacle 5 -10 cm across, in the centre of the flower, with fruits embedded in its surface, white as the flower opens, turning completely white.

- Individual fruits are about 5-7 cm wide, conical, dark green, containing 12 to 15 nuts of lotus. Circumference of fruits 12 – 15 cm (Fig. 15)
- Growth period: March – September. Shallow water of lakes, ponds and rivers.
- Distribution: Scattered throughout the north Bihar region.

Vegetative propagation

Preparing lotus from rhizomes requires several steps. For best results, start with dormant tubers (before new runners form)

- Cut the tubers into pieces, ensuring each section contains at least one bud. It is from these buds, or eyes, that leaves will emerge.
- Plant the rhizome pieces in wide, round pots that lack drainage holes.
- Avoid square pots because the growing tip of the rhizome is tender and can break off if it grows into a corner.
- Pot size depends on the size of the rhizome pieces; in general, use a pot with a diameter ranging from 20 to 36 cm. Since lotus grows vigorously, no more than one piece should be planted in each pot.
- Use extra care so that the growing tip is not damaged during planting because at this sensitive stage, a damaged tip can result in rhizome death.
- The pot should be filled with a rich, loamy-clay soil and then topped with a thin layer of pea gravel.
- Correctly planted rhizome pieces have about 1.3 cm of the growing tip visible above the pea gravel.
- Place the pots in a warm, sunny location so that the growing tip is submerged 5 to 7.5 cm below the water surface.
- Water temperatures between 10 and 16°C are ideal.
- If all goes well, the first set of leaves will emerge in about three (3) weeks.



Fig. 14. Vegetative stage of lotus (Experimental farm at NRC-M, Darbhanga)



Fig. 15. lotus pods

Natural Resource Management

Project: Performance of Activated Carbon from Makhana (*Euryale ferox* Salisbury) seed coat for Removal of Arsenic in Water

Groundwater survey of Darbhanga district

Groundwater is the primary source of drinking water in both rural and urban areas of Bihar. The presence of arsenic (As) in groundwater has raised significant public health concerns across the district. However, groundwater is crucial for agricultural practices, particularly for irrigating agricultural land during summer, which may raise concerns about bioconcentration and bioaccumulation. Field surveys were carried out in Darbhanga district during April and May 2025 (Fig. 16) to analyse groundwater quality parameters. The results revealed that arsenic concentrations ranged from 5 to 50 $\mu\text{g/L}$. Total dissolved solids (TDS) levels varied between 175 and 1010 mg/L , while electrical conductivity (EC) ranged from 340 to 2000 $\mu\text{S/cm}$. The recorded arsenic levels in drinking water exceeded the permissible limits set by the World Health Organization (WHO).

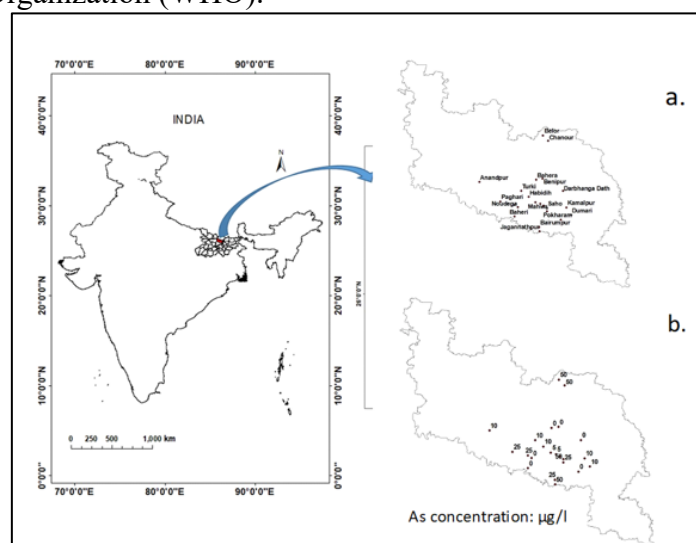
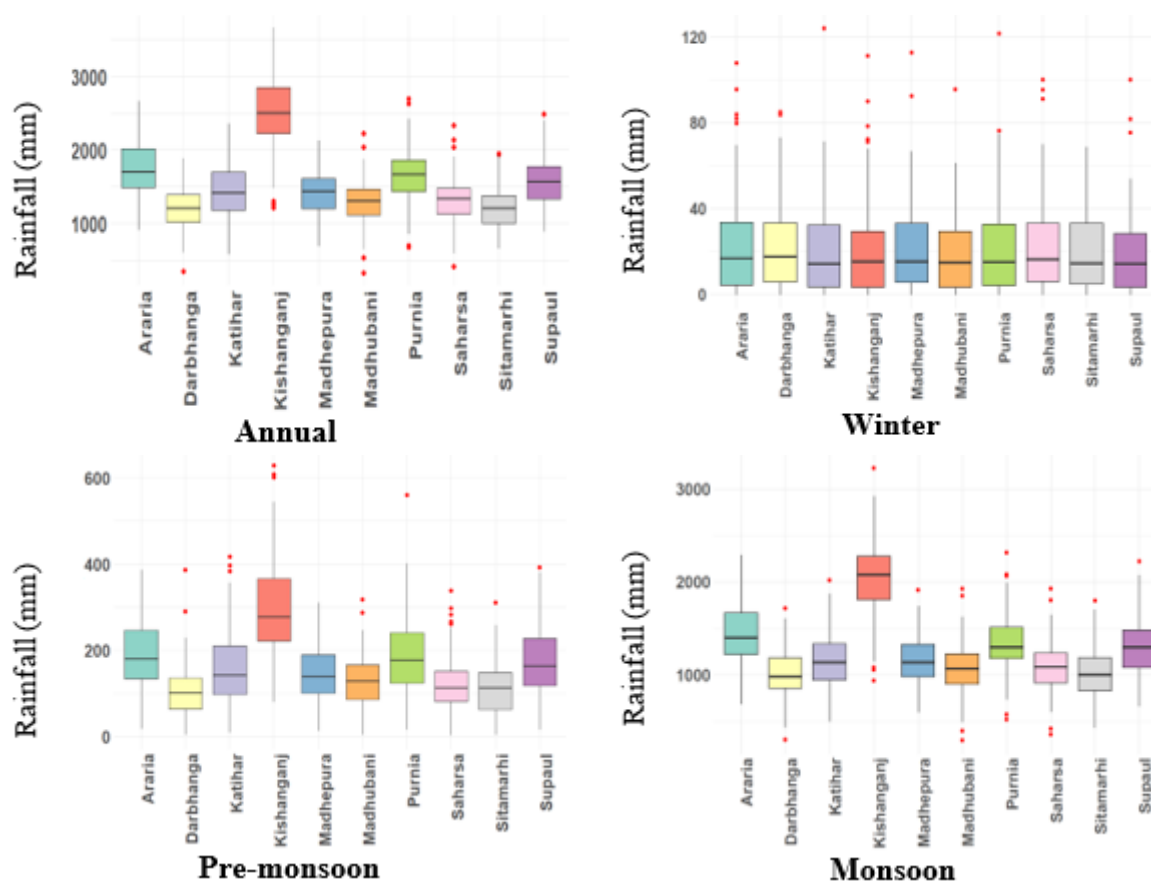


Fig. 16. Conducted a field survey in the Darbhanga district

Project title: Assessment of water productivity of makhana under field conditions

Characteristics of rainfall in the major makhana growing districts

The spatio-temporal variability and long-term trends of rainfall across the major makhana-growing wetland districts of north Bihar were investigated using rainfall data spanning from 1901 to 2022. The statistical parameters of rainfall like mean, standard deviation (SD), coefficient of skewness (CS) and coefficient of kurtosis (CK) for annual and seasonal rainfall over the districts were assessed. Box plots of annual and seasonal rainfall (mm) over year 1901 to 2022 (122 years) for different districts of study area is shown in Fig. 17. Here it was observed that for annual scale the mean rainfall, SD, CS and CK varies from 1204.5 to 2162 mm, 290.1 to 459.4 mm, -0.32 to 0.31, -0.4 to 1.17, respectively. Mean rainfall, SD, CS and CK of winter season varies from 18.44 to 22.81 mm, 17 to 22.15 mm, 0.83 to 1.61, -0.32 to 4.17, respectively. Mean rainfall, SD, CS and CK of pre-monsoon season varies from 104.71 to 295.84 mm, 55.24 to 110.89 mm, 0.32 to 1.24, -0.28 to 4.19, respectively. Monsoon seasonal rainfall mean, SD, CS and CK varies from 1004.49 to 2052.29 mm, 330.59 to 303.15 mm, 0.28 to 0.42, -0.18 to 0.37. Mean rainfall, SD, CS and CK of post-monsoon season varies from 71.38 to 132.69 mm, 69.69 to 111.31 mm, 1.07 to 1.72, 0.41 to 3.14, respectively.



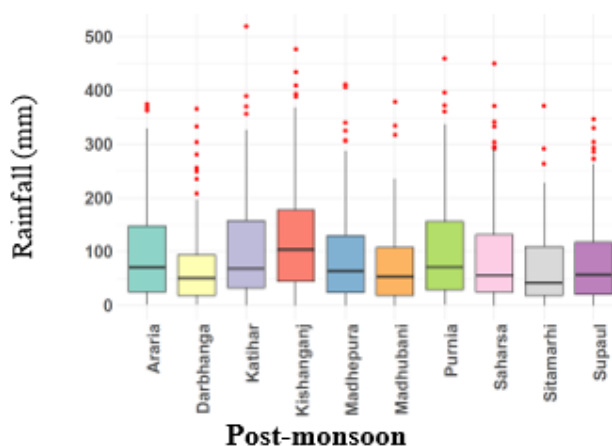


Fig. 17. Box plots of annual and seasonal rainfall (mm) over year 1901 to 2022 (122 years) for different districts of study area

Spatio-temporal variability of land surface temperature (LST) (1995–2024)

The analysis of the mean annual LST across major makhana growing districts from 1995 to 2024 reveals notable spatial and temporal variations (Fig. 18). Landsat satellite imagery was utilized to analyze the LST in the major makhana growing districts. The districts experienced significant fluctuations in mean annual LST, indicating potential influences of climatic variability, land use/land cover changes, and surface waterbody dynamics. The latter part (2018-2024) of the study period shows a distinct warming trend. The years 2022 and 2023 witnessed considerable LST increases across most districts, with Katihar (34.42°C) in 2022 and Darbhanga (35.72°C) in 2023 exhibiting notably higher temperatures. Nevertheless, the overall trend in the past decade indicates a progressive rise in mean annual LST across all districts. The observed LST dynamics align with broader regional climate trends, highlighting the potential implications of rising temperatures for waterbody extent and overall agricultural productivity in the study area. This analysis focuses on correlating these temperature dynamics with waterbody fluctuations and rainfall variability to ascertain the interconnectedness of these climatic parameters.

