वार्षिक प्रतिवेदन
ANNUAL REPORT
2022-2023





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Front Cover **:**

1. The historic Banyan Tree point at Botanic Garden, CSIR- NBRI, Lucknow
2. Flower of *Victoria amazonica*

3-4. Water Lily germplasm collection at Botanic Garden

5. *Chrysanthemum* in flower show

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Annual Report

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With best compliments from

Director

CSIR-NBRI, Lucknow

राष्ट्रीय वनस्पति अनुसंधान संस्थान
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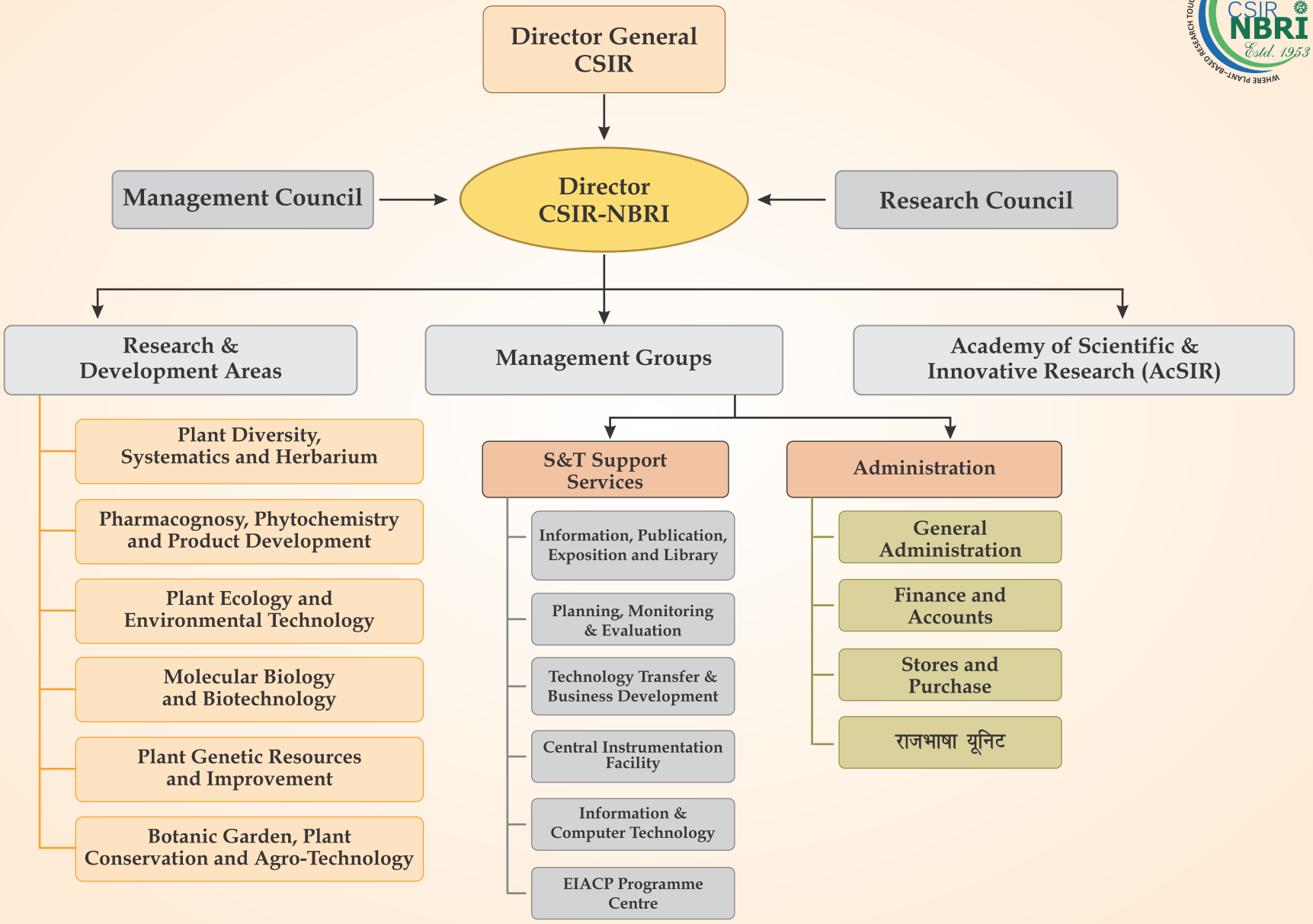
Organizational Set-Up



CONTENTS

Annual Progress At A Glance

Publications

SCI Journals	177
Average IF Per Paper	3.59
Total IF Per Scientist	11.22

Technologies Transferred

- Certified Reference Materials
- Microbial Biofertilizer Technology
- CROMA-3: Bioavailable Curcumin

Patents Granted

National	06

Patents Filed

National	01

HRD

Ph.D Awarded/Submitted	16/17
Training Programmes Organized	31
Skill Development Programmes	07
No. of Individuals Trained	2083
PG Students Trained	89

Extra Budgetary Resources

(Rupees in lakh)

Total ECF	121.732
EBR	742.446

Projects Undertaken

New Projects Initiated	15
Projects Under Implementation	103

Plant Inventory

New Species Discovered	06
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Staff Strength

Group IV	57
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CSIR-NBRI

निदेशक की कलम से

मुझे आपके समक्ष सीएसआईआर–राष्ट्रीय वनस्पति अनुसंधान संस्थान (सीएसआईआर–एनबीआरआई) की वार्षिक रिपोर्ट (2022–2023) प्रस्तुत करते हुए खुशी हो रही है। यह वर्ष हमारी संस्था के लिए एक महत्वपूर्ण मोड़ के रूप में है, जो वैज्ञानिक दृढ़ता और सकारात्मक सामाजिक योगदान के प्रति हमारे समर्पण की पुष्टि करता है।

यह पादप विविधता, वर्गिकी एवं पादपालय समूह के लिए एक असाधारण वर्ष रहा है। पूरे भारत में सर्वेक्षणों के माध्यम से, अकेले चंबल बीहड़ों और पचमढ़ी बायोस्फीयर रिजर्व में 50 से अधिक अद्वितीय टेरिडोफाइट प्रजातियों की पहचान की गई है। ये खोजें देश की जैव विविधता की समृद्धि और इसके संरक्षण की तत्काल आवश्यकता को रेखांकित करती हैं, खासकर श्योपुर, मुरैना और भिंड जैसे जिलों में पहचाने गए आर्थिक रूप से मूल्यवान औषधीय पौधों के लिए। नई प्रजातियों की खोज एक अन्य मील का पत्थर रही है। अरुणाचल प्रदेश और मणिपुर में अद्वितीय रूपात्मक विशेषताओं के साथ दो लाइकेन प्रजातियों, *नेफ्रोमोप्सिस अवस्थियाई* और *पाइरेनुला अवस्थियाई* की पहचान की गई। इसी तरह, दक्षिणी पश्चिमी घाट में *इस्चेमम सुनीली* और पश्चिमी हिमालय में *ब्रोमस कश्मीरेंसिस* और *पोआ पिंडारिएंसिस* जैसी नई घास प्रजातियों को हमारे रिकार्डों में जोड़ा गया है। इसके अलावा, हेटरोट्रॉफिक सूक्ष्मशैवाल में बीटा–ग्लूकन के उत्पादन को अनुकूलित करके उत्पाद विकास में एक सफलता हासिल की गई है। पादप विविधता पर निष्कर्षों को समाहित करने और उन्हें सुलभ बनाने के लिए, एक विशेष स्थानीय डेटाबेस, ''चंबल बीहड़ों के पादप संसाधन'' बनाया गया है। इसके अलावा, इन विट्रो बीजाणु संवर्धन के द्वारा सक्रिय प्रसार के माध्यम से *साइक्लोसोरस* प्रजाति पौधे के पौधे पैदा किये गए, जिससे संस्थान का फर्न हाउस समृद्ध हुआ है। ऐसी उपलब्धियों के साथ, अग्रणी पादप अनुसंधान और संरक्षण के अपने मिशन को जारी रखने के लिए हम तत्पर हैं।

औषधि विज्ञान, पादप रसायनिकी और उत्पाद विकास समूह के पास अंतःविषय नवाचार के लिए अग्रणी अनुसंधान मानक उपलब्ध हैं। सबसे अच्छी सफलता जीवाणुरोधी अनुसंधान के क्षेत्र में आई, जहां बहु–दवा प्रतिरोधी 'सुपरबग' के महत्वपूर्ण मुद्दे से निपटा गया। समूह ने *कोलेरेयूटेरिया पैनिकुलेटा* (Ka&AgNPs) के पत्तों के अर्क का उपयोग करके चांदी के नैनोकणों को संश्लेषित किया, जो विशेष रूप से कोरम सेंसिंग (QS) विनियमित विषाणु कारकों को रोकने में रासायनिक रूप से संश्लेषित नैनोकणों से बेहतर प्रदर्शन करता है, जो दवा प्रतिरोधी *स्यूडोमोनास एरुजिनोसा* संक्रमण के इलाज के लिए एक आशाजनक अवसर प्रदान करता है। चिकित्सीय समाधानों में प्रगति हुई है, विशेष रूप से, *एंड्रोग्राफिस पैनिकुलेटा* और *पाइपर लोंगम* से तैयार हर्बल मलहम, जो महत्वपूर्ण रूप से घाव भरने और जीवाणुरोधी गतिविधियों को प्रदर्शित करता है। गाउटी आर्थराइटिस स्थितियों के लिए एक हर्बल सप्लीमेंट का विकास भी उतना ही उल्लेखनीय है, जिसने मानक दवा कोल्चीसिन की तुलना में रक्त में यूरिक एसिड के स्तर में 80% की कमी प्रदर्शित की। इस वर्ष *थैलिक्ट्रम फोलियोसम* और *महोनिया* प्रजातियों जैसे औषधीय पौधों के पारंपरिक दावों की पुष्टि की गई, जिससे उनकी चिकित्सीय प्रभावकारिता को प्रमाणित करने के लिए वैज्ञानिक प्रमाण मिले।

पादप पारिस्थितिकी और पर्यावरण प्रौद्योगिकी समूह की व्यापक अनुसंधान पहलों ने जटिल पारिस्थितिक प्रणालियों और टिकाऊ प्रौद्योगिकियों के बारे में हमारी समझ में सुधार किया है। पादप पारिस्थितिकी और जलवायु परिवर्तन समूह ने जमीनी ओजोन के बढ़े हुए स्तर पर कुछ शहरी उष्णकटिबंधीय वृक्ष प्रजातियों की प्रतिक्रिया का अध्ययन किया। समूह ने पाया कि जहां *एजादिरक्ता इंडिका* और *नेरियम इंडिकम* ने उच्च ओजोन स्थितियों के तहत रंध्र संचालन में वृद्धि दिखाई, वहीं अन्य प्रजातियों ने प्रकाश संश्लेषण और वाष्पोत्सर्जन दर में कमी प्रदर्शित की। विशेष रूप से, *फाईकस रिलिजियोसा* और *सराका असोका* सहिष्णु प्रजातियों के रूप में उभरे हैं, जो भविष्य की शहरी वानिकी पहलों के लिए उनकी उपयुक्तता का सुझाव देते हैं। समूह ने

भविष्य के जलवायु परिदृश्यों के तहत भारत में संकटग्रस्त तीन *आइलेक्स* प्रजातियों के अनुकूलन का भी पता लगाया। निष्कर्षों से तापमान और नमी के तनाव के प्रति प्रजातियों की संवेदनशीलता के अनुरूप विशेष संरक्षण रणनीतियों की आवश्यकता का संकेत मिलता है। इसके अलावा, जैव–जलवायवीय मॉडलिंग में अनुसंधान ने बढ़ते तापमान के कारण भारत में गेहूं की खेती के लिए उपयुक्त क्षेत्रों में कमी का अनुमान लगाया है, जिससे गेहूं की सहिष्णु किस्मों के तत्काल विकास की आवश्यकता उत्पन्न होती है। इस वर्ष आनुवंशिक तंत्र की समझ में भी सफलताएँ देखी गईं जो कपास और चावल में सूखा सहिष्णुता में योगदान करती हैं, जो कि जलवायु परिवर्तन परिस्थितियों को देखते हुए एक महत्वपूर्ण क्षेत्र है।

सूक्ष्मजैविक प्रौद्योगिकी समूह ने पौधों की वृद्धि और तनाव सहनशीलता पर ध्यान केंद्रित किया। *बैसिलस सबटिलिस* उपभेदों को सोया में चारकोल रॉट रोग को कम करने और टमाटर में *फ्यूसेरियम ऑक्सीस्पोरम* के खिलाफ जैव–नियंत्रण प्रदान करने में सहायक पाया गया। अनुसंधान से यह भी पता चला कि *बैसिलस सबटिलिस* (एनबीआरआई–डब्ल्यू9) में टमाटर के पौधों में उपापचय होमियोस्टैसिस को बहाल करने की क्षमता है, जिससे उत्पादकता में काफी वृद्धि होती है। इसके अलावा, तनाव की स्थिति में *बैसिलस एमाइलो लिक्वीफेसिएंस* एसएन13 द्वारा कार्बोहाइड्रेट और फैटी एसिड उपापचय में परिवर्तन करके चावल के अंकुर के विकास में सुधार प्रदर्शित किया गया है।

पर्यावरण प्रौद्योगिकी समूह ने कृषि मिट्टी में माइक्रोप्लास्टिक की मात्रा निर्धारित करने के लिए 90% से अधिक पुर्नप्राप्ति दर के साथ एक विश्वसनीय विधि विकसित करके एक महत्वपूर्ण मील का पत्थर हासिल किया है। लखनऊ के आसपास के क्षेत्र में एक पायलट अध्ययन ने मृदा प्रदूषण के बड़े पैमाने पर मूल्यांकन की नींव रखी है। कवक संघ के माध्यम से पर्यावरणीय उपचार में प्रगति हुई है, जिसने अल्प अवधि के भीतर मुक्त साइनाइड के स्तर में 99% की कमी हासिल की है। मिट्टी के सुधार में *हेलिएन्थस एनुअस* की प्रभावकारिता और चावल के भूसे के यथास्थान अपघटन के लिए सूक्ष्मजैविक संघ पर शोध पर्यावरणीय रूप से टिकाऊ प्रौद्योगिकियों के प्रति संस्थान की प्रतिबद्धता को रेखांकित करता है।

आणुविक जीव विज्ञान और जैव प्रौद्योगिकी समूह की असंख्य खोजें और नवाचार देश में कृषि, पादप जीव विज्ञान और सार्वजनिक स्वास्थ्य के क्षेत्र में क्रांति ला सकते हैं। कपास अनुसंधान एवं विकास में एक उल्लेखनीय उपलब्धि मिली है, जहां Tma12 GM कपास सफेद मक्खी के खिलाफ अत्यधिक प्रभावी साबित हुई है, जिससे इसकी आबादी 60–70% कम हो गई है। पीएनयू08 जीएम कपास लाइनों की टी3 पीढ़ी तक प्रगति भी उल्लेखनीय है, जिससे भविष्य के अनुप्रयोगों के लिए एक मजबूत मंच तैयार हुआ है। *गोसीपियम हिर्सुटम* से जुड़े बहु–स्थान परीक्षण ने 8,000 से अधिक संभावित मार्करों की पहचान की, जो प्रजनन कार्यक्रमों के लिए अमूल्य आंकड़े प्रदान करते हैं। टमाटर पर अनुसंधान ने संशोधित *कोकुलस हिर्सुटस* ट्रिप्सिन अवरोधकों की अभिव्यक्ति के माध्यम से कीट प्रतिरोध में बड़ी आशा प्रदर्शित की है, जिसमें उपज में कमी के बिना पूर्ण कीट मृत्यु दर देखी गई है। एचएसपी90 चौपरोन जैसे जीन को लक्षित करने वाले जीनोम संपादन ने टमाटर में बेहतर वृद्धि विशेषताओं को भी जन्म दिया है, जो टिकाऊ कृषि के लिए उज्ज्वल भविष्य का संकेत देता है। सार्वजनिक स्वास्थ्य सुरक्षा के क्षेत्र में, सब्जियों में आर्सेनिक के संपर्क पर अध्ययन में एएसएमटी गतिविधि वाले रोगाणुओं की पहचान की गई, जो आर्सेनिक शमन के लिए नए रास्ते उपलब्ध करा सकते हैं। यह सफलता उन्नत कृषि पद्धतियों के माध्यम से मानव के लिए आर्सेनिक जोखिम को कम करने में महत्वपूर्ण प्रभाव डालने के लिए तैयार है। समूह ने अन्य निष्कर्षों के अलावा, सुगंधित गुलाबों में विलगन के हार्मोनल नियंत्रण, चने में मुरझाने के प्रति प्रतिरोध और *अरेबिडोप्सिस* बीज निर्माण में *RabC1 GTPase* की भूमिका को समझने में भी प्रगति की है।

पादप आनुवंशिक संसाधन एवं सुधार समूह के प्रयासों से प्रभावशाली परिणाम मिले हैं। विशेष रूप से, *क्राईसेंथेमम मोरीफोलियम* की नई उत्परिवर्ती लाइनों एवं संकरों के प्रसार ने उन्नत फूलों की खेती की किस्मों का मार्ग प्रशस्त किया है। इसके अतिरिक्त, लक्षित *ग्लैडियोलस* प्रजनन में, 237 अंतर–किस्मीय संकर पौधों की सफल खेती सजावटी पौधों की बागवानी में एक महत्वपूर्ण उपलब्धि है। गुलदाउदी और ग्लेडियोलस दोनों के लिए फूलों की खेती पर आईसीएआर–एआईसीआरपी के साथ पंजीकरण के लिए औपचारिक प्रस्तुतियाँ चल रही हैं, जो इन अनुसंधान पहलों की परिपक्वता की गवाही देती हैं। *सोफोकार्पस टेट्रागोनोलोबस* जैसी कम उपयोग की जाने वाली फलीदार फसलों पर काम ने एक महत्वपूर्ण उपलब्धि हासिल कर ली है। वायरस–प्रेरित जीन साइलेंसिंग के अनुप्रयोग से संघनित टैनिन जैसे कारकों में उल्लेखनीय कमी आई, जिससे इन मूल्यवान संसाधनों को मुख्यधारा में लाने के रास्ते तैयार हुए। 63K और 50K SNP ऐसे का उपयोग करके उच्च–घनत्व आनुवंशिक मानचित्रण ने कपास में उत्पादकता और फाइबर गुणवत्ता को प्रभावित करने वाले कई क्यूटीएल की पहचान की है, जो भविष्य के प्रजनन कार्यक्रमों के लिए मूल्यवान अंतर्दृष्टि प्रदान करता है। *कॉमिफोरा वाइटी* में *डी नोवो* हाइब्रिड असेंबल ड्राफ्ट जीनोम के माध्यम से फाइटोस्टेरॉल जैवसंश्लेषण के आनुवंशिक आधार को समझने में भी महत्वपूर्ण प्रगति हुई। इस सफलता का फार्मास्युटिकल और न्यूट्रास्युटिकल क्षेत्रों पर व्यापक प्रभाव पड़ सकता है। जैसे–जैसे हम आगे बढ़ रहे हैं, ये सफलताएँ पादप अनुसंधान और जैव प्रौद्योगिकी के अग्रणी केंद्र के रूप में संस्थान की भूमिका की पुष्टि करती हैं।

वानस्पतिक उद्यान, पादप संरक्षण और कृषि–प्रौद्योगिकी समूह ने डीयूएस दिशानिर्देशों का पालन करते हुए *बोगेनविलिया* की दस संदर्भ किस्मों की सावधानीपूर्वक पहचान की। स्वदेशी वनस्पतियों के संरक्षण के प्रयास उल्लेखनीय रहे हैं, जिनमें कई पौधों की प्रजातियों और फूलों की खेती की सफल शुरूआत हुई है, जिनमें *साइकस नाथोरस्टीयाई* और *हेडिचियम कोक्सीनियम* जैसी दुर्लभ प्रजातियां शामिल हैं। सोडिक मिट्टी के प्रति उच्च सहनशीलता प्रदर्शित करने के लिए पांच एलो प्रजातियों की पहचान की गई, जो सीमांत भूमि के उपयोग में महत्वपूर्ण संभावनाएं रखती हैं। इसी तरह, हल्दी की किस्म 'केसरी' हमारे सीएसआईआर–अरोमा मिशन को पूरक करते हुए, सोडिक मिट्टी में असाधारण प्रदर्शन करती है। कृषि के मोर्चे पर, पांच अलग–अलग कृषि जलवायु क्षेत्रों में नीम की नई बौनी किस्मों का बहु–स्थानक परीक्षण किया गया। ये किस्में शीघ्र परिपक्वता और उच्च लिमोनोइड्स उपज प्रदर्शित करती हैं, और उनका तुलनात्मक मूल्यांकन वर्तमान में चल रहा है।

जनसंपर्क के संदर्भ में, संस्थान द्वारा आयोजित प्रशिक्षण कार्यक्रमों का प्रभावशाली प्रभाव पड़ा। किसानों और उद्यमियों सहित 500 से अधिक व्यक्तियों को विभिन्न पहलों के तहत प्रशिक्षित किया गया। समूह की भागीदारी से बिहार राज्य में छह जिलों में कृषि क्षेत्र का विस्तार हुआ, जिसमें 91 किसान एवं 6.81 हेक्टेयर क्षेत्र शामिल था। इस वर्ष में काफी बुनियादी ढांचे का विकास भी हुआ, जिसमें वानस्पतिक उद्यान में हमारे ओपन–एयर इंटरप्रिटेशन सेंटर का उन्नयन भी शामिल है, जिससे हमारे शैक्षिक मिशन को पूरा किया जा सके। सामुदायिक भागीदारी और क्षमता–निर्माण पहल के हिस्से के रूप में, वानस्पतिक उद्यान और कृषि–प्रौद्योगिकी समूह ने वानस्पतिक उद्यान में घरेलू बागवानी, बोन्साई तकनीक और निर्जलीकृत पुष्प शिल्प पर 8 प्रशिक्षण आयोजित किए। इसके अतिरिक्त, हर्बल गुलाल की तैयारी पर ध्यान केंद्रित करते हुए सीएसआईआर फ्लोरीकल्चर मिशन के तहत 6 प्रशिक्षण और सीएसआईआर अरोमा मिशन के तहत 8 प्रशिक्षण दिए गए। इसके अलावा, कौशल वृद्धि और ज्ञान प्रसार की प्रतिबद्धता को आगे बढ़ाते हुए, सीएसआईआर–एकीकृत कौशल पहल के तहत 7 कौशल विकास कार्यक्रम आयोजित किए गए।

संस्थान ने उत्कृष्टता की खोज और देश के अनुसंधान और विकास प्रयासों को बढ़ावा देने में अपनी भूमिका में उल्लेखनीय उपलब्धियां हासिल की हैं। भारत में हमें छह पेटेंट स्वीकृत किये गए हैं जबकि एक पेटेंट को फाइल किया गया, जो नवाचार के प्रति हमारी चल रही प्रतिबद्धता का प्रमाण है। वर्ष 2022–23 में हमने 15 नई शोध परियोजनाएं शुरू की हैं। इसके अलावा, संस्थान ने तीन प्रौद्योगिकियों का सफलतापूर्वक व्यावसायीकरण किया है और 28 विभिन्न समझौतों को औपचारिक रूप दिया है, जिनमें एमओयू, एमओए, और एमटीए शामिल हैं, जिससे हमारे सहयोगी नेटवर्क का विस्तार हुआ है। अकादमिक प्रकाशन के क्षेत्र में, हमने एससीआई–अनुक्रमित पत्रिकाओं में 177 शोध पत्रों का योगदान दिया है, जिनका संचयी प्रभाव कारक 639.85 है। अकादमिक उत्कृष्टता को बढ़ावा देने के प्रति हमारा समर्पण वैज्ञानिक और नवोन्मेषी अनुसंधान अकादमी (एसीएसआईआर) और अन्य भारतीय विश्वविद्यालयों के माध्यम से 16 डॉक्टरेट डिग्रियां प्रदान करने में परिणत हुआ है।

मैं हमारे संस्थान की गतिविधियों को बनाए रखने में अटूट प्रतिबद्धता, उत्साह और समर्पण के लिए हमारे वैज्ञानिक, तकनीकी और प्रशासनिक कर्मियों के साथ–साथ हमारे छात्रों की हार्दिक सराहना करता हूं। इसके अलावा, मैं इस क्षण का उपयोग हमारे संस्थान के व्यापक विज्ञान और प्रौद्योगिकी प्रबंधन में अमूल्य समर्थन, प्रोत्साहन और सलाह के लिए सीएसआईआर की महानिदेशक डॉ. नल्लाथम्बी कलाईसेल्वी के प्रति अपनी हार्दिक कृतज्ञता व्यक्त करने के लिए करता हूँ। हम हमारे अनुसंधान एवं विकास और प्रबंधन रणनीतियों को आकार देने में मार्गदर्शन और संस्थान के प्रदर्शन एवं प्रगति की देखरेख के लिए प्रोफेसर (डॉ.) परमजीत खुराना, अध्यक्ष, के साथ–साथ सीएसआईआर– एनबीआरआई की अनुसंधान और प्रबंधन परिषदों के सम्मानित सदस्यों के आभारी हैं। इसके अतिरिक्त हम अपने प्रायोजकों, वित्तीय समर्थकों, औद्योगिक भागीदारों, सहयोगियों, शैक्षणिक समुदाय और आम जनता सहित अन्य समर्थकों द्वारा विभिन्न रूपों में उदार समर्थन और सहयोग के लिए उनके प्रति आभारी हैं। हम उनके सहायक कार्यों की सराहना करते हैं और हमारे आगामी कार्यों के लिए उनके निरंतर समर्थन की आशा करते हैं।

अजित

(अजित कुमार शासनी)
निदेशक

From the Director's Desk

I am pleased to present before you the Annual Report (2022-2023) for the CSIR-National Botanical Research Institute (CSIR-NBRI). This year serves as a pivotal juncture for our institution, reaffirming our dedication to scientific rigor and positive societal contributions.

This has been an exceptional year for the Plant diversity, systematics & herbarium group. Through meticulous floristic surveys across India, over 50 unique pteridophyte species have been identified in Chambal Ravines and Pachmarhi Biosphere Reserve alone. These discoveries underscore the richness of the country's biodiversity and the urgent need for conservation, especially for economically valuable medicinal plants identified in districts like Sheopur, Morena, and Bhind. New species discovery has been another milestone. Two lichen species, *Nephromopsis awasthii* and *Pyrenula awasthii*, were identified with unique morphological features in Arunachal Pradesh and Manipur. Similarly, new grass species like *Ischaemum sunilii* in the southern Western Ghats and *Bromus kashmirensis* and *Poa pindariensis* in the Western Himalayas have been added to our records. Moreover, the group achieved a breakthrough in product development, optimizing the production of Beta-glucan in heterotrophic microalgae. To encapsulate the findings on plant diversity and make them accessible, a specialized local database, "Plant Resources of Chambal Ravines," has been created. Furthermore, active plant propagation with *in vitro* spore culture producing plantlets of *Cyclosorus* sp. has been undertaken, thereby enriching the institute's fern house. With such achievements, we look forward to continuing our mission of pioneering plant research and conservation.

The Pharmacognosy, phytochemistry and product development group has advanced pioneering research setting benchmarks for interdisciplinary innovation. The most compelling breakthrough came in the realm of antibacterial research, where the critical issue of multi-drug resistant 'superbugs' was tackled. The group synthesized silver nanoparticles using leaf extracts of *Koelreuteria paniculata* (Ka-AgNPs), which notably outperformed chemically synthesized nanoparticles in inhibiting quorum sensing (QS) regulated virulence factors, offering a promising avenue for treating drug-resistant *Pseudomonas aeruginosa* infections. Strides were made in therapeutic solutions, notably, the herbal ointment formulated from *Andrographis paniculata* and *Piper longum*, which exhibit significant wound healing and antibacterial activities. Equally notable is the development of a herbal supplement for Gouty Arthritic Conditions, which showed an 80% reduction in blood uric acid levels compared to the standard drug colchicine. The year also saw the validation of traditional claims of medicinal plants such as *Thalictrum foliolosum* and *Mahonia* species, providing scientific evidence to substantiate their medical efficacy.

Comprehensive research initiatives by the Plant Ecology and Environmental Technology group have improved our understanding of the complex ecological systems and sustainable technology. The plant ecology and climate change group studied the response of some urban tropical tree species to increased levels of ground level ozone. The group found that while *Azadirachta indica* and *Nerium indicum* show increased stomatal conductance under elevated ozone conditions, other species exhibited decreased photosynthesis and transpiration rates. Notably, *Ficus religiosa* and *Saraca asoca* emerged as resilient species, suggesting their suitability for future urban forestry initiatives. The group also explored the adaptation of three threatened *Ilex* species in India, under future

climate scenarios. The findings indicate the need for specialized conservation strategies tailored to individual species' sensitivities to temperature and moisture stress. In addition, research in bioclimatic modeling forecasted dwindling suitable areas for wheat cultivation in India due to rising temperatures, which necessitates the urgent development of resilient wheat cultivars. This year also saw breakthroughs in the understanding of genetic mechanisms that contribute to drought tolerance in cotton and rice, a critical area given the ongoing climate changes.

The Microbial technology group focused on plant growth and stress tolerance. *Bacillus subtilis* strains were found to be instrumental in suppressing charcoal rot disease in soy and providing bio-control against *Fusarium oxysporum* in tomato. Research also showed that *Bacillus subtilis* (NBRI-W9) has the capability to restore metabolic homeostasis in tomato plants, thereby enhancing productivity significantly. Furthermore, *Bacillus amyloliquefaciens* SN13 has been shown to improve rice seedling growth under stress conditions by altering carbohydrate and fatty acid metabolism.

The Environmental technology group achieved a significant milestone by developing a reliable method to quantify microplastics in agricultural soil with a recovery rate exceeding 90%. A pilot study in the vicinity of Lucknow has laid the foundation for large-scale assessment of soil contamination. Advancements have been made in environmental remediation through a fungal consortium that achieved a 99% reduction in free cyanide levels within a short period. Research into the efficacy of *Helianthus annuus* in soil improvement and a microbial consortium for *in situ* decomposition of rice straw further underline the institute's commitment to environmentally sustainable technologies.

The myriad of discoveries and innovations by the Molecular biology and biotechnology group can revolutionize the fields of agriculture, plant biology, and public health in the country. A notable achievement has been in the Cotton R&D, where Tma12 GM cotton has shown to be highly effective against whitefly, reducing its population by 60-70%. The advancement of Pnu08 GM cotton lines to T3 generation is also worth mentioning, setting a robust platform for future applications. The multi-location trial involving *G. hirsutum* identified over 8,000 potential markers, which provide invaluable data for breeding programs. Research in tomato has shown great promise in insect resistance through the expression of modified *Cocculus hirsutus* trypsin inhibitors, with complete insect mortality observed without yield penalty. Genome editing targeting HSP90 chaperone-like genes has also led to superior growth characteristics in tomato, indicating a bright future for sustainable agriculture. In the area of public health safety, study on arsenic exposure in vegetables identified microbes with AsMT activity, which may offer new avenues for arsenic mitigation. This breakthrough is poised to have a significant impact on reducing human arsenic exposure through advanced agricultural practices. The group has also made strides in understanding the hormonal control of abscission in fragrant roses, chickpea's resistance to wilt, and the role of *RabC1 GTPase* in *Arabidopsis* seed formation, among other findings.

The endeavors by the Plant genetic resources and improvement group have yielded impressive results. Notably, the propagation of new mutant lines and hybrids of *Chrysanthemum morifolium* has paved the way for advanced floricultural varieties. Additionally, in targeted *Gladiolus* breeding, the successful cultivation of 237 inter-varietal hybrid seedlings marks a substantial achievement in ornamental horticulture. Formal submissions for registration with ICAR-AICRP on Floriculture for both *Chrysanthemum* and *Gladiolus* are underway, testifying to the maturity of these research initiatives. The work on underutilized legume crops, such as *Psophocarpus tetragonolobus*, has attained a pivotal milestone. The application of Virus-Induced Gene Silencing led to a notable reduction in limiting factors like condensed tannins, creating avenues for mainstreaming these valuable resources. Concurrently, high-density genetic mapping in cotton using 63K and 50K SNP arrays has led to the identification of multiple QTLs affecting productivity and fiber quality, offering valuable insights for future breeding programs. Significant advancements were also made in understanding the genetic basis of phytosterol biosynthesis in *Commiphora wightii* through *de novo* hybrid assembled draft genome. This breakthrough has broad implications for the pharmaceutical and nutraceutical sectors. As we forge ahead, these successes affirm the institute's role as a leading hub for plant research and biotechnology.

The Botanic Garden, plant conservation and agro-technology group meticulously characterized ten reference varieties of *Bougainvillea* adhering to DUS guidelines. The efforts in conserving indigenous flora have been remarkable, with successful introductions of several plant species and floricultural crops, including rare species like *Cycas nathorstii* and *Hedychium coccineum*. Five *Aloe* species were identified to exhibit heightened tolerance to sodic soils, which holds significant promise in the utilization of marginalized lands. Similarly, the turmeric variety 'Kesari' shows exceptional promise in sodic soils, complementing our CSIR-Aroma Mission. On the agricultural front, multi-location trials of new dwarf cultivar of Neem were conducted across five distinct agroclimatic zones. These cultivars exhibit early maturity and higher Limonoids yield, and their comparative evaluation is currently underway.

In terms of outreach, training programs organized by the institute had an impressive impact. Over 500 individuals, including farmers and entrepreneurs, were trained under various initiatives. Involvement of the group also lead to cultivation area expansion in the state of Bihar across six districts, involving 91 farmers and covering 6.81 hectares. The year also witnessed considerable infrastructure development, including the upgradation of our open-air interpretation center in the Botanic Garden, thereby serving our educational mission. As part of the community engagement and capacity-building initiatives, the Botanic Garden and Agro-technology group organized 8 trainings on home gardening, bonsai techniques, and dehydrated floral craft at the Botanic Garden. Additionally, 6 trainings were imparted under the CSIR Floriculture Mission focusing on the preparation of Herbal gulal, and 8 under the CSIR Aroma Mission. In addition, 7 skill development programmes were conducted under the CSIR-Integrated Skill Initiative, furthering the commitment to skill enhancement and knowledge dissemination.

The institute has marked noteworthy accomplishments in its quest for excellence and its role in boosting the country's research and development endeavours. We have been awarded six patents within India and have an additional patent pending, which stands as a testament to our ongoing commitment to innovation. In the year 2022-23, we have launched 15 new research projects. Moreover, the institution has successfully commercialized three technologies and has formalized 28 various agreements, including Memorandums of Understanding (MoUs), Memorandums of Agreement (MoAs), and Material Transfer Agreements (MTAs), thereby expanding our collaborative network. In the area of academic publication, we have contributed 177 research papers to SCI-indexed journals, amassing a cumulative impact factor of 639.85. Our dedication to promoting academic excellence has culminated in the awarding of 16 doctoral degrees through the Academy of Scientific and Innovative Research (AcSIR) and other Indian universities.

I extend my heartfelt appreciation to our scientific, technical, and administrative personnel, as well as our students, for their unwavering commitment, zeal, and dedication in upholding the activities of our institution. Further, I seize this moment to convey our earnest gratitude to Dr. Nallathamby Kalaiselvi, Director General of CSIR, for her invaluable support, encouragement, and counsel in the comprehensive science and technology management of our institute. We are indebted to Prof. (Dr.) Paramjit Khurana, Chairperson, along with the esteemed members of the Research and Management Councils of CSIR-NBRI, for their guidance in shaping our research and development and management strategies, and for overseeing the institution's performance and progress. Additionally, we are profoundly thankful to our sponsors, financial backers, industrial partners, collaborators, academic community, and other supporters, including the general public, for their generous support and collaboration in various forms. We acknowledge their supportive actions and anticipate their continued support for our upcoming initiatives.