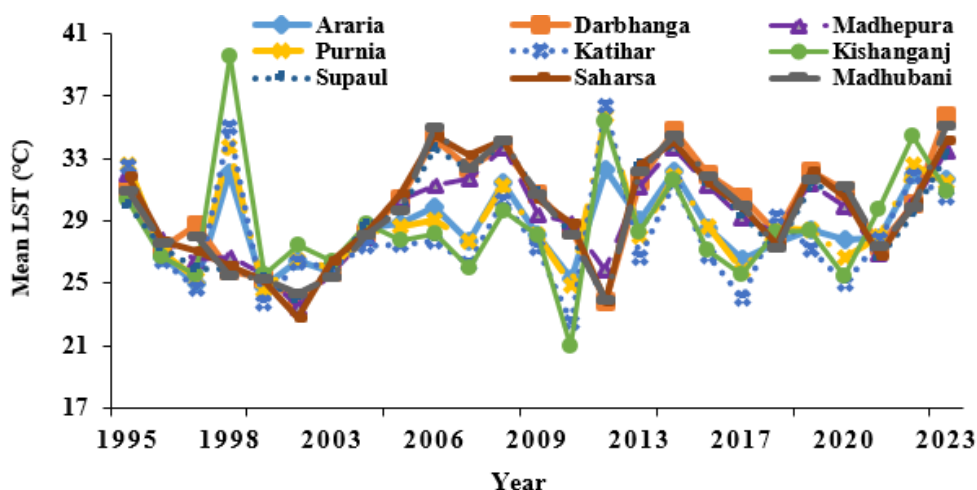


Fig. 18 Variations in the district level mean LST (°C) of the study area

Spatio-temporal dynamics of surface water bodies

Aquatic crop i.e. makhana is predominantly cultivated in the wetland areas of North Bihar, India, particularly in the districts of Darbhanga, Madhubani, Araria, Madhepura, Saharsa,

Supaul, Purnea, Kishanganj, and Katihar. The spatio-temporal dynamics of surface water bodies were assessed in these districts of North Bihar using remote sensing-based water indices for post-monsoon season over the period 1995-2024 (Fig. 19). A comprehensive district-wise assessment of surface water body dynamics from 1995 to 2024 reveals considerable spatial and temporal heterogeneity across the selected districts of the study area (Fig. 20). Katihar consistently recorded the largest surface water areas, with Modified Normalized Difference Water Index (MNDWI)-derived extents peaking at approximately 47,000 ha in 2022, indicative of extensive floodplains and permanent water bodies. Darbhanga, Supaul, and Saharsa displaying significant variability due to their susceptibility to seasonal inundation, particularly during high rainfall and flood years (e.g., 1999, 2009, 2020). Darbhanga, Supaul, and Saharsa showed significant water surface fluctuations, which effectively detected seasonal inundation and recession. Saharsa experienced large episodic increases in water surface (e.g., in 1999, 2000 and 2014) suggesting flood-induced surges. In contrast, districts like Madhepura, Araria, and Kishanganj demonstrated comparatively stable but smaller water surface extents, reflecting either reduced wetland presence or lower flood vulnerability. Purnia and Madhubani exhibited moderate fluctuations, influenced by a combination of topography, river proximity, and land use. The spatial distribution of water bodies, as identified using remote sensing indices, underlines the importance of localized hydrological patterns, floodplain connectivity, and landscape configuration in governing surface water availability in the region.

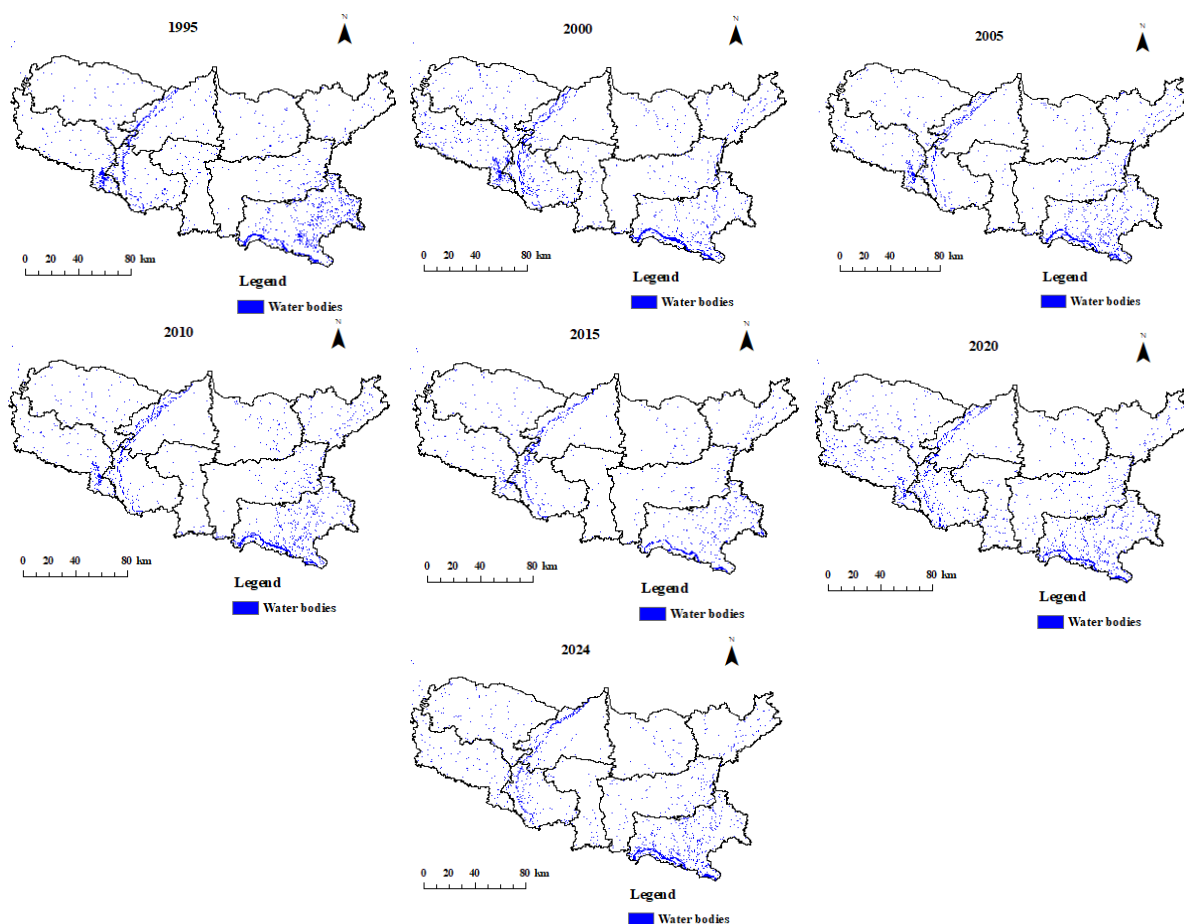


Fig. 19 Spatio-temporal variability of surface water body area using MNDWI over the study period (1995-2024)

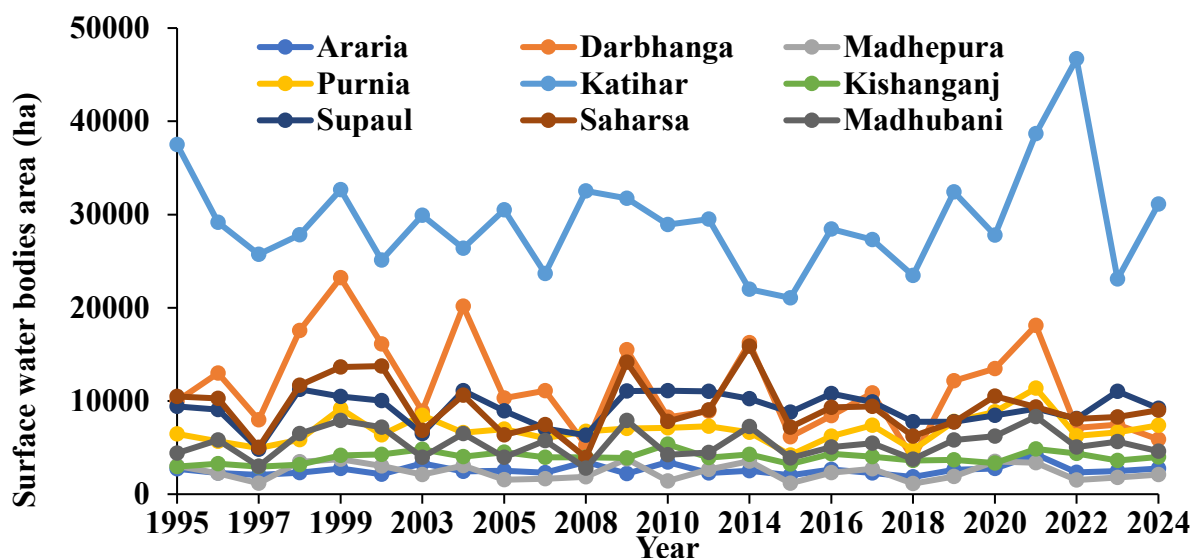


Fig. 20. Variation of surface water bodies in major makhana growing districts in the study area over the period 1995 to 2024.

Correlation between water body dynamics, annual rainfall and LST

The correlation analysis between annual rainfall and waterbody dynamics reveals significant spatial variability across the districts (Table 5). The Pearson correlation coefficients indicate that annual rainfall is positively associated with waterbody extent in certain districts, particularly in Madhubani and Madhepura. These findings suggest that in these districts, increased annual rainfall may contribute to larger waterbody areas, potentially due to higher water retention capacity in floodplain and wetland areas. The factors beyond rainfall, such as land use/land cover changes, urbanization, and agricultural intensification, may also play critical roles in reducing waterbody areas. In districts like Darbhanga, where significant negative trends are observed for multiple indices, land conversion for agriculture and infrastructure development could be contributing to waterbody shrinkage despite periodic rainfall. The consistent rise in LST across all districts further exacerbates water loss through increased evaporation, intensifying the decline in waterbody areas in regions experiencing both declining rainfall and rising temperatures. Thus, the observed spatial variability underscores the complex interplay between hydrological, climatic, and anthropogenic factors, necessitating comprehensive water management strategies that consider both climatic variability and land use dynamics to sustain aquatic agro-ecosystems, particularly in makhana-growing regions. The correlation analysis between annual rainfall and waterbody areas reveals spatial variability across the study districts. The positive and significant correlations are observed in Darbhanga ($r = 0.44$), Madhepura ($r = 0.58$), and Madhubani ($r = 0.66$), suggesting that higher rainfall is associated with increased waterbody areas in these districts.

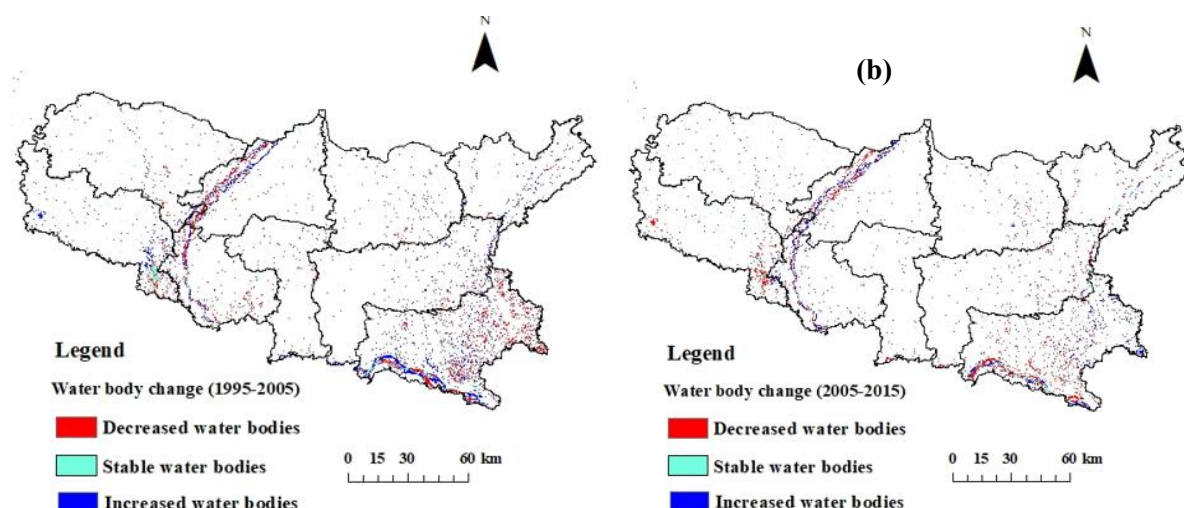
Table 5: Pearson correlation coefficient (r) value between surface water body areas to that of annual rainfall and LST

Year	Araria	Darbhangha	Madhepura	Purnia	Katihar	Kishanganj	Supaul	Saharsa	Madhubani
Annual rainfall (mm)									
Surface water body areas	0.09	0.44*	0.58 *	0.27	0.06	0.04	-0.05	0.33	0.66*
LST									

Surface water body areas	-0.06	-0.43*	-0.18	-0.28	0.19	-0.31	0.037	-0.22	-0.18
--------------------------	-------	--------	-------	-------	------	-------	-------	-------	-------

* Statistically significant at 5 % level of significance

The correlation between LST and waterbody areas across the study districts is summarized in Table 6. The statistically significant negative correlations indicate that as waterbody extent decreases, LST increases. The most pronounced negative correlation was observed in different districts, indicating that the reduction in waterbody extent is associated with an increase in surface temperature. The overall analysis underscores that rainfall variability plays a crucial role in influencing waterbody extent, particularly in districts with significant agricultural and aquatic ecosystems. This highlights the importance of integrating rainfall projections in water resource management strategies to mitigate the impacts of climatic variability. Annual rainfall is decreasing in key districts, and LST is consistently rising across all districts, suggesting increasing temperatures. These changes indicate potential climate-related risks, such as water scarcity and altered water dynamics, which can affect aquatic crop systems like makhana. Thus, effective water management strategies, tailored to the specific conditions of floodplain and wetland areas, are crucial to address these challenges and support sustainable agricultural practices. The decline in surface waterbody extent indicated by different indices, coupled with increasing LST, suggests potential adverse effects on aquatic ecosystems. Aquatic crops like makhana, which are highly dependent on stable water levels, are likely to experience stress due to fluctuating surface water extent and rising temperatures. The temporal analysis of surface waterbody extent during post-monsoon season reveals pronounced spatial and temporal variability across the study districts over the three decades (1995–2024) as presented in Table 6 and depicted in Fig. 21. Over the entire study period (1995–2024), long-term reductions are evident in Darbhanga (-41.3%) followed by Madhepura (-30.3%), Katihar (-17.0 %) Saharsa (-14.2%) and Supaul (-2.2%). These results indicate that while some districts showed short-term recovery in waterbody areas after 2015, the overall multi-decadal trends point to progressive shrinkage in traditionally water-abundant districts such as Darbhanga, Saharsa, Madhepura and Katihar, underscoring the combined influence of climatic variability and anthropogenic land-use pressures.



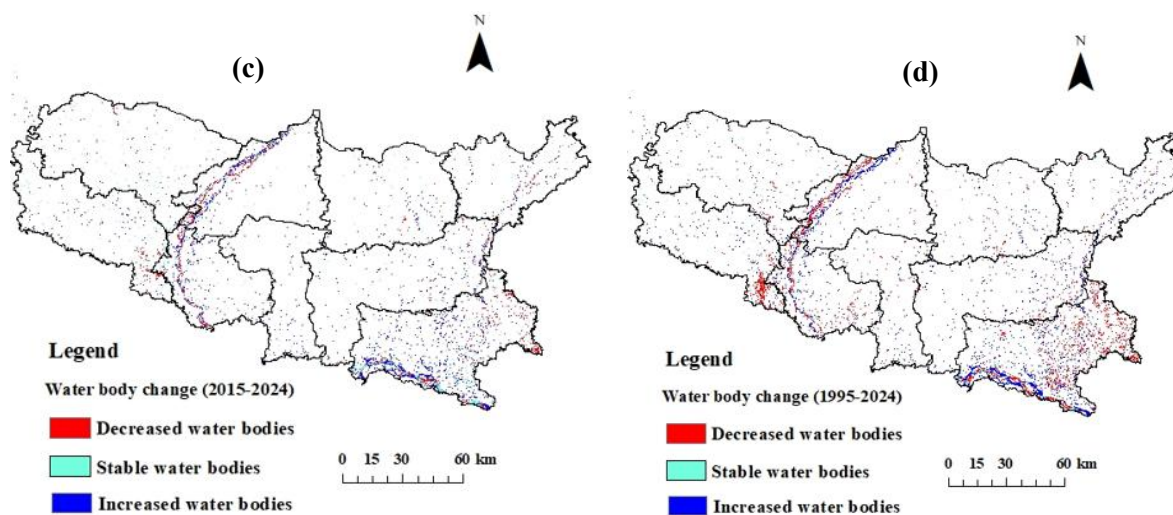


Fig. 21. Water body change maps: (a) 1995-2005; (b) 2005-2015; (c) 2015-2024; (d) 1995-2024 over the study area

Table 6. Per cent change of body area in different districts of the study area over the study period

Year	Araria	Darbhangha	Madhepura	Purnia	Katihar	Kishanganj	Supaul	Saharsa	Madhubani
2024-1995	1.3	-41.3	-30.3	13.9	-17.0	35.6	-2.2	-14.2	4.6

The overall decline in surface waterbodies (-15.7%) in the entire study area from 1995 to 2024 is not solely linked to rising temperatures but strongly influenced by land use/land cover changes. Built-up land expanded rapidly while dense vegetation declined sharply, reflecting urban encroachment, agricultural intensification, and groundwater abstraction. These transformations disrupted recharge zones and altered runoff, reducing wetland resilience.

Project title: Mapping of Makhana, Water chestnut crop, storage protocol, establishment of makhana processing and value-addition plant, and by-product utilization

Crop area estimation using remote sensing data

The Sentinel-2 remote sensing satellite datasets derived primarily from Sentinel-2 Multispectral Instrument (MSI) imagery was used for makhana crop area estimation. For optical analysis, cloud-free Sentinel-2 Surface Reflectance (S2 SR Harmonized) data were collected for the major makhana-growing districts of North Bihar of India during the main growth period of the crop for year 2024 and 2025. Based on the remote sensing analysis for 2024, the estimated district-wise makhana crop area in North Bihar is shown in Fig. 22. Katihar recorded the largest cultivated area with 6,829 ha, followed by Purnia with 5,797 ha and Darbhanga with 3,782 ha. Other significant areas include Madhubani (3,588 ha), Saharsa (2,965 ha), and Supaul (2,671 ha). The cultivated area in Araria was 1,802 ha, while Kishanganj and Madhepura recorded 1,584 ha and 1,478 ha, respectively. Samastipur reported the smallest extent with 828 ha. The total makhana crop area across all districts in year 2024 was estimated at 31,325 ha. The unsupervised K-means classification for the year 2025 provided a clear spatial quantification of makhana cultivation across the major producing districts of North Bihar. The results indicate substantial variability in areal distribution, reflecting the heterogeneous landscape and waterbody availability across districts. Among all districts,

Katihar recorded the highest mapped makhana area with 9642.28 ha, followed by Supaul (5988.27 ha) and Purnia (5528.98 ha), which continue to serve as major production zones due to water availability and favourable hydrological conditions. Saharsa also exhibited a considerable mapped area of 5161.43 ha, while Araria and Madhubani accounted for 3179.51 ha and 3064.33 ha, respectively. Moderate levels of makhana cultivation were identified in Madhepura (1628.28 ha) and Darbhanga (2038.02 ha). In contrast, relatively smaller extents were observed in Kishanganj (886.31 ha) and Samastipur (761.32 ha). Overall, the 2025 K-means derived estimates highlight strong spatial concentration of makhana cultivation in the eastern and north-eastern districts, consistent with regional hydrological patterns.