(Ajit Kumar Shasany)
Director

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सीएसआईआर–एनबीआरआई भारत की पादप विविधता के क्षेत्र में मूलभूत वैज्ञानिक अनुसंधान में अपने विशिष्ट योगदान के लिए प्रसिद्ध है। इसमें पारंपरिक एवं अत्याधुनिक जैव–प्रौद्योगिकी तरीकों और दृष्टिकोणों के माध्यम से व्यवस्थित दस्तावेजीकरण, विवेकपूर्ण संरक्षण और जिम्मेदार तरीके से दोहन शामिल है।

संस्थान बहुआयामी कौशल के साथ कई विषयों में उत्कृष्टता प्राप्त है, जिनमें पादप विविधता की खोज और मूल्यांकन, वर्गीकरण, संरक्षण रणनीतियों का विकास, जीनोमिक्स, तथा पारंपरिक प्रजनन एवं उन्नत आणविक तकनीकों, दोनों के माध्यम से पौधों की प्रजातियों का संवर्धन शामिल हैं, लेकिन यह यहीं तक सीमित नहीं हैं। इसके अतिरिक्त संस्थान विभिन्न अजैविक और जैविक तनावों का सामना करने के लिए डिजाइन किए गए ट्रांसजेनिक पौधों की इंजीनियरिंग, जलवायु परिवर्तन से संबंधित अध्ययनों एवं पादप आधारित उपचार और सूक्ष्म जैविक माध्यम से पर्यावरण प्रदूषण के निवारण में अग्रणी है। यह पादप–सूक्ष्मजीव सहजीवन, पुष्पकृषि, बागवानी और कृषि–तकनीकी प्रगति की भी सक्रिय रूप से जांच करता है। इसके अलावा संस्थान आर्थिक रूप से महत्वपूर्ण पौधों की किस्मों के विकास, औषधि विज्ञान, पादप रसायनिकी के अध्ययन के साथ–साथ न्यूट्रास्यूटिकल्स, कॉस्मास्यूटिकल्स और स्वास्थ्य उत्पादों के जैव पूर्वेक्षण और फॉर्मूलेशन के लिए प्रतिबद्ध है। सामाजिक उत्थान के उद्देश्य से अनेक जनसंपर्क कार्यक्रमों के माध्यम से समाज के साथ जुड़ाव इसके मिशन का अभिन्न अंग है।

सीएसआईआर–एनबीआरआई के लिए वर्ष 2022–23 वैज्ञानिक, तकनीकी और सामाजिक जनसंपर्क क्षेत्रों में बड़ी उपलब्धियों को चिह्नित करता है। इन महत्वपूर्ण मील के पत्थरों का संक्षिप्त सारांश यहां प्रस्तुत है:

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भारत में कई पादप–भौगोलिक क्षेत्रों में व्यापक पादप सर्वेक्षण आयोजित किए गए, जिससे पादप जैवविविधता पर महत्व–पूर्ण डेटा प्राप्त हुआ जिनमें से चंबल के बीहड़ और पचमढ़ी बायोस्फीयर रिजर्व उल्लेखनीय हैं जहाँ से 50 से अधिक अद्वितीय टेरिडोफाइट प्रजातियों की पहचान की गयी है। संरक्षण आकड़ों के लिए 500 से अधिक नमूनों का आंकलन किया गया जिनमें मुख्य रूप से *साइथिया जाईगेंटिया* पर ध्यान केंद्रित किया गया। शिवपुर, मुरैना और भिंड जिलों में सर्वेक्षण से स्थानीय समुदायों द्वारा उपयोग किए जाने वाले लगभग 50 आर्थिक रूप से मूल्यवान औषधीय पौधों की जानकारी प्राप्त हुई, जो संरक्षण प्रयासों की आवश्यकता को रेखांकित करती है। केरल, तमिलनाडु और कर्नाटक में अन्वेषणों से इम्पेशेंस की 15 प्रजातियों के 60 नमूने प्राप्त हुए।

चंबल के बीहड़ों और सुहेलवा वन्यजीव अभयारण्य में सर्वेक्षण के परिणामस्वरूप 550 से अधिक शैवाल नमूने एकत्र किए गए। कुल 284 शैवाल टैक्सा की पहचान की गई, जिनमें *सायनोबैक्टीरिया* और *क्लोरोफाइटा* सबसे विविध फाइला हैं। उल्लेखनीय है कि भारत में पहली बार 15 शुद्ध शैवाल उपभेदों को अलग किया गया और दो जातियों की पहचान की गई।

चंबल और पंजाब में केंद्रित अध्ययनों के परिणामस्वरूप 150 शैक नमूनों का संग्रह हुआ, जिसमें 24 जातियों की 36 प्रजातियों की पहचान की गई। वर्गिकी संशोधनों ने भारत के शैकों में 11 नई प्रजातियों के रिकॉर्ड जोड़े, जिनमें से नौ स्थानिक हैं।

मध्य भारत के लिए स्थानिक पौधे *फाईकस क्युपूलेटा* को पचमढ़ी बायोस्फीयर रिजर्व और तामिया के भीतर 15 स्थानों पर पाए जाने वाले 585 परिपक्व पौधों के साथ 'संकटग्रस्त' के रूप में वर्गीकृत किया गया है। हिमाचल प्रदेश के चंबा जिले के मूल वासी *जैस्मीनम पार्केरी* को 'गंभीर रूप से संकटग्रस्त' रूप में वर्गीकृत किया गया है।

फर्न हाउस में संरक्षण की विभिन्न श्रेणियों से संबंधित फर्न की लगभग 68 प्रजातियों को बनाए रखा और संरक्षित किया गया है। फर्न–हाउस को समृद्ध करने के लिए *लाइकोपोडिएला सेरेनुआ* और *एक्टिनोप्टेरिस रेडिएटा* के जीवित पौधे लाए गए थे।

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अरुणाचल प्रदेश और मणिपुर में अद्वितीय रूपात्मक विशेषताओं के साथ दो नई शैक प्रजातियों, *नेफ्रोमोप्सिस अवस्थियाई* और *पाइरेनुला अवस्थियाई* की पहचान की गई। तीन नई घास प्रजातियों की खोज की गई, जैसे दक्षिणी पश्चिमी घाट में *इस्चेमम सुनीलियाई*, और पश्चिमी हिमालय में *ब्रोमस कश्मीरेंसिस* और *पोआ पिंडारिएंसिस*। उत्तराखंड में नए लाइकेनिकोलस कवक, *एंडोहायलाईना परमोट्रेमेटिस* की खोज की गई।

लाइकेन और लाइकेनाइज्ड कवक के कई नए रिकॉर्ड सामने आए हैं, जिससे भारत के विभिन्न क्षेत्रों में जैव विविधता के बारे में हमारी समझ का विस्तार हुआ है। लाइकेनिकोलस कवक के नए रिकॉर्ड भी रिपोर्ट किए गए, जो भारत में कुछ प्रजातियों के पहली बार दस्तावेजीकरण का प्रतीक है।

वायोला सिनेरिया किस्म *स्टॉकसिआई* को मध्य प्रदेश में 52 साल बाद फिर से खोजा गया है। *बोहेमेरिया क्लिडेमियोइड्स*

को इसके ज्ञात वितरण क्षेत्र का विस्तार करते हुए पहली बार उत्तराखंड में प्रलेखित किया गया। महाराष्ट्र के विदर्भ क्षेत्र में 144 साल बाद *रिंकोसिया सुवेओलेंस* को फिर से खोजा गया है। *एलीमस नेपालेंसिस,* जो पहले नेपाल में पाया जाता था, मणिपुर और नागालैंड की सीमा पर जोउको घाटी में पाया गया है।

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टैरेना फ्लेवा के वर्गीकरण को पूर्व की गलत पहचानों को संबोधित करने के लिए संशोधित किया गया, एवं इसे *टैरेना एशियाटिका* से स्पष्ट रूप से अलग किया गया। *टैरेना फ्लेवा* और इसके हेटरोटाइपिक पर्यायवाची दोनों के लिए नए लेक्टोटाइप नामित किए गए। भारत में *कैम्पैनुला* पर एक व्यापक अध्ययन में कई पादपालयों से परामर्श किया गया और विस्तृत रूपात्मक और शारीरिक विश्लेषण के उद्देश्य से छह राज्यों में क्षेत्रीय संग्रह आयोजित किए गए।

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साइट्रस मेडिका पर आनुवंशिक विविधता अध्ययन से मध्यम विविधता और विभेदन का पता चला, जिसमें दो मुख्य आनुवंशिक समूहों की पहचान की गई। *जिम्नेमा सिल्वेस्ट्रे* की 11 भारतीय आबादियों पर शोध से जनसंख्या के भीतर मध्यम विविधता लेकिन जनसंख्या के बीच उच्च अंतर प्रदर्शित हुआ। जलवायु मॉडल ने 2050 तक निवास स्थान में गिरावट की भविष्यवाणी की लेकिन 2070 तक अनुकूलन क्षमता में वृद्धि प्रदर्शित की। टिकाऊ कृषि एवं प्रजनन के लिए सिफारिशें प्रस्तावित की गई हैं। *क्वार्कस ग्रिफिथिआई* के लिए मैक्सएंट मॉडलिंग 2050 तक निवास स्थान में 36.3% कमी की भविष्यवाणी करता है। आनुवंशिक अध्ययन मध्यम विविधता और उच्च जीन प्रवाह का सुझाव देते हैं, जो पूर्वोत्तर भारत की संरक्षण योजनाओं में सहायता करते हैं।

ikni çlkj

इन–विट्रो बीजाणु संवर्धन से *साइक्लोसोरस* प्रजाति के पौधों का सफलतापूर्वक उत्पादन किया गया जो अब सीएसआईआर–एनबीआरआई के फर्न हाउस में रखे गए हैं। 12 सजावटी फर्नों का बड़े पैमाने पर प्रसार किया गया, जो बिक्री के लिए उपलब्ध हैं। इसके अलावा, आणुविक पूर्वेक्षण के लिए *प्रोनेफ्रियम नुडाटम, टेक्टेरिया कोडुनाटा* और *माइक्रोसोरम स्कोलोपेंड्रियम* का बड़े पैमाने पर प्रचार–प्रसार चल रहा है। विशेष रूप से, गंभीर रूप से संकटग्रस्त फर्न *क्रिस्टेला केंदुझारेंसिस* के बड़े पैमाने पर प्रसार के लिए एक प्रोटोकॉल को अनुकूलित किया गया है, जिसमें प्रभावी खेती के लिए विशिष्ट हार्मोनल संयोजनों की रूपरेखा तैयार की गई है।

ikni l;lk/ku MVkcl

''चंबल के बीहड़ों के पादप संसाधन (पीआरसीआर) – चंबल के बीहड़ों का एक डिजिटल फ्लोरा'' नामक एक विशेष स्थानीय डेटाबेस बनाया गया है। यह डेटाबेस आंतरिक आईपी एड्रेस 192.168.1.214/prcr के माध्यम से उपलब्ध है। वर्तमान में इस डेटाबेस में 36 शैवाल प्रजातियों और 135 पुष्पीय प्रजातियों की जानकारी है।

mRikn fodkl

विभिन्न जैविक गुणों वाले एक ग्लूकोज पॉलिमर बीटा–ग्लूकन को 75 ली बायोरिएक्टर में हेटरोट्रॉफिक सूक्ष्मशैवाल में उत्पादन के लिए अनुकूलित किया गया। माध्यम की संरचना, तापमान और पीएच जैसे मापदंडों को परिष्कृत करके, सूक्ष्मशैवाल ने छठे दिन 58% बीटा–ग्लूकन युक्त 14.6 ग्राम/लीटर शुष्क जैवभार प्राप्त किया। फिर इस बीटा–ग्लूकन को विभिन्न तकनीकों का उपयोग करके निष्कर्षित किया गया, शुद्ध किया गया और विश्लेषण किया गया। इस उत्पादन को बढ़ाने के प्रयास चल रहे हैं।

vk"kf/k foKku] ikni jlk;fudh ,oa mRikn fodkl

çekf.kr lnHk lkexh

जेरेनियोल और (+) लिमोनेन के दूसरे बैच के साथ–साथ एक नई प्रमाणित संदर्भ सामग्री, यूकेलिप्टोल, सफलतापूर्वक तैयार की गयी। जनवरी 2023 में एक निगरानी ऑडिट के बाद, एनएबीएल–गुरुग्राम ने सीआरएम उत्पादन के लिए सीएसआईआर–एनबीआरआई की एनएबीएल मान्यता को जारी रखने का समर्थन किया, और इसके दायरे का विस्तार किया।

lj{k.k v/;;u

विभिन्न स्थानों से 144 चंदन के नमूनों की कार्बन आइसोटोप संरचना ($^{13}C/^{12}C$) पर एक व्यापक अध्ययन पूरा किया गया। यह विभिन्न इलाकों में चंदन की खेती के बारे में हमारी समझ में योगदान देता है।

कर्नाटक में चार स्थानों पर रेड सैंडर्स पेड़ों से 198 हार्टवुड कोर नमूनों स्थिर कार्बन आइसोटोप संरचना ($^{13}C/^{12}C$) का विश्लेषण किया गया। यह इस मूल्यवान प्रजाति की उत्पादकता के संरक्षण और सुधार के प्रयास में महत्वपूर्ण आंकड़े जोड़ता है।

कमल (*नेलुम्बो न्यूसीफेरा*) की तीन किस्मों के विभिन्न भागों में फेनोलिक सामग्री का गहन विश्लेषण पूरा किया गया। गैलिक एसिड के सापेक्ष मापों को मानकीकृत किया गया, जिससे विभिन्न पौधों के हिस्सों में कुल फेनोलिक और फ्लेवोनोइड सामग्री का पता चला, इस प्रकार इस आर्थिक रूप से महत्वपूर्ण पौधे पर आगे के अध्ययन के लिए आधार प्रदान किया गया।

thok.kjk/kh 'kk/k

मल्टी–ड्रग प्रतिरोधी 'सुपरबग' की गंभीर चुनौती, विशेष रूप से *स्यूडोमोनास एरुजिनोसा* पर ध्यान केंद्रित किया गया, जो

नोसोकोमियल संक्रमण और संबंधित मृत्यु दर का एक प्रमुख कारण है। *कोएलरेउटेरिया पैनिकुलेटा* की पत्ती के अर्क का उपयोग करके संश्लेषित सिल्वर नैनोकणों (Ka&AgNPs) को कोरम सेंसिंग (QS) को बाधित करने के लिए सक्षम पाया गया, जो एंटीबायोटिक प्रतिरोध और बायोफिल्म निर्माण के पीछे एक प्रमुख तंत्र है। इन पादप–संश्लेषित नैनोकणों ने जीवाणु कोशिका व्यवहार्यता को प्रभावित किए बिना क्यूएस–विनियमित विषाणु कारकों को रोकने में रासायनिक रूप से संश्लेषित नैनोकणों (Cs&AgNPs) से बेहतर प्रदर्शन किया। आरटी–पीसीआर के माध्यम से आगे सत्यापन ने क्यूएस–विनियमित जीन अभिव्यक्ति के दमन की पुष्टि की। अध्ययन से पता चलता है कि Ka&AgNPs दवा प्रतिरोधी *स्यूडोमोनास एरुजिनोसा* संक्रमण के इलाज के लिए एक आशाजनक अवसर प्रदान करता है।

घाव भरने और जीवाणुरोधी गतिविधि में *एंड्रोग्राफिस पैनिकुलेटा* और *पाइपर लोंगम* से बनाए हर्बल मरहम की चिकित्सीय क्षमता का अध्ययन किया गया। अध्ययन में चूहों में घाव भरने के लिए एक हर्बल मरहम तैयार करने के लिए *पाइपर लोंगम* और *एंड्रोग्राफिस पैनिकुलेटा* की जड़ों का उपयोग किया गया। प्लेसीबो की तुलना में मरहम से घाव तेजी से भरता है और सूजन कम होती है। इसने *एस्चेरिचिया कोलाई* और *स्टिफाइलोकोकस ऑरियस* जैसे सामान्य रोगजनकों के खिलाफ महत्वपूर्ण जीवाणुरोधी गतिविधि का भी प्रदर्शन किया। कोई विषाक्तता या प्रतिकूल प्रभाव नहीं देखा गया, जो सतही अनुप्रयोग की सुरक्षा की पुष्टि करता है।

बायोफिल्म बनाने वाले रोगजनक *एस्चेरिचिया कोलाई* को नियंत्रित करने में औषधीय पौधों की भूमिका का पता लगाया गया। अध्ययन *एस्चेरिचिया कोलाई* के 18 उपभेदों के खिलाफ तीन पौधों के अर्क की जीवाणुरोधी और एंटी–बायोफिल्म गतिविधियों का पता लगाता है। दो अर्क, एनबीआरआई पीएस1 और एनबीआरआई पीएस3, ने एनबीआरआई पीएस2 की तुलना में जीवाणुओं के विकास और बायोफिल्म निर्माण को रोकने में उच्च प्रभावकारिता का प्रदर्शन किया। विशेष रूप से, एनबीआरआई पीएस3 ने उच्च एंटीऑक्सीडेंट गतिविधि दिखाई, जो इसके संभावित फार्मास्युटिकल अनुप्रयोगों को दर्शाता है, विशेष रूप से बायोफिल्म बनाने वाले *एस्चेरिचिया कोलाई* के खिलाफ।

vk"k/kh; ik/kk ij v/;;u

स्ट्रेप्टोजोटोसिन–प्रेरित मधुमेह चूहों में *मुकुना प्रूरीन्स* पौधे के विभिन्न भागों के मधुमेह विरोधी गुणों का मूल्यांकन किया गया। अर्क ने भोजन और पानी के सेवन को प्रभावित किए बिना रक्त शर्करा के स्तर और मूत्र शर्करा जैसे मार्करों में काफी सुधार किया। फेनोलिक यौगिकों और फ्लेवोनोइड्स जैसे पादप–घटकों की उपस्थिति इन प्रभावों के लिए जिम्मेदार हो सकती है।

गेंदा (*टैगेट्स इरेक्टा*) और शहतूत (*मोरस नाइग्रा*) की रोगाणुरोधी क्षमता और रासायनिक संरचना की जांच की गई। फूल और फल दोनों के अर्क में उच्च नमी की मात्रा पाई गई। अर्क ने मजबूत रोगाणुरोधी गतिविधि प्रदर्शित की, जिससे प्राकृतिक रंगों और स्वास्थ्य पूरकों में उपयोग की उनकी क्षमता का पता चलता है। जीसी–एमएस विश्लेषण से *टैगेट्स इरेक्टा* और *मोरस नाइग्रा* दोनों में हेक्साडेकैनोइक एसिड और मायो–इनोसिटोल जैसे प्रमुख यौगिकों का पता चला। *मोरस नाइग्रा* में तेरह विभिन्न यौगिकों की पहचान की गई, जो विविध उपापचय प्रोफाइल और संभावित अनुप्रयोगों का संकेत देते हैं।

कैथ (*लिमोनिया एसिडिसिमा*) की पत्तियों में क्वेरसेटिन और स्टिगमास्टरोल जैसे सक्रिय यौगिकों की मात्रा निर्धारित करने के लिए एक एचपीटीएलसी विधि विकसित की गई थी। इस विधि ने अच्छी परिशुद्धता प्रदर्शित की है और इसका उपयोग विभिन्न कच्ची दवाओं और अर्क में इन यौगिकों के नियमित विश्लेषण के लिए किया जा सकता है।

कैसिया की चार प्रजातियों की पत्तियों का उनकी पादप रसायनिकी सामग्री और एंटीऑक्सीडेंट गतिविधि के लिए विश्लेषण किया गया। *कैसिया सुरैटेंसिस* ने महत्वपूर्ण एंटीऑक्सीडेंट क्षमता दिखाई, जो ऑक्सीडेटिव तनाव से संबंधित बीमारियों के लिए इसके संभावित चिकित्सीय अनुप्रयोगों का सुझाव देती है।

अकेशिया निलोटिका के बीज के विभिन्न भागों का पादप–रसायनिकी और एंटीऑक्सीडेंट गतिविधि के लिए विश्लेषण किया गया। भ्रूणकोष ने उच्च एंटीऑक्सीडेंट गतिविधि प्रदर्शित की, जबकि बीजपत्र पोषक तत्वों से भरपूर था। अध्ययन से संकेत मिलता है कि *अकेशिया निलोटिका* के बीज पोषक तत्वों की खुराक और स्वास्थ्य को बढ़ावा देने वाले बायोएक्टिव अर्क के स्रोत के रूप में काम कर सकते हैं।

vk"k/kh; ik/kk dk ikjifjd nkok dk lR;kiu

प्रभाग ने पारंपरिक रूप से महत्वपूर्ण औषधीय पौधों जैसे *थैलिक्ट्रम फोलियोलोसम, महोनिया* प्रजाति और अन्य पर व्यापक औषधीय और पादप–रसायनिक अध्ययन किए। *इन–विट्रो* जैविक जांच के माध्यम से, इन पौधों के पारंपरिक औषधीय दावों की पुष्टि की गई। विशेष रूप से, *एंटाडा रीडियाई* के बीज प्रोटीन, कम–ग्लाइसेमिक इंडेक्स वाले कार्बोहाइड्रेट, फाइबर और आवश्यक तत्वों से भरपूर पाए गए। *थैलिक्ट्रम फोलियोलोसम* पर एक अन्य अध्ययन ने यूरोलिथियाटिक स्थितियों और सूजन के खिलाफ इसकी प्रभावशीलता की पहचान की, जिसमें बर्बेरिन और पामिटाइन को प्रमुख जैव सक्रिय यौगिकों के रूप में शामिल किया गया।

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सेंटेला एशियाटिका के विशिष्ट रसायन प्रकारों और उपयुक्त कृषि क्षेत्रों की पहचान करने पर ध्यान केंद्रित किया गया। 109 जर्मप्लाज्मों के संग्रह को रासायनिक प्रोफाइलिंग और

पारिस्थितिक निश मॉडलिंग (ईएनएम) के अंतर्गत अध्ययन किया गया। अध्ययन ने विभिन्न प्राकृतिक आबादियों के बीच एशियाटिक एसिड और मैडेकैसिक एसिड जैसे बायोएक्टिव यौगिकों में भिन्नता को इंगित किया। इससे ''कस्टम–निर्मित कीमोटाइप्स'' की पहचान हुई, जो विशेष रूप से बायोएक्टिव मेटाबोलाइट्स में समृद्ध हैं और इन केमोटाइप्स के लिए स्थान–विशिष्ट पर्यावरण–क्षेत्रों की मैपिंग की गई।

çk–frd ijdk dk fodkl

गठिया की स्थिति के लिए सात औषधीय पौधों से तैयार एक हर्बल पूरक सफलतापूर्वक विकसित किया गया। मानक दवा कोल्चीसिन की तुलना में, पूरक ने रक्त में यूरिक एसिड के स्तर में 80% की कमी और इन्फ्लेमेटरी मेडीएटर्स में 70% की कमी देखी। इसने दर्द से राहत और हरकत में सुधार भी प्रदर्शित किया।

एक न्यूट्रास्युटिकल फॉर्मूलेशन विकसित किया गया था जो *एस्चेरिचिया कोलाई* और *साल्मोनेला* प्रजाति जैसे डायरिया पैदा करने वाले कारकों का प्रभावी ढंग से दमन करता है। यह उत्पाद गैस्ट्रोइंटेस्टाइनल माइक्रोफ्लोरा को भी बनाए रखता है, आवश्यक पोषक तत्वों की पूर्ति करता है, और दस्त की स्थिति के दौरान जिंक की कमी को पूरा करता है।

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यह प्रभाग आयुर्वेद और पारंपरिक ज्ञान को बढ़ावा देने के उद्देश्य से विभिन्न व्याख्यानों और शिविरों के माध्यम से शैक्षिक जनसंपर्क में लगा हुआ है। श्री रामचन्द्र वैद्य आयुर्वेदिक मेडिकल कॉलेज और बाबू युगराज सिंह आयुर्वेदिक मेडिकल कॉलेज जैसे शैक्षणिक संस्थानों में कार्यक्रम आयोजित किए गए।

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इसके तीन प्रभाग हैं, पादप पारिस्थितिकी और जलवायु परिवर्तन विज्ञान, सूक्ष्मजीव प्रौद्योगिकी और पर्यावरण प्रौद्योगिकी। इन तीन प्रभागों द्वारा किए गए कार्यों को निम्नलिखित शीर्षकों के अंतर्गत संक्षेपित किया गया है:

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वर्ष 2050 के लिए जलवायु परिदृश्यों के लिए भारत के मेघालय में तीन खतरे वाली *आइलेक्स* प्रजातियों, जैसे *आइलेक्स खासियाना, आइलेक्स वेनुलोसा* और *आइलेक्स एम्बेलिओइड्स* के अनुकूलन की जांच की गई। *आइलेक्स खासियाना* बढ़े हुए तापमान और नमी तनाव के प्रति संवेदनशील है, जबकि *आइलेक्स वेनुलोसा* और *आइलेक्स एम्बेलिओइड्स* मुख्य रूप से तीव्र नमी से प्रभावित होते हैं, जो संरक्षण अनुरूप रणनीतियों के महत्व पर जोर देते हैं।

जैव जलवायु मॉडलिंग और मुक्त वायु CO_2/O_3/तापमान संवर्धन (FACE) प्रयोगों का उपयोग करते हुए एक अध्ययन में जलवायु परिवर्तन, विशेष रूप से बढ़ते तापमान के कारण भारत में गेहूं की खेती के लिए उपयुक्त क्षेत्रों में कमी का अनुमान लगाया गया है। आमतौर पर उगाई जाने वाली आठ गेहूं की किस्मों में से केवल दो ने भविष्य के इन परिदृश्यों के खिलाफ लचीलापन प्रदर्शित किया, जो फसल अनुकूलन और शमन रणनीतियों की तत्काल आवश्यकता पर प्रकाश डालता है।

शहरी वानिकी में कार्बन पृथक्करण अध्ययन से पता चला है कि *टेक्टोना ग्रैंडिस* जैसे देशी उष्णकटिबंधीय पेड़ शहरी परिस्थितियों में कार्बन जब्ती और अन्य पारिस्थितिक लाभों में अन्य प्रजातियों से काफी बेहतर प्रदर्शन करते हैं। इन निष्कर्षों से पता चलता है कि *टी. ग्रैंडिस* को प्राथमिकता देने से शहरी कार्बन पृथक्करण प्रयासों में तेजी आ सकती है।

जमीनी ओजोन के बढ़े हुए स्तर पर नौ आम शहरी उष्णकटिबंधीय वृक्ष प्रजातियों की प्रतिक्रिया का अध्ययन किया गया। *एजाडिरेक्टा इंडिका* और *नेरियम इंडिकम* ने उच्च ओजोन स्थितियों के तहत रंध्र चालन में वृद्धि देखी, जबकि अन्य प्रजातियों ने प्रकाश संश्लेषण और वाष्पोत्सर्जन दर में कमी का अनुभव किया। *फाईकस रिलिजियोसा* और *सराका असोका* जैसी प्रजातियों ने उच्च ओजोन स्तरों के प्रति अधिक सहनशीलता प्रदर्शित की, जिससे वे भविष्य की शहरी वानिकी पहल के लिए मजबूत उम्मीदवार पाए गए। इसके विपरीत, *बोगेनविलिया स्पेक्टाबिलिस* और *एजाडिरेक्टा इंडिका* को सबसे संवेदनशील पाया गया, जिससे शहरी हरियाली के लिए इनके प्रयोग हेतु सतर्क विचार की आवश्यकता पड़ी।

ikni of) ,oa ruko lgu'khyrk

वाणिज्यिक फसल सोया में चारकोल रॉट रोग को दमन करने में *बैसिलस सबटिलिस* एम–4 (एनएआईएमसीसी–बी–03238) की भूमिका स्थापित की गई।

बैसिलस सबटिलिस पीबीई–8 (एमटीसीसी 25189) ने *फ्यूसेरियम ऑक्सीस्पोरम* प्रभेद प्रजाति *लाइकोपर्सिसि* (एफओएल) के खिलाफ प्रभावी जैव–नियंत्रण का प्रदर्शन किया है।

कपास की किस्मों में सूखा सहनशीलता तंत्र पर अध्ययन से पता चला है कि एलआरए–5166 कपास किस्म ने एनबीआरआई–67 किस्म की तुलना में बेहतर सहनशीलता प्रदर्शित की है, जिसका मुख्य कारण इसका उच्च रंध्र घनत्व और अधिक कुशल रंध्र विनियमन है। ईपीएफ2, एसडीडी1 और टीएमएम जैसे प्रमुख रंध्र जीनों को दोनों किस्मों में जल तनाव की स्थिति के तहत अप–रेगुलेट किया गया था। इस आनुवंशिक अनुकूलन ने पानी के उपयोग की दक्षता में प्रभावी ढंग से सुधार किया और सूखे के प्रति पौधे की प्रतिरोधक क्षमता को बढ़ा दिया।

चावल में सूखा सहनशीलता पर एक व्यापक अध्ययन में, उत्तर प्रदेश में खेती की जाने वाली आठ किस्मों में से मेंहदी (एच) और किरण (के) किस्मों को क्रमशः सूखा–सहिष्णु और संवेदनशील के रूप में पहचाना गया।

नमक और सूखे की तनाव की स्थिति में कार्बोहाइड्रेट और वसीय अम्ल उपापचय को नियंत्रित करके चावल के अंकुर के विकास को बढ़ाने में जीवाणु *बैसिलस एमाइलोलिकफेसिएन्स* एसएन13 की भूमिका को स्पष्ट किया गया।

बैसिलस सबटिलिस (एनबीआरआई–डब्ल्यू9) ने रासायनिक कवकनाशी प्रोपिकोनाजोल से प्रभावित टमाटर के पौधों में उपापचय होमियोस्टैसिस को प्रभावी ढंग से बहाल किया। जैव कवकनाशी से विभिन्न मेटाबोलाइट्स में उल्लेखनीय वृद्धि हुई, ऑक्सीडेटिव तनाव कम हुआ और पौधों की प्रतिरक्षा से संबंधित जीन अभिव्यक्ति में वृद्धि हुई। नतीजतन, इसने कृषि के लिए अधिक टिकाऊ दृष्टिकोण का समर्थन करते हुए, जीवाणु रोगजनकों की उपस्थिति में उत्पादकता में पांच गुना तक सुधार किया।

बैसिलस संघ को *एराबिडोप्सिस* में लवण सहनशीलता बढ़ाने वाला पाया गया। ये जीवाणु जीन अभिव्यक्ति और उपापचय मार्गों में परिवर्तन करके पौधों के विकास पर सकारात्मक प्रभाव डालते हैं। निष्कर्षों से पता चलता है कि जीवाणु संघ लवणता के खिलाफ फसल के लचीलेपन को बढ़ाने के लिए एक जैव प्रौद्योगिकी उपकरण के रूप में काम कर सकता है।

अलग–अलग CO_2 और ओजोन परिस्थितियों में उगाई गई दो गेहूं की किस्मों पर एथिलीनडाईयूरिया (EDU) के सुरक्षात्मक प्रभावों का आकलन किया गया। ईडीयू उपचार ने, विशेष रूप से ऊंचे CO_2 स्तरों के तहत वृद्धि, क्लोरोफिल मात्रा और उपज को बढ़ाया।

किस्म WH–1105 की पहचान ओजोन के प्रति अधिक संवेदनशील किस्म के रूप में की गई। इसके अतिरिक्त, EDU ने ओजोन तनाव और अनाज पोषक तत्व सामग्री में CO_2–प्रेरित गिरावट, दोनों के नकारात्मक प्रभावों को प्रभावी ढंग से कम किया।

गेहूं को ओजोन क्षति से बचाने में बायोजेनिक सिल्वर नैनोकणों (बी–एजीएनपी) और ईडीयू की प्रभावशीलता की तुलना की गई। दोनों उपचारों से विकास और उपज में उल्लेखनीय सुधार हुआ, साथ ही डीबीडब्ल्यू–17 किस्म ने बेहतर प्रतिक्रिया दिखाई। ओजोन से संबंधित उपज हानि का मुकाबला करने में बी–एजीएनपी को ईडीयू जितना ही प्रभावी पाया गया, जिससे भविष्य की सुरक्षात्मक रणनीतियों के लिए एक आशाजनक विकल्प पेश किया गया।

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सीएसआईआर–एनबीआरआई के पर्यावरण प्रौद्योगिकी प्रभाग ने कृषि मृदा में माइक्रोप्लास्टिक की मात्रा निर्धारित करने के लिए एक विश्वसनीय तरीका विकसित किया है, जिससे 90% से अधिक रिकवरी प्राप्त हुई है। लखनऊ के आसपास के क्षेत्र में एक पायलट अध्ययन में अपशिष्ट डंप और आर्द्रभूमि के पास कृषि क्षेत्रों सहित विभिन्न स्थलों में माइक्रोप्लास्टिक संदूषण का आंकलन किया गया।

48 घंटों के भीतर मुक्त साइनाइड में 99% की कमी हासिल करने के लिए कॉलम–आधारित अध्ययन में कवक, *ट्राइकोडर्मा सैटर्निसपोरम* और *ट्राइकोडर्मा सिट्रिनोविराइड* के एक नए संघ का उपयोग किया गया था। यह गतिविधि जीएसजी/जीएसएसएच अनुपात पर निर्भर पाई गई, जो फर्स्ट ऑर्डर काइनेटिक मॉडल के अनुकूल है।

बैटरी अपशिष्ट से दूषित मिट्टी में *हेलिएंथस एनुअस* की पादप उपचार प्रभावकारिता को दो जीवाणु उपभेदों यानी *ब्रुसेला इंटरमीडियम* (ई1) और *बैसिलस वेलेजेंसिस* (ईडब्ल्यू8) के माध्यम से काफी बढ़ाया गया था, जिससे मिट्टी की गुणवत्ता में सुधार हुआ।

चार प्रमुख फसलों के अंकुरण और प्रारंभिक विकास चरणों पर फ्लोराइड (एफ–) की अलग–अलग सांद्रता के प्रभावों की जांच की गई। *ट्रिटिकम एस्टिवम* को सबसे संवेदनशील के रूप में पहचाना गया, जबकि *पेनिसेटम ग्लौकम* ने उच्चतम सहनशीलता प्रदर्शित की। अध्ययन यह समझने में सहायता करता है कि फ्लोराइड जैसे अजैविक तनाव कारक फसल की उपज और गुणवत्ता को कैसे प्रभावित करते हैं, जिससे पर्यावरणीय तनाव के तहत फसल के लचीलेपन में अंतर्दृष्टि मिलती है।

चावल में आर्सेनिक तनाव को कम करने के लिए जीवाणु (*सिट्रोबैक्टर*) और मिथाइलट्रांसफेरेज युक्त *पी. ओलेवोरन्स* के साथ यीस्ट (*डेबरोमाइसेस हंसेनी*) का एक सूक्ष्मजैविक संघ विकसित किया गया है। प्रारंभिक निष्कर्ष चावल के पौधों में आर्सेनिक कमी में इस दृष्टिकोण की प्रभावशीलता को प्रदर्शित करते हुए आशाजनक दिखते हैं। उनकी भूमिका को उपकोशिकीय वितरण, एसईएम–ईडीएस और ट्रांसक्रिप्टोम विश्लेषण द्वारा मान्य किया गया है।

शोध में पाया गया कि *राइजोक्टोनिया सोलेनी* में हाइपरमेथिलेशन *बैसिलस एमाइलोलिकफेशियन्स* के साथ संपर्क करने पर होता है, जिससे चावल में शीथ ब्लाइट रोग के प्रबंधन के नए तरीके सामने आ सकते हैं।

3 कवक और 4 बैक्टीरिया से युक्त एक नव विकसित सूक्ष्म जैविक संघ चावल के भूसे के यथास्थान अपघटन के लिए आशाजनक परिणाम दिखाता है, जिससे मृदा स्वास्थ्य में सुधार होता है और पर्यावरण प्रदूषण में कमी आती है। इसकी डीआरसी क्षेत्र, बंथरा में पुष्टि की जा रही है, और कम पर्यावरणीय प्रदूषण और कम रासायनिक इनपुट के साथ यह अत्यधिक सामाजिक महत्व का होगा।

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सफेद मक्खी के खिलाफ टीएमए12 जीएम कपास का दूसरे वर्ष का प्रदर्शन मूल्यांकन परीक्षण क्रमशः पीएयू, लुधियाना और सीआईसीआर, नागपुर के सहयोग से फरीदकोट, पंजाब और सिरसा, हरियाणा में आयोजित किया गया।

आईसीएआर–आईआईवीआर वाराणसी में, टमाटर और पपीते में सफेद मक्खी से होने वाली वायरल बीमारियों से सुरक्षा के लिए Msc14 GM गार्ड कॉटन पर दूसरे वर्ष का प्रदर्शन मूल्यांकन परीक्षण आयोजित किया गया।

Pnu08 GM कपास लाइनों की T3 पीढ़ी तक उन्नति हासिल की गई। 907 लेबल युक्त एक प्रसंग, जो सफेद मक्खी की आबादी को 60–70% तक कम करने में प्रभावी थी, को बिना किसी विकल्प और बहु–विकल्प वाली सफेद मक्खी बायोएसे के माध्यम से चुना गया।

पिंक बॉलवॉर्म और लीफ आर्मीवॉर्म से अभिव्यक्ति और सुरक्षा के लिए Cry1EC GM कपास लाइनों को T2 पीढ़ी में उन्नत और मूल्यांकन किया गया था। इवेंट चयन परीक्षण के लिए पांच आशाजनक पंक्तियों का चयन किया गया।

Tma12 को लाईटिक पॉलीसेकेराइड मोनोऑक्सीजिनेज (एलपीएमओ) के रूप में स्थापित किया गया था, और इसकी एलपीएमओ गतिविधि कीटनाशक कार्रवाई से जुड़ी थी। यीस्ट में Tma12 की अभिव्यक्ति के लिए एक प्रोटोकॉल स्थापित किया गया।

उस तंत्र को स्पष्ट किया गया जिसके माध्यम से Msc14 सफेद मक्खी के लिए विषैला होता है। कीट के मध्य आंत में कई पाथवे सक्रिय हो गए, जिससे पोषक तत्वों के अवशोषण पर नकारात्मक प्रभाव पड़ा।

ट्रांसजेनिक टमाटरों में *हेलिकोवर्पा आर्मिगेरा* और *स्पोडोप्टेरा लिटुरा* के खिलाफ प्रतिरोध में वृद्धि तब देखी गई जब संशोधित *कोकुलस हिर्सुटस* ट्रिप्सिन अवरोधक (सीएचटीआई) को व्यक्तिगत रूप से या Bt&Cry1विष के साथ संयोजन में व्यक्त किया गया। बिना किसी यील्ड पेनाल्टी के संपूर्ण कीट मृत्यु दर देखी गई।

ट्रांसजेनिक कपास के पौधों में *एस्परजिलस नाइजर* पेक्टिन मिथाइलएस्टरेज की अत्यधिक अभिव्यक्ति मेथनॉल उत्सर्जन को बढ़ाने और कीटों के प्रति प्रतिरोध प्रदान करने के लिए देखी गई। लीफ डिस्क एसेज और इन–प्लांटा बायोएसेज ने रस–चूसने वाले कीटों की आबादी में 50–60% की कमी का संकेत दिया।

एक घाव–प्रेरित प्रमोटर के तहत cry1Ac अभिव्यक्ति के साथ ट्रांसजेनिक चना लाइनें विकसित की गई हैं। टी2 पीढ़ी के पौधों पर जीन अभिव्यक्ति अध्ययन किए जा रहे हैं, जिनका बाद में कीट सहनशीलता के लिए विश्लेषण किया जाएगा।

फ्यूसेरियम ऑक्सीस्पोरम फॉर्म प्रजाति *सिसरिस* नामक एक कवक, जो संवहनी विल्ट और महत्वपूर्ण उपज हानि के लिए जिम्मेदार है, को एक गंभीर चुनौती के रूप में पहचाना गया है। प्रतिरोधी जर्मप्लाज्म से जीन को लक्षित करने के लिए एक ट्रांसजेनिक दृष्टिकोण की योजना बनाई गई है। संक्रमण के प्रारंभिक चरण में *फ्यूसेरियम* के प्रति उनकी प्रतिक्रिया के बाद, विल्ट–प्रतिरोधी जीनोटाइप की जड़ के जाइलम में अप–रेगुलेटेड जीन (टीएलपी 1, पीजीआईपी 2, जीआरएक्सएस 2, एलटीपी 1 और एसएन 2) को जीनोम संपादन के लिए चुना गया है।

कीट संक्रमण के दौरान तनाव सहिष्णुता प्रदान करने में एचएटी और एचडीएसी जीन की संभावित भूमिका प्रस्तावित की गई है। प्रारंभिक सत्यापन के लिए ट्रांसक्रिप्टोमिक डेटा का उपयोग किया गया है, और कार्यात्मक सत्यापन की योजना बनाई गई है।

पैर विच्छेदन के बाद अलग–अलग अंतराल पर *कीलोमेनेस सेक्समैक्युलाटा* पर *डी नोवो* ट्रांसक्रिप्टोम विश्लेषण किया गया। चार जीनों (एंग्रेल्ड, डिशेवेल्ड और क्यूबिटस इंटरप्टस) की पहचान की गई और क्यूआरटी–पीसीआर के माध्यम से आगे इनकी पुष्टि की गई। पुनर्जनन में शामिल जीन की कार्यात्मक रूप से पुष्टि करने के लिए वर्तमान में *इन विट्रो* ट्रांसक्रिप्शन प्रक्रिया को क्रियान्वित किया जा रहा है।

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अच्छी तरह से सिंचित परिस्थितियों में जड़ और पौधों की वृद्धि में सुधार करने और सूखा सहनशीलता प्रदान करने के लिए एक जीन, GhNAC2 की पहचान की गई थी। इसके तंत्र को समझने के लिए अध्ययन वर्तमान में आयोजित किए जा रहे हैं।

गोसीपियम हिर्सुटम के 320 कोर जर्मप्लाज्मों को शामिल करते हुए एक बहु–स्थान परीक्षण पूरा किया गया। कृषि संबंधी महत्वपूर्ण लक्षणों से संबंधित उच्च गुणवत्ता वाले 27 फेनोटाइपिक आंकड़े उत्पन्न किए गए, और जीडब्ल्यूएएस विश्लेषण के माध्यम से 8,000 से अधिक संभावित मार्करों की पहचान की गई।

सब्जियों को आर्सेनिक जोखिम के एक महत्वपूर्ण स्रोत के रूप में पहचाना गया है, जो भूजल और चावल–आधारित आहार के बाद तीसरे स्थान पर है। AsMT गतिविधि वाले सूक्ष्मजीवों की खोज की गई है, जो सब्जी की विभिन्न फसलों में आर्सेनिक शमन के लिए संभावित मार्ग प्रदान करते हैं। इस प्रगति से उन्नत कृषि पद्धतियों के माध्यम से मानव हेतु आर्सेनिक जोखिम को कम करने का अनुमान है, जो सार्वजनिक स्वास्थ्य सुरक्षा की दिशा में एक महत्वपूर्ण कदम है।

कई मेटल ट्रांसपोर्टर जीन (Lsi1, Lsi2, NRAMP, NIP3;1, और INT सहित) द्वारा चावल में आर्सेनिक ग्रहण और परिवहन की मध्यस्थता का दस्तावेजीकरण किया गया है। इन जीनों के लिए नॉक–आउट लाइनें CRISPR/Cas9 प्रणाली का उपयोग करके तैयार की गई हैं, जिसका उद्देश्य चावल के दानों में आर्सेनिक संचय को कम करना है। फेनोटाइपिक और आणुविक दोनों स्तरों पर इन आनुवंशिक संशोधनों के प्रभावों को भविष्य के मूल्यांकन के लिए निर्धारित किया गया है।