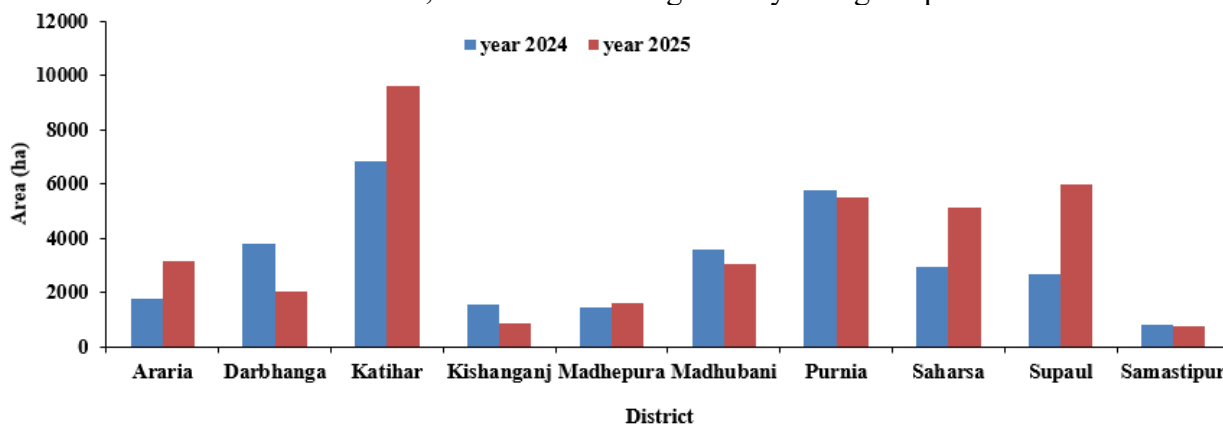


Fig. 22. Comparison of makhana crop area in year 2024 and 2025 as per unsupervised (K-means) classification

Spectral reflectance curve of the makhana

The temporal spectral reflectance behaviour of makhana was analysed using Sentinel-2 multispectral data for its major phenological stages from April to August (Fig. 23). The spectral signatures clearly outline the crop's seasonal progression, beginning from the early establishment stage in April, followed by vigorous vegetative expansion in May, and transitioning into the reproductive and physiological maturity stages during June and July, before entering the post-maturity/harvesting phase in August. During April, makhana exhibited relatively low reflectance in the red-edge (B5–B7; 705–783 nm) and NIR bands (B8: 842 nm; B8A: 865 nm), corresponding to sparse leaf cover and incomplete canopy development. Reflectance increased sharply in May as rapid vegetative growth, expansion of floating leaves, and enhanced chlorophyll content strengthened the crop's photosynthetic capacity.

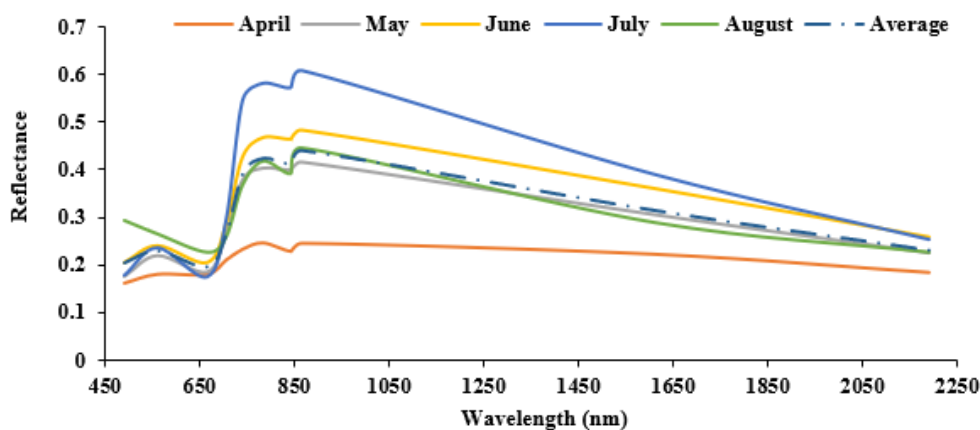


Fig. 23. Spectral reflectance curves of makhana crop during different months

A pronounced peak in the NIR region occurred during June and July, marking the period of maximum biomass, dense canopy closure, and high physiological activity. This strong NIR response is typical of healthy aquatic vegetation with well-developed mesophyll structure and high-water support, making it a reliable indicator of makhana's biomass accumulation and canopy vigour. The red-edge bands also showed progressive enhancement from April to July, reflecting increasing chlorophyll concentration and leaf structural complexity. In contrast, visible bands (B2–B4; 490–665 nm) remained consistently low across months due to strong pigment absorption by chlorophyll and carotenoids. By August, a slight decline in NIR and red-edge reflectance was observed, coinciding with the onset of senescence, reduction in leaf vitality, and partial canopy degradation during the harvesting stage. However, reflectance remained higher than the early season (April–May), indicating that a substantial portion of the mature canopy was still present. The SWIR bands (B11, B12) exhibited moderate seasonal variation, influenced by changes in leaf water content and moisture conditions within the aquatic environment. Overall, the seasonal spectral reflectance curves of makhana depict a coherent and physiologically consistent trajectory from early growth to maturity and into the harvesting stage. The strong seasonal response observed in the NIR and red-edge regions underscores their value for monitoring biomass dynamics, assessing phenology, and differentiating makhana from surrounding land covers in aquatic cultivation systems.



AWARDS AND RECOGNITIONS

Name of the awardee	Name of award	Awarded from
राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा	कृषि प्रदर्शनी में राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा को तृतीय पुरस्कार	डॉ. राजेंद्र प्रसाद केंद्रीय कृषि विश्वविद्यालय पूसा, समस्तीपुर
S.M. Raut, B.R. Jana, Manoj Kumar, S.B. Tarate, I.S. Singh and Pragati	Best Oral Presentation Award in a Global Conference on "Innovations to Impact: Gender Transformative Approaches for Sustainable Agri-Food Systems" for paper presentation on "Socio-economic empowerment of women through aquatic crops based integrated aquaculture technologies in North Bihar" during 8-10 March 2025	ICAR - Central Institute for Women in Agriculture, Bhubaneswar, India.
Dr Nachiket Kotwaliwale & Er. Rahul Kumar Rout	ISAE Team Award 2025: Reformation of makhana through Mechanization of Harvesting, Processing, and Value- addition	Indian Society of Agricultural Engineers



ISAE Team Award at ICAR-CIAE, Bhopal, during ISAE Conference 2025



LINKAGES AND COLLABORATIONS

Sr. No.	Universities/ Institutions	Purpose	Venue & Date
1	Memorandum of Understanding (MoU) exchanged between the Director, ICAR-NRC-M, Darbhanga, and the Vice Chancellor, SKUAST, Kashmir.	Collaborative research, makhana and water chestnut promotion.	ICAR-NRC-M, Darbhanga 7 th Oct 2025
2	MoU exchanged between the Director, ICAR-NRC-M, Darbhanga, and the Regional Manager, ITC Ltd.	Training and capacity building of stakeholders.	ICAR-NRC-M, Darbhanga 7 th Oct 2025
3	MoU exchanged between the ICAR-NRC-M and the Choibari Tea & Industries Ltd	Promotion of makhana cultivation in tea gardens of Assam.	Choibari Tea Estate, Assam 7 th March, 2025



HUMAN RESOURCE DEVELOPMENT AND CAPACITY BUILDING PROGRAM

Training and Capacity Building

Sr. No.	Staff name	Title of the programme	Venue	Duration	Dates
1.	Dr. Vinod Kumar Padala	Morphological and molecular identification, including mass production of natural enemies associated with economically important insect pests (including invasives) of the Indian agroecosystem	ICAR-NBAIR, Bengaluru.	21 days	16.01.2025 to 05.02.2025
2.	Dr. Suryakant Bajirao Tarate	Geo-spatial Technologies for Agriculture	ICAR-NAARM, Hyderabad	5 days	17.02.2025 to 21.02.2025

Seminar and Symposia

Participation in Conferences/Seminars/ Symposia/Workshops/ Meetings

Name of the official	Title of the programme	Name of conference/ seminar/ symposia/ workshop/ meetings	Organised by	Date
Dr. Vinod K. Padala	Biocontrol Contributions to One Health	International Conference	Society for Biocontrol Advancement & ICAR– National Bureau of Agricultural Insect Resources	25.02. 2025 to 28.02 2025
Sh. Shailendra Mohan Raut	Innovations to Impact: Gender Transformative Approaches for Sustainable Agri-Food Systems	Global Conference	ICAR - Central Institute for Women in Agriculture, Bhubaneswar, India.	08.03. 2025 to 10.03.2025

Dr. Manoj Kumar, Sh. Shailendra Mohan Raut, Dr. Vinod K. Padala, Dr. S. B. Tarate	Makhana: Unlocking India's Aquatic Superfood for Rural Prosperity	National symposium	Bihar Agricultural Science Academy (BASA), Agricultural Economics Research Association (AERA), International Food Policy Research Institute (IFPRI), and Dr. Rajendra Prasad Central Agricultural University (RPCAU), at Patna.	20.05.2025
Dr. Suryakant Bajirao Tarate & Er. Rahul Kumar Rout	Engineering Innovations for Agriculture 5.0 and Mechatronics and Robotics in Pre- and Post-Production Agriculture	Convention and International Symposium	ICAR-CIAE, Bhopal, Madhya Pradesh	10.11.2025 to 12.11.2025
Er. Rahul Kumar Rout	Innovation in Nutrition, Dietetics, Upcycling and Local foods on Gastronomic Engineering (INDULGE)	Indian Convention	NIFTEM, Thanjavur	18.12.2025 to 20.12.2025



Oral presentation at ICAR-CIAE, Bhopal, during the ISAE Conference, November 10-12, 2025



Oral presentation in the 31st Indian Convention of Food Scientists & Technologists (ICFoST) on “Innovation in Nutrition, Dietetics, Upcycling and Local foods on Gastronomic Engineering (INDULGE)” from December 18-20, 2025, at NIFTEM (Thanjavur)



Participation in the National Symposium on Makhana: Unlocking India's Aquatic Superfood for Rural Prosperity at Patna (20.05.2025)

Training and Exposure Visit

The following trainings and exposure visits are conducted under various funding agencies for the makhana stakeholders.