एराबिडोप्सिस वृद्धि और बीज निर्माण में RabC1 GTPase की महत्वपूर्ण भूमिका का प्रदर्शन किया गया है।

एफ1 संकरों में हेटेरोसिस और एंडोरेडुप्लीकेशन के बीच एक आणुविक लिंक की पहचान फेनोटाइपिक आंकड़ों और पॉलीप्लोइडी विश्लेषण के माध्यम से की गई है। एंडोरेडुप्लिकेशन के दौरान उप–जीनोम प्रभुत्व के मूल जीनोम की एपिजेनेटिक स्थिति से जुड़ा होने की पुष्टि की गई है।

पौधों में संशोधित न्यूक्लियोसोम की जांच के लिए नाभिक अलगाव विधि का मानकीकरण किया गया है। MNase पाचन जैसी डाउनस्ट्रीम प्रक्रियाओं के लिए उपयुक्त के रूप में इस प्रोटोकॉल की पुष्टि की गई है।

उच्च और निम्न ऊंचाईयों से प्राप्त *एराबिडोप्सिस थैलियाना* आबादियों में उच्च CO_2 से प्रेरित डीएनए मिथाइलेशन में स्थानीय भिन्नताएं देखी गई हैं। इन आबादी में विभेदक जीन मिथाइलेशन की भी पुष्टि की गई।

काबुली चना MT1 जीन को अत्यधिक अभिव्यक्त करने वाली *एराबिडोप्सिस* लाइनों द्वारा जहरीली भारी धातुओं के प्रति बढ़ी हुई सहनशीलता प्रदर्शित की गई है। इन ट्रांसजेनिक लाइनों में उन्नत रक्षा प्रणालियाँ और कम तनाव मार्कर देखे गए हैं।

फार रेड सिग्नलिंग मार्ग में LAF1 की भूमिका का अध्ययन करने के लिए ट्रांसजेनिक लाइनें तैयार की गई हैं, और उनके फेनोटाइपिक लक्षणों के वर्णन का कार्य प्रगति पर है।

मेथनॉल उत्सर्जन को बढ़ाने के लिए WsPME28 को अधिक अभिव्यक्त करने वाले ट्रांसजेनिक तम्बाकू पादप विकसित किए गए हैं। इन पौधों में मेथनॉल सामग्री में 8 गुना वृद्धि और मेथनॉल उत्सर्जन में 12 गुना वृद्धि देखी गई है।

उच्च मेथनॉल उत्सर्जित करने वाले ट्रांसजेनिक पौधों का उपयोग प्रणालीगत–प्रेरित रक्षा प्रतिक्रिया अध्ययनों के लिए किया गया है। इस आणविक अध्ययन के लिए वायु–प्रवाह कैबिनेट कक्षों का निर्माण किया गया है।

इन कक्षों के भीतर पौधों से पत्ती के नमूने आरएनए और प्रोटीन अलगाव के लिए तीन अलग–अलग समय बिंदुओं (0 घंटे, 2 घंटे और 24 घंटे) पर एकत्र किए गए हैं। गुणवत्ता जांच के बाद, इन नमूनों का ट्रांसक्रिप्टोम और प्रोटीओम अनुक्रमण हेतु अध्ययन किया गया।

नेगेटिव बाईनोमियल डिस्ट्रीब्यूशन मॉडल के आधार पर क्म्मि पैकेज का उपयोग करके विभेदक जीन अभिव्यक्ति विश्लेषण किया गया। प्रारंभिक निष्कर्षों ने जैस्मोनिक अम्ल जैव संस्लेषण मार्ग और इसके सिग्नलिंग में शामिल जीन (CYP94B, AOS, JAZ8, AOC, LOX2, और MYC2) में महत्वपूर्ण अप–रेगुलेशन की पहचान की है।

छह ब्रायोफाइट प्रजातियों में आर्सेनिक सहिष्णुता की जांच की गई, जिसमें *मार्कैशिया पॉलीमोर्फा* ने AsIII के संपर्क में आने पर सबसे अधिक आर्सेनिक संचय दिखाया। आर्सेनिक तनाव सहिष्णुता के पीछे आणुविक तंत्र का अध्ययन करने के लिए ट्रांसक्रिप्टोमिक विश्लेषण किया गया था। यह कार्य आर्सेनिक तनाव के प्रति उन्नत लचीलेपन के साथ ट्रांसजेनिक पौधों को विकसित करने की संभावनाएं प्रदान करता है।

Qyk ,oa Qyk dh 'kYQ ykbQ c<kuk

जड़ विकास और संरचना पर केंद्रित अध्ययन में, एचएसएफ, एमवाईबी, डब्ल्यूआरकेवाई और स्टार्ट डोमेन परिवारों से जीन की परिवर्तित अभिव्यक्ति के साथ ट्रांसजेनिक लाइनों का विश्लेषण किया जा रहा है। टमाटर की जड़ की वृद्धि को प्रभावित करने में एबीए, एथिलीन, स्ट्रिगोलैक्टोन और जीए की भूमिका का प्रदर्शन किया गया है।

फलों के विकास और पकने से संबंधित शोध में, एबीए, एथिलीन, ऑक्सिन और जीए के बीच बातचीत की पहचान की गई और वर्तमान में एपी2/ईआरएफ डोमेन परिवार से जीन के ट्रांसजेनिक हेरफेर के माध्यम से आगे की खोज की जा रही है।

सुगंधित गुलाबों में आणुविक आधार और विच्छेदन के हार्मोनल नियंत्रण पर शोध में, एथिलीन और जैस्मोनिक अम्ल और सैलिसिलिक अम्ल जैसे अन्य हार्मोन के बीच संपर्क देखा गया है। जबकि विच्छेदन में देरी करने में जैस्मोनिक अम्ल की भूमिका की पहचान की गई है और सैलिसिलिक अम्ल विच्छेदन को बढ़ावा देने के लिए पाया गया है, खासकर उच्च सांद्रता में। विच्छेदन के संदर्भ में इन मार्गों को नियंत्रित करने वाले नियामक तंत्र वर्तमान में जांच के अधीन हैं।

फल पकने के प्रारंभिक चरणों में, दो एचएसपी90 चौपरोन जैसे जीनों को अप–रेगुलेशन के लिए लक्षित किया गया। उत्परिवर्तन के लिए जीनोम–संपादित पौधों की जांच की गई, और विभिन्न इंडल्स की खोज की गई। उन्नत पीढ़ी के अध्ययन और फेनोटाइपिक विश्लेषण ने सुझाव दिया कि संपादित सीआरआईएसपीआर लाइनों में नियंत्रण की तुलना में बेहतर विकास विशेषताएं देखी गयीं। चल रहे अध्ययन उपापचय आंकड़ों और फल पकने पर केंद्रित हैं।

फलों के पकने से संबंधित छोटे आरएनए की पहचान विभिन्न चरणों में की गई और उनकी विभेदक अभिव्यक्ति की पुष्टि की गई। miR159 के लिए पेप्टाइड परीक्षण भी किए गए।

dEI;wVs'kuy tSfodh ,oa thukfeDl

कम्प्यूटेशनल जीव विज्ञान में, विभिन्न पर्यावरणीय कारकों के प्रति तनाव सहनशीलता प्रतिक्रियाओं का अध्ययन किया गया है। सूखे और नमक तनाव की स्थिति से जुड़े प्रमुख नियामक जीन की पहचान की गई है।

लॉन्ग रीड्स के लिए PacBioHiFi और शोर्ट रीड्स के लिए इलुमिना हाईसेक का उपयोग करके, 108 पंखुड़ियों वाले भारतीय कमल के जीनोम को अनुक्रमित किया गया। असेंबली ने 99.3% पूर्णता दर का संकेत दिया। चीन के प्राचीन जीनोम की तुलना में बड़ी संख्या में अनुक्रम भिन्नताएँ देखी गईं। ट्रांसक्रिप्टोमिक विश्लेषण ने विभिन्न नमूनों में भिन्न रूप से व्यक्त जीन की पहचान की।

कॉमिफोरा वाइटी और *कॉमिफोरा अगालोचा* में विभिन्न ऊतकों के ट्रांसक्रिप्टोमिक विश्लेषण के माध्यम से गुग्गुलस्टेरोन और जर्मेक्रोन संश्लेषण से संबंधित प्रमुख जीन की पहचान की गई।

ikni vkuqf'kd lalk/ku ,oa lajkj

Qyksa dh ubZ fdLeksa dk fodkl

क्राईसेंथेमम मोरिफोलियम की नई उत्परिवर्ती लाइनों, संकरों और बौने/प्रकाश–असंवेदनशील चयनों का प्रसार सकर्स से प्राप्त किया गया और बाद में कटिंग के माध्यम से प्रसार किया गया। चयनित म्यूटेंट और नियंत्रित नमूनों के पुष्प ऊतकों पर व्यापक संपूर्ण ट्रांसक्रिप्टोमिक अनुक्रमण भी निष्पादित किया गया था, जिसका विश्लेषण वर्तमान में चल रहा है।

इस वर्ष की शुरुआत में लक्षित *ग्लेडियोलस* प्रजनन के क्षेत्र में, अंतर–किस्मीय संकर बीजों की एक महत्वपूर्ण मात्रा उत्पन्न की गई, कटाई की गई, और इष्टतम परिस्थितियों में संग्रह किया गया। 237 अंतर–किस्मीय संकर पौधों की खेती सफलतापूर्वक पूरी की गई, जिससे अगले सीजन के लिए प्रथम वर्षीय कॉर्म का उत्पादन शुरू हुआ।

फूलों की खेती पर आईसीएआर–एआईसीआरपी के साथ पंजीकरण के लिए क्रमशः संस्थागत रूप से विकसित *गुलदाउदी* और *ग्लेडियोलस* किस्मों के लिए विभिन्न एआईसीआरपी केंद्रों में जड़दार कटिंग और कॉर्म की औपचारिक प्रस्तुति की गई है।

सजावटी वृद्धि के उद्देश्य से, पॉलिप्लोइडी को प्रेरित करने के लिए गेंदे के बीज और पौधों का कोल्चीसिन और ओरिजेलिन से उपचार किया गया।

मादक फसलों विशेष रूप से *पैपावर सोम्निफेरम* में, उत्परिवर्तन प्रजनन के दायरे में, एम3 आबादी की कृषि की गई है, जिसमें आगामी सीजन के लिए उच्च ओरिपेवाइन सामग्री की स्क्रीनिंग की योजना बनाई गई है।

xqykc dh ubZ fdLeksa

गुलाब की किस्मों अर्थात 'ऑनेस्ट रेड', 'वेटरन्स ऑनर', 'जडिस', 'रक्तिमा' और 'सुगंधा' को प्रजनन उद्देश्यों के लिए वानस्पतिक उद्यान में सफलतापूर्वक लगाया गया।

de mi;ksx dh tkus okyh Qlyksa dk e[;/kkjk esa ykus d`fy, mudk vk.kfod tho foKku v/;;u

एक कम उपयोग वाली फली *सोफोकार्पस टेट्रागोनोलोबस* की व्यापक स्वीकृति के लिए एक सीमित कारक के रूप में संघनित टैनिन (सीटी) या प्रोएन्थोसाइनिडिन (पीए) की उपस्थिति को पहचाना गया है। वायरस–प्रेरित जीन साइलेंसिंग (वीआईजीएस) के अनुप्रयोग के माध्यम से सीटी जैवसंश्लेषण में उल्लेखनीय कमी हासिल की गई। अलग–अलग पीए सामग्री के साथ *सोफोकार्पस टेट्रागोनोलोबस* की विशिष्ट लाइनों की पहचान की गई है। पत्ती के ऊतकों में miRNA प्रोफाइलिंग द्वारा पीए उत्पादन को नियंत्रित करने वाले नियामक तंत्र में मूल्यवान अंतर्दृष्टि प्रदान की गई। पीए जैवसंश्लेषण में संभावित भूमिकाओं वाले miRNAs की पहचान और सत्यापन सफलतापूर्वक पूरा किया गया। पीए जैवसंश्लेषण में APETALA2 प्रतिलेखन कारक को लक्षित करने वाले miR172 की नियामक भूमिकाओं को कार्यात्मक सत्यापन के माध्यम से प्रमाणित किया गया है। मूल रूप से ग्लाइसिन मैक्स से क्लोन किए गए पूर्ववर्ती miR172 का आगे सत्यापन, वर्तमान में *सोफोकार्पस टेट्रागोनोलोबस* में किया जा रहा है।

ikni fdLeksa d`fodkl d`fy, vyhZ esa vkuqf'kd ,oa thukfeDl lalk/ku

अलसी (*लाइनम यूसिटेटिसिमम*) के लिए पारंपरिक और आणुविक प्रजनन तकनीकों के मिश्रण के माध्यम से आनुवंशिक और जीनोमिक संसाधन विकास की सुविधा पूरी की गई है। 2022–23 का फसली मौसम के दौरान फेनोटाइपिक लक्षणों के लिए दो द्वि–अभिभावक मैपिंग आबादी, जिन्हें आरआईएल के रूप में जाना जाता है, का मूल्यांकन किया गया। तेल मात्रा एवं अन्य लक्षणों से संबंधित क्यूटीएल की पहचान पहली आरआईएल आबादी के माध्यम से की गई थी, जो आरकेवाई–14 और केएल–213 के बीच एक क्रॉस के परिणामस्वरूप उत्पन्न हुई थी। पद्मिनी और केएल–213 के बीच मिश्रण से उत्पन्न दूसरी आरआईएल आबादी ने फूल और परिपक्वता लक्षणों से जुड़े क्यूटीएल की टैगिंग में योगदान दिया।

Rofjr vkuqf'kd lalk/ku d`fy, ,ejFk d`f vkuqf'kd lalk/kuksa dk nksgu

मात्रात्मक एवं गुणात्मक दोनों प्रकार के फेनोटाइपिक लक्षणों की एक श्रृंखला पर ध्यान केंद्रित करते हुए, ऐमरैंथ के 300 मुख्य नमूनों का एक व्यापक मूल्यांकन किया गया। मात्रात्मक लक्षणों जैसे कि पौधे की ऊंचाई, प्रति पौधा शाखाओं की संख्या, पुष्पक्रम की लंबाई की सीमा, पार्श्व पुष्पक्रम की लंबाई, प्रति पौधा बीज की उपज, तने की मोटाई और अनाज में प्रोटीन की मात्रा में महत्वपूर्ण परिवर्तनशीलता देखी गई।

dkl esa mRikndrk ,oa j'ksa d`f xq.koÙkk y{k.kksa d`fy, **63K** d`vkj **50K** d`,l,uih ,j&vk/kkfjr mPp ?kuRo vkuqf'kd ekufp=.k vkj D;Vh,y fo'y"k.k

कपास की उत्पादकता और रेशों की गुणवत्ता को प्रभावित करने वाले आनुवंशिक कारकों का पता लगाने के लिए दो एसएनपी एरे, एक 63,000 एसएनपी के साथ और दूसरा 50,000 एसएनपी के साथ, का उपयोग करके उच्च–घनत्व आनुवंशिक मानचित्रण और क्यूटीएल विश्लेषण किया गया। जीनोटाइपिंग के बाद उच्च–घनत्व आनुवंशिक मानचित्रों का निर्माण किया गया, जो लक्षित लक्षणों के लिए आनुवंशिक संरचना के विस्तृत प्रतिनिधित्व के रूप में कार्य करता था। उत्पादकता और रेशों की गुणवत्ता से संबंधित कई क्यूटीएल की पहचान की गई, जो कपास प्रजनन कार्यक्रमों के लिए मूल्यवान अंतर्दृष्टि प्रदान करते हैं।

यह अध्ययन कपास की उत्पादकता और रेशों की गुणवत्ता लक्षणों की जांच में उच्च घनत्व आनुवंशिक मानचित्रण और क्यूटीएल विश्लेषण का उपयोग करने की प्रभावकारिता की पुष्टि करता है।

xXxy ¼*dkehQkjk okbVkbZ*½ dk *M* *ukoy* gkbfcM vlEcYM MkV¶V thuke

कॉमिफोरा वाइटाई में फाइटोस्टेरॉल जैवसंश्लेषण के लिए प्रमुख एंजाइमों की पहचान के माध्यम से आनुवंशिक आधार की जानकारी प्राप्त की गयी और डे नोवो हाइब्रिड असेंबली दृष्टिकोण का उपयोग करके एक ड्राफ्ट जीनोम तैयार किया गया। जीनोम विश्लेषण से फाइटोस्टेरॉल जैवसंश्लेषण के लिए प्रमुख एंजाइमों की पहचान की गई। ये अंतर्दृष्टि फाइटोस्टेरॉल उत्पादन को बढ़ाने के लिए रणनीतियों के निर्माण में सहायता कर सकती हैं और फार्मास्यूटिकल्स और न्यूट्रास्यूटिकल्स जैसे क्षेत्रों में आगे के शोध और अनुप्रयोगों के लिए मूल्यवान दृष्टिकोण प्रदान कर सकती हैं।

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लिथोकार्पस डीलबेटस के संपूर्ण क्लोरोप्लास्ट जीनोम को इसके मोनोफाईलेटिक मूल की पुष्टि करने और उत्परिवर्तन हॉटस्पॉट की पहचान करने के लिए अनुक्रमित और विश्लेषित किया गया। निष्कर्ष प्रजातियों के विकासवादी इतिहास और आनुवंशिक विविधता में अंतर्दृष्टि प्रदान करते हैं। उत्परिवर्तनीय हॉटस्पॉट की पहचान अनुकूलन तंत्र के अध्ययन के लिए केंद्र बिंदु प्रदान कर सकती है। यह आंकड़े फैगेसी परिवार के भीतर तुलनात्मक जीनोमिक अध्ययन के लिए मूल्यवान है और पौधों के आनुवंशिकी और विकास में भविष्य के अनुसंधान के लिए निहितार्थ हैं।

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बोगेनविलिया की दस संदर्भ किस्मों का लक्षणों का वर्णन किया गया, जिनमें रेड ट्राइएंगल, सुवर्णा, मिसेज बट, एनिड वॉकर, थिम्मा, फिलोमन, स्प्रिंग फेस्टिवल, विशाखा, कैमारिलो फिएस्टा और चेरी ब्लॉसम शामिल हैं। डीयूएस दिशानिर्देशों के अनुसार विभिन्न विशेषताओं जैसे तने का रंग, कांटों का आकार और माप, पत्ती का आकार और माप, ब्रैक्ट का रंग, एवं फूल के आकार और रंग का विश्लेषण किया गया।

वानस्पतिक उद्यान में, विभिन्न पौधों की प्रजातियों और फूलों की खेती वाली फसलों को सफलता पूर्वक शामिल किया गया, जिनमें *साइकस नाथोरस्टी, फ्लोगैकैंथस जेनकिंसियाई, हेडिचियम कोक्सीनियम,* ऑर्किड (*सीलोगाइन* प्रजाति, *डेंड्रोबियम डेवोनियानम, डेंड्रोबियम प्रिमुलाइनम, डेंड्रोबियम फिम्ब्रिएटम*), *फरेरिया इंडिका, कैरालुमा एडसेन्डेंस, कैरालुमा अम्बेलेटा, कलेन्चो भिदेई, कोडारियोकैलिक्स मोटोरियस* और *कोरिफेन्था एलिफेंटिडेंस* शामिल हैं। इसके अतिरिक्त, फूलों की खेती वाली फसलें जैसे कार्नेशन, जिप्सोफिला, एवं कमल, वॉटरलिली और कैना की कई किस्मों को सफलतापूर्वक संग्रह में जोड़ा गया।

एलो की नौ प्रजातियों के लिए सफल अनुकूलन हासिल किया गया, एवं *एलो* की 11 प्रजातियों का गुणन किया गया। सोडिक मिट्टी पर प्रदर्शन के लिए 23 एलो प्रजातियों का मूल्यांकन किया गया। पाँच प्रजातियाँ, विशेष रूप से *एलो कैमरोनी, एलो चाबौदी, एलो ट्राईनर्विस, एलो वेरा,* और *एलो वेरा* × *एलो चाबौदी,* सोडिक स्थितियों के प्रति अधिक सहिष्णु पाई गईं।

जेल उपज का मूल्यांकन 21 *एलो* प्रजातियों पर किया गया। उनमें से *एलो चाबौदी* × *एलो अमोफिला, एलो सैपोनारिया, एलो ट्राईनर्विस,* और *एलो वेरा* × *एलो एलो* ने प्रति पत्ती उच्च जेल उपज प्रदर्शित की।

अध्ययन द्वारा एबिस डेलावायी और *पाईसिया ब्रैकिटाईला* (पाईनेसी), साथ ही *नेजिया वालिचियाना* (पोडोकार्पेसी) की एक नामकरणात्मक समीक्षा प्रदान की गई, जिसमें उनका लेक्टोटाइपीकरण भी शामिल था।

भारत के ओडिशा की एक स्थानिक जिम्नोस्पर्म प्रजाति *साइकस नायागढ़ेन्सिस* को IUCN रेडलिस्ट के अनुसार मानदंड B1ab (iii,v) के तहत गंभीर रूप से संकटग्रस्त के रूप में वर्गीकृत किया गया है।

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सोडिक मिट्टी के लिए सर्वोत्तम जननद्रव्य की पहचान करने के लिए *बिक्सा* और *करकुमा लोंगा* की उपज और गुणवत्ता पर निरंतर मूल्यांकन किया जा रहा है। सीएसआईआर–अरोमा मिशन के तहत किसानों की आय दोगुनी करने के उद्देश्य से हल्दी की किस्म 'केसरी' को इसकी पत्ती में आवश्यक तेल सामग्री के माध्यम से बढ़ावा दिया जा रहा है।

शीघ्र परिपक्वता और उच्च लिमोनोइड उपज वाली नीम की नई बौनी किस्मों का प्रचार–प्रसार किया गया। इन किस्मों का बहु–स्थान परीक्षण 05 अलग–अलग कृषि जलवायु क्षेत्रों अर्थात उत्तर पूर्व (शिलांग); उत्तर मध्य (लखनऊ); उत्तर (चंडीगढ़); दक्षिण (बैंगलोर); पूर्व (भुवनेश्वर) में किया गया। इन किस्मों का तुलनात्मक मूल्यांकन प्रक्रियाधीन है।

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रिपोर्टिंग अवधि के दौरान घरेलू बागवानी, बोन्साई और निर्जलीकृत पुष्प शिल्प सहित विभिन्न विषयों पर प्रशिक्षण कार्यक्रमों की एक श्रृंखला आयोजित की गई। हमारी सामुदायिक भागीदारी और क्षमता–निर्माण पहल के हिस्से के रूप में, घरेलू बागवानी, बोन्साई तकनीक और निर्जलीकृत पुष्प शिल्प पर 8 प्रशिक्षण आयोजित किए गए। इसके अतिरिक्त, सीएसआईआर फ्लोरीकल्चर मिशन के तहत हर्बल गुलाल बनाने पर केंद्रित 6 प्रशिक्षण और सीएसआईआर अरोमा मिशन

के तहत 8 प्रशिक्षण दिए गए। हमने कौशल विकास और ज्ञान प्रसार के प्रति अपनी प्रतिबद्धता को आगे बढ़ाते हुए सीएसआईआर–एकीकृत कौशल पहल के तहत 7 कौशल विकास कार्यक्रम भी संचालित किए।

रिपोर्टिंग वर्ष के दौरान सीएसआईआर–एनबीआरआई हरित प्रौद्योगिकियों को लोकप्रिय बनाने के लिए विभिन्न विस्तार/जनसंपर्क गतिविधियाँ/प्रशिक्षण कार्यक्रम आयोजित किए गए। कार्यक्रमों के तहत किसानों, उद्यमियों सहित 500 से अधिक व्यक्तियों को प्रशिक्षित किया गया। विभिन्न स्कूलों और कॉलेजों के छात्रों और शिक्षकों के लिए दूरस्थ अनुसंधान केंद्र (बंथरा) में क्षेत्र का दौरा आयोजित किया गया। वर्ष के दौरान 200 से अधिक व्यक्तियों ने दूरस्थ अनुसंधान केंद्र (बंथरा) का दौरा किया।

बिहार राज्य में कृषि क्षेत्र को छह जिलों में विस्तारित किया गया, जिसमें 6.81 हेक्टेयर क्षेत्र शामिल था और इसमें 9 समूहों के 91 किसान शामिल थे। हल्दी, नागरमोथा, गेंदा, ग्लेडियोलस, गुलाब और रजनीगंधा फसलों की खेती की गई। कुल 17 प्रशिक्षण कार्यक्रम आयोजित किये गये जिससे 718 व्यक्ति लाभान्वित हुए।

अरोमा मिशन के दूसरे चरण में, पत्ती के आवश्यक तेल हेतु हल्दी की खेती के लिए कर्नाटक, झारखंड, उत्तर प्रदेश, बिहार, उत्तराखंड, ओडिशा और महाराष्ट्र सहित विभिन्न राज्यों में किसानों तक कृषि–प्रौद्योगिकी का प्रसार किया गया। कृषि क्षेत्र में 256 हेक्टेयर का विस्तार हासिल किया गया। इसके अतिरिक्त, 37 किसानों को 27 क्विंटल हल्दी की उन्नत किस्म 'केसरी' वितरित की गई।

मध्य प्रदेश, राजस्थान और उत्तर प्रदेश के विभिन्न स्थानों से नागरमोथा (*साइपरस स्केरियोसस*) के कुल 85 नमूने एकत्र किये गए। सोडिक बंजर भूमि स्थितियों के तहत व्यावसायिक खेती और जड़ के आवश्यक तेल के निष्कर्षण के लिए क्षमता का मूल्यांकन करने हेतु अध्ययन किया जा रहा है।

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बिहार के गया, राजगीर, नालंदा और आरा जिलों में स्थित केंद्रीय विद्यालयों में सीएसआईआर फ्लोरीकल्चर मिशन द्वारा पुष्प कृषि उद्यान स्थापित किए गए। वानस्पतिक उद्यान परिसर में ओपन–एयर इंटरप्रिटेशन सेंटर का उन्नयन किया गया है। निर्जलीकृत पुष्प शिल्प उत्पादों के विकास के लिए वानस्पतिक उद्यान में कौशल केंद्र विकसित किया गया है।

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संस्थान ने देश के अनुसंधान और विकास पारिस्थितिकी तंत्र में योगदान एवं उत्कृष्टता की खोज में महत्वपूर्ण मील के पत्थर हासिल किए हैं। संस्थान को भारत में 6 पेटेंट प्रदान किए गए हैं, एक अतिरिक्त पेटेंट दायर किया गया है, जो हमारे निरंतर नवाचार को दर्शाता है। 2022–23 के दौरान 15 नई परियोजनाएं शुरू की गई हैं। संस्थान ने तीन प्रौद्योगिकियों को सफलतापूर्वक स्थानांतरित किया है और सहयोगात्मक पहुंच को बढ़ाते हुए 28 एमओयू, एमओए, एमटीए आदि में प्रवेश किया है। 639.85 संचयी प्रभाव कारक के साथ एससीआई पत्रिकाओं में 177 शोध पत्र प्रकाशित किये गए तथा विद्वत्तापूर्ण गतिविधियों को बढ़ावा देने के समर्पण के परिणामस्वरूप वैज्ञानिक और नवोन्वेषी अनुसंधान अकादमी (एसीएसआईआर) और भारत के अन्य विश्वविद्यालयों द्वारा 16 पीएचडी प्रदान की गई हैं।

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एनविस–एनबीआरआई ने उभरते प्रदूषकों पर ध्यान केंद्रित करते हुए एक ऑनलाइन डेटाबेस विकसित किया है और सूचना प्रसारित करने के लिए 2022 और 2023 में समाचार पत्र प्रकाशित किए हैं। एनबीआरआई ईआईएसीपी केंद्र पूरे रिपोर्टिंग वर्ष में विभिन्न कार्यक्रमों और जागरूकता कार्यक्रमों में सक्रिय रूप से शामिल रहा है। इनमें केंद्रीय विद्यालय, सीआरपीएफ बिजनौर, लखनऊ में विश्व पृथ्वी दिवस, लखनऊ विश्वविद्यालय में अंतर्राष्ट्रीय जैविक विविधता दिवस एवं विश्व पर्यावरण दिवस और हरियाली सप्ताह 2022 शामिल हैं। केंद्र ने मिशन LiFE पर एक राष्ट्रीय कार्यशाला में भी भाग लिया और मृदा स्वास्थ्य और उर्वरता की निगरानी के उद्देश्य से परमाणु अवशोषण स्पेक्ट्रोफोटोमेट्री पर पांच दिवसीय प्रशिक्षण कार्यक्रम की मेजबानी की। इसके अलावा, सीएसआईआर–जिज्ञासा के सहयोग से केंद्रीय विद्यालय गोमती नगर और प्रयागराज में मिशन लाइफ पर जागरूकता कार्यक्रम आयोजित किए गए।

EXECUTIVE SUMMARY

CSIR-NBRI is renowned for its distinguished contributions to foundational scientific research in the realm of India's plant diversity. This encompasses methodical documentation, judicious conservation, and responsible exploitation through both traditional and cutting-edge biotechnological methods and approaches.

With a multifaceted skill set, the institute excels in a range of disciplines including but not limited to: the exploration and evaluation of plant diversity, taxonomic classification, developing conservation strategies, genomics, and the augmentation of plant species via both traditional breeding and advanced molecular techniques. Furthermore, the institute is a leader in the engineering of transgenic plants designed to withstand various abiotic and biotic stresses, studies related to climate change, and the remediation of environmental pollution via phytoremediation and microbial interventions. It also actively investigates plant-microbe symbiosis, floriculture, horticulture, and agrotechnological advancements. In addition, the institute is committed to the creation of economically significant plant varieties, the study of pharmacognosy, phytochemistry, and pharmacology, as well as the bioprospection and formulation of nutraceuticals, cosmeceuticals, and healthcare products. Integral to its mission is the engagement with society through a plethora of outreach programs aimed at societal upliftment.

The year 2022-23 marked a plethora of monumental accomplishments across the scientific, technological, and societal outreach spheres for CSIR-NBRI. A concise summation of these pivotal milestones is provided herein:

PLANT DIVERSITY, SYSTEMATICS AND HERBARIUM (PDSH)

Plant diversity exploration and documentation

Comprehensive floristic surveys were conducted across multiple phytogeographical regions in India, yielding significant data on plant biodiversity. Noteworthy are the Chambal ravines and Pachmarhi Biosphere Reserve, which collectively identified over 50 unique pteridophyte species. Over 500 specimens were processed for conservation data, focusing mainly on *Cyathea gigantea*. Surveys in Sheopur, Morena, and Bhind districts revealed about 50 economically valuable medicinal plants used by local communities, underscoring the need for conservation efforts. Explorations in Kerala, Tamil Nadu, and Karnataka yielded 60 accessions of *Impatiens* across 15 species.

Survey in Chambal Ravines and Suhelwa Wildlife Sanctuary resulted in the collection of over 550 algal samples. A total of 284 algal taxa were identified, with *Cyanobacteria* and *Chlorophyta* being the most diverse phyla. Notable were 15 pure algal strains isolated and two genera identified for the first time in India.

Focused studies in Chambal and Punjab resulted in the collection of 150 lichen specimens, identifying 36 species across 24 genera. Taxonomic revisions added 11 new species records to India's lichen flora, nine of which are endemic.

Ficus cupulata, endemic to central India, has been classified as endangered with 585 mature individuals found across 15 locations within Panchmarhi Biosphere Reserve and Tamia. *Jasminum parkeri*, native to the Chamba district in Himachal Pradesh, has been classified as critically endangered.

About 68 species of ferns belonging to different categories of conservation status have been maintained & conserved in the fern house. Live plants of *Lycopodiella cerenua* and *Actiniopteris radiata* were brought to enrich the fern-house.

New species discovery and new distribution records to India

Two new lichen species, *Nephromopsis awasthii* and *Pyrenula awasthii*, were identified in Arunachal Pradesh and Manipur, with unique morphological features. Three new grass species were discovered viz., *Ischaemum sunilii* in the southern Western Ghats, and *Bromus kashmirensis* & *Poa pindariensis* in the Western Himalayas. New lichenicolous fungus, *Endohyalina parmotrematis* was discovered in Uttarakhand.

Several new records of lichens and lichenized fungi have been reported, expanding our

understanding of biodiversity in various regions of India. New records of lichenicolous fungi were also reported, marking the first-time documentation of certain genera in India.

Viola cinerea var. *stocksii* has been rediscovered after 52 years in Madhya Pradesh. *Boehmeria clidemioides* was documented for the first time in Uttarakhand, extending its known distribution. *Rhynchosia suaveolens* has been rediscovered in the Vidarbha region of Maharashtra after 144 years. *Elymus nepalensis*, previously endemic to Nepal, has been discovered in Dzoukou valley at the border of Manipur and Nagaland.

Revisionary and taxonomic studies

The taxonomy of *Tarenna flava* was revised to address prior misidentifications, clearly differentiating it from *T. asiatica*. New lectotypes were designated for both *Tarenna flava* and its heterotypic synonym. For comprehensive study on *Campanula* in India multiple herbaria consulted and field collections was done across six states, aiming for detailed morphological and anatomical analyses.

Genetic diversity and distribution modelling

Genetic diversity study on *Citrus medica* revealed moderate diversity and differentiation, with two main genetic clusters identified. Research on *Gymnema sylvestre* across 11 Indian populations showed moderate within-population diversity but high between-population differentiation. Climate models predicted habitat decline by 2050 but increased adaptability by 2070. Recommendations for sustainable cultivation and breeding have been proposed. MaxEnt modeling for *Quercus griffithii* predicts a 36.3% habitat reduction by 2050. Genetic studies suggest moderate diversity and high gene flow, aiding in India's northeastern conservation plans.

Plant propagation

In-vitro spore culture successfully produced plantlets of *Cyclosorus* sp., which are now housed in CSIR-NBRI's fern house. Mass propagation was achieved for 12 ornamental ferns, which are available for sale. In addition, large-scale propagation of *Pronephrium nudatum*, *Tectaria coadunata*, and *Microsorum scolopendrium* is underway for molecular prospecting. Notably, a mass propagation protocol for the critically endangered fern *Christella kendujharensis* has been optimized, outlining specific hormonal combinations for effective cultivation.

Plant resource database

A specialized local database named "Plant Resources of Chambal Ravines (PRCR) – A Digital Flora of Chambal Ravines" has been created. The database is accessible via the internal IP address 192.168.1.214/prcr. Currently, the database houses information on 36 algae species and 135 angiosperm species.

Product development

Beta-glucan, a glucose polymer with various biological properties, was optimized for production in heterotrophic microalgae in a 75 L bioreactor. By refining parameters such as the composition of the medium, temperature, and pH, the microalga yielded 14.6 g/L dry biomass containing 58% beta-glucan on the sixth day. This beta-glucan was then extracted, purified, and analyzed using various techniques. Efforts are underway to upscale this production.

PHARMACOGNOSY, PHYTOCHEMISTRY AND PRODUCT DEVELOPMENT

Certified reference materials

The division successfully prepared one new certified reference material, Eucalyptol, along with a second batch of Geraniol and (+) Limonene. Following a surveillance audit in January 2023, NABL-Gurugram endorsed the continuation of CSIR-NBRI's NABL accreditation for CRM production, expanding its scope.

Conservation research

A comprehensive study on the carbon isotope composition ($^{13}C/^{12}C$) of 144 sandalwood samples from diverse locations was completed. This contributes to our understanding of sandalwood cultivation across different terrains.

Analysis of stable carbon isotope composition ($^{13}C/^{12}C$) was carried out for 198 heartwood core samples from Red Sanders trees in four locations in Karnataka. This adds critical data to the effort to conserve and improve the productivity of this valuable species.

An in-depth analysis of the phenolic content in various parts of three Lotus (*Nelumbo nucifera*) varieties was completed. Measurements were standardized against Gallic acid, revealing the total phenolic and flavonoid content across different plant parts, thus providing a baseline

for further studies on this economically important plant.

Antibacterial research

The pressing challenge of multi-drug resistant 'superbugs,' specifically focusing on *Pseudomonas aeruginosa*, a leading cause of nosocomial infections and associated mortalities was addessed. Silver nanoparticles synthesized using leaf extracts of *Koelreuteria paniculata* (Ka-AgNPs) were found to inhibit quorum sensing (QS), a key mechanism behind antibiotic resistance and biofilm formation. These phyto-synthesized nanoparticles outperformed chemically synthesized nanoparticles (Cs-AgNPs) in inhibiting QS-regulated virulence factors without affecting bacterial cell viability. Further validation through RT-PCR confirmed the suppression of QS-regulated gene expression. The study suggests that Ka-AgNPs offer a promising avenue for treating drug-resistant *Pseudomonas aeruginosa* infections.

Therapeutic potential of Herbal Ointment from *Andrographis paniculata* and *Piper longum* in wound healing and antibacterial activity was studied. The study employed the roots of *Piper longum* and *Andrographis paniculata* to formulate an herbal ointment for wound healing in rats. The ointment showed accelerated wound healing and reduced inflammation compared to a placebo. It also demonstrated significant antibacterial activity against common pathogens like *Escherichia coli* and *Staphylococcus aureus*. No toxicity or adverse effects were observed, affirming the safety of topical application.

The role of medicinal plants in controlling biofilm-forming pathogenic *Escherichia coli* was explored. The study explores the antibacterial and anti-biofilm activities of three plant extracts against 18 strains of *E. coli*. Two extracts, NBRI PS1 and NBRI PS3, demonstrated higher efficacy in inhibiting bacterial growth and biofilm formation compared to NBRI PS2. Notably, NBRI PS3 showed high antioxidant activity, indicating its potential pharmaceutical applications, especially against biofilm-forming *E. coli*.

Studies on medicinal plants

The antidiabetic properties of various parts of the *Mucuna pruriens* plant in streptozotocin-induced diabetic rats was evaluated. The extract significantly improved markers such as blood glucose levels and urine sugar without affecting feed and water intake. The presence of phyto-constituents like phenolic compounds and flavonoids could be responsible for these effects.

The antimicrobial potential and chemical composition of Marigold (*Tagetes erecta*) and Mulberry (*Morus nigra*) was investigated. High moisture content was found in both flower and fruit extracts. The extracts displayed strong antimicrobial activity, suggesting their potential for use in natural colorants and health supplements. GC-MS analysis revealed major compounds like Hexadecanoic acid and Myo-inositol in both *T. erecta* and *M. nigra*. Thirteen different compounds were identified in *M. nigra*, indicating diverse metabolic profiles and potential applications.

An HPTLC method was developed for the quantification of active compounds like quercetin and stigmasterol in wood-apple *(Limonia acidissima L.)* leaves. The method displayed good precision and can be used for routine analysis of these compounds in various crude drugs and extracts.

Leaves of four *Cassia* species were analyzed for their phytochemical content and antioxidant activity. *Cassia suratensis* showed significant antioxidant potential, suggesting its possible therapeutic applications for oxidative stress-related diseases.

Different parts of the *Acacia nilotica* seed were analyzed for phytochemicals and antioxidant activity. The endosperm displayed high antioxidant activity, while the cotyledon was rich in nutrients. The study indicates that *Acacia nilotica* seeds could serve as a source for nutritional supplements and health-promoting bioactive extracts.

Validation of traditional claims of medicinal plants

The division conducted comprehensive pharmacognostical and phytochemical studies on traditionally important medicinal plants such as *Thalictrum foliolosum*, *Mahonia* species, and others. Through *in-vitro* biological assays, the traditional medicinal claims of these plants were substantiated. Notably, *Entada rheedi* seeds were found to be rich in proteins, low-glycemic index carbohydrates, fibers, and essential elements. Another study on *Thalictrum foliolosum* identified its effectiveness against urolithiatic conditions and inflammation, singling out Berberine and Palmitine as key bioactive compounds.