Scheduled Castes Sub Plan (SCSP)

Sr. no.	Training title	Venue	Number of participants	Duration
1	Hands-on training on the primary roasting of makhana	Saharasa	20	15.03.2025 to 19.03.2025
2	Aquaculture training cum farm demonstration & input distribution	Darbhanga	50	31.07.2025

Makhana Vikas Yojna (MVY)

Sr. no.	Training title	District	Number of participants	Date
1	One-day training on improved makhana production practices and exposure visit for makhana farmers	Saharasa	50	18.12.2025

ITC Limited

Sr. no.	Training title	Number of participants	Duration
1	मखाना खेती के लिए नर्सरी की तैयारी	110	25.11. 2025- 26.11. 2025

Bihar Agricultural Management Extension Training Institute (BAMETI)

Sr. no.	Training title	Number of participants	Duration
1	Preparation of value-added products from makhana and water chestnut	40	08.01.2025
2	Method of makhana-based cropping system under field condition	40	12.09.2025
3	Insect and disease management techniques in makhana and water chestnut	40	16.09.2025
4	Water chestnut cultivation in ponds and shallow rice fields/ lowland	40	22.09.2025
5	Preparation and ways of trading of value-added products from makhana, water chestnut and lotus	40	24.09.2025
6	Integrated nutrient management under pond & field system of makhana cultivation (Exposure Visit)	40	26.09.2025
7	Nursery preparation techniques for makhana cultivation	40	14.10.2025

Post-Harvest Training*At NRC-M, Darbhanga:*

Sr. no.	Training title	Number of participants	Date
1	Makhana processing and value addition	20	13. 02. 2025
2	Safe storage and packing of makhana pop/lawa	60	18.02.2025
3	Hands-on training on primary roasting of makhana	20	15.03.2025 to 19.03.2025
4	Operators' training on makhana Processing	16	28.07.2025 to 03.08.2025
5	Operator's Training on makhana Processing	10	01.09.25 to 06.09.25

Outstation:

Sr. no.	Training title	Venue	Number of participants	Duration
1	Makhana Processing and Value Addition for Makhana Processing Workers (Fodia)	Jhanjharpur, Bihar	20	08.10.2025 to 10.10.2025
2	Makhana Processing and Products Development	Harishchandrapur Makhana Processing Cluster, Malda, West Bengal	30	20.07.2025 to 26.07.2025

Training for other state stakeholders

Sr. no.	Training title	District	Number of participants	Date
1	Makhana Production, Processing & Marketing	Narmadapuram, (Madhya Pradesh)	20	25.08.2025
2	Advanced Makhana Production Technology	ATMA, Wardha (Maharashtra)	20	24.09.2025 to 26.09.2025



Organized one-day training program on “Insect Pest and Disease Management Techniques in Makhana and Singhara Cultivation’ on 16.09.2025 (BAMETI)



Training program on “Preparation of value-added products from Makhana and water chestnut” on 08.01.2025 (BAMETI)



Training organized on “Makhana Processing and Value Addition for Makhana Processing Workers (Fodia)” during 8th to 10th October 2025 at Jhanjharpur, Bihar



One-day training program on “Preparation and Ways of Trading of Value-added Products from Makhana, Water Chestnut and Lotus” on 24.09.2025 (BAMETI)



Operators' training on "Makhana Processing" on 01st to 06th September 2025



Advanced training program on "Makhana Processing and Products Development", organized at Harishchandrapur Makhana Processing Cluster, Malda, West Bengal (20th -26th July 2025)



Five-day SCSP training program on "Hands-on training on primary roasting of Makhana" (15th -19th March 2025) at Saharasa



Five-day SCSP training program on "Aquaculture training cum farm demonstration & input distribution " (31st July 2025) at Saharasa

Technology Demonstrations

Sr. no.	Technologies	Venue	Date	Occasion
1	Makhana Production Technology	Choibari Tea Estate, Assam	4 th - 7 th March, 2025	A visit under MoU signed between the ICAR-NRCM and the Choibari Tea and Ind. Ltd.
2	Makhana Production Technology	J.P. Infratech Ltd., Noida, U.P.	2 nd – 4 th July, 2025	Visited the Office of Project Officer, J.P. Infratech Ltd., Noida and their ponds situated along the Noida-Agra expressway to explore the possibility of makhana cultivation.
3	Makhana Production Technology	ICAR-CIPHET, Research Centre, Abohar (Punjab)	31 st December, 2024 - 02 nd January 2025	A demonstration of makhana seed broadcast was conducted in the ponds at the Research Centre's (CIPHET) experimental farm in Abohar.
4	Makhana Production Technology	Sant Longowal Institute of Technology, Longowal (Punjab)	3 rd - 4 th January 2025	Broadcast of makhana seed in the pond condition to determine the suitability of the soil and water for makhana cultivation at the SLITE campus, Longowal
5	Makhana Production Technology	KVK, Bandipora, SKUAT, Kashmir	13 th -16 th December, 2025	The seeds of makhana and water chestnut were introduced in the existing ponds of KVK Bandipora.



Visit and demonstrations of makhana production technology at Choibari Tea & Industries Limited, Choibari Tea Estate, Assam



Visit at JP Infratech Ltd., Noida



Visit at Research Farm of the CIPHET - Research Centre, Abohar, Punjab



Demonstration of makhana seed in the pond at SLIET, Longowal, Punjab



Visit to KVK Bandipora, SKUAT, Kashmir



STAKEHOLDER/ OFFICER/ FARMER/ EXPOSURE VISITS

Sr. no.	Visitor(s)	Number of visitors	Date
1	Exposure visits for women farmers of Madhubani on “Makhana processing & Value Addition”, coordinated by Sakhi & Funded by SIDBI.	25	13.01.2025
2	SMS of KVKs and ATARI (PATNA) Scientists	20	25.05.2025
3	Block Horticulture Officers (Darbhanga)	06	07.07.2025
4	Dr. Ch. Srinivasa Rao, Hon’ble Director of ICAR–IARI, New Delhi	01	07.08.2025
5	BSc Ag. Students from Sandip University, Madhubani	200	09.09.2025
6	Exposure visit of Teachers from various schools of Bihar & Jharkhand to NRC-M, Darbhanga. एनसीईआरटी की एक प्रमुख इकाई "पंडित सुंदरलाल शर्मा केंद्रीय व्यावसायिक शिक्षा संस्थान, भोपाल" द्वारा आयोजित	50	04.12.2025
7	Exposure visit of makhana farmers from Sitamarhi (selected under Makhana Development Scheme) to NRC-M, Darbhanga.	40	29.11.2025
8	Agro-industrial visit of UG Students from College of Horticulture (Motihari) RPCAU under RAWE (7 th Semester).	60	18.12.2025
9	Exposure visit of makhana growers from the Saharsa district to the NRC-M, Darbhanga	50	19.12.2025



Dr. Ch. Srinivasa Rao, Hon'ble Director of ICAR-IARI, New Delhi, visited NRC-M Darbhanga (07/08/2025)



A team of faculty members and students from Sandip University, Madhubani, visited the ICAR-NRC-M, Darbhanga (09.09.2025).



VIKSIT KRISHI SANKALP ABHIYAN (VKSA–2025)

Under the *Viksit Krishi Sankalp Abhiyan (VKSA–2025)*, outreach programmes were conducted from 29.05.2025 to 12.06.2025 by ICAR–NRC-M, Darbhanga, in the Madhubani and Sitamarhi districts of Bihar. The programmes were implemented by teams comprising Dr. V. K. Padala, Dr. S. B. Tarate, Er. R. K. Rout, and Shri Ashok Kumar in Madhubani district, and Dr. M. Kumar, Dr. B. R. Jana, and Shri S. M. Raut in Sitamarhi district. The campaign covered villages across each district, raising overall awareness among more than 2,500 farmers. During the programme, farmers were sensitized about various government schemes, particularly those related to makhana and other mandate crops of the centre, scientific cultivation practices, post-harvest processing and value addition of makhana, use of machinery for efficient processing, availability of institutional facilities for accessing machines and technologies, and important aspects of organic farming, soil health management, and water conservation and management.





Viksit Krishi Sankalp Abhiyan (VKSA–2025), outreach programmes were conducted by ICAR–National Research Centre for Makhana, Darbhanga, in the Madhubani and Sitamarhi districts of Bihar.



EVENT ORGANIZED

Visit of the Hon'ble Union Minister of Agriculture & Farmers Welfare and Deputy Chief Minister of Bihar to ICAR–NRC- M, Darbhanga

The Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India, Shri Shivraj Singh Chauhan, along with the Hon'ble Deputy Chief Minister of Bihar, Shri Samrat Chaudhary, visited ICAR–National Research Centre for Makhana (NRC-M), Darbhanga, on 23rd February 2025. During the visit, the Hon'ble Minister transplanted makhana seedlings in the experimental plots, planted fruit saplings, and interacted extensively with makhana farmers under the “*KISAN SAMWAD*” programme. The Hon'ble Minister, accompanied by the Deputy Chief Minister, Hon'ble Member of Parliament Dr. Gopal Thakur from Darbhanga, Dr. K. Narsaiah, Hon'ble Assistant Director General (Process Engineering), ICAR, New Delhi, other State Ministers, and MLAs, also visited the exhibition stalls and makhana processing units of the Centre. A press conference was held in the conference hall, wherein the Hon'ble Minister stated that the proposed makhana board would be constituted after obtaining inputs from makhana farmers and emphasized the need to develop a thornless variety of makhana to facilitate ease of cultivation. The event witnessed the participation of over 1,200 farmers and makhana entrepreneurs from various districts of north Bihar.



Makhana plantation by the Hon'ble Union Minister Shri Shivraj Singh Chauhan, along with the Hon'ble Deputy Chief Minister of Bihar, Shri Samrat Chaudhary.

Krishi Chaupal

A *Krishi Chaupal* programme was recorded by DD Kisan on 4th April 2025 and broadcast on 12th April 2025. The programme was attended by over 125 makhana farmers and entrepreneurs, along with more than a dozen experts in makhana cultivation, processing, value addition, marketing, and mechanization. In the *Kisan Chaupal* Programme, the different expert panel of the NRC-M were participated and discussed on various practice packages such as cultivation on makhana, variety, water and soil management, integrated nutrient management practices, opportunities in the integrated farming system, crop rotation, mechanisation, processing, value addition, marketing, formation of farmer producer organisation (FPO) and export potential, etc.



Interaction of the NRC-M team with stakeholders during the *DD Chaupal* program



Glimpses of *DD Chaupal* Programme

Rashtriya Makhana Mahotsav

The ICAR–NRC-M, Darbhanga, Bihar, organized the *Rashtriya Makhana Mahotsav* on 7th October 2025 in collaboration with the ICAR–CIPHET, Ludhiana, Punjab, and ITC Limited. The event was organized with the objective of promoting makhana as a nationally important crop and showcasing recent advancements in its production, processing, value addition, and marketing. The *Mahotsav* witnessed enthusiastic participation of more than 5,000 farmers, along with scientists, entrepreneurs, processors, industry representatives, and other stakeholders associated with the makhana sector. The programme highlighted the significance of makhana as a nutritionally rich, high-value aquatic crop with immense potential for income generation, employment creation, and export promotion. Scientists from ICAR–NRC-M and

ICAR–CIPHET shared technical insights on improved makhana production technologies, mechanization, post-harvest management, and processing innovations aimed at reducing drudgery and enhancing efficiency. Special emphasis was laid on value addition, quality improvement, packaging, and standardization to meet both domestic and international market requirements. The participation of ITC Limited added a strong industry perspective to the event, with discussions focusing on market demand, quality specifications, supply chain development, branding, and opportunities for linking farmers and processors with organized markets. Interactive sessions provided a platform for farmers and entrepreneurs to engage directly with scientists and industry experts, helping bridge the gap between research, production, and marketing.

On the occasion of the *Mahotsav*, two Memoranda of Understanding (MoUs) were signed on 7th October 2025 between ICAR–NRC-M and the Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), and with ITC Ltd. to strengthen collaboration in research, education, and extension to boost aquatic crop production. Also, it promotes joint research programmes, technology exchange, capacity building, and the dissemination of improved technologies for makhana and other aquatic crops. Exhibitions and live demonstrations of makhana-based value-added products and processing technologies attracted widespread attention and raised awareness of the diverse uses and commercial potential of makhana. The *Mahotsav* also emphasized entrepreneurship development, start-up opportunities, and capacity building of farmers, youth, and self-help groups. Overall, the *Rashtriya Makhana Mahotsav* served as an important platform for strengthening collaboration among research institutions, industry, and stakeholders, and reaffirmed the commitment of ICAR–NRC-M towards the holistic development of the makhana sector and the improvement of farmers' livelihoods.



MoU exchanged between the Director, ICAR-NRC-M, Darbhanga, Dr. Nachiket Kotwaliwale and the Vice Chancellor, SKUAST, Kashmir Prof. N.A Ganai (7th October 2025).

Inauguration of renovated facilities

Inauguration of the renovated office building of ICAR-NRC-M, Darbhanga and the *Makhana Processing cum Quality Testing Laboratory* at the institute by the Dr. S.N. Jha, Deputy Director General, Agril. Engineering, ICAR New Delhi, in presence of the Dr. Nachiket Kotwaliwale, Director, and Dr. I.S. Singh, Centre in-charge, on June 03, 2025.



Inauguration of the renovated office building and *Makhana Processing cum Quality Testing Laboratory* of ICAR-NRC-M, Darbhanga.

1st FAD20/WG10 meeting

The first FAD20/WG10 meeting on “Development of Indian Standards on Makhana Processing Machinery” was held on 23rd June 2025 at ICAR – NRC-M, Darbhanga, Bihar. It brought together scientists, engineers, experts, BIS representatives, and stakeholders to discuss standard guidelines for makhana processing. Key topics included design, efficiency, safety, quality, and suitability for small/medium units. Experts highlighted that Indian Standards would improve processing, product quality, worker safety, and support mechanization and commercialization. The standardization aims to help manufacturers adopt reliable, cost-effective technologies. This milestone will strengthen the makhana value chain, fostering

innovation, entrepreneurship, and sustainable growth, benefiting farmers and processors in makhana-growing regions.



1st meeting of FAD20/WG10 held at NRC-M Darbhanga (23.05.2025)

Live telecast of PM Kisan Samman Nidhi

The Hon'ble Prime Minister Shri Narendra Modi released the 20th instalment of the *PM Kisan Samman Nidhi* scheme, under which an amount of Rs. 20,500 crore was directly transferred to the bank accounts of over 9.7 crore farmers, empowering farmers and strengthening rural India. The live telecast of the *PM Kisan Samman Nidhi Prakashan* event was organized at ICAR–NRC–M, Darbhanga, Bihar, on 2nd August 2025. All scientists, technical staff, and other staff members of the Centre were present during the programme.

Interaction with C-DAC Patna

A team of scientists from C-DAC Patna, the premier R & D organisation under the Ministry of Electronics and Information Technology (MeitY), Government of India, visited ICAR–NRC–M, Darbhanga on 8th August 2025. During the interaction, the team held insightful discussions with Dr. Manoj Kumar, Sr. Scientist, on an innovative concept for real-time monitoring of makhana farm conditions and the instant delivery of customised advisories to growers. This initiative represents a significant step towards smart, data-driven, and precision farming in makhana cultivation. ICAR–NRC–M expresses its sincere gratitude to the C-DAC Patna team for their visit and valuable deliberations.



Interaction of scientists from C-DAC, Patna, and Dr. Manoj Kumar Sr. Scientist, NRC-M, Darbhanga

Live Broadcast of the Announcement on the Establishment of the National Makhana Board in Bihar

On 15th September 2025, the live broadcast of the announcement made by the Hon'ble Prime Minister of India regarding the establishment of the National Makhana Board in Bihar was organised at the auditorium of the ICAR–NRC–M, Darbhanga. The programme was witnessed with great enthusiasm by the Hon'ble Member of Parliament, Dr. Gopal Thakur (Darbhanga), along with makhana farmers and entrepreneurs from the region.



Felicitating Dr. Gopal Thakur, MP (Darbhanga) by Dr. I. S. Singh, Head I/c, NRC-M, Darbhanga

Live Telecast of the 21st Instalment of Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) Scheme

On 19th November 2025, the Hon'ble Prime Minister of India transferred the 21st instalment of the *Pradhan Mantri Kisan Samman Nidhi* (PM-KISAN) scheme, amounting to approximately Rs. 18,000 crores, directly into the bank accounts of nearly 9 crore farmers across the country. To mark this occasion, the programme was live telecast through video conferencing at the ICAR–NRC–M, Darbhanga. The programme was chaired by the I/C Head, Dr. I. S. Singh. The speakers elaborated on the objectives, benefits, eligibility criteria, and the scheme's significance in providing financial assistance and income security to farmers. The programme helped raise participants' awareness of the PM-KISAN scheme and reinforced its crucial role in strengthening farmers' socio-economic conditions.



Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme live telecast programme at NRC-M Darbhanga

Agriculture Outreach Program

An agriculture outreach program was organized by the ICAR–NRC-M, Darbhanga, Bihar, in collaboration with Canara Bank on 24th November 2025. The programme aimed to create awareness among makhana farmers, entrepreneurs, and other stakeholders about various banking schemes and financial benefits available for strengthening makhana-based livelihoods. During the programme, officials from Canara Bank elaborated on different financial schemes, credit facilities, and support services relevant to the agriculture and allied sectors. Special emphasis was placed on crop loans, *Kisan Credit Card* (KCC), agri-infrastructure financing, term loans for processing and value-addition units, start-up and entrepreneurship support, and government-linked subsidy schemes beneficial to makhana growers and processors.

Celebration of National and Other Significant Days



The 76th Republic Day was celebrated at NRC-M, Darbhanga, on 26th January 2025



Celebrated the International Day of Yoga on June 21st, 2025, at NRC-M with enthusiastic participation from all scientists and staff.



The 79th Independence Day was celebrated at NRC-M, Darbhanga, on 15th August 2025.



National Unity Day celebrated at NRC-M Darbhanga (31.10.2025)



A collective singing programme of the National Song “*Vande Mataram*” was organised at the NRC-M, Darbhanga, to honour the completion of 150 years of the National Song (10.11.2025).



The Constitution Day celebration with Pledge on 26th November 2025 at the NRC-M, Darbhanga, Bihar.



World Soil Day 2025 was celebrated at the NRC-M, Darbhanga, on 5th December 2025.



National Farmers' Day was celebrated on 23rd December 2025 at the NRC-M, Darbhanga, with the active participation of farmers from Madhya Pradesh and Bihar.

Swachhata Pakhwada

Swachhata Pakhwada 2025 was organised at ICAR–NRC-M, Darbhanga, during 16th – 31st December 2025 in a comprehensive and impactful manner, aligning with the objectives of the *Swachh Bharat Mission*. The campaign commenced with a *Swachhata* Pledge administered by Dr. I. S. Singh, I/c Head of the Centre, followed by a series of awareness programmes focusing on waste segregation, personal hygiene, plastic waste reduction, and environmental cleanliness. Systematic identification and scientific disposal of obsolete and scrap materials were undertaken to improve workspace efficiency and environmental safety. A campus-wide cleanliness and sanitation drive was organised around the villages, covering laboratories, administrative buildings, gardens, and common areas, complemented by a green drive that involved planting native and fruit-bearing saplings to enhance campus greenery. The programme extended beyond the Centre through community outreach activities in nearby villages, educational institutions, and public places, where awareness on solid waste management, plastic waste reduction, and cleanliness of shared spaces was disseminated through demonstrations and voluntary participation. *Swachhata* themes were also integrated with *Kisan Diwas* celebration, wherein farmers were sensitized on clean farming practices, safe disposal of agro-chemical containers, and sustainable farm waste management. To promote internal engagement, healthy competition among different staffs of the Centre was encouraged through cleanliness initiatives. Technical deliberations on water conservation, rainwater harvesting, and wastewater recycling were conducted for scientific and technical staff, linking water management with sustainable sanitation practices. A large-scale plastic waste collection drive, involving staff and community members, was conducted as a flagship activity, significantly raising awareness of the environmental hazards posed by single-use plastics. The *Pakhwada* further included brainstorming sessions on long-term environmental conservation strategies, emphasising integration of sustainability into institutional research and operations. The programme concluded with a press interaction and valedictory session highlighting key achievements, community participation, and institutional resolutions aimed at achieving a clean, green, and sustainable campus.