Chemotaxonomic studies and quality planting material identification

The division focused on identifying elite chemotypes of *C. asiatica* and suitable cultivation regions. A collection of 109 germplasms was subjected to chemical profiling and Ecological Niche Modeling (ENM). The study pinpointed variations in bioactive compounds like asiatic acid and madecassic acid among different natural populations. This led to the identification of "custom-made chemotypes," which are specifically rich in particular bioactive metabolites and to the mapping of location-specific eco-regions for these chemotypes.

Development of natural supplements

The division successfully developed an herbal supplement formulated from seven medicinal plants for Gouty Arthritic Conditions. Compared to the standard drug colchicine, the supplement showed an 80% reduction in blood uric acid levels and a 70% reduction in inflammatory mediators. It also demonstrated improvements in pain relief and locomotion.

A nutraceutical formulation was developed that effectively suppresses diarrhea-causing agents like *Escherichia coli* and *Salmonella* sp., among others. The product also maintains gastrointestinal microflora, replenishes essential nutrients, and complements zinc deficiencies prevalent during diarrheal conditions.

Community outreach: Health and herbs awareness

The division engaged in educational outreach through various lectures and camps aimed at promoting Ayurveda and traditional knowledge. Events were organized at academic institutions such as Shri Ramchandra Vaidya Ayurvedic Medical College and Babu Yugraj Singh Ayurvedic Medical College, among others.

PLANT ECOLOGY AND ENVIRONMENTAL TECHNOLOGY

This DU has three divisions viz., Plant Ecology and Climate Change Science, Microbial Technology, and Environmental Technology. The work done by these three divisions has been summarized under the following heads:

Plant adaptation and climate change

The adaptation of three threatened *Ilex* species viz., *I. khasiana*, *I. venulosa* and *I. embelioides* in Meghalaya, India, to climate scenarios for 2050 was investigated. *I. khasiana* is vulnerable to increased temperature and moisture stress, while *I. venulosa* and *I. embelioides* are primarily impacted by intense moisture stress, which emphasize the importance of tailored conservation strategies.

A study utilizing bioclimatic modeling and Free Air CO_2/O_3/Temp Enrichment (FACE) experiments, forecasts a reduction in suitable areas for wheat cultivation in India due to climate change, especially rising temperatures. Out of eight commonly cultivated wheat cultivars, only two displayed resilience against these future scenarios, which highlights the need for urgent crop adaptation and mitigation strategies.

Carbon sequestration study in urban forestry revealed that native tropical trees like *Tectona grandis* significantly outperformed other species in carbon capture and other ecological benefits in urban settings. These findings suggest that prioritizing *T. grandis* could expedite urban carbon sequestration efforts.

Response of nine common urban tropical tree species respond to increased levels of ground ozone was studied. *Azadirachta indica* and *Nerium indicum* showed increased stomatal conductance under elevated ozone conditions, while other species experienced decreased photosynthesis and transpiration rates. Species such as *Ficus religiosa* and *Saraca asoca* exhibited greater tolerance to elevated ozone levels, making them strong candidates for future urban forestry initiatives. Conversely, *Bougainvillea spectabilis* and *Azadirachta indica* were found to be the most sensitive, warranting cautious consideration for urban greening.

Plant growth and stress tolerance

The role of *Bacillus subtilis* M-4 (NAIMCC-B-03238) in suppressing charcoal rot disease in commercial crop soy was established.

Bacillus subtilis PBE-8 (MTCC 25189) has demonstrated effective bio-control against *Fusarium oxysporum* f. sp. *lycopersici* (FOL).

Study on drought tolerance mechanisms in cotton varieties showed that the LRA-5166 cotton variety exhibited superior drought tolerance compared to the NBRI-67 variety, mainly due to its higher stomatal density and more efficient stomatal regulation. Key stomatal genes such as EPF2, SDD1, and TMM were up-regulated under water stress conditions in both varieties. This genetic adaptation effectively improved

water use efficiency and increased the plant's resilience to drought.

In a comprehensive study on drought tolerance in rice, varieties Henna (H) and Kiran (K) were identified as drought-tolerant and sensitive, respectively, among eight varieties cultivated in U.P., India.

The role of the bacterium *Bacillus amyloliquefaciens* SN13 in enhancing rice seedling growth under salt and drought stress conditions by modulating carbohydrate and fatty acid metabolism has been elucidated.

Bacillus subtilis (NBRI-W9) effectively restored metabolic homeostasis in tomato plants affected by the chemical fungicide Propiconazole. The biofungicide led to significant increases in various metabolites, reduced oxidative stress, and enhanced gene expression related to plant immunity. Consequently, it improved productivity by up to five times in the presence of bacterial pathogens, advocating for a more sustainable approach to agriculture.

Bacillus consortia was found to enhance salt tolerance in *Arabidopsis*. These bacteria positively impact plant growth by altering gene expression and metabolic pathways. The findings suggest that bacterial consortia can serve as a biotechnological tool for enhancing crop resilience against salinity.

The protective effects of ethylenediurea (EDU) on two wheat cultivars grown under varying CO_2 and ozone conditions was assessed. EDU treatment enhanced growth, chlorophyll content, and yield, particularly under elevated CO_2 levels. The cultivar WH-1105 was identified as more sensitive to ozone. Additionally, EDU effectively mitigated the negative impacts of both ozone stress and CO_2-induced decline in grain nutrient content.

The effectiveness of biogenic silver nanoparticles (B-AgNPs) and EDU in protecting wheat from ozone damage was compared. Both treatments significantly improved growth and yield, with cultivar DBW-17 showing superior responsiveness. B-AgNPs were found to be as effective as EDU in countering ozone-related yield losses, thereby offering a promising alternative for future protective strategies.

Environmental contaminant remediation

The Environmental Technology Division of CSIR-NBRI has developed a reliable method for quantifying microplastics in agricultural soil, achieving over 90% recovery. A pilot study in the vicinity of Lucknow assessed microplastic contamination in various sites including agricultural fields near waste dumps and wetlands.

A novel consortium of fungi, *Trichoderma saturnisporum* and *T. citrinoviride*, was used in a column-based study to achieve a 99% reduction in free cyanide within 48 hours. The activity was found to be dependent on the GSG:GSSH ratio, fitting a first-order kinetic model.

Phytoremediation efficacy of *Helianthus annuus* in soil contaminated with battery waste was significantly enhanced through two bacteria strains i.e., *Brucella intermedium* (E1) and *Bacillus velezensis* (EW8) contributing to soil quality improvement.

The effects of varying concentrations of fluoride (F−) on the germination and early growth stages of four staple crops was examined. *Triticum aestivum* was identified as the most sensitive, while *Pennisetum glaucum* displayed the highest tolerance. The study aids in understanding how abiotic stress factors like fluoride impact crop yield and quality, providing insights into crop resilience under environmental stress.

A microbial consortium of yeast (*Debaromyces hansenii*) with bacteria (*Citrobacter* sp.) and methyltransferase-containing *P. oleovorans* has been developed for reducing arsenic stress in rice. Preliminary findings show promise, demonstrating the effectiveness of this approach in arsenic diminution in rice plants. Their role has been validated by subcellular distribution, SEM-EDS, and transcriptome analysis.

Research found that hypermethylation in *Rhizoctonia solani* occurs when interacting with *Bacillus amyloliquefaciens*, which could lead to new ways of managing sheath blight disease in rice.

A newly developed microbial consortium consisting of 3 fungi and 4 bacteria show promising results for *in situ* decomposition of rice straw, leading to improved soil health and reduced environmental pollution. It is being validated at DRC field, Banthara, and will be of great societal importance with less environmental pollution, and reduced chemical input.

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Biotic stress tolerance

A second-year performance evaluation trial of Tma12 GM cotton against whitefly was conducted at Faridkot, Punjab and Sirsa, Haryana, in collaboration with PAU, Ludhiana, and CICR, Nagpur, respectively.

At ICAR-IIVR Varanasi, a second-year performance evaluation trial was conducted on Msc14 GM guard cotton for protection against viral diseases vectored by whitefly in tomato and papaya.

The advancement of Pnu08 GM cotton lines to T3 generation was achieved. An event labeled 907, effective in reducing whitefly population by 60-70%, was selected through no-choice and multi-choice whitefly bioassay.

Cry1EC GM cotton lines were advanced and evaluated in the T2 generation for expression and protection from Pink Bollworm and Leaf Armyworm. Five promising lines were selected for event selection trial.

Tma12 was established as a Lytic Polysaccharide Monooxygenase (LPMO), and its LPMO activity was associated with insecticidal action. A protocol for the expression of Tma12 in yeast was established.

The mechanism through which Msc14 is toxic to whitefly was elucidated. Multiple pathways were activated in the insect midgut, negatively affecting nutrient absorption.

Increased resistance against *Helicoverpa armigera* and *Spodoptera litura* in transgenic tomato was observed when the modified *Cocculus hirsutus* trypsin inhibitor (ChTI) was expressed either individually or in combination with Bt-Cry1Ab toxin. Complete insect mortality was observed without any yield penalty.

Over-expression of *Aspergillus niger* pectin methylesterase in transgenic cotton plants was observed to increase methanol emission and confer resistance to insect pests. Leaf disc assays and in-planta bioassays indicated a 50–60% population reduction in sap-sucking pests.

Transgenic chickpea lines with cry1Ac expression under a wound-inducible promoter have been developed. Gene expression studies are being conducted on plants in the T2 generation, which will subsequently be analyzed for insect tolerance.

F. oxysporum f. sp. *ciceris*, a fungus responsible for vascular wilt and significant yield losses, has been identified as a critical challenge. A transgenic approach is planned for targeting genes from resistant germplasm. Upregulated genes (TLP1, PGIP2, GRXS2, LTP1, and SN2) in the root xylem of wilt-resistant genotypes have been selected for genome editing, following their response to Fusarium at early stages of infection.

Potential roles of HAT and HDAC genes in providing stress tolerance during insect infestation have been proposed. Transcriptomic data have been used for initial validations, and functional validations are planned.

De novo transcriptome analysis was performed on *Cheilomenes sexmaculata* at different intervals post-leg amputation. Four genes (engrailed, dishevelled, and cubitus interruptus) were identified and further validated through qRT-PCR. The *in vitro* transcription process is currently being executed to functionally validate the genes involved in regeneration.

Abiotic stress responses and plant development

A gene, GhNAC2, was identified to improve root and plant growth under well-watered conditions and impart drought tolerance. Studies to understand its mechanism are currently being conducted.

A multi-location trial involving 320 core germplasms of *G. hirsutum* was completed. High-quality phenotypic data related to 27 agronomically important traits were generated, and more than 8,000 potential markers were identified through GWAS analysis

Vegetables have been identified as a significant source of arsenic exposure, ranking third after groundwater and rice-based diets. Microbes with AsMT activity have been discovered, offering potential routes for arsenic mitigation in various vegetable crops. This advancement is anticipated to reduce human arsenic exposure through enhanced agricultural practices, constituting a significant step in public health safety.

The mediation of arsenic uptake and transport in rice by several metal transporter genes (including Lsi1, Lsi2, NRAMP, NIP3;1, and INT) has been documented. Knock-out lines for these genes have been generated using the CRISPR/Cas9 system, aimed at reducing arsenic accumulation in rice grains. The effects of these

genetic modifications on both phenotypic and molecular levels are slated for future assessment.

The vital role of RabC1 GTPase in *Arabidopsis* growth and seed formation has been demonstrated.

A molecular link between heterosis and endoreduplication in F1 hybrids has been identified through phenotypic data and polyploidy analysis. Sub-genome dominance during endoreduplication is confirmed to be linked to the epigenetic status of the parent genome.

Standardization of a nuclei isolation method for examining modified nucleosomes in plants has been achieved. This protocol is confirmed as suitable for downstream processes like MNase digestion.

Local variations in DNA methylation induced by elevated CO_2 have been observed in *Arabidopsis thaliana* populations from high and low elevations. Differential gene methylation in these populations was also validated.

Enhanced tolerance against toxic heavy metals has been exhibited by *Arabidopsis* lines over-expressing the chickpea MT1 gene. Elevated defense systems and reduced stress markers have been observed in these transgenic lines.

Transgenic lines for studying the role of LAF1 in the far-red signaling pathway have been generated, and their phenotypic characterization is in progress.

Transgenic tobacco plants overexpressing WsPME28 have been developed to enhance methanol emission. An 8-fold increase in methanol content and a 12-fold increase in methanol emission have been observed in these plants.

The high-methanol emitting transgenic plants have been utilized for systemic-induced defense response studies. Air-flow cabinet chambers have been constructed for this molecular study.

Leaf samples from plants within these chambers have been collected at three distinct time points (0 h, 2 h, & 24 h) for RNA and protein isolation. Following quality checks, these samples were subjected to transcriptome and proteome sequencing.

Differential gene expression analysis was conducted using the DESeq package based on a negative binomial distribution model. Preliminary findings have identified significant upregulation in genes (CYP94B, AOS, JAZ8, AOC, LOX2, & MYC2) involved in the jasmonic acid biosynthesis pathway and its signaling.

Arsenic tolerance in six bryophyte species was investigated, with *Marchantia polymorpha* showing the highest arsenic accumulation when exposed to AsIII. Transcriptomic analysis was conducted to study the molecular mechanisms behind arsenic stress tolerance. This work offers prospects for developing transgenic plants with enhanced arsenic stress resilience.

Enhancing fruit and flower shelf life

In the study focused on root development and architecture, transgenic lines with altered expression of genes from the HSF, MYB, WRKY, and START domain families are being analyzed. The roles of ABA, ethylene, strigolactones, and GA in influencing tomato root growth have been demonstrated.

In research pertaining to fruit growth and ripening, interactions between ABA, ethylene, auxin, and GA were identified and are currently being further explored through transgenic manipulation of genes from the AP2/ERF domain family.

In the research on the molecular basis and hormonal control of abscission in fragrant roses, interactions between ethylene and other hormones like jasmonic acid and salicylic acid have been observed. While the role of jasmonic acid in delaying abscission has been identified, salicylic acid has been found to promote abscission, especially at high concentrations. The regulatory mechanisms governing these pathways in the context of abscission are currently under investigation.

In early ripening stages, two HSP90 chaperone-like genes were targeted for up-regulation. Genome-edited plants were screened for mutations, and various indels were discovered. Advanced generation studies and phenotypic analysis suggested that edited CRISPR lines had superior growth characteristics compared to controls. Ongoing studies are focused on metabolome data and ripening.

Small RNA related to fruit ripening was identified at various stages, and their differential expression was confirmed. Peptide assays for miR159 were also conducted.

Computational Biology and Genomics

In computational biology, stress tolerance responses to various environmental factors have

been studied. Key regulatory genes associated with drought and salt stress conditions have been identified.

Using PacBioHiFi for long reads and Illumina HiSeq for short reads, the genome of the Indian Lotus with 108 petals was sequenced. The assembly indicated a 99.3% completeness rate. A large number of sequence variations were observed when compared to the China antique genome. Transcriptomic analysis identified differentially expressed genes across different accessions.

Key genes related to guggulsterone and germacrone synthesis were identified through the transcriptomic analysis of various tissues in *Commiphora wightii* and *Commiphora agalocha*.

PLANT GENETIC RESOURCES AND IMPROVEMENT

Development of new floricultural varieties

Propagation of new mutant lines, hybrids, and dwarf/photo-insensitive selections of *Chrysanthemum morifolium* was achieved from suckers, and subsequent propagation was carried out through cuttings. Comprehensive Whole Transcriptomic sequencing on floral tissues of selected mutants and controls was also executed, with analysis currently underway.

In the area of targeted *Gladiolus* breeding earlier this year, a significant quantity of inter-varietal hybrid seeds was generated, harvested, and stored under optimal conditions. The cultivation of 237 inter-varietal hybrid seedlings was successfully completed, leading to the production of first-year corms for the next season.

Formal submissions of rooted cuttings and corms for institutionally developed *Chrysanthemum* and *Gladiolus* varieties, respectively, have been made to various AICRP centers for registration with ICAR-AICRP on Floriculture.

For the purpose of ornamental enhancement, treatment of Marigold seeds and seedlings with colchicine and oryzalin was administered to induce polyploidy.

Within the scope of mutation breeding in narcotic crops, specifically *Papaver somniferum*, cultivation of an M3 population has been achieved, with screenings for high oripavine content planned for the upcoming season.

New Rose Varieties Introduced

Rose varieties viz. 'Honest Red', 'Veteran's Honor', 'Jadis', 'Raktima' and 'Sugandha' were successfully introduced at Botanic Garden for breeding purposes.

Molecular biology studies on underutilized crops for their mainstreaming

The presence of condensed tannins (CT) or proanthocyanidins (PA) has been identified as a limiting factor for the wider acceptance of *Psophocarpus tetragonolobus* (L.) DC., an underutilized legume. A notable reduction in CT biosynthesis was achieved through the application of virus-induced gene silencing (VIGS). Distinct lines of *P. tetragonolobus* with varying PA content have been identified. Valuable insights into the regulatory mechanisms governing PA production were provided by miRNA profiling in leaf tissues. The identification and validation of miRNAs with probable roles in PA biosynthesis were successfully accomplished. Regulatory roles of miR172 targeting the APETALA2 transcription factor in PA biosynthesis have been substantiated through functional validation. Further validation of the precursor miR172, originally cloned from *Glycine max*, is currently being undertaken in *P. tetragonolobus*.

Genetic and genomics resources in linseed for varietal development

The facilitation of genetic and genomic resource development for Linseed (*Linum usitatissimum*) has been accomplished through a blend of traditional and molecular breeding techniques. Evaluation of two bi-parental mapping populations, known as RILs, was conducted for phenotypic traits during the 2022-23 cropping season. Identification of QTLs related to oil content and other traits was enabled through the first RIL population, resulting from a cross between RKY-14 and KL-213. The second RIL population, stemming from a cross between Padmini and KL-213, contributed to the tagging of QTLs linked to flowering and maturity traits.

Exploitation of grain amaranth genetic resources for accelerated genetic improvement

A comprehensive evaluation of 300 core accessions of grain amaranth was conducted, focusing on a range of phenotypic traits, both quantitative and qualitative. Significant variability in quantitative traits was observed namely in plant height, number of branches per plant, ranges in inflorescence length, lateral inflorescence length, seed yield per plant, stem thickness, and protein content in grains.

63K and 50K SNP array-based high-density genetic mapping and QTL analysis for productivity and fiber quality traits in cotton

High-density genetic mapping and QTL analysis were conducted using two SNP arrays, one with 63,000 SNPs and the other with 50,000 SNPs, to explore genetic factors affecting cotton's productivity and fiber quality. High-density genetic maps were constructed post-genotyping, serving as a detailed representation of the genetic architecture for targeted traits. Multiple QTLs related to productivity and fiber quality were identified, providing valuable insights for cotton breeding programs. The study confirms the efficacy of using high-density genetic mapping and QTL analysis in the investigation of cotton's productivity and fiber quality traits.

De novo hybrid assembled draft genome of guggul *Commiphora wightii*

Understanding of the genetic basis for phytosterol biosynthesis in *Commiphora wightii* was sought through the identification of key enzymes, and a draft genome was generated using a de novo hybrid assembly approach. Key enzymes for phytosterol biosynthesis were identified upon genome analysis. These insights can aid in the formulation of strategies for enhancing phytosterol production and offer valuable perspectives for further research and applications in sectors such as pharmaceuticals and nutraceuticals.

Complete chloroplast genome sequence of *Lithocarpus dealbatus*

The complete chloroplast genome of *Lithocarpus dealbatus* was sequenced and analyzed to confirm its monophyletic origin and identify mutational hotspots. The findings offer insights into the species' evolutionary history and genetic diversity. Identification of mutational hotspots could provide focal points for studying adaptation mechanisms. The data is valuable for comparative genomic studies within the Fagaceae family and has implications for future research in plant genetics and evolution.

BOTANIC GARDEN, PLANT CONSERVATION AND AGRO-TECHNOLOGY

Plant characterization, conservation and germplasm enrichment

Ten reference varieties of *Bougainvillea* were characterized, including Red Triangle, Suvarna, Mrs. Butt, Enid Walker, Thimma, Filoman, Spring Festival, Vishakha, Camarillo Fiesta, and Cherry Blossom. Various attributes such as stem color, thorn size and shape, leaf shape and size, bract color, and flower size and color were analyzed in accordance with DUS guidelines.

In the Botanic Garden, successful introductions were made of various plant species and floricultural crops, including *Cycas nathorstii, Phlogacanthus jenkinsii, Hedychium coccineum*, Orchids (*Coelogyne* sp., *Dendrobium devonianum, D. primulinum, D. fimbriatum*), *Frerea indica, Caralluma adscendens, C. umbellata, Kalanchoe bhidei, Codariocalyx motorius*, and *Coryphantha elephantidens*. Additionally, floricultural crops such as Carnation, Gypsophila, and several varieties of lotus, waterlilies, and canna were successfully added to the collection.

Successful acclimatization was achieved for nine *Aloe* species, and multiplication was accomplished for 11 species of *Aloe*. Evaluations were conducted on 23 *Aloe* species for their performance on sodic soil. Five species, specifically *A. cameronii, A. chabaudii, A. trinervis, A. vera*, and *A. vera* × *A. chabaudii*, were found to be more tolerant to sodic conditions.

Gel yield evaluations were conducted on twenty-one *Aloe* species. Among them, *Aloe chabaudii* × *A. ammophila*, *A. saponaria*, *A. trinervis*, and *A. vera* × *A. chabaudii* exhibited high gel yield per leaf.

A nomenclatural review of *Abies delavayi* and *Picea brachytyla* (Pinaceae), as well as *Nageia wallichiana* (Podocarpaceae), was provided by the study, including their lectotypification.

Cycas nayagarhensis, an endemic gymnosperm species to Odisha, India, has been classified as Critically Endangered under criteria B1ab (iii,v) as per the IUCN Redlist.

Agricultural advancements and yield optimization

Continuous evaluations are being made on the yield and quality of *Bixa* and *Curcuma longa* to identify the best germplasm for sodic soils. The turmeric variety 'Kesari' is being promoted under the CSIR-Aroma Mission with the aim of doubling farmers' income through its leaf essential oil content.

Propagation of new dwarf cultivars of Neem with early maturity and higher Limonoids yield were done. Multi-location trials of these cultivars were performed at 05 different agroclimatic zones viz., North East (Shillong); North Central (Lucknow); North (Chandigarh); South (Bangalore); East (Bhubaneshwar). Comparative evaluation of these cultivars is under process.

Area expansion, outreach, and skill development

A series of training programs on various topics including home gardening, bonsai, and dehydrated floral crafts were conducted during the reporting period. As part of our community engagement and capacity-building initiatives, 8 trainings on home gardening, bonsai techniques, and dehydrated floral craft were organized. Additionally, 6 trainings were imparted under the CSIR Floriculture Mission focusing on the preparation of Herbal gulal, and 8 under the CSIR Aroma Mission. We also conducted 7 skill development programs under the CSIR-Integrated Skill Initiative, furthering our commitment to skill enhancement and knowledge dissemination.

To popularize CSIR-NBRI green technologies, various extension/outreach activities/training programmes were organized during the reporting year. More than 500 individuals including farmers, entrepreneurs were trained under the programmes. The field visits were organized at Distant Research Centre (Banthara) for students & teachers from various schools & Colleges. More than 200 individuals were visited the Distant Research Centre (Banthara) during the year.

In the state of Bihar, the cultivation area was expanded across six districts, covering 6.81 hectares and involving 91 farmers from 9 clusters. Crops including turmeric, nagarmotha, marigold, gladiolus, rose, and tuberose were cultivated. A total of 17 training programs were conducted, benefiting 718 individuals.

In the second phase of the Aroma Mission, agro-technology for the cultivation of turmeric for essential leaf oil was disseminated to farmers in various states including Karnataka, Jharkhand, Uttar Pradesh, Bihar, Uttarakhand, Odisha, and Maharashtra. An expansion of 256 hectares in the cultivation area was achieved. Additionally, 27 quintals of the promising turmeric variety 'Kesari' were distributed to 37 farmers and is being popularized for essential oil for doubling the farmers income.

A total of 85 accessions of Nagarmotha (*Cyperus scariosus*) were collected from various locations in Madhya Pradesh, Rajasthan, and Uttar Pradesh. These accessions are being studied to evaluate their potential for commercial cultivation and extraction of root essential oil under sodic wasteland conditions.

Infrastructure and educational initiatives

Floriculture gardens in Kendriya Vidyalayas located in the districts of Gaya, Rajgir, Nalanda, and Ara in Bihar were established by the CSIR Floriculture Mission.

Upgradation of open-air interpretation centre has been done in the Botanic Garden campus.

For the development of dehydrated floral craft products, Skill Satellite Center has been developed in the Botanic Garden.

PROJECTS, PUBLICATIONS, AND PATENTS

The institute has achieved significant milestones in its pursuit of excellence and contribution to the nation's research and development ecosystem. The institute has been granted 6 patents in India, with an additional patent filed, reflecting our continuous innovation. During 2022-23, 15 new projects have been initiated. The institution has successfully transferred three technologies and entered into 28 MoUs, MoAs, MTAs etc. enhancing the collaborative reach. Published 178 research papers in SCI journals, with a cumulative impact factor of 639.85 The dedication to foster scholarly pursuits has resulted in 16 PhDs being awarded by the Academy of Scientific and Innovative Research (AcSIR) and other universities of India.

ENVIRONMENTAL INFORMATION AWARENESS, CAPACITY (EIACP) PROGRAMME CENTRE

The ENVIS-NBRI has developed an online database focusing on emerging pollutants and published newsletters in 2022 and 2023 to disseminate information. The NBRI EIACP programme centre has been actively involved in various events and awareness programmes throughout the reporting year. These include World Earth Day at Kendriya Vidyalaya, CRPF Bijnaur, Lucknow, International Day of Biological Diversity, World Environment Day at the University of Lucknow, and Hariyali Saptah 2022. The centre also participated in a National Workshop on Mission LiFE and hosted a five-day training programme on Atomic Absorption Spectrophotometry, aimed at monitoring soil health and fertility. Further, they conducted awareness programmes on Mission LiFE at Central School Gomti Nagar, and KVS Prayagraj in collaboration with CSIR-Jigyasa.

Research & Development Areas

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वै.औ.अ.प.–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ की स्थापना वर्ष 1953 में हुई थी। यह वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद, वैज्ञानिक एवं औद्योगिक अनुसंधान विभाग, विज्ञान एवं प्रौद्योगिकी मंत्रालय, भारत सरकार के 37 संस्थानों में से एक है।

संस्थान पिछले छह दशकों से राष्ट्रीय महत्व के संस्थान के रूप में पादप अनुसंधान के क्षेत्र में पूरे देश में अग्रणी रहा है। विश्व स्तर पर वानस्पतिक अनुसंधान के एक आधुनिक केन्द्र के रूप में मान्यता प्राप्त यह संस्थान पादप विज्ञान के लगभग सभी क्षेत्रों में बहुआयामी अनुसंधान एवं विकास कार्यक्रम चला रहा है। संस्थान का मूल उद्देश्य सतत विकास एवं मानव कल्याण हेतु देश के गैर–पारंपरिक, अल्प–प्रयुक्त एवं वन्य पादप आनुवांशिक संसाधनों पर विशेष ध्यान देते हुए पादप विज्ञान के विभिन्न पहलुओं जैसे कि संरक्षण, वर्गिकी, प्रलेखन, पूर्वेक्षण एवं आनुवांशिक सुधार आदि पर बुनियादी एवं प्रायोगिक अनुसंधान करना है। संस्थान निम्न क्षेत्रों के प्रमुख सामर्थ्य रखता है।

- पादप विविधता, वर्गिकी एवं निम्न तथा उच्च पादप समूहों के लिए डेटाबेस
- जैव पूर्वेक्षण तथा पौष्टिक–औषधीय, प्रसाधन–औषधीय एवं स्वास्थ्य देखभाल हेतु उत्पादों का विकास
- जलवायु परिवर्तन अनुकूलन अध्ययन एवं कार्बन जब्तीकरण
- वर्धित पादप उत्पादकता हेतु सूक्ष्मजीवी
- पारंपरिक एवं आणुविक प्रजनन द्वारा पादप सुधार एवं आनुवांशिक अभियांत्रिकी
- वनस्पति उद्यान, पादप संरक्षण एवं पुष्प कृषि हेतु पौधों की नवीन किस्मों का विकास
- सोडिक एवं अन्य बंजर भूमि के सतत् विकास हेतु कृषि–प्रौद्योगिकियाँ
- आउटरीच कार्यक्रमों के द्वारा समाज कल्याण हेतु गतिविधियाँ

संस्थान नये ज्ञान का सृजन करने और मानव स्वास्थ्य, कृषि और पर्यावरण संरक्षण के लिए सस्ती प्रौद्योगिकियों के निर्माण हेतु देश की गैर–अन्वेषिक पादप विविधता की अप्रयुक्त क्षमता की खोज करने के लक्ष्य के साथ आगे बढ़ रहा है।

CSIR-NBRI: Mission and Mandate

The Council of Scientific and Industrial Research-National Botanical Research Institute (CSIR-NBRI), Lucknow was established in the year 1953. It is one of the 38 constituent laboratories of CSIR, Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India.

The institute has been in the forefront of plant sciences research in the country for past six decades and is an institution of national importance. As globally recognized advance center of botanical research, CSIR-NBRI carries out multidisciplinary R&D Programmes in almost all fields of plant sciences. The mandate of the institute is to undertake basic and applied research on various aspects of plant sciences, including conservation, systematics, documentation, prospection and genetic improvement with particular emphasis on under-exploited, non-traditional and wild plant genetic resources of the country for the sustainable development and human welfare. The institute has core strength in the following areas:

- Plant diversity, systematics and database for lower and higher plant groups.
- Bio-prospection and development of nutraceutical, cosmaceutical and health care products.
- Climate change adaptation studies and carbon sequestration.
- Microbes for enhanced plant productivity.
- Plant improvement through conventional and molecular breeding and genetic engineering.
- Botanic garden, plant conservation and development of new varieties of floriculture plants.
- Agro-technologies for sustainable development of sodic land and other wastelands.
- Societal development activities through outreach programmes.

The institute is surging ahead with its envisioned goals of exploring the untapped potential of the underexplored and unexplored plant diversity of the country for generating new knowledge, and affordable technologies for human health care, agriculture and environmental protection.

R&D-01: PLANT DIVERSITY, SYSTEMATICS & HERBARIUM (PDSH)

Area Co-ordinator

Dr. TS Rana, Chief Scientist

Scientist

- Dr. Anand Prakash, Sr. Principal Scientist
- Dr. Sanjeeva Nayaka, Sr. Principal Scientist
- Dr. AP Singh, Principal Scientist
- Dr. SK Rath, Principal Scientist
- Dr. Priyanka Agnihotri, Principal Scientist
- Dr. VV Wagh, Principal Scientist
- Dr. KM Prabhukumar, Senior Scientist
- Dr. SK Behera, Senior Scientist
- Dr. Gaurav Kumar Mishra, Scientist

Technical and Support Staff

- Dr. Kiran Toppo, Senior Technical Officer
- Dr. Sushma Verma, Senior Technical Officer
- Dr. Vinay Sahu, Senior Technical Officer
- Dr. MK Shukla, Senior Technical Officer
- Dr. KK Rawat, Senior Technical Officer
- Mr. Rameshwar Prasad, Technical Officer
- Dr. KK Ingle, Technical Officer
- Dr. Vandana Tiwari, Technical Assistant
- Mr. MK Srivastava, Senior Technician
- Smt. Gomta Devi, Lab. Assistant
- Mr. Mohan Lal, MTS
- Mr. Mauje Lal, Lab Assistant

R&D Area Research Scholars Statistics

Sr. No.	Position Name	Numbers
1.	Post-Doc Fellow	02
2.	TARE Fellow	01
3.	JRF/SRF/INSPIRE	52
4.	Project Staff	20

Broad Areas of R&D

Taxonomy of Algae, Lichens, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms, Molecular Systematics, Conservation of Threatened Plants and Herbarium

Aims and Objectives

- Diversity assessment of plants and lichens of under-explored/un-explored areas of India.
- Revisionary and monographic studies of Algae, Lichens, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
- Molecular systematics of plants.
- Conservation of threatened plants in India.
- Enrichment and maintenance of the herbarium (LWG).
- Digital databases of plant resources.

R&D Highlights

- The scientists of the division are presently working on 14 grant-in-aid projects sponsored by different funding agencies like SERB-DST, New Delhi; DBT, New Delhi; MOEF & CC and CSIR, New Delhi.
- The group has significantly contributed towards bio-prospecting plant resources with other disciplines like Molecular Biology, Phytochemistry, Pharmacognosy and pharmacology, and the Botanical Gardens of the institute, which has led to the development of new varieties, processes, and technologies. The scientists of the division have published 53 research papers, 01 book, 01 book chapter, 06 new species to science, 02 generic records from India and 39 new records from India. Besides scientists of the division are also teaching various courses to AcSIR students.

Floristics, revision and conservation of threatened plants

The group is involved in the floristic study of different areas of the country, such as Chambal Ravines, Chandrapur district and its surrounding areas (Maharashtra), Suhelwa Wildlife Sanctuary (Uttar Pradesh), Kotgarh Wildlife Sanctuary (Odisha) and Pilibhit Tiger Reserve (Uttar Pradesh). Besides, studies on some specific groups of plants, such as Acanthaceae, Balsaminaceae, Lamiaceae, Euphorbiaceae, and Asteraceae of Uttar Pradesh, Herbaceous flora of Lucknow and its adjoining districts, cultivated legumes of Uttar Pradesh, grasses of the Western Himalaya are in progress.

Molecular systematics and ecological niche modeling

The group has significantly contributed to the studies on genetic diversity, phylogeny, and ecological niche modeling (ENM) of some important plant groups like *Bergenia, Betula, Campanula, Citrus, Gymnema, Quercus,* and *Uraria*.

HERBARIUM: A NATIONAL FACILITY

Curator

Dr. KM Prabhukumar, Senior Scientist

The herbarium of CSIR-National Botanical Research Institute (LWG) is a designated 'National Repository of Indian Flora' by National Biodiversity Authority, Govt. of India.

Following are the major activities conducted in the herbarium during the reporting period:

Accessioning of specimens and Herbarium enrichment

The scientists of CSIR-NBRI in general and particularly Plant Diversity, Systematics and Herbarium Division are regularly collecting plant samples from different parts of the country under various research projects. These plant samples are then properly processed for the preparation of herbarium specimen and ultimately deposited to the institute's herbarium (LWG). During the reporting period, a total of 20,573 specimens of different groups, submitted by various scientist and scholars, were accessioned and incorporated in LWG herbarium.

Work has been initiated to rearrange the herbarium accessions and approx. 7,000 accessions have been rearranged as per the new guidelines for herbarium restructuring. A primary database (list) of approx. 44,000 accessions has been made so far for quick and easy access.

A type specimen is of paramount importance for the taxonomical and nomenclature studies. During the reporting period a total of 48 type specimens were deposited in the herbarium.

Visits of Students and Researchers to the Herbarium

The herbarium of CSIR-NBRI facilitates the visits of students and academicians from schools, colleges, universities and research organizations to know about the plant diversity, identification, techniques of herbarium preparation and authentication of plant materials. A total of 46 visits comprising 2,132 students and faculty members were facilitated during the reporting period.

Plant Specimen Identification / Authentication and Certification

The herbarium provides services of plant identification and authentication to general public, students, researchers and also facilitate the preservation of their voucher samples for future records. During the period, the authentication certificates of 46 plants were issued to students and researchers from different organizations including Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur; Integral University, Lucknow; Era Medical University, Lucknow; CSIR-Central Building Research Institute, Roorkee; Institute of Engineering and Technology, Lucknow; Central Ayurveda Research Institute, Jhansi; Amity University, Lucknow; Kailash Institute of Pharmacy & Management, Gorakhpur and CSIR-National Botanical Research Institute, Lucknow.

New facility established

A new herbarium processing area along with herbarium drier were established. A new section for processing of foreign specimens, seed collection, pollen collection and ethnobotanical collections have also been developed.

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Genetic diversity and distribution modelling of *Citrus medica* L.

Genetic diversity analysis of *Citrus medica* was conducted on 18 populations using 15 SSR primers. The results indicated moderate genetic diversity (I=0.64, Ho=0.36, He= 0.38) and identified two genetic populations with weak clustering. Bayesian analysis showed two subpopulations with high admixture. AMOVA revealed moderate genetic differentiation (Fst=0.19) and gene flow (Nm=1.06).

Genetic diversity, population genetic structure, and habitat suitability under climate change scenarios for *Gymnema sylvestre* (Retz.) R. Br. ex Schult. in India

Genetic analysis of 118 *Gymnema sylvestre* individuals from 11 Indian populations were performed using 14 SSR markers from the NCBI database, revealing moderate genetic diversity within the populations and high differentiation between them due to low gene flow. The analysis identified two distinct genetic clusters and a link between genetic and geographic distances. Climate modeling predicted a decrease in suitable habitats for *G. sylvestre* by 2050, but potential range expansion into non-native regions by 2070. For sustainable use, commercial cultivation in suitable habitats and the use of diverse populations for breeding are recommended. Future cultivation techniques are needed to reduce the reliance on wild resources.

Distribution modeling and genetic diversity of *Quercus griffithii* Hook. f. & Thomson ex Miq (Fagaceae)

Quercus griffithii - a deciduous tree native to India and China - is threatened by climate change and human activity (Fig. 1). The MaxEnt model highlighted current habitats in the East Khasi Hills in Meghalaya, the western and eastern region of Arunachal Pradesh, northern Manipur, including the bordering area of Nagaland and the eastern parts of Mizoram as highly suitable. Predictions for 2050 indicate a reduction in highly suitable habitats by 29.96% under RCP4.5 and 36.30% under RCP8.5. By 2070, these figures change to 26.80% (RCP4.5) and 12.05% (RCP8.5). A genetic study in 72 samples using 16 SSR markers showed moderate genetic diversity (Ho=0.56; He=0.51), low differentiation (Fst=0.06), and high gene flow (Nm=3.91). 94% of the genetic variation exists within populations. Two genetic clusters were identified. This information may aid in the conservation of *Q. griffithii* in northeast India.

Systematics of the genus *Gymnosporia* (Wight & Arn.) Benth & Hook.f. (Celastraceae) in India

Gymnosporia includes 18 species and three varieties in India. A study was undertaken that focused on collection, documentation, and molecular phylogeny. Data were sourced from libraries and online resources. Field trips resulted in 120 voucher specimens of eight species. These specimens were subjected to macro and micromorphological examination. The study also addressed the nomenclatural status of all *Gymnosporia* species in India and investigated long-established names.