Glimpses of Swachhata Pakhwada 2025

हिंदी पखवाड़ा

16 दिसंबर 2025 को भाकृअनुप - राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में हिंदी पखवाड़ा सह कार्यशाला का आयोजन किया गया। कार्यक्रम का उद्घाटन केंद्र के प्रभारी प्रमुख डॉ. आई. एस. सिंह ने किया। कार्यक्रम में इस बात पर विशेष बल दिया गया कि हिंदी आम जनमानस के साथ अनुसंधान एवं नीतिगत पहलों को जोड़ने का एक प्रभावी माध्यम है। प्रतिभागियों को संबोधित करते हुए विशेषज्ञों ने बताया कि भाषा वैज्ञानिक अनुसंधान को किसानों और हितधारकों तक सरल और समझने योग्य बनाने में महत्वपूर्ण भूमिका निभाती है। यह भी कहा गया कि हिंदी में प्रभावी संप्रेषण के माध्यम से अनुसंधान परिणामों, तकनीकी नवाचारों तथा नीतिगत जानकारी का प्रसार विशेष रूप से ग्रामीण क्षेत्रों में अधिक प्रभावी ढंग से किया जा सकता है। कार्यशाला के दौरान नोट-लेखन, मसौदा तैयार करने, तथा राजभाषा नियमों से संबंधित विशेष प्रशिक्षण दिया गया। साथ ही, निबंध और वाद-विवाद जैसी प्रतियोगिताओं के माध्यम से हिंदी में कार्य करने के लिए प्रोत्साहित किया गया। आधिकारिक दस्तावेजों, वैज्ञानिक लेखन, संचार एवं प्रसार गतिविधियों में हिंदी के महत्व पर विशेष प्रकाश डाला गया। प्रतिभागियों ने पत्राचार, दस्तावेजीकरण, डिजिटल प्लेटफॉर्म तथा जनसंपर्क कार्यक्रमों में हिंदी के उपयोग को बढ़ाने पर अपने विचार साझा किए, ताकि अनुसंधान के लाभ समाज के अंतिम स्तर तक पहुंच सकें। कार्यक्रम में शिक्षा, अनुसंधान प्रसार, प्रशासन तथा सामाजिक विकास में हिंदी के उपयोग की आवश्यकता पर भी जोर दिया गया। वक्ताओं ने यह स्पष्ट किया कि हिंदी का प्रसार वैज्ञानिक प्रगति में बाधा नहीं है, बल्कि यह जनभागीदारी और जागरूकता को और अधिक सुदृढ़ करता है। रा.म.अनु.कें. के वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने हिंदी पखवाड़ा में सक्रिय रूप से भाग लिया और अपने अनुभव एवं सुझाव साझा किए। कार्यक्रम का समापन इस सामूहिक संकल्प के साथ हुआ कि संस्थान में राजभाषा नीति के अनुरूप आधिकारिक कार्यों तथा अनुसंधान संचार में हिंदी के उपयोग को और अधिक सुदृढ़ किया जाएगा।



डॉ. मनोज कुमार, वरिष्ठ वैज्ञानिक, रा.म.अनु.कें. दरभंगा में आयोजित हिंदी पखवाड़ा के दौरान दैनिक जीवन में हिंदी भाषा की महत्वपूर्ण भूमिकाएँ एवं महत्व को बताते हुए।



PRIORITIZATION, MONITORING AND EVALUATION CELL

Research Publications

Research Paper

- Ahirwal, S. K., Sarma, K., Kumar, T., Bharti, V., Kumar, R., Singh, J., **Raut, S. M.** (2025) Insights into biological indices of six indigenous fish species from Bihar, India. *Indian J. Fish*, 72(3):177-180.
- Bezbaruah H. K., Mogalekar H.S., **Raut S. M.**, Ram R.K., Nayak S. K., Gupta B. K., Sahu B. (2025) First study on habitat ecology, biometric parameters and biology of Rita rita (Hamilton, 1822) from tropical perennial River Burhi Gandak, India. *Environ Monit Assess*, 197:568. <https://doi.org/10.1007/s10661-025-14042-1>.
- Joshi, J., Kumar, S. S., **Rout, R. K.**, Rao, P. S. (2025) Millet processing: prospects for climate-smart agriculture and transition from food security to nutritional security. *Journal of Future Foods*, 5(5):470-479.
- Kumar, R., **Singh, I. S.**, Jha, V. N. (2025) Bioactive compounds in Euryale ferox Salisb. and their nutritional and therapeutic actions-a review. *Vegetos*, <https://doi.org/10.1007/s42535-025-01209-x>
- Padala, V. K., Sinha T., Tyagi S., Ramya, N., Narayana S. (2025) DNA barcoding and genetic diversity studies of Water lily aphid, *Rhopalosiphum nymphaeae* from India. *Journal of Environmental Biology*. 46(1): 87-94.
- Rajna, S., A. Vishwakarma, **V. K. Padala**, K. V. Raghavendra, S. Chander (2025) Development and validation of predictive regression model for Brown planthopper population in rice. *J. Environ. Biol.*, 46: 694-700.
- Raut, S. M., Sarma, K., Lataye, D.H. *et al.* (2025) Arsenic in Aquatic Ecosystems: Sources, Risks, Remediation, and Governance in India with Respect to Global Significance. *Water Air Soil Pollut* 236:1012. <https://doi.org/10.1007/s11270-025-08681-w>
- Raut, S. M., Sarma, K., Singh, I.S., Singh, J., Padala, V. K., Ahirwal, S.K., Kumar, T., Kumar, R., Jana, B. R., Bhatt, B. P. (2025) Performance and sustainability of the makhana (Euryale ferox Salisbury) cum fish culture system in India. *Indian Journal of Fisheries*, 72(2):84-93
- Raut, S. M., Singh, J., Nair, S., Singh, I. S. *et al.* (2025). Impact of periphyton on makhana (Euryale ferox Salisbury) cum fish culture: a study in North Bihar, India. *Aquat Living Resour*: 38 (6), <https://doi.org/10.1051/alr/2025003>.
- Rout, R. K., Sivaranjani, S., Puja, N., Singh, S. M., Kumar, T. D., Joshi, J. (2025) Valorization of fish wastes and by-products towards green circular bio-economy. *Next Research*, 2(4):101037.
- Rout, R. K., Sivaranjani, S., Puja, N., Singh, S. M., Kumar, T. D., Joshi, J., Rao, P. S. (2025). Valorization of Fish Wastes and By-products Towards Green Circular Bio-economy. *Next Research*, 101037.

Tarate, S. B., Singh, I. S., Raut, S. M., Madana, D. A. (2025) Waterbody decline and warming trends in aquatic ecosystems of selected districts of North Bihar in India (1995–2024): A remote sensing perspective. *Theoretical & Applied Climatology*, 156:560. <https://doi.org/10.1007/s00704-025-05820-5>

Yadav, P. K., Kumar, A., Choudhary, G. L., Gorai, T., Nath, P., Saha, R., Kumar, R., **Singh, I. S.** (2025) Effect of integrated nutrient management on production performance of Makhana under field condition. *Indian Journal of Agronomy*, 70 (2): 224-227.

Book Chapter

Kumar M., Krishna, S. T., Mandal, N., Biswas, S. (2025) Opportunities and Challenges of Nanofertilizer Use in Agriculture. In *Nanofertilizers in Agriculture*, edited by AK Patra, published by Springer Nature, pp. 89-112.

Rout, R. K., Kukde, R. B., Sivamma, P., Kumar, A., Prakash, R. (2025) Methodology for Extraction of Essential Oil Using Ultrasonic-Microwave-Assisted Hydrodistillation. In *Essential Oil Extraction from Food By-Products* (pp. 183-217). New York, NY: Springer US. https://doi.org/10.1007/978-1-0716-4634-2_12

Singh, I.S., Kumar, M., Jana, B.R., Raut, S.M., and Padala, V.K. (2025) Research and Innovation for empowering Makhana Farmers. In: Anup Das, Abhay Kumar, SK Naik, Pankaj Kumar, SS Mali, Rachana Dubey and Anirban Mukherjee. ICAR RCER: 25 Years of Glorious Journey of Innovation and Excellence. ICAR-Research Complex for Eastern Region, Patna, India. pp-240. ISBN No.978-81-954348-8-6

Popular Article

मनोज कुमार (२०२५). मखाना: स्वास्थ्य और समृद्धि का है खजाना. प्रिय अन्नदाता, दैनिक भास्कर, दरभंगा, 2 सितम्बर २०२५.

Kumar, M., Tarate, S. B., Rout, R. K., Padala, V. K., Raut, S. M. (2025) Water Crisis in Bihar, Causes, Impacts and the road to recovery. *Biotica Research Today*, 7(09): 258-260.

Vishwakarma, A., **Padala, V. K.** and Ramya N. (2025). Ecological Engineering: A Nature-Based Path to Sustainable Pest Management. *Agriculture and Food e-Newsletter*. 7(12):292-294.

Technical Bulletin

शैलेन्द्र मोहन राऊत, सूर्यकांत बाजीराव तराटे, मनोज कुमार, इंदु शेखर सिंग, सुरेन्द्र अहीरवाल, कमल सर्मा, धीरज प्रकाश (2025). मत्स्य पालन में शीतकालीन सतर्कता एवं प्रबंधन, टेक्निकल बुलेटिन नं. 2, भाकृअनुप-राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा-८४६ ००५ बिहार, पृष्ठ 35.

Extension Folder

Jana, B. R., Kumar, M. (2025) Jaivik Makhana Utpaadan, Extension Folder no. 5. ICAR-NRC for Makhana, Darbhanga.

e-publications

Ramya, N. and **Padala V. K.** (2025). Black Soldier Fly *Hermetia illucens*: the star insect of animal feed industry. *Agriculture and Food e-Newsletter*. 7(2):99-100.

Vishwakarma, A., **Padala, V. K.** and N Ramya (2025). Insects: Not Only Harm Us but Also Benefit Us a Lot. Agriculture and Food e-Newsletter. 8(1): 301-302.

Ongoing Research Project

Institute funded

Project Name	Project Leader & Associates	Period of Association	
		From	To
Performance of Activated Carbon from makhana (<i>Euryale ferox</i> Salisbury) seed coat for Removal of Arsenic in Water	Shri S. M. Raut (PI) Dr. Kamal Sarma (Co-PI), ICAR-RCER, Patna Dr. I. S. Singh (Co-PI)	01.07.2023	30.06.2025
Effect of Secondary and Micronutrients on Performance of Water Chestnut (<i>Trapa natans</i>) and India lotus (<i>Nelumbo nucifera</i>)	Dr. Manoj Kumar (PI) Dr. B. R. Jana (Co-PI) Dr. Vinod Kumar Padala (Co-PI) Er. Rahul Kumar Rout (Co-PI)	25.07.2023	24.07.2027
Assessment of water productivity of makhana under field condition	Dr. Suryakant Bajirao Tarate (PI) Dr. Indu Sekhar Singh (Co-PI)	01.11.2024	31.10.2027
Evaluation of bio efficacy of novel insecticides and bio pesticides for the management of Singhara beetle (<i>Galerucella birmanica</i> Jacoby)	Dr. Padala Vinod Kumar (PI) Dr. Manoj Kumar (Co-PI)	01.08.2024	31.08.2026

ICAR Funded

(CRP on Secondary Agriculture- NRC Makhana Centre)

Reformation of makhana processing and value addition industry through mechanization and automation	Dr. V. K. Padala (PI) Dr. S. B. Tarate (Co-PI) Er. R. K. Rout (Co-PI)	30.05.2024	--
--	---	------------	----

External Funded

Participatory Seed Production of Makhana, Water Chestnut and Lotus (RKVY)	---	15.03.2024	14.03.2027
---	-----	------------	------------