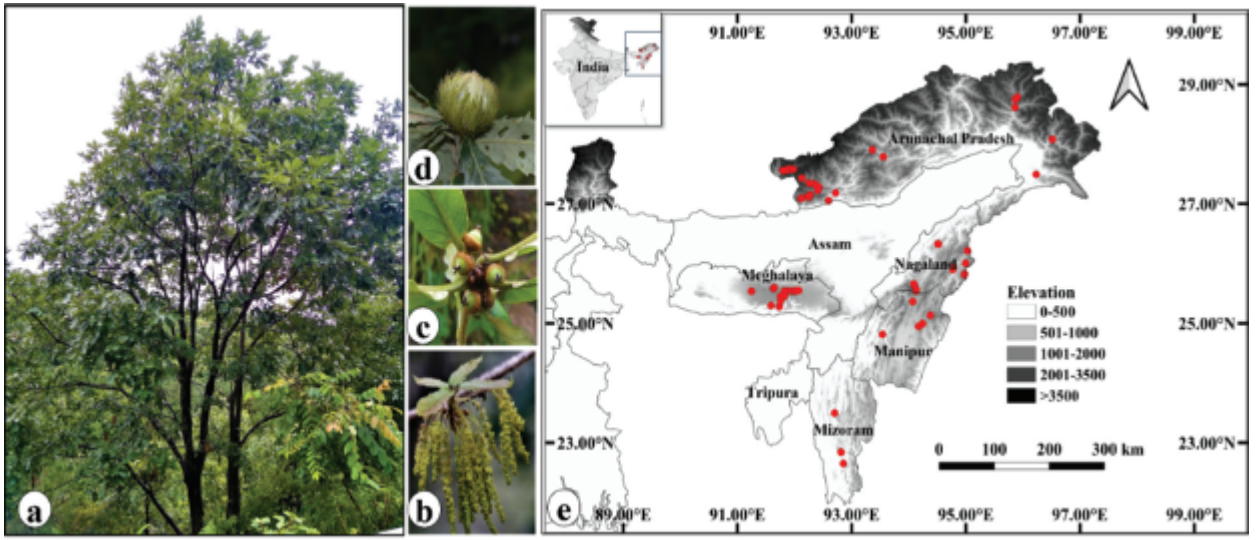

Fig. 1: *Quercus griffithii* (a) Habit, (b) Flower, (c) Acorns, (d) Gall, (e) Map showing the sampling locations

The DNA of collected species was isolated using the CTAB method and the quantity and quality were checked. Preliminary work with phylogenetic tools has begun. Future work will collect and analyze the remaining *Gymnosporia* species.

Taxonomic revision and molecular phylogeny of the genus *Campanula* L. (Campanulaceae) in India

Campanula comprises approximately 650 species worldwide, with 13-17 species in India, including some introduced from neighboring countries. This genus exhibits significant morphological diversity based on environmental factors. During the period, 18 Indian and 10 international herbaria were consulted and roughly 1,535 and 35 specimens were examined. Collection tours in 6 states resulted in 120 voucher specimens of eight species. Twenty five specimens have been microscopically analyzed, and geographic and climatic data were recorded. DNA was extracted from 64 samples, with PCR amplification and sequencing in progress for several loci. Plans for the next year include additional collections, microscopic examinations, DNA analyses, and updates to the Indian *Campanula* species list, situating them within the global *Campanula* phylogeny.

Taxonomic revision and phylogeny of the genus *Tribulus* L. (Zygophyllaceae) in India

Tribulus L., a genus in the Zygophyllaceae family, is morphologically diverse and posses taxonomic challenges due to its phenotypic variations. In India, the genus comprises of 8 taxa, of which *T. terrestris*, a economically important species which is widely distributed through out the country. A taxonomic revisionary study was conducted that consulted 20 Indian and 18 international herbaria, examining 1900 specimens in total. Collection tours in nine states resulted 112 voucher specimens of four taxa. The morphological characteristics of 10 samples were studied and DNA from 69 samples was extracted and analyzed. The project aimed to clarify the taxonomy and phylogeny of *Tribulus* in India, particularly the medicinal species, to ensure their proper identification and usage.

Lab Members:

(L to R): Mr. Narender Kumar, Mr. Harish C Singh, Ms. Jahnabi Gogoi, Mr. Aakash Maurya, Ms. Kanchana

Vaishnav, Mr. Naresh Kumar, Mr. Ram Mohan, Mr. Ranjith Layola M. R., Ms. Bhavya P Mishra, Mr. Abhishek T. Bhat, Mr. Jaideep Sharma, Ms. Arshi Fatima, Mr. Benerjit Wairokpam, Mr. LA Singh

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Plant resource mapping of Chambal Ravines

Under the Chambal Ravines Plant Resource Mapping project, several surveys were conducted to collect plant specimens, charting of plant resources, and recording of ethnobotanical knowledge within the forest and tribal territories. The survey spanned several forest and tribal areas, including Jailalpura Sevapur, Bagadia, Danteti, Dimarsha Ghat, Jimarcha, and Barotha in the Chambal ravines of Sheopur district, Madhya Pradesh. Additionally, it covered Dope Gaon Ater Ghat, Jhundpura, Sarsami, Rajghat, Jaitpura, Bhilpur, Ambah in Morena district, and Kuthiana, Essah, Ater, Cholonga Barhi, Gyanpura, Sankari in Bhind District in Madhya Pradesh. The study documented approximately 50 economically valuable plant species *viz.*, *Xanthium strumarium, Ficus benghalensis, Curcuma longa, Azadirachta indica, Aloe vera, Basella alba, Digera muricata, Commelina benghalensis, Boerhavia diffusa, Phyllanthus fraternus, Euphorbia thymifolia, Ficus racemosa, Papaver somniferum,* and *Eulaliopsis binata*. These plants are frequently used for medicinal purposes in treating a variety of diseases and disorders among the tribal and rural populace.

Lab Member:

Dr. MK Shukla

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New species of lichenicolous fungi discovered

Endohyalina parmotrematis R. Ngangom, Shweta Sharma, S. Joseph & Nayaka (Fig. 2) was discovered from Jaiharikhal, Pauri district, Uttarakhand at 1689 msl (Ngangom et al. 2022). It is characterized by lichenicolous habitat having endokapylic to epikapylic thallus, densely inspersed hymenium and slightly enlarged apical cell of paraphyses, large Mischoblastia-type ascospores. The new species distinct from *E. brandii* the latter has a subsquamulose thallus, non inspersed hymenium, smaller Dirinaria-type (11–14 × 6–7 µm) ascospores and *Aspicilia* as host genus.

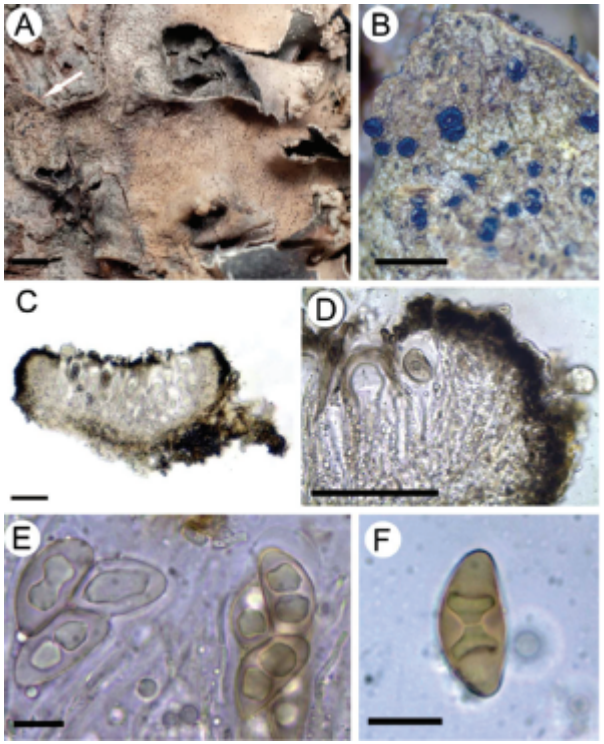

Fig. 2: *Endohyalina parmotrematis*. A–B. Habit showing black lecideine apothecia growing on the necrotic lichen thallus of *Parmotrema austrosinense*; C–D. Apothecial section showing reduced exciple with carbonaceous external layer; E–F. Ascospores ontogeny showing *Pachysporaria*- or *Dirinaria*-type grading into *Mischoblastia*-type at maturity. Scales: A = 2 mm. B = 1 mm. C–D = 50 µm, E–F = 10 µm.

New records for India

Several species of lichenized fungi have been reported as new records for India viz., *Allographa myolensis* (Aptoot) Lücking & Kalb., *Graphis subintermedians* Hale ex Lücking, *Malmidea coralliformis* Kalb., *M. perplexa* Kalb., *M. subgranifera* Kalb & Elix, *M. tratiana* Kalb & Mongk., *Parmeliella cinerata* (Zahlbr.) P.M. Jørg., and *Pyrenula microtheca* R.C. Harris (Islary et al., 2022a); *Ocellularia calvescens* (Fée) Müll. Arg., and *Rhabdodiscus subcavatus* (Nyl.) Rivas Plata, Lücking & Lumbsch (*Islary* et al. 2022b); *Lichinella iodopulchra* (Cauderc ex Croz.) P.P. Moreno & Egea (Saraswat et al. 2023); *Pallidogramme chapadana* (Redinger) Staiger (Ingle et al. 2022); and *Pyrenula chlorospila* (Nyl.) Arnold, (*Biswas* et al. 2022).

Several species of lichenicolous fungi have also been reported as new records for India *viz.*, *Bachmanniomyces santessonii* Etayo, *Intralichen lichenum* (Diederich) D. Hawksw. & M.S. Cole, *Milospium graphideorum* (Nyl.) D. Hawksw, and *Roselliniella* cf. *oxyspora* Matzer and Hafellner (Kumar et al. 2022); *Cladophialophora* aff. *megalosporae* Diederich, *Nesolechia falcispora* (Triebel & Rambold) Diederich, *Phacopsis oxyspora* var. *defecta* Triebel & Rambold, *Punctelia oxyspora* (Tul.) Divakar, A. Crespo & Lumbsch, *Sclerococcum phaeophysciae* Diederich & van den Boom, *Spirographa lichenicola* (D. Hawksw. & B. Sutton) Flakus, Etayo & Miądl, and *Zwackhiomyces kantvilasii* S.Y. Kondr (Sharma et al. 2022); and *Scutula epiblastematica* (Wallr.) Rehm. Also, new generic records of lichenicolous fungi for India were also reported *viz.*, *Milospium* and *Roselliniella* (Kumar et al. 2022).

Lab Members:

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Floristic survey and biodiversity assessment

Chambal Ravines Ecosystem (CRE): Three expeditions resulted over 90 pteridophyte

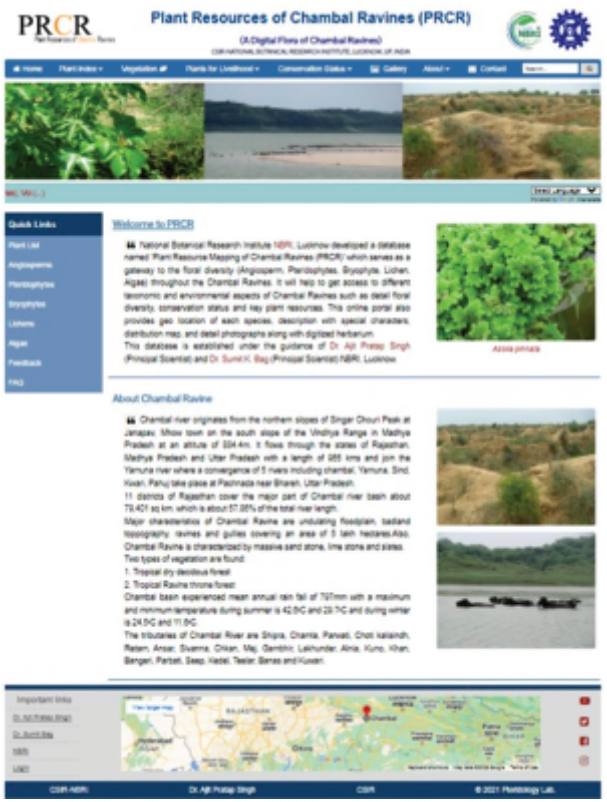

Fig. 3: A database (user interface) named "Plant Resources of Chambal Ravines (PRCR) – A Digital Flora of Chambal Ravines".

samples, identifying 12 species, with special note of *Marsilea crenata*. Conservation needs were highlighted based on grid based diversity studies, and ethno-botanical data for 201 species.

Pachmarhi Biosphere Reserve (PBR): A 10-day, survey from 18 to 28 November, 2022, resulted 93 pteridophyte specimens, spanning 40 species from 22 genera and 18 families. Details on habitat, altitude, and other factors were recorded along with notable species like *Adiantum philippense*, *Ampelopteris prolifera*, *Athyrium falcatum* and *Cyathea gigantea*.

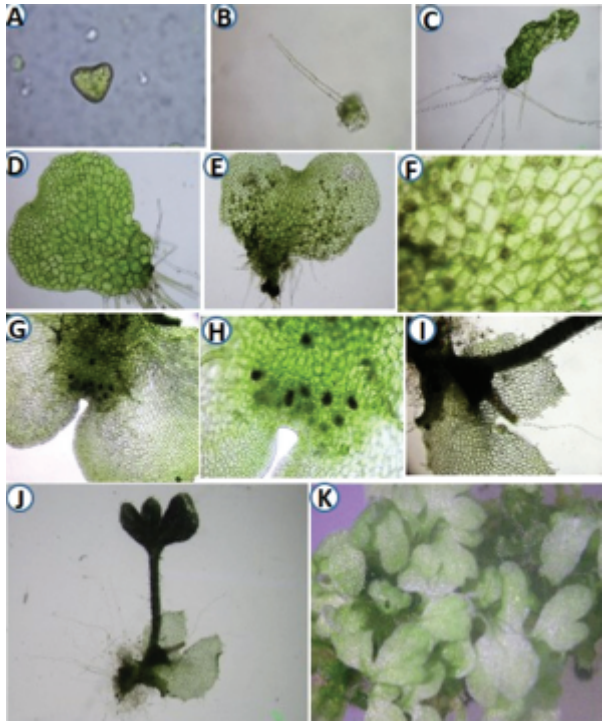

Fig. 4: A-K. Reproductive biology of *Cyathea crinita*. **A.** Spore, **B.** Germinating spore, **C.** Spathulate gametophyte, **D.** Semi-cordate gametophyte, **E.** Cordate gametophyte, **F.** Antheridia on gametophyte, **G.** Archegonia near sinus, **H.** Magnified view of archegonia, **I.** Sporophyte developing on gametophyte, **J-K.** Juvenile sporophytes

Suhelwa Wildlife Sanctuary (SWLS): 95 pteridophyte specimens were collected during a field survey done in SWLS during January 2023, revealing 21 species. New species for the Terai region of Uttar Pradesh, including *Selaginella pinnata*, were discovered.

West Kameng district: 190 pteridophyte specimens were collected between September 20 and October 11, 2022, unveiling 73 species under 32 genera. Noteworthy species included *Adiantum philippense*.

Tamil Nadu & Kerala: 91 specimens were examined, resulting in identification of 40 species from 19 genera.

Conservation Baseline Data: Data for five pteridophyte species was prepared using literature and herbaria consultations. The LWG herbarium processed 512 Pteridophyte specimens, with a database referencing 102 herbarium sheets, primarily *Cyathea gigantea*.

Preparation of database on plant resources of Chambal Ravines

A database named "Plant Resources of Chambal Ravines (PRCR) – A Digital Flora of Chambal Ravines" was prepared (accessible at IP 192.168.1.214/prcr). The database contains information on various plant species and allows for primary data upload, and currently include 36 algae and 135 angiosperms species (Fig. 3).

Developmental biology and reproductive behavior

The developmental and reproductive biology of *Cyathea crinita* was studied. *In-vitro* analysis revealed *Cyathea*-type spore germination and *Adiantum*-type prothalial development. Germination started on day 11, with various gametophyte stages forming over the next 42 days. Protandrous sexuality was observed, with antheridia appearing on day 65 and archegonia on day 72. Sporophytes were produced by day 85, resulting in 33 sporophytes (Fig. 4).

In-vitro multiplication and new introduction

The plantlets of *Cyclosorus* sp. were produced through *in-vitro* spore culture and have been introduced in the fern house of CSIR-NBRI.

Mass propagation and large-scale production

Mass propagation of 12 ornamental ferns viz. *Adiantum capillus-veneris, Colysis elliptica, Christella dentata, Diplazium esculantum, Microlepia strigosa, Microsorum punctatum, M. alternifolium, Nephrolepes biserrata, N. cordifolia, N. exaltata, N. tuberosa, Pteris vittata, Tectaria macrodonta, Selaginella bryopteris* (Sanjeevani Booti) was made for sale. Besides, large-scale propagation of *Pronephrium nudatum, Tectaria coadunata* and *Microsorum scolopendrium* has been made for prospection of potential molecules.

Conservation of plants in Fern House

About 68 species of ferns belonging to different categories of conservation status have been maintained and conserved in the fern house. Live plants of *Lycopodiella cerenua* and *Actiniopteris radiata* were brought to enrich the fern-house.

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Optimization of beta 1,3 glucan production using heterotrophic microalgae

Beta-glucan, a glucose polymer with various biological properties, was optimized for production in heterotrophic microalgae in a 75 L bioreactor. By refining parameters such as the composition of the medium, temperature, and pH, the microalga yielded 14.6 g/L dry biomass containing 58% beta-glucan on the sixth day. This beta-glucan was then extracted, purified, and analyzed using various techniques. Efforts are underway to upscale this production.

Bioresource inventory of Suhelwa Wild Life Sanctuary (SWLS), Uttar Pradesh

In a bioresource inventory at Suhelwa Wild Life Sanctuary (SWLS), five collection tours yielded 273 algal samples from 55 sites. These samples contained 142 algal taxa across eight classes, with Cyanophyceae being dominant. Two genera were identified in India for the first time, and 14 taxa were recorded new to the algal flora of Uttar Pradesh. Additionally, 15 pure algal strains were isolated and identified from SWLS.

Algal diversity in the Chambal Ravines across Uttar Pradesh, Madhya Pradesh, and Rajasthan

Algal diversity was studied in the Chambal ravines that cover Uttar Pradesh, Madhya Pradesh, and Rajasthan. From 282 collected samples, 142 taxa from 72 genera and 48 families were identified across 26 orders. The most diverse phylum was Cyanobacteria (40%) with 29 genera, followed by Chlorophyta (33%) with 24 genera. *Scenedesmus* was the dominant genus. In particular, the brackish water alga *Enteromorpha intestinalis* was recorded for the first time in the Chambal Ravines, as was *Pithophora mooreana*, commonly known as horse hair. Other rare species were also documented (Fig. 5).

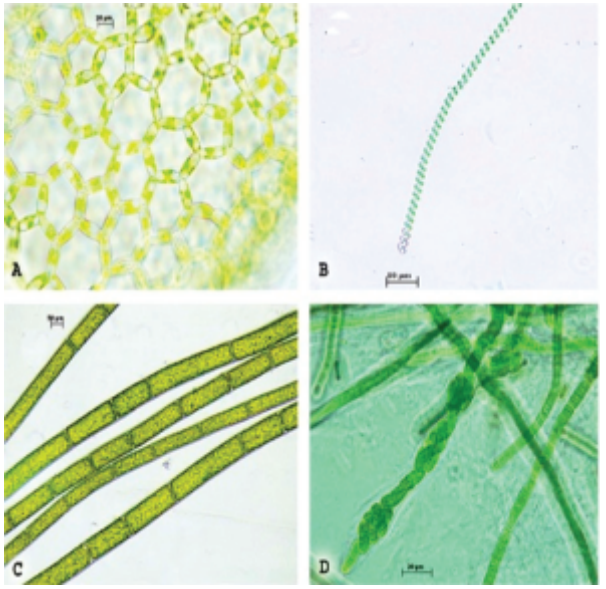

Fig. 5: Microphotographs of some sporadic microalgae documented from Chambal ravine (A) *Hydrodictyon reticulatum* (Linnaeus) Bory, (B) *Spirulina major* Kützing ex Gomont, (C) *Rhizoclonium pachydermum* Kjellman, and (D) *Blennothrix brebissonii* (Kützing ex Gomont) Anagnostidis & Komárek.

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New plant species of grasses discovered

A new species, *Bromus kashmirensis* P. Agnihotri & R. Yadav was discovered from Baramulla dist., Gulmarg, Kashmir, Jammu & Kashmir at an elevation of 2662m (Yadav et al. 2023a) (Fig. 6A). The species is closely related to *Bromus ramosus* and *B. benekenii* but differing from the former by its pubescent culm (versus glabrous), leaf sheath margin smooth (versus retrorsely hirsute), ligule 2.2–2.6 mm long, abaxial surface densely pubescent and pilose hairs present beneath the abaxial side (versus 1.1–6.0 mm long, abaxial surface glabrous or sparsely pilose and pilose hairs absent beneath the abaxial side) and lemma 3-nerved (versus 5 or 7-nerved), and from *B. benekenii* by its retrorsely pubescent upper leaf sheath (versus glabrous or puberulent), lemma 3-nerved (versus 5-nerved rarely 3-nerved) and anthers 3.5–4.5 mm long (versus 1.5–3.0 mm long).

Fig. 6: [A] *Bromus kashmirensis* P. Agnihotri & R. Yadav a newly species discovered. A. Spikelet, B. glumes with rachis (lateral view), C. lower glume (adaxial surface), D. lower glume (abaxial surface), E. upper glume (adaxial surface), F. upper glume (abaxial surface), G. lemma (adaxial surface), H. lemma (abaxial surface), I. palea (adaxial surface), J. palea (abaxial surface), K. anthers, L. lodicules, M. gynoecium. [B] *Poa pindariensis* P. Agnihotri, S. Sharma, D. Prasad A. spikelet, B. spikelet, open view, C. lower glume, lateral view, D. upper glume, lateral view, E. remove florets, F. lemma, G. palea, H. anthers, I. lodicules

Another new species, *Poa pindariensis* P. Agnihotri, S. Sharma, D. Prasad was discovered from Bageshwar, Pindari Valley, Uttarakhand at an elevation of 2650m (Sharma et al. 2022) (Fig. 6B). The new species is quite distinct from *P. trivialis* in having ligules shorter than width of leaf blades; apex obtuse or rounded (versus longer than width of leaf blades; apex acute to acuminate), lower panicle branches spreading and reflexed; spikelets spacious on upper 1/2nd to 2/3rd (versus obliquely ascending, rarely spreading; spikelets crowded on the upper half), lower glumes 1(3)-nerved (versus 1-nerved), callus scanty hairy with hairs 0.65–0.10 mm long (versus webbed with hairs 3.0–5.5 mm long hairs), lemma surface between keel and intermediate nerve ciliated at lower 1/3rd (versus glabrous), dorsal surface of palea densely hairy (versus glabrous or rarely with papilla), keels of palea scabrid, with short prickles (versus minutely bumpy) and anthers (2.0)2.1– 2.7(3.0) mm long (versus (0.8)1.3–1.8 mm long).

Species reported as new record for India

Elymus nepalensis (Melderis) Melderis (Poaceae, Triticeae) is collected for the first time from Dzoukou valley, situated at the border of Manipur and Nagaland states at an elevation of 2452m (Yadav et al. 2023b). The species was only known from Nepal as endemic taxa.

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Assessmentoftheconservation status of threatened plant

Ficus cupulata Haines, a rare tree species endemic to central India, has been found in 15 locations in Panchmarhi Biosphere Reserve and Tamia region (Fig 7). With 585 mature individuals recorded in a 1500 km² area, and an estimated area of occupancy of 64 km² and extent of occurrence of 409 km², it has been classified as Endangered based on IUCN protocol. Another plant, *Jasminum parkeri*, one of the smallest Jasminum species and found only in the Chamba district of Himachal Pradesh in the western Himalayas, faces threats from development activities like hydroelectric projects. It has been classified as Critically Endangered, with an area of occupancy of 8 km² and an extent of occurrence of 23825 km² as calculated by GeoCAT software.

Nomenclature updates

Viola Linnaeus is a genus of approximately 600 species found in temperate and tropical high mountain regions worldwide. After reviewing the literature and protologue consultation, it was determined that the typification of *Viola cinerea* var. *stocksii* was inadequate, and the original material was selected, along with its synonyms, following ICN rules. Additionally, the lectotype (K000901337) and epitype (K000901336) were selected for *Jasminum parkeri* and *Boehmeria clidemioides* (L1624156).

Extended distribution and rediscovery of the taxa

Several taxa have recently experienced extended distribution and rediscovery. *Viola cinerea* var. *stocksii* has been rediscovered in the Chambal ravines of Madhya Pradesh after 52 years. *Boehmeria clidemioides* Miq. (Urticaceae) has been documented for the first time in Uttarakhand state, India. Previously, this species was known to occur in the Eastern Himalayan region, and a potential distribution area map has been provided to facilitate further search for the species in the Western Himalaya. *Rhynchosia suaveolens* (L.f.) DC. has been reported for the first time in the Vidarbha region of Maharashtra. This rediscovery comes after 144 years since its last record in Maharashtra, as the species was previously only documented in the southern part of India.

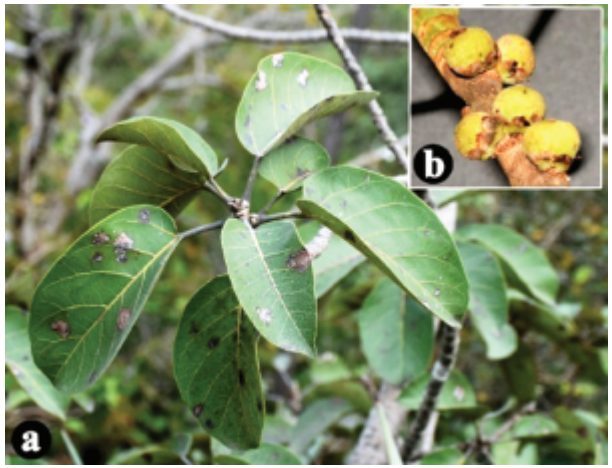

Fig. 7: *Ficus cupulata* Haines: (a) habit, (b) fruits.

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New plant species of Poaceae discovered

A new species of plant named *Ischaemum sunilii* Nithya, K.M.P. Kumar & Maya belonging to Poaceae family was discovered from the Govindamala forest in Nelliyampathy hill range of southern Western Ghats (Jabeena et al. 2022) (Fig. 8).

Revisionary and other taxonomic studies

The taxonomy of *Tarenna flava* Alston, a species in the Rubiaceae: Ixoroideae family, was revisited (Nair et al. 2022). Earlier, the species' strong morphological similarity to *T. asiatica* led to many instances of misidentification in various herbaria. A comprehensive study has now been carried out on this species using fresh samples, which led to the designation of the lectotypes

Fig. 8: *Ischaemum sunilii* A. Habit. B. Inflated peduncle. C. C.S. of peduncle. D. Leaf apex. E. Pseudopetiole of lower leaf. F. Culm at nodal region. G. Ligule bearing bulbous based hairs. H. Leaf sheath bearing bulbous based hairs.

for the names *Tarenna flava* and its heterotypic synonyms, *Stylocoryna webera* A.Rich var. *montana* Thwaites.

Taxonomic and phylogenetic studies on *Impatiens* Sect. *Annuae* (Balsaminaceae)

This study focuses on the taxonomic and phylogenetic investigation of the *Impatiens* species under the section Annuae in India's Western Ghats, with financial support from DST-SERB. Using both morphological and molecular markers, it explores the systematics, molecular phylogeny, intraspecific distribution, and bioclimatic factors related to *Impatiens*. It represents the first attempt to combine morphological, phylogenetic, and ecological studies to understand this genus with a significant proportion of endemic species in India. The section Annuae consists of around 48 taxa, including complex clusters of species. During the reporting period, four major exploration surveys were conducted across 27 different forest regions in Kerala, Tamil Nadu, and Karnataka. The surveys resulted in the collection of 60 accessions from over 15 species. Ten specimens were identified through micro-morphology studies, and DNA isolation was conducted, with ongoing efforts to standardize the protocol for high-quality DNA extraction. The remaining specimens will be identified in subsequent surveys in the coming year.

Plant explorations and IUCN conservation assessment

Four exploration surveys were conducted over 74 days in Uttar Pradesh, Kerala, and Tamil Nadu parts of Western Ghats, relating to the conservation of threatened plants of India and Chambal Ravine. In total, 654 plants were collected and documented, including 61 that are critically endangered or endangered. Out of these, 199 were provided for *ex-situ* conservation. From the southern parts of Western Ghats, 34 samples were documented, with 21 accessions collected for conservation at CSIR-NBRI, and six tuber accessions provided to the Pharmacognosy, Phytochemistry and Product Development division. IUCN threat status assessment for five threatened species *viz*. *Citrus indica, Cycas annaikalensis*, *Garcinia travancorica, Indopiptadenia oudhensis* and *Ixora jhonsonii* has been completed.

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In vitro development of gametophytes and sporophytes of critically endangered fern *Christella kendujharensis*

Two consecutive plant survey and collection expeditions were conducted in various regions of Kotgarh Wildlife Sanctuary. A total of 108 specimens representing 26 taxa from 17 genera across 10 families were collected, with these plants found in diverse habitats such as rocks, soil, and water bodies. Additionally, a survey and collection trip focused on Pteridophytes

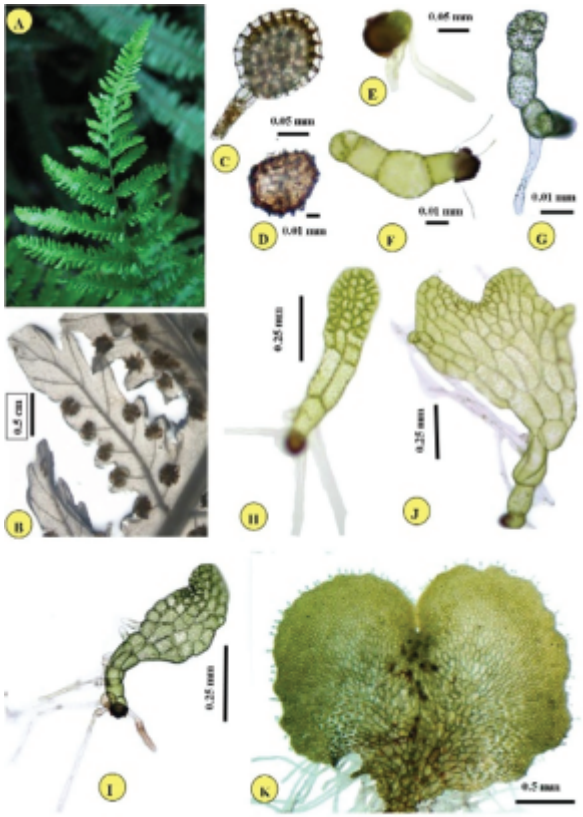

Fig. 9: Spore germination & developmental pattern of *Christella kendujharensis*: A. Habit, B. Pinnule with sori, C. Sporangium, D. A spore, E. Emerging protonema cell, F. 4-celled filamentous stage of the developing gametophyte, G. The beginning of the spathulate stage H. Semi spathulate gametophyte, I. Spathulate gametophyte, J. Semi-cordate gametophyte, K. Cordate gametophyte with apical notch.

was carried out in Suhelwa Wildlife Sanctuary, Uttar Pradesh. A total of 41 specimens belonging to 10 species from 8 genera were collected. Furthermore, a survey and collection of Pteridophytes took place at different sites of Mayudia Pass and Namsai in Arunachal Pradesh. A total of 78 specimens representing 35 taxa from 20 genera across 13 families were collected, with these plants observed in various habitats. In addition, reproductive biology of a critically endangered fern i.e., *Christella kendujharensis* S.K. Behera & S.K. Barik was studied and protocol for its mass propagation has been optimized by taking mature gametophyte as an explant (Fig. 9). Based on the maximum number of regenerated gametophytes, two combinations i.e. (i) 2 mgL−1 kinetin, and 0.01 mgL−1/l 2,4-D, and (ii) 0.1 mgL−1 NAA and 2 mgL−1 kinetin in P&TV media were recommended for mass propagation of this fern.

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New species of lichens discovered

Two new species of lichens have been discovered, viz., *Nephromopsis awasthii* G.K. Mishra, Nayaka & Upreti (Misra et al. 2022a) and *Pyrenula awasthii* G.K. Mishra, S. Nayaka & Upreti (Misra et al. 2022b). *N. awasthii* features a small thallus, plentiful pycnidia, and a lower surface that is reticulately ridged, with veined pseudocyphellae and filiform pycnoconidia. This species grows on tree bark at elevations of 3635-4137 meters and has so far only been found around its type locality in Arunachal Pradesh. On the other hand, *P. awasthii* is characterized by a corticate UV+ yellow thallus, a yellow to orange K+ red medulla, solitary perithecia embedded in thalline warts, non-inspersed hamathecium, and muriform ascospores that measure 40–57 × 17.5–25 µm. This species is found in the states of Arunachal Pradesh and Manipur growing on smooth-barked trees at altitudes ranging from 700–1738 meters (Fig. 10).

Species reported as new record for India

A number of species have been identified in India for the first time *viz*. These include *Cetraria endochrysea* (Lynge) Divakar, A. Crespo & Lumbsch, discovered in the alpine region of Uttarakhand, and *Cetraria sinensis* (X.Q. Gao) Divakar, A. Crespo & Lumbsch, located in the subalpine region of Sikkim (Mishra et al. 2022a). *Nephromopsis morrisonicola* M.J. Lai was discovered in both Arunachal Pradesh and Sikkim, while *Nephromopsis pseudocomplicata* (Asahina) M.J. Lai was only discovered in Arunachal Pradesh (Mishra et al. 2022a). Both *Nephromopsis pseudoweberi* (Essl.) Divakar, A. Crespo & Lumbsch and *Nephromopsis rugosa* Asahina were found in Arunachal Pradesh and Sikkim. Sikkim is also the site of the first record of *Nephromopsis weii* X.Q. Gao & L.H. Chen, and the Eastern Himalayan state of Sikkim reported the first sighting of *Nephromopsis yunnanensis* (Nyl.) Randlane & Saag (Mishra et al. 2022).

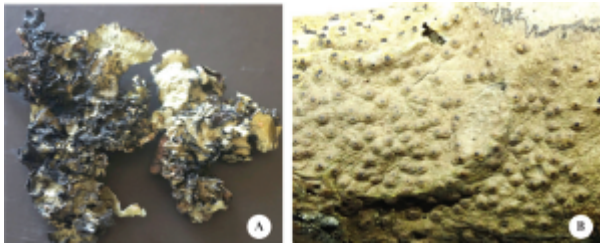

Fig. 10A-B: Habitat of newly plant species discovered- A. *Nephromopsis awasthii,* B. *Pyrenula awasthii*

Assessment of biodiversity and floristic studies

As a result of exploration surveys in the chambal ravines and the state of Punjab, 50 lichen samples were documented. In the Chambal ravines, identified 14 lichen species across 07 genera under three families including two new records to the country. In Pathankot district, the lichen flora is represented by 22 species from 17 genera and 11 families. The dominant families in the area are Physciaceae, with six species, and Ramalinaceae, with four species. Revisionary study of Cetrarioid lichens resulted in the identification of 46 species across 04 genera. This includes one new species and ten species that are new additions to India's flora. The *Nephromopsis* genus was the most dominant, with 27 species, followed by *Cetraria*, with 16 species. Of the 46 identified species, the following are endemic to the subcontinent: *Cetraria ambigua*, *C. stracheyi*, *Nephromopsis hypotrachyna*, *N. isidioidea*, *N. leucostigma*, *N. melaloma*, *N. nephromoides*, *N. stracheyi*, and *N. sikkimensis*. Further revisionary studies on the lichen genus *Pyrenula* were also carried out. After detailed study of around 95 specimens, *Pyrenula awasthii* emerged as a new species.

We also carried out phylogenetic studies of *Typethelium* at the Field Museum in Chicago, USA. Based on freshly collected specimens preserved in the Field Museum (F) herbarium, we performed Polymerase chain reaction (PCR) amplifications of the ITS locus using fungal specific primers ITS1F and ITS4A on 15 specimens. DNA extraction and further phylogenetic studies are currently in progress.

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R&D-02: PHARMACOGNOSY, PHYTOCHEMISTRY AND PRODUCT DEVELOPMENT

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- Dr. Mahesh Pal, Senior Principal Scientist
- Dr. Sharad Srivastava, Sr. Principal Scientist
- Dr. SK Ojha, Sr. Principal Scientist
- Dr. Subha Rastogi, Sr. Principal Scientist
- Dr. Manjoosha Srivastava, Sr. Principal Scientist
- Dr. BN Singh, Principal Scientist

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- Dr. Abhishek Niranjan, Sr. Technical Officer
- Dr. M M Pandey, Senior Technical Officer
- Dr. Anil Kumar, Senior Technical Officer
- Mr. Jai Chand, Technical Officer
- Mr. Dileep Singh, Technican
- Mr. Dileep Singh, Technician
- Mr. Pawan Kumar, Technician
- Mr. Santram, Lab Assistant

Divisions

- Pharmacognosy
- Phytochemistry
- Pharmacology and Product Development

R&D Area Research Scholars Statistics

Sr. No	Position Name	Numbers
1.	Women scientist	01
2.	NPDF	02
3.	JRF/SRF	20
4.	Project Staff	20

Pharmacognosy, Phytochemistry and Product Development

- Preparation of Certified Reference Materials (CRMs)/Reference Materials (RMs): One certified reference material (Eucalyptol) and 2nd batch of two certified reference materials (Geraniol and (+) limonene) were prepared.
- Lotus: Phenolic content was estimated in seed pod, petiole and rhizome of three varieties of *Nelumbo nucifera*.
- Biosynthesized silver nanoparticles (Ka-AgNPs) using the aqueous leaf extract of *Koelreuteria paniculata* as a reducing and capping agent. The anti-QS activity of Ka-AgNPs was tested against a bio-indicator bacterium *Chromobacterium violaceum* and a multi-drug resistant model strain of *P. aeruginosa*. Phyto-synthesized AgNPs could be used as promising anti-infective agents for treating drug-resistant *P. aeruginosa*.
- The root parts of *Piper longum* and *Andrographis paniculata*, were used to make an herbal ointment. The extracts significantly enhanced the rate of wound healing in rats had effective antibacterial activity. These results support the traditional medical practice of using this plant to treat wounds.
- Chemical characterization, stability and antibacterial activity of anthocyanin during storage of color extracts from *Tagetes erecta* and *Morus nigra* study indicates that *Tagetes erecta* flower and *Morus nigra* fruit color extract have a strong antimicrobial activity against microorganisms, and can be explored for health benefits.
- Phytochemical estimation and free radical scavenging activity of some *Cassia suratensis* leaves and *Acacia nilotica* seed was found to be a good source of antioxidants for preventing oxidative stresses-related disease and utilization in therapeutic uses.
- Systematic chemotaxonomic study was carried out for identification of centelloside specific elite chemotypes of *Centella asiatica* and potential cultivation areas.
- Validation of traditional claims of medicinal plants and product development.
- *Thalictrum foliosum* was explored for the efficacy against urolithiatic conditions, inflammation. Berberine and palmitine were quantified as the major bioactive markers.
- An herbal supplement has been developed which is effective in gouty arthritic conditions when compared with standard drug.
- Developed a nutraceutical supplement for the amelioration of diarrheal conditions. It suppresses the growth of diarrhoea causing agents such as *Escherichia coli, Salmonella* sp., *Shigella* sp., and *Vibrio cholerae,* and maintains the gastrointestinal microflora.

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Preparation of Certified Reference Materials (CRMs)/ Reference Materials (RMs)

First batch of certified reference material (Eucalyptol) and 2nd batch of two certified reference materials (Geraniol and (+) limonene) were prepared.

NABL-Gurugram after surveillance audit held in January 2023, recommended the continuation of NABL accreditation of CSIR-NBRI as certified reference material producer with additional scope.

Certificate Number	RC-1015
Validity	March 31, 2023-March 2025
Scope	Certified Reference Materials: Eucalyptol (New aromatic CRM), (+) Limonene, Geraniol (2nd batch of CRMs).

Conservation, management and promotion of Sandalwood (*Santalum album*) Cultivation in India

The carbon isotope composition was determined ($^{13}C/^{12}C$) for the 144 samples of Sandal wood growing in different locations.

Conservation and productivity improvement of Red sanders (*Pterocarpus santalinus*)

Stable carbon isotope composition ($^{13}C/^{12}C$) was determined for 198 heartwood core samples of Red sanders growing in four different locations (Yeshwantpur, Settihalli, Nallal and Jarakbande) of Karnataka.

Lotus - Conservation, agronomics, metabolomics and genomics of India Lotus (KAMAL)

Phenolic content was estimated in seedpod, petiole and rhizome of three varieties of *Nelumbo nucifera*. Total phenolic content (TPC) was estimated using gallic acid as standard and absorption at 720 nm in spectrophotometer. TPC of seedpod, petiole and rhizome was recorded in the range of 40.77 – 58.252, 10.776 to 13.66 and 3.756-13.989 mg/g, respectively. TPC of seedpod was recorded (mg/g) in the range of 7.67- 14.25, 4.15-4.33 in petiole while in rhizome, it was in the range of 1.767 to 17.1.

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Mechanistic insights and therapeutic potential of *Andrographis paniculata* & *Piper longum* root extract against antimicrobial & wound healing in rats

In the current study, the root parts of *Piper longum* (PL, pipermula) and *Andrographis paniculata* (AP, kalmegh) were used to make a herbal ointment that was used to treat incision wounds on albino rats. The phyto-constituents found in kalmegh include diterpenoid lactone, flavonoid, glycoside, and piermula, which are primarily alkaloid in nature and have the potential to promote wound healing in established pharmacological models. Extraction of these two plants was done by cold percolation and HPLC-based fingerprint profiling was carried out to analyze the phyto-constituents of kalmegh and pipermula. Herbal ointment formulation was prepared by mixing the extracts with wool fat and paraffin. Four groups of rats were each given a wound on the back of the neck. A blank placebo was applied topically to the wounds and divided into four groups and each group containing six rats was dressed with a placebo containing 5% and 10% extracts of *A. paniculata*, and 3% and 5% extracts of *P. longum* respectively. The wounds in group 4 were treated topically with the intrasite gel. Macroscopic analysis showed that wounds treated with 10% extract or intrasite gel healed more quickly than wounds dressed with a 5% *A. paniculata* extract placebo. Similarly, 5% of *P. Longum* healed wound faster as compared with a placebo containing 3% extracts. The results showed that wounds treated with 10% *A. paniculata* had more collagen and less angiogenesis with no inflammatory cells present compared to the blank placebo. These investigations show that the herbal ointment formulation of kalmegh and pipermula used for wound healing is safe for topical administration. No toxicity or mortality was noticed during the study time. Ethanol extracts of both plants tested against several clinical isolates of five

respiratory infections; showed antibacterial action and interacted with amoxicillin to inhibit the growth of the bacteria: *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Candida albicans*. Ethanol extracts of *A. paniculata* and *P. longum* exhibited antibacterial activity against both *S. aureus* and *C. albicans* bacteria with minimum inhibitory concentrations of 0.5 mg/mL (Fig. 1). *A. paniculata* and *P. longum* extracts significantly enhanced the rate of wound healing in rats, had effective antibacterial activity, is safe, more efficient and recognized worldwide as natural potential candidates drugs for healing wounds, burns, and cuts. These results support the traditional medical practice of using these plant to treat wounds.

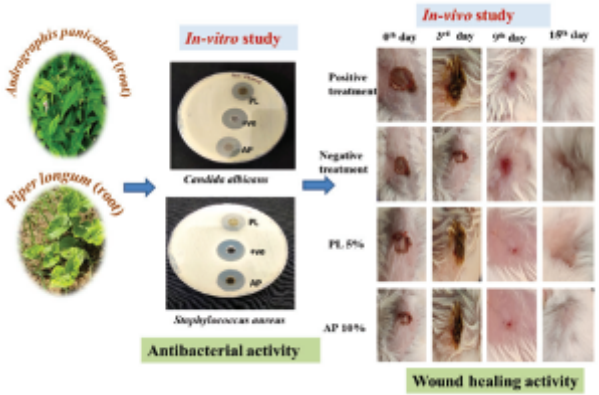

Fig. 1: Wound healing & antimicrobial activity of *Andrographis paniculata* (root) *&* *Piper longum* (root)

Study of medicinal plants to control biofilm-forming pathogenic bacteria *Escherichia coli*

This study demonstrates "the medicinal properties of plants in controlling biofilm forming pathogenic bacteria". In this study, 3 plant crude extracts (NBRI PS1, NBRI PS2, and NBRI PS3,) were tested against bacteria for their antibacterial and anti-biofilm properties. Out of 18 bacterial strains of *Escherichia coli*, one was selected based on biofilm formation assay for the antibacterial and anti-biofilm experiment. According to the result of this study, the yield of plant extract NBRI PS1 (*Terminalia bellirica)* and NBRI PS3 *(Dioscorea bulbifera)* gives a higher yield as compared to NBRI PS2 (*Punica granatum*) crude extracts. The antioxidant activity of the crude extracts NBRI PS3 showed high antioxidant activity in comparison to other plant crude extracts. The antibacterial activity of the crude extracts was tested on gram-negative strains i.e., *E. coli* and was measured in terms of the diameter of the clear zone of growth inhibition at the tested concentration (1mg/ml and 5mg/ ml). NBRI PS3 and NBRI PS1 showed the highest antibacterial activity towards *E. coli* strains at 5mg/ml concentration as compared to NBRI PS2 at 5mg/ml concentration. The anti-biofilm activity demonstrates that among all the three crude extracts NBRI PS3 showed high activity against the pathogenic *E. coli* strains and NBRI PS2 showed less anti-biofilm activity among them (Fig. 2). The pharmaceutical sector may benefit from these two extracts' potential to prevent *E. coli*, particularly in the case of biofilms.

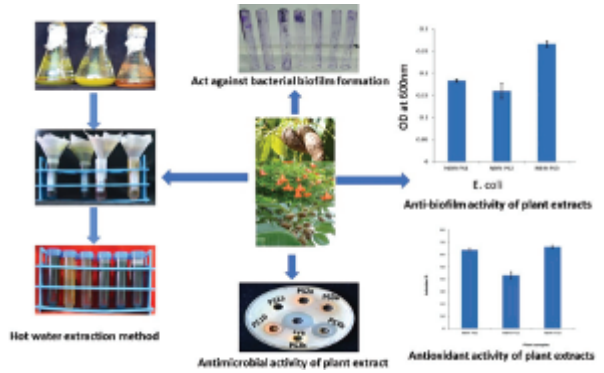

Fig. 2: Antimicrobial & anti-biofilm activity against *Escherichia coli* bacteria

Antidiabetic potential of whole plant extract of *Mucuna prurines* in streptozotocin-induced hyperglycemia in rats

This study aimed to assess the potential antidiabetic effects of the alcoholic extract derived from various parts of *Mucuna pruriens* (seeds, roots, pods, and leaves) in diabetic rats induced with streptozotocin (STZ) (Fig. 3). To induce diabetes associated with pancreatic toxicity in Albino Wistar rats, a single intraperitoneal injection of 60 mg/kg (w/v) of streptozotocin (STZ) dissolved in citrate buffer with a pH of 4.5 was administered and different doses of the extract were administered to rats. Blood glucose levels, body weight, feed intake, and water intake were measured on 0, 7, 14, 21, and 28 days and results were compared with normal and untreated diabetic rats. The disease control had significant changes in body weight, urine sugar, water intake but no changes were seen in feed intake. The oral administration of hydro-methanolic extracts of *M. pruriens*, MPME200 and MPME400, was observed to significantly change the level of urine sugar, but no changes were observed in feed intake, water intake, and body weight, and producing hypoglycemia in STZ-induced diabetic rats when compared with the disease control group.

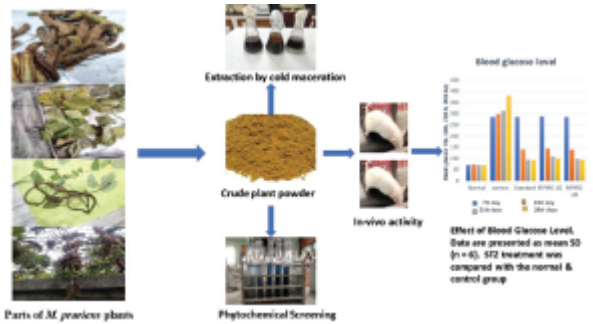

Fig. 3: Antidiabetic activity of whole plant *Mucuna pruriens*

The presence of phyto-constituents such as phenolic compounds, flavonoids, tannins, and triterpenoids, which have demonstrated anti-diabetic properties in standard pharmacological models, may be responsible to bring about hypoglycemia.

Lab members:

(L to R): Mr. Santram, Dr. Pooja Gaur, Mr. Pashupatinath Shukla, Mr. Nandlal Kumar

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Validation of traditional claims of medicinal plants

A study was carried out on pharmacognostical and phytochemical characterization of some traditionally used and ethnobotanically important medicinal plants like *Thalictrum foliolosum*, *Mahonia leschenaultii*, *Mahonia napaulensis*, *Mahonia borealis*, *Eulophia nuda*, *Coscinium fenestratum*, and *Entada rheedi*. The traditional claims of these species were scientifically validated through various *in-vitro* biological assays.

The seeds of *Entada rheedi* are rich source of protein, carbohydrates of low glycemic index, fibers and various micro-macro elements. The study explored the scope of using this underutilized legume through bioactive phytomolecule guided phytochemical and pharmacological studies (Fig. 4).

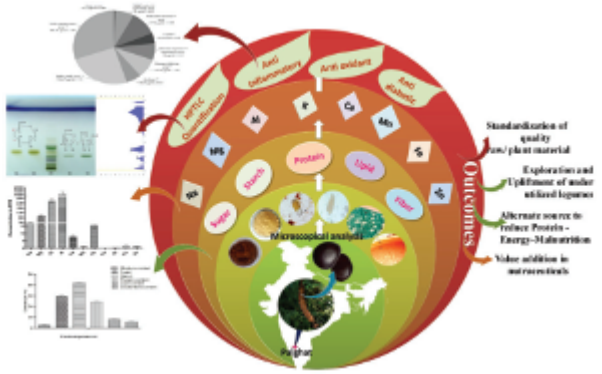

Fig. 4: A grahical representation elucidating the standardization of quality raw material (*Entada rheedii* Spreng.) and scientific validation of its nutritional profile.

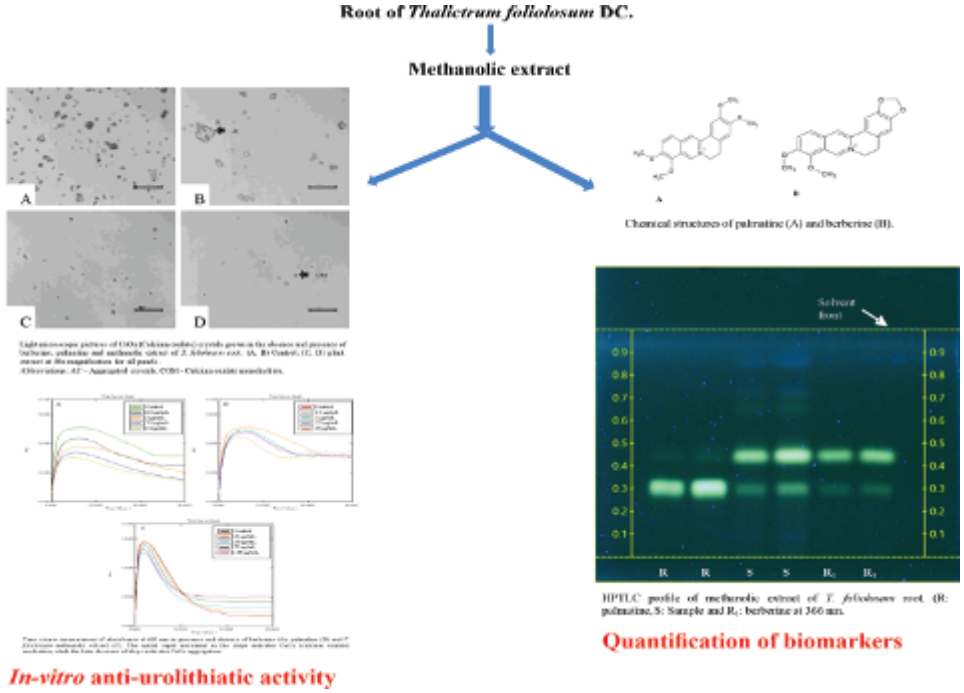

Fig. 5: A graphical representation of *in-vitro* anti-urolithiatic activity and quantification of bioactive markers in standardized extract of *Thalictrum foliosum* DC. roots through HPTLC.

In another study, *Thalictrum foliosum* was explored for the efficacy against urolithiatic conditions, inflammation and ROS. Berberine and palmitine have been quantified as the major bioactive markers (Fig. 5).

Chemotaxonomic studies and identification of quality planting material of *Centella asiatica*

The study aimed at the identification of centelloside specific elite chemotypes of *C. asiatica* and potential cultivation areas. The work involved collection of 109 germplasms of *C. asiatica* from natural habitats of different phytogeographical zones of the country, chemical profiling through RP-HPLC-DAD method and identification of specific metabolite rich germplasm through Ecological Niche Modelling (ENM) approach. Based on variations in bioactive centellosides viz. asiatic acid, madecassic acid, asiaticoside and madecassoside among the natural populations, resulted in identification of suitable eco-regions, specific to these metabolites. This study leads to the identification of "custom-made chemotypes", rich in a particular bioactive metabolite and identification of location specific chemotype (Fig. 6).

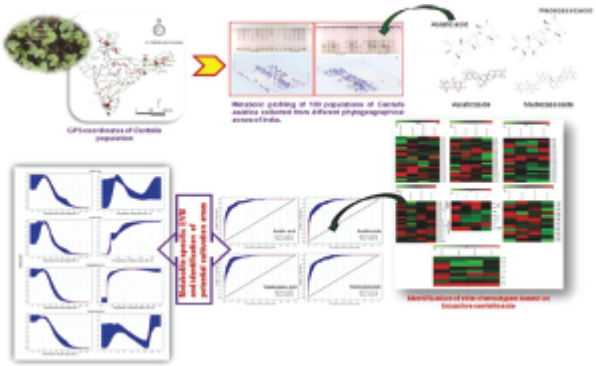

Fig. 6: Diagrammatic representation of work flow of chemotaxonomic study on *Centella asiatica*, showing the collection of germplasms from different locations of India, followed by their analysis using HPTLC and Ecological Niche Modelling for identifying potential cultivation areas for centelloside-specific elite chemotypes

Product development

Natural supplement for gouty arthritic conditions

An herbal supplement was developed containing seven medicinal plants which are synergistically effective in gout when compared with standard drug colchicine. There is significant reduction (80%) reduction in blood uric acid level, 70% reduction in inflammatory mediators (IL-6, TNF-α, IL-1β), reduced pain and improved locomotion (Fig. 7).

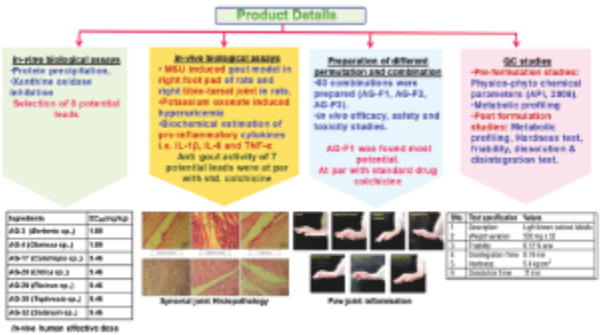

Fig. 7: A graphical representation of herbal formulation for gouty arthritis, using different combinations of seven medicinal plants. The analysis of plants was done using *in-vitro* biological assays and further validated through *in-vivo* studies

A nutraceutical supplement for diarrheal condition

A nutraceutical supplement for the amelioration of diarrheal condition has been developed. It suppresses the growth of diarrhoea causing agents such as *Escherichia coli, Salmonella* sp., *Shigella* sp., and *Vibrio cholerae* and maintains the gastrointestinal microflora. The formulation also replenishes nutrients and maintains sodium level, fibre, vitamin C, vitamin B6, folate, and potassium level in the body. It also complements zinc deficiency during diarrheal conditions (Fig. 8).

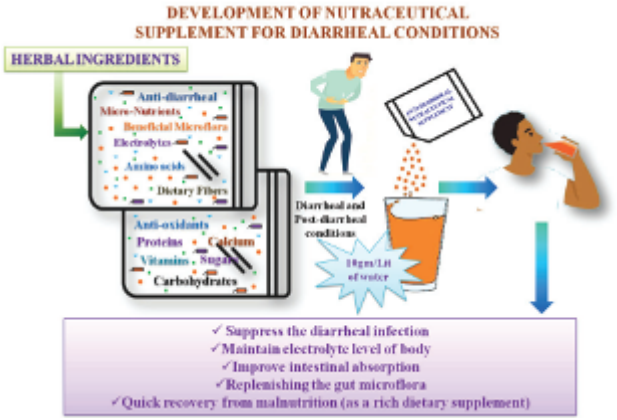

Fig. 8: A graphical representation for the herbal supplement developed for diarrheal conditions, showing constituent and actions and salient features of the formulation

Lab Members:

(L to R): Dr. Ankita Misra, Dr. Bhanu Kumar, Mr. MK Chaudhary, Ms. Poonam Rawat, Mr. Satyam Kumar, Mr. VK Nirala, Ms. Akanksha Srivastava, Ms. Amrita Limboo, Ms. Divya Pradhan, Mr. Adarsh, Ms. Versha S Chauhan, Mr. Naimish Purohit, Mr. Manish Gahalout

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Stability and antibacterial activity of anthocyanin during storage of color extracts from *Tagetes erecta* and *Morus nigra*

The flowers of Marigold (*Tagetes erecta*) and the fruits of Mulberry (*Morus nigra*) have been used for production of food supplements. The present study was based on the evaluation of antimicrobial activity of the extract of the flower and fruit to identify the chemical constituents responsible for antimicrobial potential and also focused on the examination and description of anthocyanins, phenolic compounds, and heavy metals. The moisture content was 82.50% in red petals, 83.12% in the yellow petals of *T. erecta* and 81.01% in black fruit of *M. nigra*. The red flower and yellow flower extract of *Tagetes* obtained by 100% alcoholic and acetonic extraction showed the highest anthocyanin 16.32% and 19.73% stored at elevated temperature (45°C/0 days) while the solvent extracts in *M. nigra* showed, 21.46 mg/100g anthocyanin. Results of the study indicate that these flower and fruit extract have strong antimicrobial activity against mentioned microorganisms of MBFA (MIC: 120 - 562 µg/mL). The *T. erecta* flower and *M. nigra* fruit can be used in dietary applications, beneficial for the agricultural and commercial sectors involved in the production of natural colorants for the health benefits.

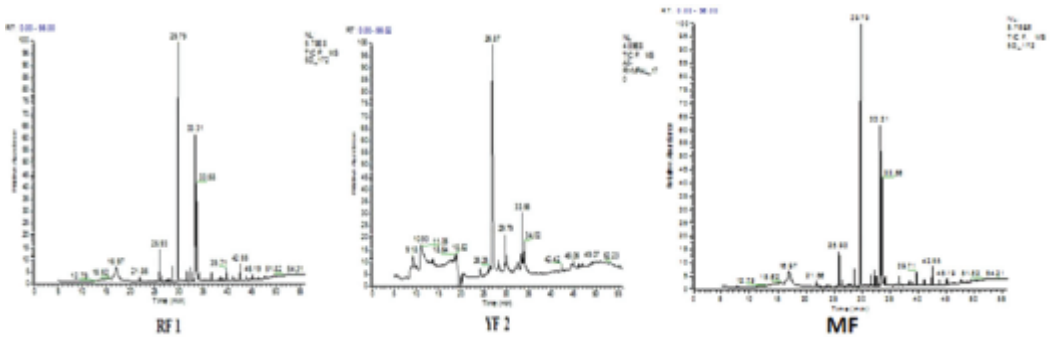

Fig. 9: GC-MS chromatogram of *T. erecta* red flower acetonic extract (RF1), yellow flower ethanolic extract (YF2) and *M. nigra* Fruit extract (MF).

Chemical characterization of *Tagetes erecta* flower and *Morus nigra* fruit extracts by GC-MS

The extract of flower samples of *T. erecta* and the fruit of *M. nigra* were screened for metabolites using GC-MS (Fig. 9). GCMS data indicate that red flower of *T. erectes* have major compounds like Hexadecanoic acid (18.83%), β-carotene (1.03%), Linoleic acid (4.58%), Linolenic acid (2.23%), α-D-Glucopyranoside (5.09%), Myo-Inositol (23.81%), Oleic acid (6.89%) while yellow flower of *T. erectes* have Linoleic acid (3.58%), Linolenic (2.29%), β-carotene (0.81%), α-D-Glucopyranoside (2.89%), and Oleic acid (5.16%). The black fruit of *M. nigra* have major compounds like Myo-Inositol (19.37%), Linoleic acid (11.75%), Linolenic (7.43%), β-carotene (0.19%), α-D-Glucopyranoside (7.13%), and Oleic acid (7.81%). While using GC/MS analysis of *M. nigra*, 13 different compounds were determined.

High–Performance Thin Layer Chromatography method for determination of quercetin, stigmasterol, psoralen and niloticin in the Leaves of Wood-Apple (*Limonia acidissima*)

Limonia acidissima (Rutaceae) is an important medicinal and fruit tree. It is native to India and Sri Lanka. Commonly known as wood apple, *L. acidissima* is also cultivated in Bangladesh,

Indonesia, Malaysia and Pakistan for edible fruits and medicinal and aromatic uses.

A study was conducted to develop and validate high-performance thin layer chromatography (HPTLC) method for quantifcation of quercetin, stigmasterol, psoralen and niloticin in methanolic extract of leaf samples of *Limonia acidissima*. For achieving good separation, a mobile phase of Ethyl acetate: Toluene: Formic acid: Methanol in the ratio of 5.5:3:1:0.5 v/v/v/v was used for stigmasterol and quercetin, and 5:2:1:0.2 v/v/v/v for psoralen and niloticin. The scanning was performed at 386 and 299 nm. Linear regression analysis showed a good linear range of 100–500 ng per spot. The highest content of quercetin (0.02%) in Karnataka, and stigmasterol (0.081%), psoralen (0.035%), niloticin (0.033%) was found in samples from Uttar Pradesh. The proposed method is precise, reliable and reproducible. The method can be used for routine analysis of quercetin, stigmasterol, psoralen and niloticin in various crude drugs and extracts that contain these compounds as active ingredients.

Lab Members:

(L to R): Mr. Abhishek Kumar, Ms. Meenu Verma, Ms. Vaishali Mishra

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Organising health and herbs awareness camps and popular lectures

Various lectures were delivered to motivate and orientate the students about Ayurveda and traditional knowledge.

- Shri Ramchandra Vaidya Ayurvedic Medical College & Hospital, Chinhat, Lucknow on 27 April 2022.
- Babu Yugraj Singh Ayurvedic Medical College & Hospital, Gomti Nagar Vistar, Lucknow on 28 April 2022
- Pharmacy Department IFTM University, Moradabad on 09 June 2022.
- Biotechnology Department, Banasthali Vidyapeeth, Rajasthan on 10th sept 2022.
- Mahila Girls PG College, Lucknow on 03.02.2023.
- Shri Ramchandra Vaidya Ayurvedic Medical College & Hospital, Chinhat, Lucknow, on 24.03.2023.

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Phytochemical estimation and free radical scavenging activity in leaves of *Cassia* species

Phytochemical analysis and antioxidant activity in leaves of *Cassia fistula, C. javanica, C. siamea* and *C. suratensis* were performed. Dried leaves of *Cassia* species were extracted in different polarity gradient solvents for qualitative analysis of primary and secondary metabolites. Quantitative estimation of phenolics and flavonoids was carried out using FCR and antioxidant activity by 2,2-Diphenyl-1-picrylhydrazyl (DPPH) scavenging assay. Phytochemical screening reveals that maximum metabolites are present in ethanol extract in all species as compared to other solvent extracts. Maximum phenolic content was detected in leaves of *C. suratensis* (200±0.046 GAE/g) followed by *C. siamea, C. fistula* and *C. javanica*, respectively. Highest flavonoids were present in *C. suratensis* and *C. siamea* (75±0.025 QE/g), respectively. Percentage inhibition (0.02–0.10 mg/ml) was found in *C. suratensis* (39.72±0.020–91.31±0.001 mg/ml) that is significant. *Cassia suratensis* was found to be a good source of antioxidants for preventing oxidative stresses-related disease and utilization in therapeutic uses.

Phytochemical investigation and antioxidant activity in different parts of *Acacia nilotica* seed

Acacia nilotica, indigenously known as 'Babool' of family Leguminosae has many traditional and ethnobotanical uses. All the parts of tree are important, and seeds are rich in different phytochemicals. The aim of this study was qualitative and quantitative analysis of phytochemicals and evaluation of the antioxidant activity in *Acacia nilotica* seed. Phytochemicals such as carbohydrate, protein, alkaloid,

flavonoids, phenolics, saponin and tannin were present in seed, cotyledon and endosperm. Cotyledon was rich in sugar, carbohydrate, protein and oil, i.e., 4.73%, 17.83%, 30.45% and 11.78% respectively whereas endosperm was rich in phenolics and flavonoids i.e., 2.66 mg/g gallic acid equivalent and 7.66 mg/g quercetin equivalent respectively. Antioxidant activity studies showed that endosperm exhibited maximum percentage inhibition i.e., 74.07% compared to the standard butylated hydroxyanisole having 82.88% inhibition of 2, 2-diphenyl-1-picrylhydrazyl radicals. The study revealed that the specific utilization of *Acacia nilotica* seed have scope in nutritional supplements and as useful bioactive extracts for sustainable health benefits.

Lab Members:

(L to R): Dr. Shobha Singh, Dr. Veenita Tomar, Ms. Geetendra Kumar, Mohd. Arif, Ms. Kajal Srivastava, Mr. Shiwa Chaubey, Mr. Mohan Tiwari, Ms. Shiwangi Srivastava

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Superior inhibition of virulence and biofilm formation of *Pseudomonas aeruginosa* PAO1 by phyto-synthesized silver nanoparticles through anti-quorum sensing activity

Infectious diseases are the most challenging and serious concern, responsible for millions of deaths worldwide every year. These infections spread due to the development of multi-drug resistance (MDR) by common pathogens called "superbug" that limit the efficacy of existing antibiotics. They can survive and proliferate in the presence of antibiotics because they have evolved several strategies to overcome or block the effect of antibiotic agents. *Pseudomonas aeruginosa* is an opportunistic and notorious superbug that causes many nosocomial infections like wounds, respiratory and urinary tract infections. It has the ability to cause both acute

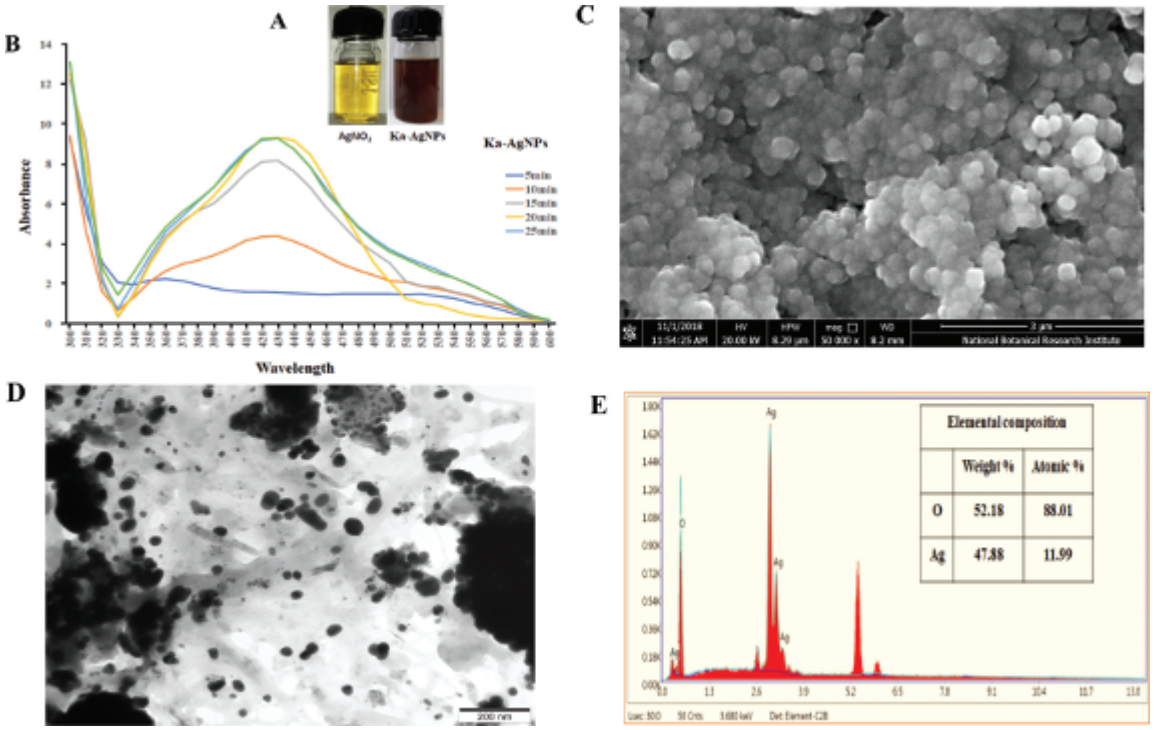

Fig. 10: Characterization of Ka-AgNPs. (A). Photographs of the results for 30 min storage after the redox reaction in the absence and presence of Ka-Ext. (B) UV–visible spectra of Ka-AgNPs. (C) SEM image of Ka-AgNPs. (D) TEM image of Ka-AgNPs. (E) EDX spectrum of Ka-AgNPs.

and chronic infections. *P. aeruginosa* is a leading cause of death in severe respiratory infections. *P. aeruginosa* accounts for around 10% of all

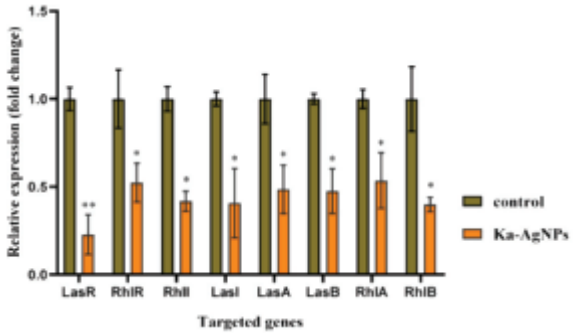

Fig. 11: Effect of Ka-AgNPs on the expression of QS-regulated genes of *P. aeruginosa* PAO1 assessed by RTqPCR analysis. Relative gene expression (represent fold change) in QS-regulated genes, namely *lasR*, *rhlR*, *rhlI*, *lasI*, *lasA*, *lasB*, *rhlA* and *rhlB*. Relative gene expression changes in treatment of Ka-AgNPs at 15 µg/ml concentration. Reference gene, *proC* was taken as internal control to normalize relative mRNA levels for target genes. The graph indicates the mean and standard deviation of three independent replicates. *p < 0.05 vs control. **p < 0.01 vs control.

nosocomial bacterial infections, with 25–60% of patients dying as a result. Quorum sensing (QS)-regulated bacterial biofilm formation is a crucial issue in causing resistance against existing antibiotics. There is a considerable necessity to disrupt the interrelationship between bacterial QS, virulence, and biofilm formation. Disabling QS could be a novel tactic of great clinical importance. We have biosynthesized silver nanoparticles (Ka-AgNPs) using the aqueous leaf extract of *Koelreuteria paniculata* as a reducing and capping agents. The UV–Vis spectroscopy confirmed the synthesis of Ka-AgNPs as a characterization peak observed at 420 nm. TEM image revealed the spherical shape distribution of Ka-AgNPs with average particle size of 30.0 ± 5 nm (Fig. 10). The anti-QS activity of Ka-AgNPs was tested against a bio-indicator bacterium *Chromobacterium violaceum* 12472 and a multi-drug resistant model strain of *P. aeruginosa* (PAO1). The results demonstrated that the Ka-AgNPs superiorly inhibited QS-regulated virulence factors in PAO1 without affecting cell viability compared to chemically synthesized AgNPs (Cs-AgNPs). The Ka-AgNPs effectively suppressed the formation of biofilm of PAO1. RT-PCR results revealed that the Ka-AgNPs inhibited the expression of QS-regulated virulence genes of PAO1 (Fig. 11). These results suggest that the phyto-synthesized AgNPs could be used as promising anti-infective agent for treating drug-resistant *P. aeruginosa*.

Lab Members:

(L to R): Dr. BS Paliya, Mr. VK Sharma, Mr. Nem K Nagpoore, Dr. Ashish Kumar, Ms. Ashwariya Jaiswal, Mr. Shushil Agrahari, Ms. Akanksha Rai, Mr. Johnson Gill, Mr. SC Gupta

R&D-03: PLANT ECOLOGY AND ENVIRONMENTAL TECHNOLOGY

Area Coordinator

Dr. P.A. Shirke, Chief Scientist

Scientific Staff

- Dr. Vivek Pandey, Chief Scientist
- Dr. PK Srivastava, Sr. Principal Scientist
- Dr. Shekhar Mallick, Sr. Principal Scientist
- Dr. SK Behera, Sr. Principal Scientist
- Dr. Suchi Srivastava, Principal Scientist
- Dr. Aradhana Mishra, Principal Scientist
- Dr. Puneet S Chauhan, Principal Scientist
- Dr. Poonam C Singh, Principal Scientist
- Dr. Dibyendu Adhikari, Principal Scientist
- Dr. Richa Rai, Senior Scientist
- Dr Anju Patel, Scientist

Technical Staff

- Dr. Sanjay Dwivedi, Sr. Technical Officer
- Dr. GG Sinam, Sr. Technical Officer
- Dr. Sumit Yadav, Sr. Technical Officer
- Dr. Rekha Kannaujia, Technical Officer
- Dr. Shashank K Mishra, Technical Officer

R&D Area Research Scholars Statistics

Sr. No	Position Name	Numbers
1.	Women scientist	01
2.	Research Associate	01
3.	NPDF	01
4.	JRF/SRF	39
5.	Project Staff	33

Plant Ecology and Climate Change Science

Broad Areas of R&D

- Plant eco-physiological and biochemical processes in response to air pollution and climate change.
- Forest ecosystem structural and functional analysis, forest biomass, and forest carbon sequestration.
- Restoration/rehabilitation of degraded ecosystems and threatened plants, developing new methods for EIA/CIA, ecological and climate change modelling, bioresource mapping & GIS.
- Arsenic detoxification mechanism in rice employing biotic and abiotic agents, monitoring and assessment of toxic and pathogenic agents in environmental matrices.

Major R&D Highlights

- Carbon sequestration potential of tropical trees *Tectona grandis*, *Mallotus nudiflorus*, and *Syzygium cumini* in an urban locality (Lucknow) was studied. *T. grandis* exhibited superior above ground biomass, photosynthetic rates, water use efficiency, and stomatal conductance, making it a favorable candidate for urban plantation.
- Net primary productivity (NPP) of three distinct communities: Mixed (DM), Sal (SM), and Teak (TP) in a North Indian Tropical Moist Deciduous Forest was quantified and related to various tree metrics, species diversity, microclimatic, edaphic variables, and leaf area index (LAI) using PCA and GLM. A significant relationship was found between NPP and microclimatic variables, notably air temperature and humidity.
- Distribution of the invasive weed *Ageratina adenophora* in the Sikkim Himalaya was examined across seven elevation levels. 81 species from 30 families were identified in association with *A. adenophora*. Species distribution model (SDM) predicted its potential geographic spread in the Sikkim Himalaya.
- Eight wheat cultivars were exposed to individual treatment of (i) ambient CO_2, temperature, and ozone representing the present climate scenario, and (ii) elevated CO_2 (550 ppm) (ECO), (iii) elevated temperature (+2°C) (ET), (iv) elevated O_3 (ambient+20 ppb) (EO), (v) elevated CO_2+elevated O_3 (ECO+EO), and (vi) elevated CO_2+ elevated temperature+ elevated O_3 (ECO+EO+ET) under FACE facility simulating the future climate change scenarios in 2050. Niche model predicted a decrease in climatically suitable areas for wheat, with "maximum temperature" being the dominant influencing factor, suggesting challenges for future wheat cultivation in India.
- The effects of ambient and elevated ozone levels were assessed on nine urban tree species under Free Air Ozone Enrichment (FAOE).

Under EO_3 treatment, stomatal density (SD) significantly decreased and guard cell length (GCL) increased in *Azadirachta indica*, *Bougainvillea spectabilis*, *Plumeria rubra*, *Saraca asoca* and *Tabernaemontana divaricata*, while SD increased and GCL decreased in *Ficus benghalensis* and *Terminalia arjuna*. EO_3 significantly reduced photosynthetic rate, stomatal conductance (gs), and transpiration rates (E). The Air Pollution Tolerance Index (APTI) varied across species, emphasizing the need for consideration in urban forestry planning.

- A FACE (Free Air Concentration Enrichment) study was conducted with ethylenediurea (EDU; 200 ppm) on two wheat cultivars (PBW-154, WH-1105) in high ambient ozone (AO_3) stress under ambient CO_2 (ACO_2) and elevated CO_2 (ECO_2; 550 ppm). EDU specifically protects crops against deleterious O_3 effects. WH-1105 cultivar was found to be more sensitive to O_3. Study showed that prevailing ambient O_3 levels are already causing yield losses and will continue to do so in future high CO_2 environment. ECO_2 negatively impacted grain nutrient content in wheat.
- The phytoremediation capability of *Helianthus annuus* in Ni-Cd battery electrolyte-contaminated soil was enhanced using e-waste tolerant bacteria, *Brucella intermedium* (E1) and *Bacillus velezensis* (EW8). Particularly, EW8 increased Ni uptake in the plant and enhanced metal bioavailability, even though the translocation factor was below 1. The overall metal bioaccumulation in the plant was improved with these bacterial treatments.
- Abiotic stresses, notably fluoride (F^-), impede plant growth right from germination stage. An analysis of four staple crops exposed to varying F^- toxicity levels during germination highlighted differing tolerances between C3 and C4 plants. Among the crops, *O. sativa* accumulated the most fluoride in its tissues, followed by *Z. mays*, *P. glaucum*, and *T. aestivum*. *T. aestivum* was the most fluoride-sensitive, while *P. glaucum* was the most tolerant. Oxidative stress markers and antioxidant activity were most enhanced in *O. sativa*. Additionally, F^- exposure altered stomatal structures and impacted metaxylem properties across all seedlings.
- Stomatal development under water stress was investigated in the cotton varieties LRA-5166 (drought-tolerant) and NBRI-67 (drought-sensitive). LRA-5166 exhibited superior stomatal characteristics. Gene expression analysis suggested a regulated increase of specific stomatal genes in response to drought, influencing stomatal numbers, guard cell length, and water use efficiency (WUE).
- Adaptations to future climate scenarios of three threatened *Ilex* species viz., *I. khasiana*, *I. embelioides*, and *I. venulosa* were studied using ecological niche modeling and eco-physiological analyses. *Ilex* species' survival was found to be contingent on their morpho-physiological and demographic adaptations to climate-induced stresses. The findings emphasize the need for species-specific conservation strategies.

Microbial Technology

Broad Areas of R&D

- The group focuses on disease management of commercially valuable crops and developing sustainable eco-friendly remedies.
- Biological control, Plant microbe interactions and sodic soil reclamation.
- Assure food safety and protect the environment through development of economical and efficient bio-inoculants formulations both for agricultural lands and stressed soils.
- Elucidation of molecular mechanism(s) of microbe mediated abiotic and biotic stress tolerance in different crop plants.

Major R&D Highlights

- The bio-control potential of *Bacillus subtilis* PBE-8 (MTCC 25189) was assessed against *Fusarium oxysporum* f. sp. *lycopersici* (FOL) using physiological and metabolic methods. The findings highlighted its promising efficacy as a biocontrol agent against *Fusarium* infection.
- *Bacillus subtilis* (NBRI-W9), an endophytic biofungicide, restores metabolic balance in tomato plants disrupted by Propiconazole and offers enhanced immunity against non-target bacterial pathogens. It outperforms the sole use or combination of the chemical fungicide.