Personalia

Institutional Staff

Name of the official	Designation	Discipline
Dr. Nachiket Kotwaliwale	Director	Agricultural Structures & Process Engineering
Dr. Indu Shekhar Singh	PS & I/c Head	Soil Science
Dr. Bakul Ranjan Jana	Senior Scientist	Horticulture
Dr. Manoj Kumar	Senior Scientist	Soil Science
Sh. Shailendra Mohan Raut	Scientist	Fisheries Resource Management
Dr. Vinod Kumar Padala	Scientist	Agricultural Entomology
Dr. Suryakant Bajirao Tarate	Scientist	Land and Water Management Engineering
Er. Rahul Kumar Rout	Scientist	Agricultural Structures & Process Engineering
Dr. Dharmender	Scientist	Agricultural Structures & Process Engineering

Technical Staff

Name of the official	Designation
Sh. Ashok Kumar	Technical Officer
Sh. Dhiraj Prakash	Senior Technical Assistant
Sh. Alok Kumar	Senior Technician

Appointment/ Recruitment/ New Joining

Name of the official	Date of Joining	Designation
Dr. Dharmender	07.07.2025	Scientist

Promotion

Name of the official	Designation
Shri Dhiraj Prakash	Senior Technical Assistant (T-4)
Shri Alok Kumar	Senior Technician (T-2)



ICAR-NRC FOR MAKHANA IN THE NEWS

दैनिक भास्कर 05-12-2025

कार्यक्रम • प्रशिक्षण में गुणवत्तापूर्ण शिक्षा और शिक्षकों की भूमिका पर विस्तार से चर्चा की गई
राष्ट्रीय मखाना अनुसंधान केंद्र दरभंगा में बिहार-झारखंड के 50 शिक्षकों को दिया गया प्रशिक्षण, परिभ्रमण भी कराया

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया।



प्रशिक्षण के बाद उपस्थित शिक्षक व अन्य।

शिक्षक भूमिका को बढ़ावा देने के लिए राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए एक दिवसीय प्रशिक्षण कार्यक्रम आयोजित किया गया।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

दैनिक भास्कर 20-12-2025

कार्यक्रम • सहस्रों जिले के 50 मखाना किसानों के लिए एक दिवसीय प्रशिक्षण सह परिभ्रमण कार्यक्रम
यदि किसान वैज्ञानिक तकनीकों को अपनाएं तो मखाना उत्पादन व प्रसंस्करण के माध्यम से आय में कई गुना वृद्धि संभव : डॉ. सिंह

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया।



मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

SKUAST-K, NRC Darbhanga sign MoU to boost aquatic crop production

GK News Service
Srinagar, Oct 7

A historic Memorandum of Understanding (MoU) was signed on Tuesday between the ICAR-National Research Centre for Makhana (ICAR-NRCM), Darbhanga, Bihar, and the Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), marking a significant milestone to boost aquatic crop production, processing and value addition.

The MoU was formally signed by Dr. Nachiket Kotwaliwale, Director, ICAR-NRCM, and Prof. Nazir Ahmad Ganai, Vice-Chancellor, SKUAST-Kashmir, in the presence of DDG (Engg) ICAR New Delhi Dr SN Jha and various scientists of NRC for Makhana Darbhanga, CIPHET Ludhiana and SKUAST Kashmir, said a press release.

The MoU opens avenues for joint research in diverse disciplines related to aquatic crops of nutritional, medicinal,



and economic importance such as makhana, lotus, and water chestnut as well as other areas aligned with the mandates of both institutions. This strategic partnership aims to strengthen the research ecosystem by facilitating the exchange of students, faculty, and scholars for academic training, research, and capacity-building initiatives. The collaboration will enable the sharing of advanced research instrumentation facilities and scientific expertise between the two institutions to enhance the quality and impact of ongoing and future research programs.

By combining ICAR-NRCM's national expertise in aquatic crop research and SKUAST-K's strong foundation in hill and mountain agriculture, this partnership seeks to promote innovation, sustainable agricultural development, and entrepreneurship in the North-Western Himalayan region. The alliance reflects a shared commitment to academic excellence, technological advancement, and the holistic One Health approach integrating plant, animal, human, and environmental health for ensuring food and nutritional security across the region and beyond.

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।

राष्ट्रीय मखाना अनुसंधान केंद्र, दरभंगा में बिहार और झारखंड के 50 शिक्षकों के लिए आयोजित एक दिवसीय प्रशिक्षण कार्यक्रम का परिभ्रमण भी कराया गया। शिक्षकों को मखाना की विशेषताएं, उत्पादन, प्रसंस्करण और बाजार में बिक्री के बारे में जानकारी दी गई।



दरभंगा भास्कर 20-12-2025

कार्यक्रम • सहरसा जिले के 50 मखाना किसानों के लिए एक दिवसीय प्रशिक्षण सह परिभ्रमण कार्यक्रम यदि किसान वैज्ञानिक तकनीकों को अपनाएं तो मखाना उत्पादन व प्रसंस्करण के माध्यम से आय में कई गुना वृद्धि संभव : डॉ. सिंह

क्राइम रिपोर्टर | दरभंगा

राष्ट्रीय मखाना अनुसंधान केंद्र में सहरसा जिले के विभिन्न प्रखंडों से चयनित 50 मखाना किसानों के लिए एक दिवसीय प्रशिक्षण सह परिभ्रमण कार्यक्रम का आयोजन किया गया।

उद्घाटन प्रधान वैज्ञानिक सह केंद्र प्रभारी डॉ. आईएस सिंह ने किया। उन्होंने कहा कि सहरसा जिले में हाल के वर्षों में मखाना के क्षेत्र में तेजी से विस्तार हुआ है, साथ ही प्रसंस्करण सुविधाओं में भी उल्लेखनीय वृद्धि दर्ज की गई है। उन्होंने कहा कि यदि किसान वैज्ञानिक तकनीकों को अपनाएं तो मखाना उत्पादन एवं प्रसंस्करण के माध्यम से आय में कई गुना वृद्धि संभव है। वरिष्ठ वैज्ञानिक डॉ. मनोज कुमार ने



बैठक में प्रतिभागियों को संबोधित करते हुए वैज्ञानिक।

कहा कि मखाना आधारित उद्योग उत्तर बिहार की अर्थव्यवस्था को मजबूती देने का सबसे प्रभावी माध्यम है। उन्होंने किसानों से आह्वान किया कि वे केवल उत्पादन तक सीमित न रहें, बल्कि प्रसंस्करण, मूल्य संवर्धन और उद्यमिता को अपनाकर

मखाना को एक संगठित उद्योग का रूप दें। उन्होंने बताया कि पिछले दो वर्षों में राष्ट्रीय मखाना अनुसंधान केंद्र द्वारा कोसी और सोनमंचल क्षेत्र के सैकड़ों किसानों को प्रशिक्षण दिया गया है, जिससे मखाना के क्षेत्र

विस्तार को नई गति मिली है। डॉ. कुमार ने यह भी कहा कि मखाना का क्षेत्र विस्तार उन्हीं क्षेत्रों में किया जाना चाहिए जहाँ जल की प्राकृतिक उपलब्धता हो, ताकि भूमिगत जल पर अनावश्यक दबाव न पड़े और वर्षा जल का अधिकतम उपयोग

सुनिश्चित हो सके। उन्होंने विश्वास जताया कि मखाना आधारित उद्योगों के विकास से उत्तर बिहार में बड़े पैमाने पर रोजगार के अवसर सृजित होंगे, युवाओं का पलायन रूकेगा और क्षेत्रीय अर्थव्यवस्था को स्थायी मजबूती मिलेगी।

आधुनिक यंत्रों की व्यावहारिक जानकारी दी : कृषि वैज्ञानिक डॉ. बीआर जाना ने मखाना नर्सरी प्रबंधन, फसल प्रबंधन एवं बीज निकासी से संबंधित वैज्ञानिक तकनीकों पर विस्तार से प्रकाश डाला। इसके साथ ही उपस्थित प्रतिभागियों को संस्थान में स्थापित मखाना प्रसंस्करण एवं मूल्य संवर्धन में प्रयुक्त आधुनिक यंत्रों का प्रत्यक्ष प्रदर्शन कर व्यवहारिक जानकारी भी दी गई।

हिंदी का अधिकाधिक करें प्रयोग, यह दिलों को जोड़नेवाली भाषा

□ मखाना अनुसंधान केंद्र में हिंदी कार्यशाला सह विचार गोष्ठी में आपील

प्रतिनिधि, सदर.

राष्ट्रीय मखाना अनुसंधान केंद्र में गुरुवार को हिंदी कार्यशाला सह विचार गोष्ठी का आयोजन किया गया। इसमें संस्थान के प्रशासनिक एवं वैज्ञानिक कार्यों में राजभाषा हिंदी के अधिकाधिक प्रयोग पर चर्चा की गयी। मौके पर राजभाषा प्रकोष्ठ के प्रभारी सह वैज्ञानिक डॉ. मनोज कुमार ने कहा



कार्यशाला में बोलते वैज्ञानिक व मंचासीन अन्य.

कि हिंदी हमारी कमजोरी नहीं, बल्कि बिहार समेत संपूर्ण हिंदी भाषी समाज की सबसे बड़ी बौद्धिक, सांस्कृतिक

और आत्मिक शक्ति है। बिहार वह भूमि है, जिसने देश को प्रशासन, विज्ञान, साहित्य और राजनीति में निरंतर दिशा

प्रदान की है। ऐसे में यहां के छात्र व युवाओं के हिंदी बोलने या प्रयोग करने में हीनता का बोध करना

आत्मविस्मरण के समान है। उन्होंने कहा कि वर्तमान में रोजगार के अवसर केवल अंग्रेजी तक सीमित नहीं हैं। हिंदी में मीडिया, विज्ञान, संग्रहण, प्रशासन, स्टार्टअप शिक्षा और डिजिटल प्लेटफॉर्म पर व्यापक संभावना मौजूद है। वहीं एसएम राउत ने हिंदी को दिलों को जोड़ने वाली भाषा बताया। आरके राउत ने हिंदी को प्रशासनिक पारदर्शिता और कार्य-दक्षता का सशक्त माध्यम बताया। डॉ. धर्मेश ने कहा कि हिंदी अनुसंधान और नीतियों को आम जनता से जोड़ने का प्रभावी साधन है।





भा.कृ.अनु.प.- राष्ट्रीय मखाना अनुसंधान केंद्र,
दरभंगा 846005, बिहार

ICAR-National Research Centre for Makhana,
Darbhanga 846005, Bihar