- *B. amyloliquefaciens* SN13 enhances rice nutrient status, stress-responsive genes, and carbohydrate and fatty acid metabolic pathways. It plays a role in the interaction between external stresses and phytohormones.
- Consortia of salt-tolerant bacteria, including *Bacillus safensis* NBRI 12M and *B. subtilis* NBRI 28B and 33N, significantly enhanced salt tolerance in *Arabidopsis* by modulating its transcriptional and metabolic processes.
- A microbial consortium comprising yeast (*Debaromyces hansenii*), bacteria (*Citrobacter* sp.), and methyltransferase-containing *P. oleovorans* was developed to improve arsenic reduction in rice.
- A novel microbial consortium of 3 fungi and 4 bacteria was formulated to effectively degrade mulched rice straw, improve soil health, and promote wheat growth, with validation in progress.

Environmental Technology

R&D Objectives

- Monitoring and assessment of soil pollutant(s)/ contaminant(s) in respect of the water-soil-crop continuum of agriculture.
- Development of technologies for remediation of pollutant(s) contamination in crops/ vegetables.
- Microplastic isolation and characterization in soil.
- Biochar for metal remediation and enhancing crop productivity.

Major R&D Highlights

- Research on *Bacopa monnieri* revealed its ability to tolerate multiple metals in tannery sludge-contaminated soil. The study also examined its antioxidant capacities and bacoside-A content. Notably, the plant effectively sequestered metals in its roots, especially when grown in a 75:25 tannery sludge-to-soil mix.
- A modified method for quantifying microplastics in agricultural soil was standardized, achieving over 90% recovery for particles ≥ 20 µm. This efficient, cost-effective technique preserves the physico-chemical properties of the extracted microplastics, which are then identified by shape, colour, size, and polymer composition.

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Drought stress inhibits stomatal development to improve water use efficiency in cotton

Stomata play a principal role in adjusting carbon dioxide (CO_2) intake and water use for plant adaptation and tolerance to water-restricted conditions. In the present study, impact of water stress-mediated stomatal development in drought-tolerant LRA-5166 and sensitive NBRI-67 cotton (*Gossypium hirsutum*) varieties was elucidated through, growth parameters, leaf gas exchange, stomatal traits and transcript level of stomatal genes. Our findings showed that the tolerance of LRA-5166 variety was associated with higher stomatal density and stomatal index and smaller guard cells as compared to the sensitive NBRI-67 variety. These developmental changes in stomata resulted in comparatively better stomatal regulation in LRA-5166 than NBRI-67 *vis-a-vis* transpiration and stomatal conductance. The expression analysis of stomatal genes showed that transcript levels of *EPIDERMAL PATTERNING FACTOR 2* (*EPF2*), *STOMATAL DENSITY AND DISTRIBUTION 1* (*SDD1*), and *TOO MANY MOUTH* (*TMM*) were distinctly enhanced in both LRA-5166 and NBRI-67 under water stress. While the transcript level of *STOMAGEN* (*STG*) was reduced in both the varieties. The up-regulation of *EPF2, SDD1,*

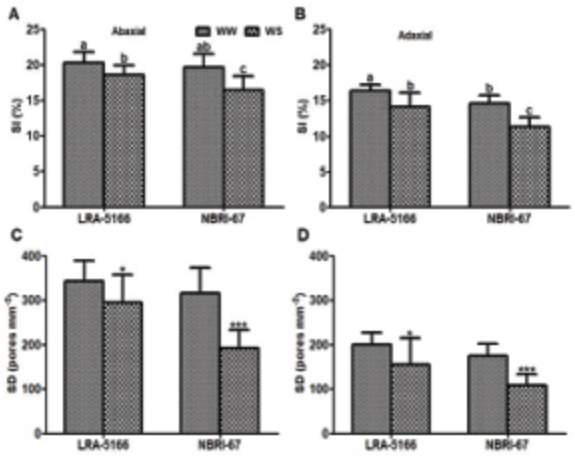

Fig. 1: Variation in stomatal development responses in cotton plants after 15 days of water stress. (**A**) SI, Stomatal index (%) of abaxial surface, and (**B**) adaxial surface. (**C**) SD, Stomatal density (mm^{-2}) on abaxial surface, and (**D**) adaxial surface. Values are means ± SD (n=15). For (**A-B**) one-way ANOVA (P<0.05) was used to determine significant differences (letters on the bar) between water treatment within the two varieties. For (**C-D**) *t*-test was performed between the water treatments in the two varieties; with significance at P<0.05*, P<0.01**, P<0.001***

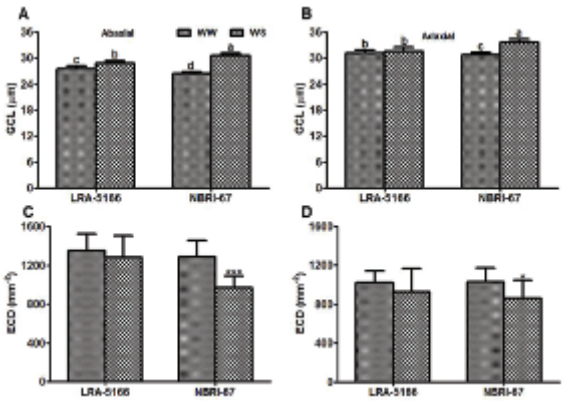

Fig. 2 Variation in GCL, guard cell length and ECD, epidermal cell density in leaves of cotton plants subjected to 15 days water stress. (**A**) GCL of abaxial and (**B**) of adaxial surface. (**C**) ECD on abaxial and (**D**) on the adaxial surface. Values are means ± SD (n=75 for **A-B** and n=15 for **C-D**). For (**A-B**) one-way ANOVA (P<0.05) was used to determine significance (letters on the bar) between the water treatment. (**C-D**) *t*-test was performed for differences in significance between water treatments in the two varieties; at P<0.05*, P<0.01**, P<0.001***

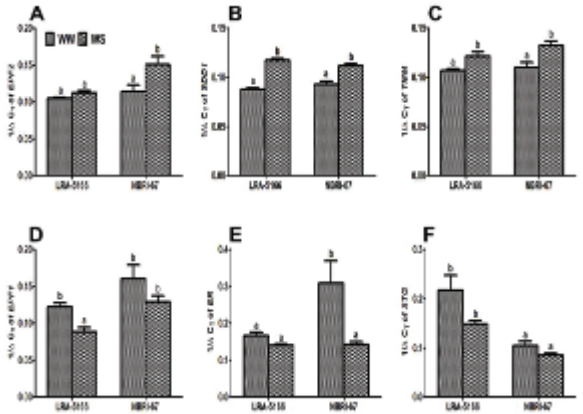

Fig. 3 Variation in the relative expression of genes involved in stomatal development in cotton plants grown under well-watered and water stress conditions. (**A**) *EPIDERMAL PATTERNING FACTOR2,EPF2*; (**B**) *STOMATAL DENSITY AND DISTRIBUTION, SDD1*; (**C**) *TOO MANY MOUTH,TMM;* (**D**) *EPIDERMAL PATTERNING FACTOR1, EPF1;* (**E**) *ERECTA,ER*, and (**F**) *STOMAGEN, STG* in developing leaves of cotton plants exposed to 15 days of water stress compared with well-watered (Control) condition. mRNA level was estimated by qRT-PCR in well-watered and water stress conditions. Relative expression levels were normalized to Ubiquitin (housekeeping gene). Data are mean ± SE of three biological replicates with two technical replicates each. The letters a and b above the bar represents significant differences at P<0.05 level by univariate ANOVA with Duncan test (the common letter showed no significant changes).

and *TMM* genes in sensitive variety reduced the stomatal density and index more than the tolerant variety. Our studies reveal that regulated increase of *EPF2, SDD1* and *TMM* to drought could be involved in plasticity of stomatal numbers and guard cell length and, therefore more efficiently regulates water use efficiency (*WUE*) and plant's ability to combat drought.

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Response of tropical trees to elevated Ozone: a Free Air Ozone Enrichment study

Tropospheric ozone (O_3) has become one of the main urban air pollutants. We assessed the impact of ambient and future ground level O_3 on nine commonly growing urban tree species under Free Air Ozone Enrichment (FAOE) condition. During the study period, mean ambient and elevated ozone (EO_3) concentrations were 48.59 and 69.62 ppb, respectively. Under EO_3 treatment, stomatal density (SD) significantly decreased and guard cell length (GCL) increased in *Azadirachta indica*, *Bougainvillea spectabilis*, *Plumeria rubra*, *Saraca asoca* and *Tabernaemontana divaricata*, while SD increased and GCL decreased in *Ficus benghalensis* and *Terminalia arjuna*. EO_3 significantly reduced photosynthetic rate, stomatal conductance (gs), and transpiration rates (E). Only *A. indica* and *N. indicum* showed higher gs and E under EO_3 treatment. Air Pollution Tolerance Index (APTI) significantly increased in *Ficus religiosa* and *S. asoca* whereas it decreased in *B. spectabilis* and *A. indica*. Of all the plant species B. spectabilis and *A. indica* were the most sensitive to EO_3 (due to high gs and less ascorbic acid content) while *S. asoca* and *F. religiosa* were the most tolerant (low gs and more ascorbic acid content). The sensitivity of urban tree species to EO_3 is a cause of concern and should be considered for future urban forestry programmes.

Ethylenediurea (EDU) mediated protection from ambient ozone-induced oxidative stress in wheat (*Triticum aestivum* L.) under a high CO_2 environment

A FACE (Free Air Concentration Enrichment) study was conducted with ethylenediurea (EDU; 200 ppm) on two wheat cultivars (PBW-154, WH-1105) in high ambient ozone (AO_3) stress under ambient CO_2 (ACO_2) and elevated CO_2 (ECO_2; 550 ppm). EDU specifically protects crops against deleterious O_3 effects. During the study period, AO_3, ACO_2, and ECO_2 concentrations were 63 ppb, 413.69 ppm, and 553.54 ppm, respectively. EDU treatment enhanced wheat photosynthesis, chlorophyll content, biomass and yield (grain weight plant^{-1}, grain no plant^{-1}, and 1000 grain weight) under ECO_2 as compared to EDU-treated cultivars grown under ACO_2. EDU-treated wheat cultivars showed less lipid peroxidation, high levels of antioxidants and antioxidant enzymes under both ambient and ECO_2 conditions. WH-1105 cultivar was found to be more sensitive to O_3. Improved growth and yield in wheat cultivars

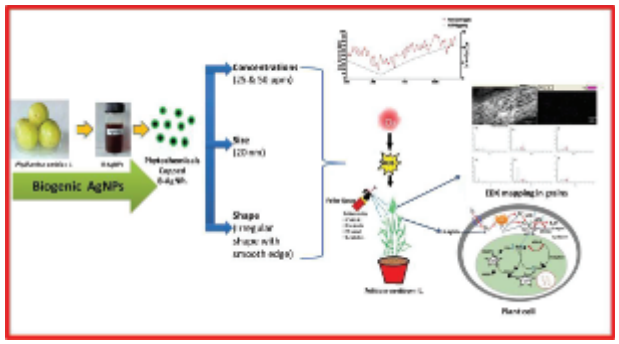

Fig. 4: Evaluating impacts of biogenic silver nanoparticles and ethylenediurea on wheat (*Triticum aestivum* L.) against ozone-induced damages

treated with EDU under ECO_2 environment showed that prevailing ambient O_3 levels are already causing yield losses and will continue to do so in future high CO_2 environment also. ECO_2 negatively impacted grain nutrients in both wheat cultivars while EDU alleviated, both, the negative impacts of high ambient O_3 stress on grains and ECO_2-caused decline in grain nutrient content in wheat.

Evaluating impacts of biogenic silver nanoparticles and ethylenediurea on wheat (*Triticum aestivum* L.) against ozone-induced damages

Tropospheric ozone (O_3) is a phytotoxic pollutant that leads to a reduction in crop yield. Nanotechnology offers promising solutions to stem such yield losses against abiotic stresses. We evaluated the anti-ozonant efficacy of biogenic silver nanoparticles (B-AgNPs) and compared them with a model anti-ozonant ethylenediurea (EDU) against ozone phyto-toxicity. Growth, physiology, antioxidant defense, and yield

parameters in two wheat cultivars (HD-2967 & DBW-17), treated with B-AgNPs (25 mg/L and 50 mg/L) and EDU (150 mg/L and 300 mg/L), were studied. Growth and yield in B-AgNPs as well as EDU-treated plants were significantly higher in both the tested cultivars over control ones. DBW-17 cultivar responded better with B-AgNPs and EDU treatments as compared to HD-2967. Meanwhile, foliar exposure of B-AgNPs (dose; 25 mg/L) significantly enhanced grain weight plant^{-1}, thousand grain weight, and harvest index in DBW-17, when compared to control. It is concluded that B-AgNPs at optimum concentrations were as effective as EDU, hence could be a promising ozone protectant for wheat (Fig. 4).

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Assessment of microplastic contamination in agroeco-systems

Microplastics from primary and secondary plastics are the cause of concern with reference to agroecosystems and contamination of the food chain (Fig. 5). We standardized and validated a modified method of microplastic quantification

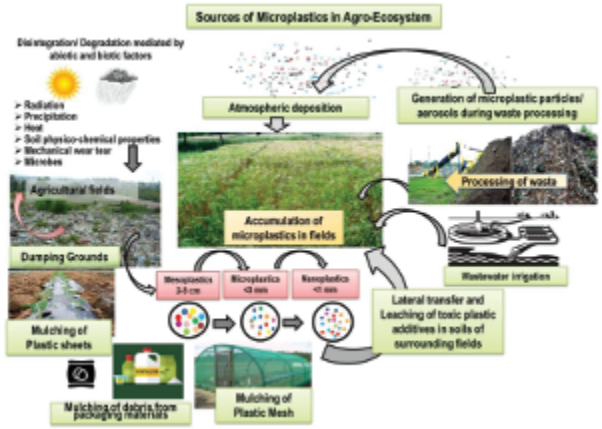

Fig. 5: Processes leading to microplastic contamination in agricultural fields

in agricultural soil with more than 90% recovery of microplastics (size ≥ 20 µm) from soil samples. The methodology contains a simple and cost-effective procedure to extract and quantify microplastics without affecting the physico-chemical properties of plastic particles in soil samples. A pilot study in and around Lucknow municipal corporation limits was carried out to assess whether the microplastics are reaching the agricultural fields nearby. Different sites have been selected for the quantification of microplastics viz., the agricultural site near the municipal solid waste dumping ground, an off-road-agricultural site, an open dumping site, and a wetland site. Microplastics were identified based on the shape, colour, size, and composition of the polymer. Risk assessment of microplastics for pollution load index, polymer hazard index and potential ecological risk indices are being computed. CSIR-NBRI reviewed and unravelled the emerging threats of microplastics in the agroecosystem.

Biological approaches for the amelioration of arsenic toxicity in rice

Different microbial approaches for mitigation of arsenic toxicity in rice were studied by the group, viz., co-inoculation of arsenate reducer yeast with multifunctional arsenite oxidizing bacteria, and inoculation of microbial strains having methyltransferase activity for lowering arsenic uptake in rice grains. The application of selected nutrient amendments containing P, Zn, SiO_2, and S for regulating soil properties to achieve the reduction of arsenic accumulation in rice grains have also been standardized.

Immobilized novel fungal consortium for the efficient remediation of cyanide-contaminated wastewater

In a column-based study, a novel consortium of *Trichoderma saturnisporum* and *T. citrinoviride* in the form of immobilized culture was employed for significant reduction (99%) of free cyanide content within 48 hours in cyanide-contaminated wastewater. In the study, microbial rhodanese activity (sulfurtransferase) was found to be dependent on GSG : GSSH ratio. First-order kinetics was the best-fitted model for CN biodegradation in the study.

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Bacillus amyloliquefaciens modulates carbohydrate metabolism in rice-PGPR cross-talk under abiotic stress and phytohormone treatments

Rice is one of the world's most important food crops that is severely affected by abiotic stresses. In our earlier study, inoculation with *Bacillus amyloliquefaciens* SN13 (SN13) improved the growth of rice seedlings under salt and drought stress as compared to other abiotic stresses. Therefore, the present study was carried out to understand the possible mechanism induced by *B. amyloliquefaciens* for salt and drought tolerance. Further, the role of SN13 in phytohormone-induced stress tolerance by exogenous application of abscisic acid and ethylene was investigated. The SN13 inoculated rice seedlings showed significantly better performance as demonstrated by physio-biochemical, antioxidant enzyme activities, and nutrient analysis. The expression of positively regulated stress-responsive genes was found under abiotic stresses and phytohormone treatments in inoculated seedlings indicating its multifaceted role in abiotic stresses and phytohormone cross-talk in response to PGPR. Inoculated seedlings also showed altered metabolites primarily related to carbohydrates (glucose, galactose, fructose, ribose, trehalose, turanose, hexapyranose, and xylose) and fatty acid (dodecanoic acid, eicosenoic acid, hexadecanoic acid, linolenic acid, and octadecadienoic acid) metabolism (Fig. 6). The findings affirm that *B. amyloliquefaciens* SN13 positively modulates plant nutrient status, stress-responsive genes, and metabolic pathways related to carbohydrate and fatty acid metabolism supporting its involvement in cross-talk between imposed stresses and phytohormones.

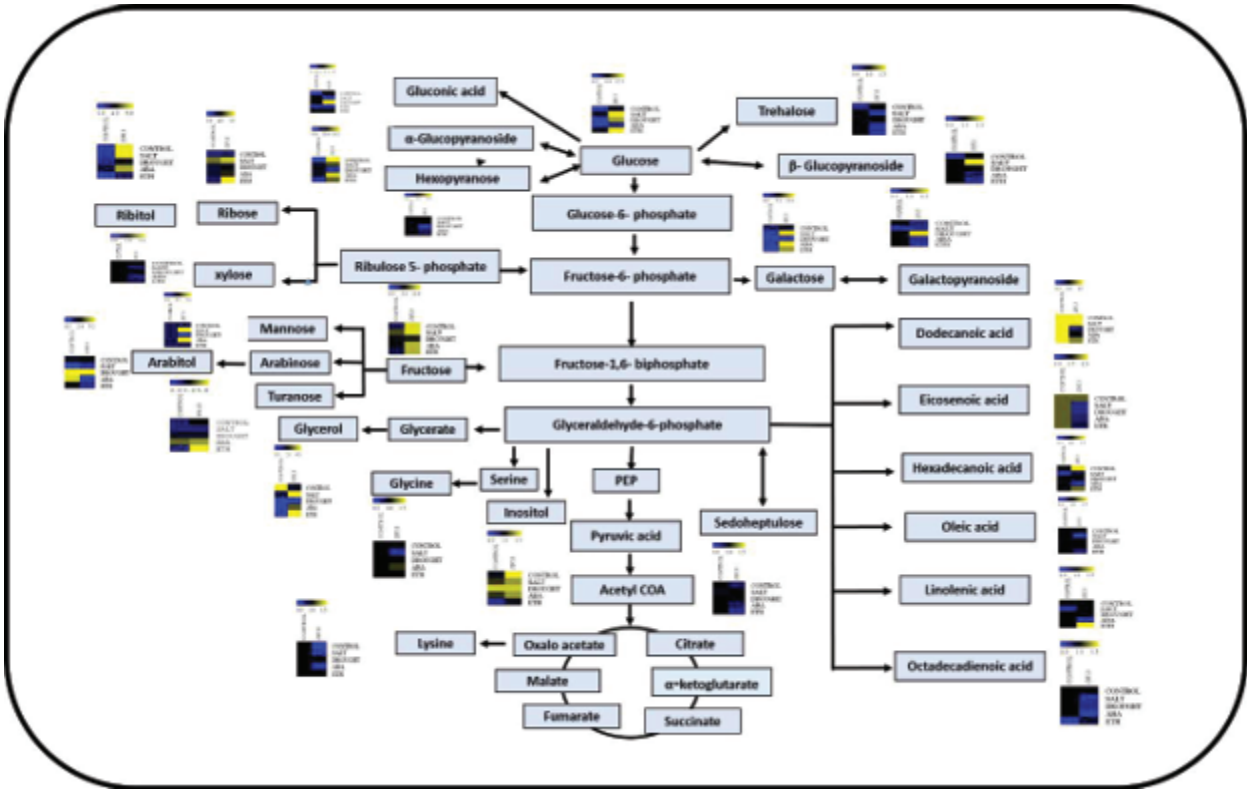

Fig. 6: Alterations in metabolic pathway of SN13 inoculated and uninoculated rice seedlings treated with salt, drought, ABA, and ETH.

Bacillus amyloliquefaciens modulate sugar metabolism to mitigate arsenic toxicity in rice

In the current study, plant growth-promoting rhizobacterium *Bacillus amyloliquefaciens* SN13 (SN13) was evaluated for arsenic (As) toxicity amelioration potential under arsenate (AsV) and arsenite (AsIII) stress exposed to rice (*Oryza sativa* var *Saryu-52*) plants for 15 days. The PGPR-mediated alleviation of As toxicity was demonstrated by modulated measures such as proline, total soluble sugar, malondialdehyde content, enzymatic status, relative water content, and electrolytic leakage in treated rice seedlings

under arsenic-stressed conditions as compared to the respective control. SN13 inoculation not only improved the agronomic traits but also modulated the micronutrient concentrations (Fe, Mo, Zn, Cu, and Co). The desirable results were obtained due to a significant decrease in the AsIII and AsV accumulation in the shoot (47 and 10 mg kg^{-1} dw), and the root (62 and 26 mg kg^{-1} dw) in *B. amyloliquefaciens* inoculated seedlings as compared to their uninoculated root (98 and 43 mg kg^{-1} dw) and shoot (57 and 12 mg kg^{-1} dw), respectively. Further, metabolome (GC-MS) analysis was performed to decipher the underlying PGPR-induced mechanisms under arsenic stress. A total of 67 distinct metabolites were identified, which influence the metabolic and physiological factors to modulate the As stress (Fig. 7). The expression analysis of metabolism- and stress-responsive genes further proclaimed the involvement of SN13 through modulating the carbohydrate metabolism in rice seedlings, to enable improved growth and As stress tolerance. These interactions not only improve seedling growth in their diverse ways

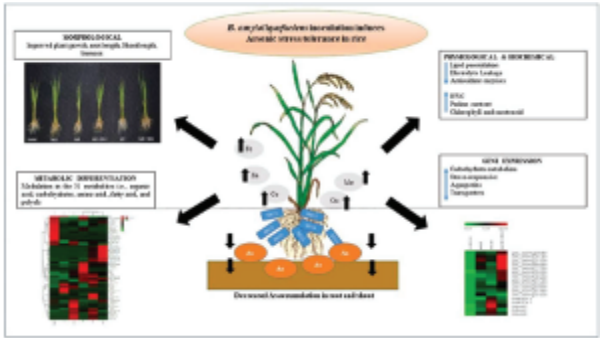

Fig. 7: *B. amyloliquefaciens* inoculation induces arsenic stress tolerance in rice.

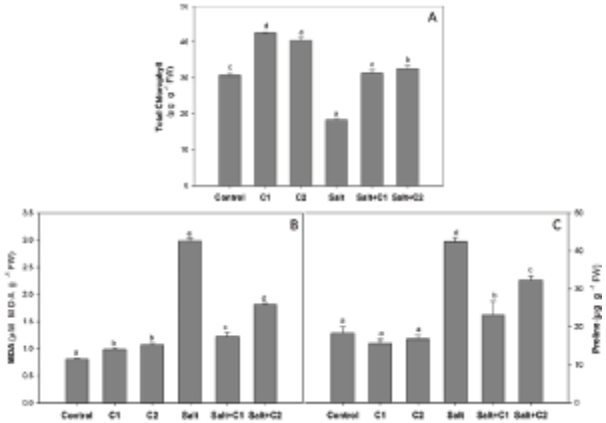

Fig. 8: A Chlorophyll content; **B.** Malondialdehyde (MDA) and; **C.** Proline content in Arabidopsis plants after 21 d of treatments viz Control, Consortia 1 (C1), Consortia 2 (C2), Salt, Salt + Consortia 1 (Salt + C1) and Salt + Consortia 2 (Salt + C2). All the values are means of 3 replicates (n = 3) ± S.E. Different letters indicate different significant values among the treatments (DMRT, $p \leq 0.05$)

but also by targeting carbohydrate metabolism which consecutively stimulates downstream signaling that makes plants resilient to stress.

Bacillus consortia modulates the transcriptional and metabolic machinery of *Arabidopsis* plants for enhancing salt tolerance

Salinity is one of the abiotic factors that has substantial impact on agricultural production. Plant beneficial rhizobacteria hold promising future for sustainable agriculture. The present study was intended to explicate consortia of salt tolerant plant beneficial rhizobacteria for the amelioration of salinity stress in *Arabidopsis* plants. Inoculation with both the consortia positively influenced the growth of plants as indicated by total chlorophyll content, MDA content and antioxidant enzyme activities under stressful conditions (Fig. 8). Both the multi-trait consortia altered the expression profiles of stress related genes including *CSD1*, *CAT1*, *Wrky*, *Ein*, *Etr* and *ACO*. Furthermore, the metabolomic analysis indicated that inoculated plants modulated the metabolic profiles to stimulate

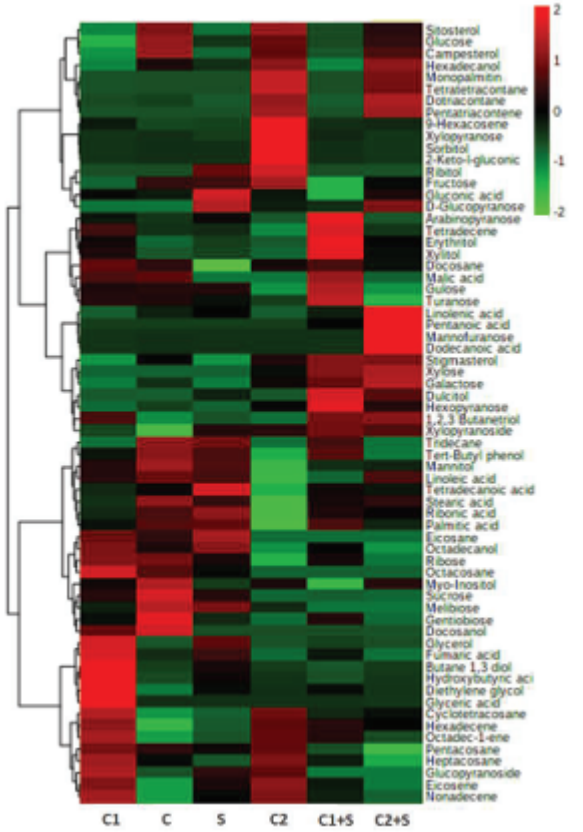

Fig. 9: Heat map showing expression profile of differentially expressed metabolites in Arabidopsis plants exposed to different treatments [Control, Consortia 1 (C1), Consortia 2 (C2), Salt (S), Salt + Consortia 1 (C1+S) and Salt + Consortia 2 (C2+ S)]

physiological and biochemical responses in Arabidopsis plants to mitigate salt stress (Fig. 9). Our study affirms that consortia of salt tolerant bacterial strains modulate the transcriptional as well as metabolic machinery of plants to protect them from salinity stress. The findings of this study revealed that consortia composed of salt tolerant bacterial strains viz. *Bacillus safensis* NBRI 12M, *B. subtilis* NBRI 28B, and *B. subtilis* NBRI 33N caused most significant improvement of *Arabidopsis* plants under saline conditions.

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Phytoremediation efficiency of *Helianthus annuus* L. in battery waste contaminated soil by bacterial augmentation

Phytoremediation efficiency of *Helianthus annuus* was enhanced by applying two e-waste tolerant and metal solubilizing bacteria viz. *Brucella intermedium* (E1) and *Bacillus velezensis* (EW8), when grown on Ni–Cd battery's electrolyte (eW) contaminated soil under simulated condition. EW8 augmentation resulted in higher Ni accumulation. Although the translocation factor was < 1, the bioaccumulation factor was enhanced with bacterial augmentations. EW8 enhanced metal bioavailability resulting in higher metal uptake in the plant. In contrast, E1 having greater plant growth promotion activities, enhanced the plant's growth. Interestingly, with rise in eW contamination, translocation of Cd increased over Ni (Table 1). Also, assessing the soil quality indices of the contaminated soil through phytoremediation, the improvement was greater with bacterial augmentation than without.

Abiotic stresses including fluoride (F^-) affect the quality and quantity of plant growth right from germination. A comparison of physiological and biochemical changes in four staple crops (*Oryza sativa*, *Triticum aestivum*, *Zea mays* and *Pennisetum glaucum*) against F^- toxicity (50, 100, 150, 200 and 250 µg mL^{-1}) during germination, shows the relative tolerance of C_3 and C_4 plants towards F^- stress. Fluoride (µg g^{-1}) accumulation

Table 1: The ratio of Ni/Cd uptake in *H. annus* against different eW contamination and bacterial augmentation.

Ni/Cd ratio				
Treatments	**Root**	**Stem**	**Leaf**	**Flower**
UA- eW0%	0	0	0	0
E1- eW0%	0	0	0	0
EW8- eW0%	0	0	0	0
UA- eW1%	1.50	1.38	2.48	8.00
E1- eW1%	1.27	1.37	2.98	1.43
EW8- eW1%	1.23	1.26	1.83	1.19
UA- eW2%	0.76	0.82	2.03	4.75
E1- eW2%	0.58	0.76	1.88	1.89
EW8- eW2%	0.55	0.81	0.83	2.32
UA- eW4%	0.87	0.52	1.57	4.67
E1- eW4%	0.57	0.64	0.92	1.56
EW8- eW4%	0.61	0.66	0.70	2.20

in tissues of seedlings exhibited: *O. sativa* (8.9) > *Z. mays* (7.89) > *P. glaucum* (6.5) > *T. aestivum* (6.17) against 250 µg F^- mL^{-1}, in 15d-old seedlings. *T. aestivum* was most sensitive among the studied crops, owing to its lowest LC50 (132 µg mL^{-1}), F^- accumulation, correspondingly highest reduction in gibberellic acid, (32.6%), enolase, (46.38%), α-amylase, (40%), total chlorophyll (7.81%) and fresh weight (20.83%) was against 50 µg F^- mL^{-1}. Contrarily, *P. glaucum* exhibited highest LC_{50} (188 µg mL^{-1}) and the highest K_m value (167.2), exhibited tolerance towards F^-. Enhancement in the expression of oxidative stress markers and antioxidant enzyme activity were in the order: *O. sativa* > *T. aestivum* > *Z. mays* > *P. glaucum*. Further, F^- stress also distorted the stomatal shape and reduced the number and diameter of metaxylem in all the F^- treated seedlings, against all F^- concentrations.

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Assessment of carbon sequestration potential of tropical tree species for urban forestry

In urban areas, green spaces, especially trees, are crucial for biodiversity preservation, combating urban heat islands, supporting the water cycle, and carbon capture. Native trees offer enhanced ecosystem benefits compared to non-native species. This study assessed the carbon sequestration capacities of three native tropical trees from the Terai region (*Tectona grandis*, *Mallotus nudiflorus*, and *Syzygium cumini*) in Lucknow's urban setting. *T. grandis* demonstrated the highest aboveground biomass (71.94 Mg/ha), carbon stock (25.54 Mg/ha), photosynthesis rate, water use efficiency, and stomatal conductance (Fig. 10). Thus, promoting *T. grandis* for urban greening can rapidly achieve carbon sequestration goals, though diverse native plantings would optimize overall ecosystem service benefits.

Atmospheric temperature and humidity demonstrated strong correlation with productivity in tropical moist deciduous forests

Tropical forests sequester six times higher carbon than that is released by humans annually into the atmosphere. These biodiversity-rich tropical forests have high net primary productivity (NPP) which differ among the constituent plant communities. Tropical moist deciduous forests occupy 179335 km^2 of India's geographical area and constitute 44% of the country's total protected area (PA) forests. We measured the annual NPP among three predominant distinct community types viz., Mixed (DM), Sal (SM) and Teak (TP) in a North Indian Tropical Moist Deciduous Forest. NPP was estimated from tree biomass data collected from nine Long-Term Ecological Research (LTER) plots of one ha each representing the above three community types. The NPP was correlated with tree density, tree height and tree diameter at breast height (DBH), species richness and diversity; microclimatic and edaphic variables; and leaf area index (LAI) using Principal Component Analysis (PCA) and Generalized Liner Modelling (GLM) (Table 2). Among microclimatic variables, air temperature and humidity were strongly related to NPP in tropical moist deciduous forests.

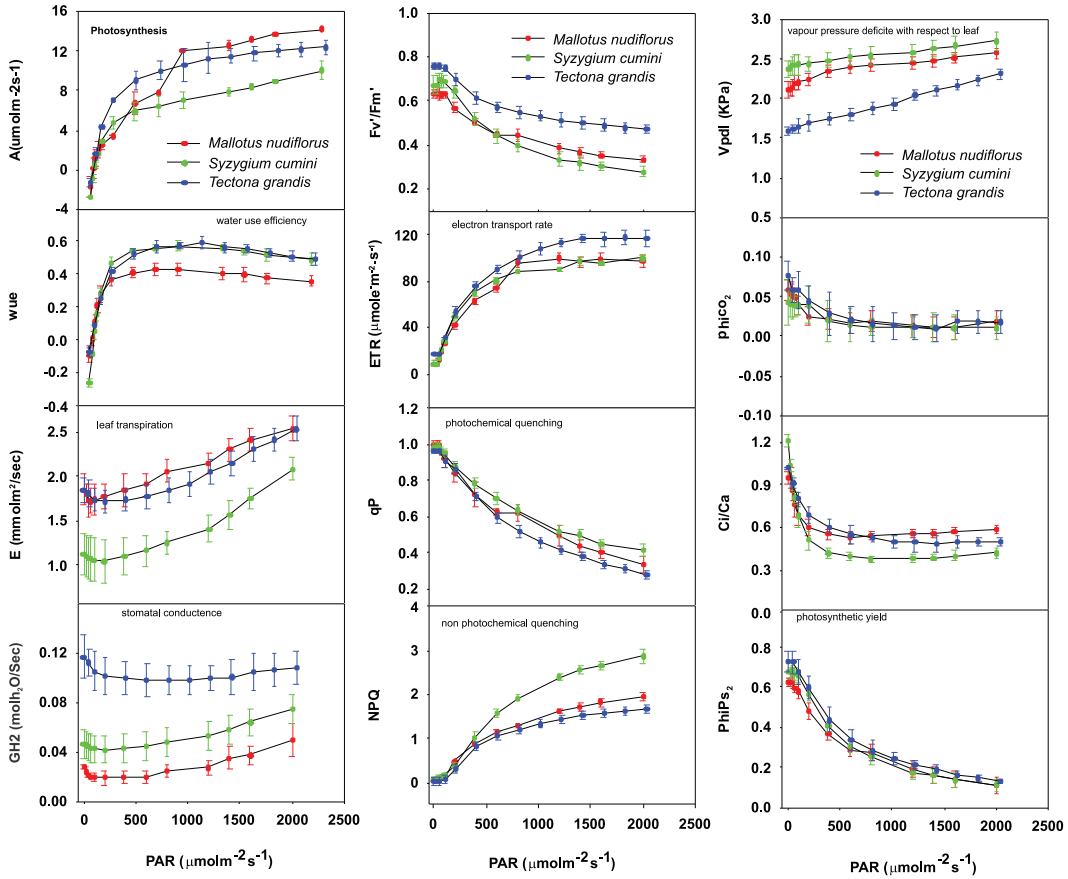

Fig. 10: Patterns of different physiological variables among three tropical tree species (*Tectona grandis, Mallotus nudiflorus* and *Syzygium cumini*) at Botanical Garden of CSIR-National Botanical Research Institute, Lucknow, India.

Distribution pattern and invasion status of *Ageratina adenophora* across elevational gradients in Sikkim Himalaya

Understanding the spread intensity and population dynamics of invasive plant species is a prerequisite for developing management strategies in the Himalayan ecosystems. Given the current data gaps, we evaluated the spread and distribution of *Ageratina adenophora*, a prominent invasive species in India that significantly affects the Himalayas, particularly within the elevational spectrum of the Sikkim Himalaya (Fig. 11). We examined the population, distribution, and species connected with *A. adenophora* across seven elevation levels from >600 m to 2700 m in the Sikkim region. In total, 81 species, encompassing 58 herbs, 19 shrubs, and 4 climbers from 30 families and 67 genera, were present in association with *A. adenophora*. However, no species consistently appeared alongside *A. adenophora* across the entire elevation range. Additionally, we utilized a species distribution model (SDM) to delineate its potential geographic spread and forecasted its likely habitat in the Sikkim Himalaya.

Table 2. GLM analysis of net primary productivity (NPP) as dependent variable with different community structural [tree density, tree height, diameter at breast height (DBH), species richness (SR), Shannon's index (H'), Simpson's index (C)], soil [available phosphorous (AVLP), total nitrogen (TOTN), microbial biomass carbon (MBC)], microclimate [air temperature (AT), absolute humidity (AH)] and canopy cover [(leaf area index, LAI; litter fall, LF] as independent variables (*ns = not significant)

		DM		SM		TP	
	Variable	Residual	% of Variance Explained	Residual	% of Variance Explained	Residual	% of Variance Explained
Structural Variables	Density	6.04E-05	69.9	ns	ns	0.000612	85.8
	Height	ns	ns	4.5E-29	100	ns	ns
	DBH	ns	ns	5.72E-07	71.4	1.05E-05	99.8
	SR	1.21E-05	94.0	ns	ns	ns	ns
	H	2.56E-07	99.9	3.24E-08	98.4	ns	ns
	C	ns	ns	7.68E-07	61.6	0.001183	72.5
Edaphic variables	AVLP	5.73E-05	71.4	1.33E-07	93.3	ns	ns
	TOTN	ns	ns	5E-07	75	0.000771	82.1
	MBC	ns	ns	1.54E-07	92.3	0.000886	79.4
Microclimate	AT	1.09E-06	99.5	1.34E-07	93.3	6.54E-05	98.5
	AH	8.98E-05	55.2	1.21E-07	94	0.000331	92.3
Canopy Cover	LAI	4.94E-05	95.4	2.5E-09	99.9	0.000104	97.6
	LF	0.0001	50.1	5.89E-07	70.6	0.001852	56.9

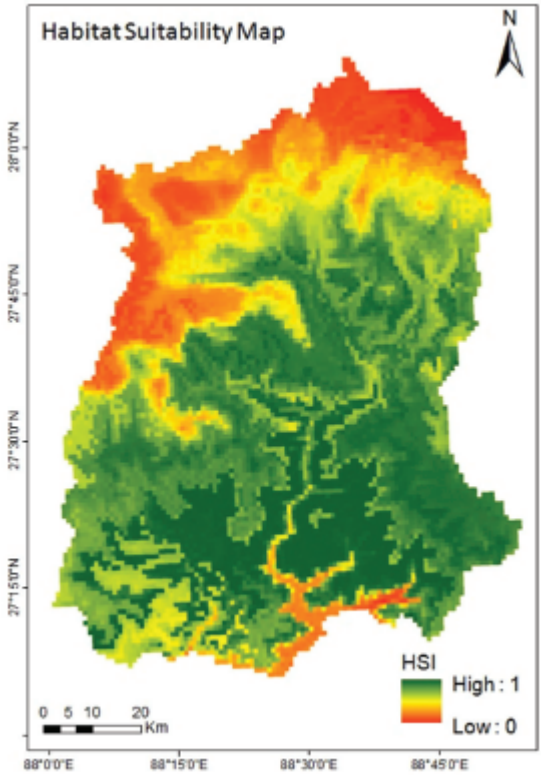

Fig. 11. Potential distribution map of *Ageratina adenophora* in Sikkim Himalaya. The colours show relative suitabilities of different localities in Sikkim Himalaya for occupancy by *Ageratina adenophora.*

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Development of microbial formulation for arsenic (As) stress amelioration in rice

Microbial consortium of yeast (*Debaromyces hansenii)* with bacteria (*Citrobacter* sp.) and methyltransferase-containing *P. oleovorans* for enhanced arsenic (As) diminution in rice has been developed. Their role has been validated by subcellular distribution, SEM-EDS, and transcriptome analysis (Fig. 12).

Alteration in methylome pattern of *Rhizoctonia solani* during interaction with *Bacillus amyloliquefaciens*

Hyper methylation in *R. solani* (RS) during bipartite interaction with *B. amyloliquefaciens* lead to identification of new marker genes in RS, responsible for sheath blight disease in rice. The bioefficacy of the developed microbial formulation is in progress at 3 different agro climatic conditions for their registration as biopesticide at CIB.

Microbial consortium for *in situ* decomposition of rice straw

A new microbial consortium consisting of 3 fungi and 4 bacteria with enhanced efficacy of degradation of mulched rice straw, better soil health and enhanced growth of subsequent crop wheat has been developed and is being validated at DRC field, Banthara. It will be of great societal importance with less environmental pollution, and reduced chemical input.

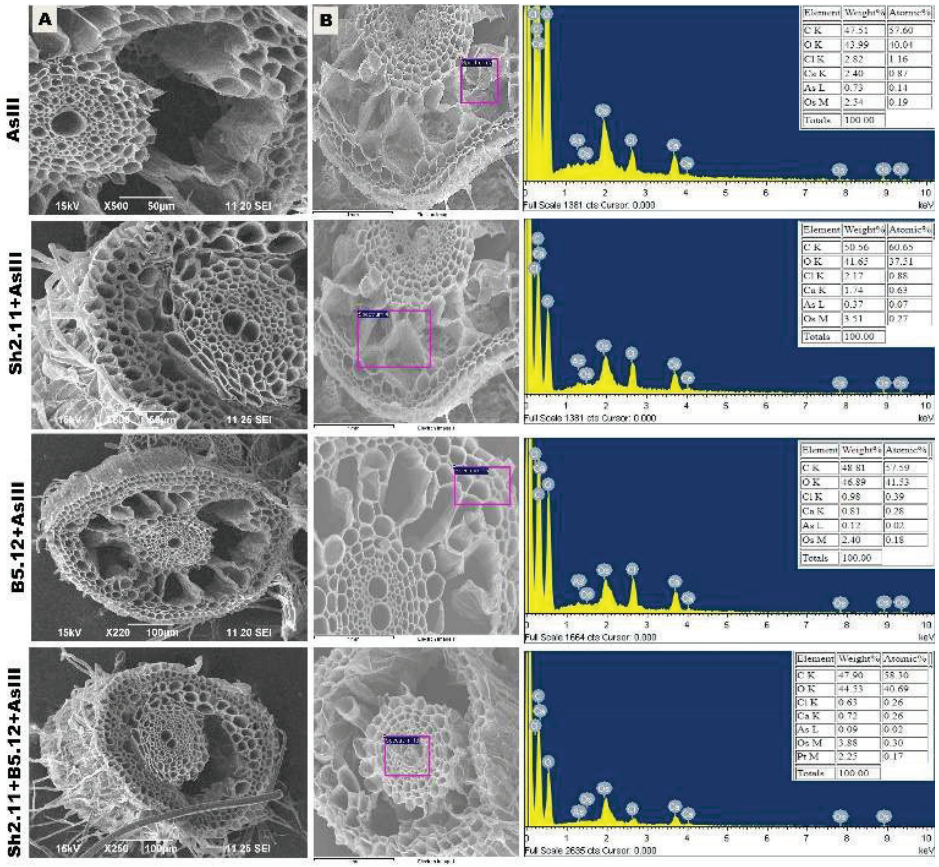

Fig. 12: Scanning electron micrograph (A), and EDS analysis (B), of rice roots grown under hydroponic conditions in presence of *D. hansenii* (NBRI-Sh2.11) and its bacterial co-inoculant *Citrobacter* sp. (NBRI-B5.12) under As III (20 mg kg^{-1}) stressed conditions.

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Efficient role of *Bacillus subtilis* M-4(NAIMCC-B-03238) to suppress charcoal rot disease in commercial crop soy

Endophytes can induce defense responses and modulate physiological attributes in host plants during pathogen attacks. In the study, 127 bacterial endophytes (BEs) were isolated from different parts of healthy soybean plants. Among them, two BEs (M-2 and M-4) resulted in a significant antagonistic property against *Macrophomina phaseolina,* which causes charcoal rot disease in soybean. The antagonistic potential was evaluated through dual culture plate assay, where M-4 expressed higher antifungal activity than M-2 against *M. phaseolina*. The M-4 produces cell wall degrading enzymes viz. cellulase, chitinase, and β,1–3 endoglucanase, which helps in the cell wall disintegration of pathogens. Additionally, M-4 also can produce siderophores, indole-3-acetic acid (IAA), and has a phosphate solubilization potential. Bio-efficacy study of the M-4 strain showed a significant reduction in disease incidence around 60 and 80% in resistant and susceptible varieties of soybean, respectively. The inoculation of M-4 potentially enhances the physiological attributes and triggers various defense-responsive enzymes viz. superoxide dismutase (SOD), phenol peroxidase (PPO), peroxidase (PO), and catalase (CAT). The histopathological study also confirmed that M-4 can reduce the persistence of microsclerotia in root and shoot tissue. The study conclusively revealed, M-4 as an efficient biocontrol agent that can provide multifaceted measures for charcoal rot disease management, by suppressing the *M. phaseolina* infection and enhancing the physiological attributes of soybean (Fig. 13).

Suppression of substrates utilization ability of pathogenic fungi *Fusarium* by *Bacillus subtilis* PBE-8's (MTCC 25189) metabolites

Bacillus subtilis PBE-8's (MTCC 25189) bio-control efficacy was evaluated through physiological and metabolic approaches against *Fusarium oxysporum* f. sp. *lycopersici* (FOL). To validate the findings, PBE-8 cell-free filtrate (CFF) antifungal activity was studied through mycelial growth inhibition, metabolite profiling, and substrate utilization patterns. Under different CFF concentrations, a reduction in spore count (94%–55%), biomass (50%), and cytoplasmic bulbous protrusions in mycelia were observed. Lipopeptide antifungal metabolites like fengycin and iturin A in the CFF were reported

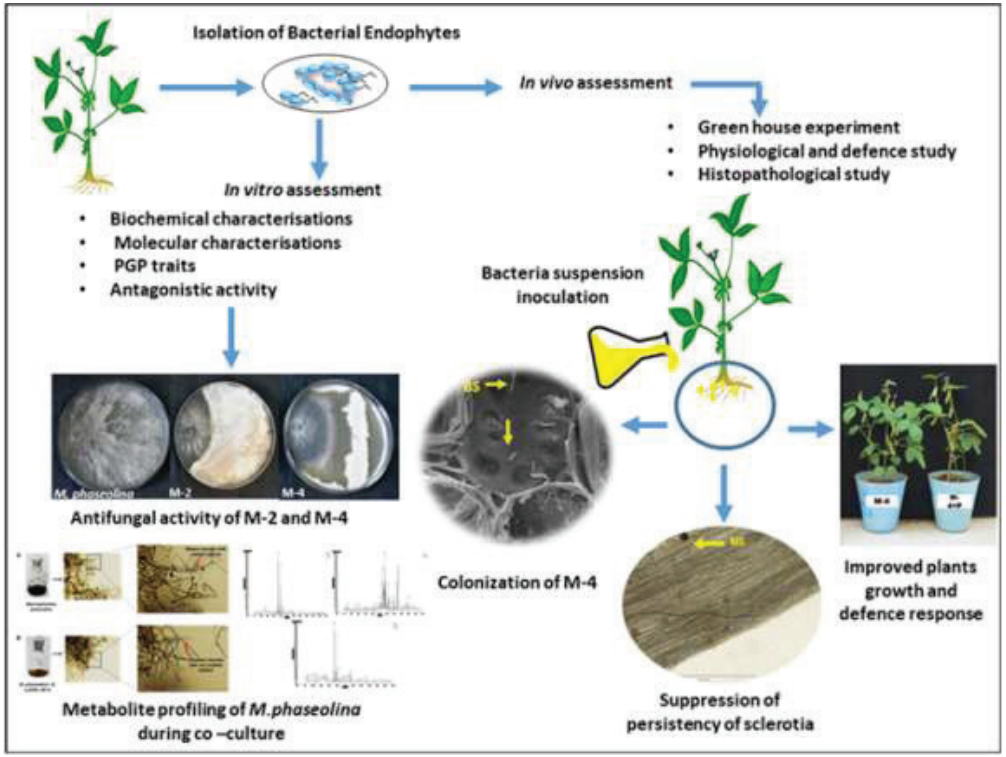

Fig. 13: Presentation of *Bacillus subtilis* M-4 suppressing charcoal rot disease in soybean.

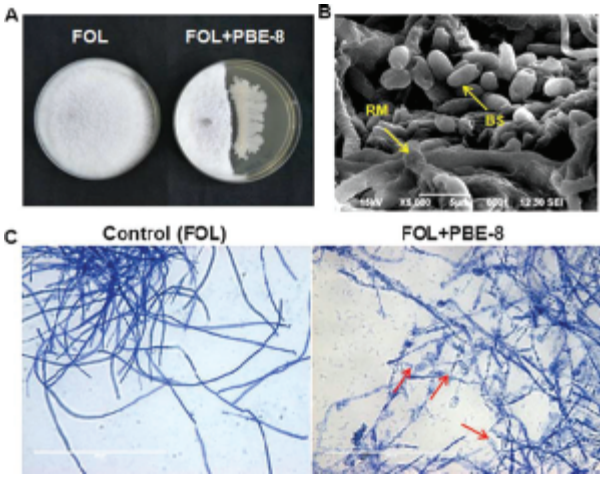

Fig. 14: Antagonistic activity of Bacillus subtilis PBE-8 against *Fusarium oxysporum* f.sp. *lycopersici*; (A) Dual culture interaction, culture plate on left is control, *Fusarium oxysporum* f.sp. *lycopersici* (FOL); culture plate on right is treatment, the interaction of FOL and PBE8 (B) SEM image at 5000x magnification, where RM refers to ruptured mycelial and BS refer to Bacillus subtilis. (C) Microscopic image of FOL mycelia stained with cotton blue; grown alone and co-cultured with 100% concentration of extracted bacterial cell-free filtrate (CFF) of PBE8. The red arrows indicate bulbous cytoplasmic protrusions in FOL fungal mycelial.

for suppression of mycelial growth and spore germination of phytopathogen (Fig. 14).

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Endophytic biofungicide *Bacillus subtilis* (NBRI-W9) reshapes the metabolic homeostasis disrupted by the chemical fungicide, Propiconazole in tomato plants to provide sustainable immunity against non-target bacterial pathogens

Chemical and microbial fungicides (Bio/fungicide) act differentially on plant systems. Propiconazole is a systemic fungicide with ramifications on the non-target microbes. We hypothesize that they differently affect the metabolic homeostasis of plants and accordingly regulate their immunity. We assessed the metabolic profile of tomato plants vis-a-vis endophytic diversity after spraying of Propiconazole (PCZ) and endophytic biofungicide *Bacillus subtilis* (W9). Bio/fungicides were sprayed on tomato plants and evaluated for phenotypic, biochemical, and metabolic profiles after one week. Plant's immunity was compromised in presence of PCZ which was reflected by the altered metabolic profile, enhanced ROS and reduced antioxidant levels in tomato plant during the present study. W9 treatment recorded a significant increase in relative abundance of several metabolites, including sugars, sugar alcohols, fatty-acids, organic-acids, and amino-acids. Polysaccharides and fatty acids showed a significant positive correlation with Rhizobiales, Burkholderiales, Bacillales, and Lactobacillales, respectively ($p < 0.05$). The PCZ and W9 treated plant's metabolic status significantly affected their resistance to non-target, bacterial pathogen *P. syringae*. Compared to PCZ and control, W9 treatment reduced the ROS deposition and expression of antioxidants gene GPx, PO (~0.1-1.7fold). It enhanced the genes related to the Phenylpropanoid pathway (~1.6-5.2 fold), PR protein (~1.2-3.4 fold), and Jasmonic acid (JA) biosynthesis (~1.7-4.3 fold), resulting in reduced disease incidence. Thus, implications of the pesticide spray can be far reaching due to the non-target pathogens (*P. syringae,* in the present study) opportunistic to systemically weak plants, reducing the quality and quantity of the produce by at least 50%. On the other hand, application of *B. subtilis* NBRI-W9 alone or with PCZ enhanced the productivity by up to 5 times in presence of the bacterial pathogen, Ps. We have provided evidence that this un-sustainability associated with usage of chemical fungicides can be minimized by the application of biological fungicides of endophytic origin (*B. subtilis* NBRI-W9) alone or in integrated application with the chemicals. The importance of plant's innate metabolic status vis-à-vis endophytic population and diversity cannot be overlooked in the interest of agriculture and environment sustainability and gives another reason to advocate use of endophytes-basedbio-inoculum. The results provide novel insights into the effects of endophytic biofungicide and chemical fungicides on the plant's metabolic status, its relation to the endophytes, and role in altering the plant's immune system (Fig. 15).

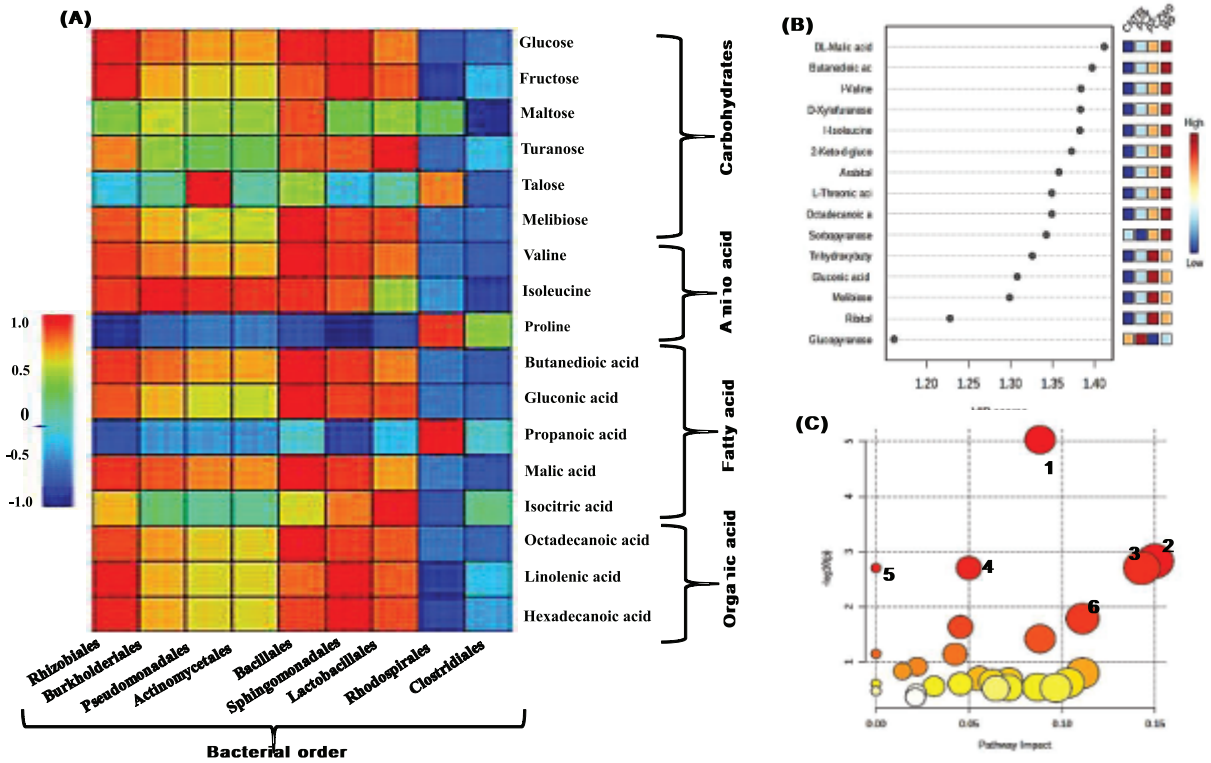

Fig. 15: Heatmap of correlation among plant-associated soil metabolites and microbiota. *p < 0.05 (A), Abundance pattern of the differentially accumulated proteins in three clusters.(B), Summary of pathway analysis with MetaboAnalyst 2.0 in leaves. All detected metabolites were considered in the pathway analysis. Altered pathways in leaves: (1) Galactose metabolism; (2) Fructose mannose metabolism; (3) Starch and sucrose metabolism; (4) Valine leucine isoleucine biosynthesis; (5) Biosynthesis of fatty acid; (6) Aminoacyl trna biosynthesis.

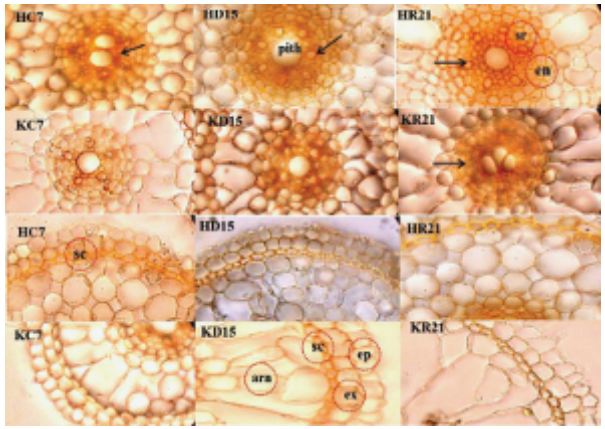

Fig. 16: Progressive changes in the root anatomy over control, drought and revival stages in Heena and Kiran rice varieties. HC7: Heena control (7days after seedling transplantation and initial day of drought induction); HD15: Heena drought(7thday after drought induction) (D15), HR21: Heena revival (7th day after re-watering) (D21), KC7: Kiran control (7days after seedling transplantation and initial day of drought induction)(D7), KD15: Kiran drought (7thday after drought induction)(D15), KR21: Kiran revival(7th day after re-watering)(D21), en: endodermis, ex: exodermis, sc: sclerenchyma, ep: epidermis, arn: aerenchyma cell, arrow indicates lignification.

Biochemical & anatomical modifications are early indicators of drought tolerance and sensitivity in rice varieties

Upland paddy experiences periodic drought and flash rainfalls, therefore, the plants showing quick and sustained adaptations will have growth advantage. In the present study, drought tolerance features enabling more effective revival on re-watering after drought spell were identified in rice. Henna (H) and Kiran (K) were screened as the drought tolerant and sensitive varieties from eight widely cultivated rice varieties in, U.P., India. The plants were exposed to drought for 7 days using poly ethylene glycol (PEG6000) followed by revival in PEG6000 free medium. After drought and re-watering exposures the biochemical and anatomical adaptations were assessed. The proline accumulated 3-4 times higher in K leaves as compared to H in control condition while it remained low and nearly constant in revival plants. As compared to K, H had two times lower SOD, CAT, and GPX antioxidants. Anatomical study in H showed plasticity in the cell structures, lignification and delignification during drought and re-watering. Thus, the drought tolerant H modulated the biochemical status of the plants to maintain its cell-wall integrity during drought which was absent in

the sensitive K variety. From the study it was concluded that the drought resistant variety are more stringent in expression of the stress markers over long periods of stress exposure, Whereas, the sensitive varieties are more prone to oxidative stress and production of osmo-protectants throughout the growth period. These observations may also be used as markers to screen sensitive and resistant varieties exposed to continuous stress conditions as in saline soils. Such anatomical and biochemical markers may expedite breeding programs in selection of drought tolerant rice varieties at seedling stage (Fig. 16).

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Future distribution and existence of *Ilex* species in Meghalaya

The lack of understanding about how threatened plants respond to present and future climate conditions affects conservation decision-making. We conducted a study on three endangered *Ilex* species: *I. khasiana*, *I. embelioides*, and *I. venulosa*, focusing on their adaptation to future climate scenarios, specifically the IPSL-CM5A-LR and NIMR-HADGEM2-AO models for 2050 in Meghalaya, India. Ecological niche modeling was employed, utilizing elevation as a temperature indicator, and eco-physiological responses concerning temperature and moisture stress were examined. The study revealed that the *Ilex* species' future existence largely depends on their morpho-physiological and demographic adaptations. *I. khasiana* showed significant vulnerability to increased temperature and combined temperature-moisture stress. Conversely, *I. venulosa* and *I. embelioides* were predominantly impacted by intense moisture stress. We also recognized various morphological indicators for gauging species' responses to climate-induced stresses (Fig. 17). Our findings accentuate the necessity of a comprehensive strategy for species-specific conservation plans, and our predictions offer guidance for conserving and reintroducing these species in their native environments.

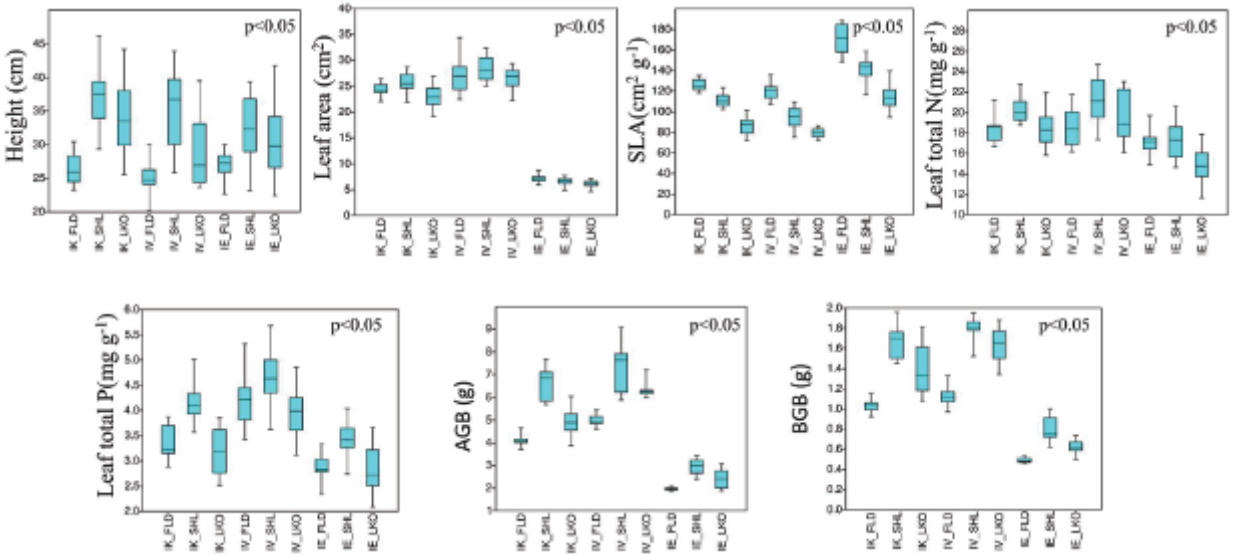

Fig. 17: Box plot showing the effect of temperature (SHL vs. LKO) on the morphological traits in three Ilex species. IK, I. khasiana; IV, I. venulosa; IE, I. embelioides; FLD, field; SHL, Shillong; LKO, Lucknow; SLA, Specific leaf area; AGB, Above-ground biomass; BGB, Below-ground biomass.

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Bioclimatic modelling and FACE study forecast a bleak future for wheat production in India

In the present study, geographic distribution and yield of wheat was assessed using two global General Circulation Models (GCMs) and field experiments using Free Air CO_2/O_3/Temp Enrichment (FACE) experiments (Fig. 1). The GCMs (IPSL-CM5A-LR and NIMR-HADGEM2-AO) with four Representative Concentration Pathways (RCPs) and 19 bioclimatic variables were used for distribution using Ecological Niche Modeling (ENM). Commonly cultivated eight wheat cultivars were exposed to individual treatment of (i) ambient CO_2, temperature, and ozone (ACO+AO+AT) representing the present climate scenario, and (ii) elevated CO_2 (550 ppm) (ECO), (iii) elevated temperature (+2°C) (ET), (iv) elevated O_3 (ambient+20 ppb) (EO), (v) elevated CO_2+elevated O_3 (ECO+EO), and (vi) elevated CO_2+ elevated temperature+ elevated O_3 (ECO+EO+ET) under FACE facility simulating the future climate change scenarios in 2050. The niche models predicted a reduction in climatically suitable areas for wheat, and identified "maximum temperature" as the most influencing factor for area reduction. The elevated CO_2, O_3, and temperature individually and in combinations had differential impacts on the yield of wheat cultivars. Only two cultivars, viz., DBW 184 and DBW 187 did not exhibit reductions in yield suggesting their suitability in the future climate change scenario. Since the performance of six out of eight cultivars significantly declined under simulated FACE experiment, and ENM predicted reduction in wheat cultivation area under RCP 8.5 in 2050, it was concluded that future of wheat cultivation in India is bleak and most influencing factor would be temperature. The study further indicates that coupling of bioclimatic modeling and FACE experiment can effectively predict the impact of climate change on different crops (Fig. 18).

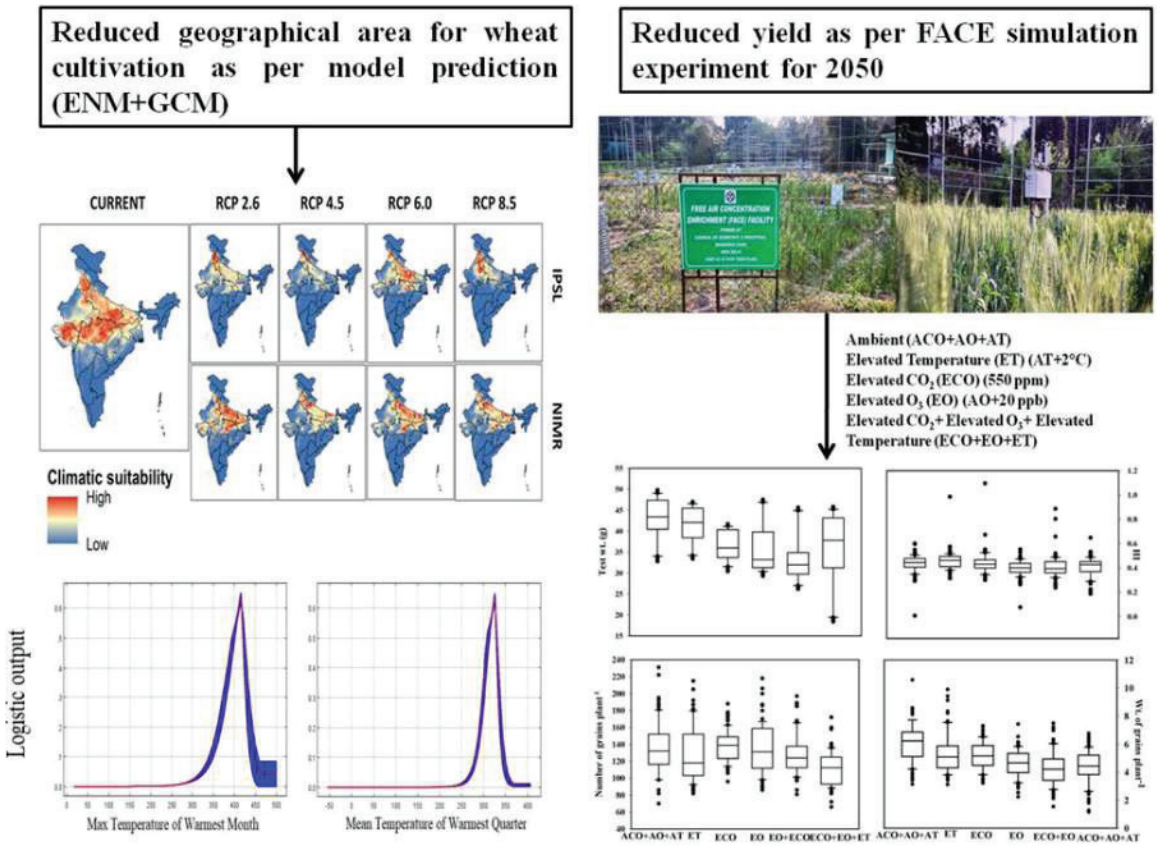

Fig. 18: Interrelationship between results of the ENM and GCM model with FACE results

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Metal Tolerance of *Bacopa monnieri*

A study was conducted to explore the potential of the *Bacopa monnieri* plant for multi-metal tolerance to facilitate its cultivation on tannery sludge-contaminated soil. The effect of tannery sludge on enzymatic and non-enzymatic antioxidant potential along with the effect on the bacoside-A content of the plant were studied. The maximum translocation factor from root to shoot for Cr, Cd, Co, Ni and Pb was observed as 0.33, 0.28, 0.75, 0.69 and 0.43, respectively (Table 3). A large portion of metals was sequestered in the root region and showed high vegetative growth in the treatment of a combination of 75:25 tannery sludge and soil.

Table 3: Heavy-metal specific translocation factor values under different treatments.

Treatment	TF Cr	TF Cd	TF Co	TF Ni	TF Pb
25sludge:75 soil	$0.26^{a}\pm0.017$	$0.19^{a}\pm0.01$	$0.68^{a}\pm0.04$	$0.51^{a}\pm0.03$	$0.55^{a}\pm0.04$
50sludge:50 soil	$0.31^{b}\pm0.02$	$0.28^{b}\pm0.016$	$0.75^{b}\pm0.05$	$0.62^{b}\pm0.04$	$0.35^{b}\pm0.02$
75sludge:25 soil	$0.38^{c}\pm0.021$	$0.24^{c}\pm0.021$	$0.69^{ac}\pm0.04$	$0.7^{c}\pm0.06$	$0.43^{c}\pm0.03$
100% sludge	$0.23^{d}\pm0.016$	$0.16^{d}\pm0.011$	$0.33^{d}\pm0.02$	$0.26^{d}\pm0.02$	$0.18^{d}\pm.012$

Superoxide dismutase, catalase, peroxidase, malondialdehyde, proline & ascorbic acid scaled up with increasing tannery sludge in the treatments. A similar trend was recorded in the bacoside-A content with 2% increase in the case of 75:25 ratio treatment compared to the control. Principal component analysis confirmed that the translocation factor played a role in the activation of the photosynthetic machinery.

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R&D-04: MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Area Co-ordinator

Dr. Samir V. Sawant

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- Dr. I Sanyal, Senior Principal Scientist
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- Mr. Om Pal Sharma, Sr. Technician

R&D Area Research Scholars Statistics

Sr. No.	Position Name	Numbers
1.	Project Scientists/ Research Associate	05
2.	Ramalinga Swami Fellow	01
3.	Consultants	02
4.	JRF/SRF	63
5.	Project Staff	40

Aims and Objectives

- Yield, quality and nutritional value of crops and produce are dependent on various biochemical processes and networks. These processes are under tight spatial and temporal regulation of gene expression. Studies suggest that modulation in expression of genes affects various processes leading to genotype-dependent changes in specific crops. Understanding the changes at genetic level in existing germplasm/cultivars through various approaches and utilization of information to develop improved varieties can lead to the enhancement in the yield to meet the increasing demand. There is need to develop new strategies for engineering crops for better yield, stress tolerance and enhanced nutritional quality through utilizing the genes of plant origin.
- In Molecular Biology and Biotechnology Division, major objective is to understand about various genetic determinants for developing superior plant varieties with enhanced yield and quality for the benefits of farmers and consumers. To fulfill this objective, gene-mining, transgenic plant development and genome-editing technologies are being used on various crops.

Major R&D Highlights

Biotic stress tolerance

- Several insect resistant plants were developed in cotton. The Tma12 GM cotton was challenged against a field population of whitefly for second year performance evaluation. The Msc14 GM guard cotton for the protection of tomato and papaya against whitefly vectored viral disease was also evaluated for the second year field trial. The Pnu08 GM cotton lines were advanced to T3 generation and line 907 selected as an event that kills whitefly population to about 60-70%. The T2 generation of Cry1EC GM cotton lines were evaluated for the protection from Pink Bollworm and Leaf Armyworm. The Tma12 was established as a Lytic Polysaccharide Monooxygenase (LPMO) and protocol for expression of Tma12 in yeast in biologically active form was established. The mechanism of toxicity of Msc14 was also established.
- Transgenic cotton plants expressing *Aspergillus* pectine methyl transferase increase methanol emission and confers resistance against polyphagous insect pests. Transgenic plants emitted ~11 fold higher methanol, displaying 96% and 93% mortality of *Helicoverpa armigera* and *Spodoptera litura*, respectively. The larvae could not survive and finish their life cycle and the surviving larvae exhibited severe growth retardation Leaf disc assays and *In-planta* bioassays also

showed 50–60% population reduction in the sap-sucking pests, such as *Bemisia tabaci* and *Phenacoccus solenopsis.*

- Tobacco plants overexpressing *WsPME28* gene to enhance methanol emission have been developed. Transgenic plants show up to 8-fold high methanol content & 12-fold high methanol emission. High methanol-emitting transgenic plants were further used for a systemic-induced defense response study. The differential gene expression analysis was performed on the commonly expressed CDS between control & treated samples by employing a negative binomial distribution model in the DESeq package. In the preliminary findings, several genes (*CYP94B*, *AOS*, *JAZ8*, *AOC*, *LOX2*, & *MYC2*) that were significantly upregulated in the jasmonic acid biosynthesis pathway & its signaling were identified. These results are promising and in-depth analysis of different molecular signaling pathways for the induced systemic defense response will be done further.
- The elucidation of genes and pathways involved in limb regeneration in *Cheilomenes sexmaculata* the prothoracic leg was amputated. The *de novo* transcriptome analysis of the beetle at different time intervals post-amputation was carried out. The *in vitro* transcription process of the genes is currently being performed to synthesize dsRNA to functionally validate the putative genes involved in regeneration.
- Transgenic chickpea lines expressing *cry1Ac* under the wound-inducible promoter have been developed. Plants in the T2 generation are being studied for gene expression and will be analyzed for insect tolerance.
- *F. oxysporum* f. sp *ciceris*, the fungus that causes vascular wilt has a significant impact on overall productivity. Around the world, fungus may result in yield losses of up to 90%. Transgenic approach will be used to target genes from resistant germplasm. The upregulated genes (*TLP1*, *PGIP2*, *GRXS2*, *LTP1* and *SN2*) in the root xylem of wilt resistant genotype in response to *Fusarium* at early time of infection were selected. The selected genes will be utilized for genome editing in chickpea.
- The modified *Cocculus hirsutus* trypsin inhibitor (*ChTI*) was expressed either alone or pyramided with the Bt-Cry1Ab toxin increases the resistance in transgenic tomato against two herbivorous insects, *Helicoverpa armigera* and *Spodoptera litura*, with complete insect mortality without yield penalty.

Abiotic stress responses and plant development

- A *NAC2* gene, *GhNAC2*, was previously identified that improves root and plant growth under well-watered conditions and also imparts drought tolerance through suppression of the ethylene pathway. Transcriptomic studies are currently under progress for understanding the basis of its action. Further, suppression lines of *GhNAC2* have been developed to understand its function and mechanism of action in root development.
- A multi-location trial of 320 core germplasms of *G. hirsutum* for two consecutive years at three locations yielded high-quality phenotypic data related to 27 agronomically important traits such as total fiber yield per hectare, number of bolls per plant, boll size, fiber strength, fiber length, disease resistance, etc. Further, GWAS analysis identified more than 8,000 potential markers associated with agronomically important traits like big-boll, fiber quality and yield, synchronous flowering (determinate phenotypes), biotic and abiotic stresses, etc. Thus, associations of SNPs and phenotypic data are expected to provide insights into the genetic basis of fiber yield-related traits and stress tolerance in cotton, which will also help us to develop SNP markers for molecular-assisted breeding of high-yield and stress resistance varieties.
- Vegetables are one of the major sources of arsenic exposure, ranking third after groundwater and rice-based diets. Encouragingly, our research has uncovered microbes with AsMT activity, offering hope for arsenic mitigation. Harnessing these microbes in various vegetable crops could curtail arsenic accumulation, bolstering safety and quality. This breakthrough promises to diminish human arsenic exposure through improved agricultural practices marking a significant stride in safeguarding public health.
- The uptake and transport of arsenic in rice are mediated by several metal transporter genes including *Lsi1, Lsi2, NRAMP, NIP3;1* and *INT*. Knocking out these genes may reduce arsenic accumulation in rice grains and enhance food safety. CRISPR/Cas9 system

is a powerful tool for genome editing which allows for precise and efficient manipulation of specific genes. Knock-out lines of various metal transporter genes (*Lsi1, Lsi2, NRAMP, NIP3;1* and *INT*) involved in arsenic uptake and transportation have been generated using the CRISPR/Cas9 system. The impact of these knock-outs on arsenic accumulation in rice grains will be assessed in both phenotype and molecular regulation.

- The arsenic tolerance in six bryophyte species: *Riccia billardieri, Marchantia papillata, Marchantia polymorpha, Plagiochasma appendiculata, Barbula indica*, and *Vesicularia montagnei* have been investigated. *Marchantia polymorpha* stood out by accumulating the highest arsenic levels among the studied species when exposed to varying concentrations of AsIII for different durations, surpassing even *Pteris vittata*.
- To unravel the molecular mechanisms behind this tolerance, the transcriptomic analysis of *Marchantia polymorpha* under AsIII stress over various time intervals is done. This research promises to elucidate the genes responsible for arsenic stress tolerance in lower plants and offers prospects for developing transgenic plant varieties with enhanced arsenic stress resilience, which could be a crucial step in addressing the environmental and health challenges posed by heavy metal pollution.
- Rab GTPases are important regulators that move different molecules to their specific compartments based on the demands of the cell. It has been shown that RabC1 GTPase plays a vital role in Arabidopsis growth and seed formation.
- Phenotypic data and polyploidy analysis identified the molecular link between heterosis and endoreduplication in F1 hybrids. Whole genome sequencing and flow cytometry analysis confirmed sub-genome dominance during endoreduplication in the F1 hybrids of *Arabidopsis thaliana* Col-0 genotype. Additionally, sub-genome dominance during endoreduplication is linked to epigenetic status of parent genome.
- Methylome, transcriptome and morpho-physiological responses of two *Arabidopsis thaliana* populations evolved at high (3400 m amsl) and low elevation (700 m amsl) zones to elevated [CO_2] was investigated. Elevated CO_2 induces local level variations in DNA methylation but global methyl cytosine (mC) remained unchanged. In both the populations there was loss of methylation and more protein coding genes were differentially methylated than other genes, but more so in the low elevation one. The hyper- and hypo-methylated status of few genes due to e[CO_2] treatment were validated.
- Differential methylated genes in low and high elevation population of *Arabidopsis* were identified and their role was validated by targeted methylation *in vivo*. *Arabidopsis* lines over-expressing the chickpea *MT1* gene showed enhanced tolerance against toxic heavy metals [As (III), As (V), Cr (VI) & Cd]. The defense system responsible for metal tolerance was elevated in the transgenic lines over-expressing *MT1* compared to WT plants. The sulfur-containing amino acid cysteine was higher in transgenic lines, suggesting that *MT1* actively regulates the thiol-dependent mechanism to reduce the heavy metals toxicity in plants. The elevated physiological as well as antioxidant parameters and the lowered levels of stress markers in the transgenic lines demonstrated the potential role of MT1 in heavy metal tolerance.
- The role of LAF1 in far red signaling pathway is not much clear. To know this, transcriptional and translational transgenic lines have been generated. The phenotypic characterization of these lines is underway.

Enhancing fruit and flower shelf life

- In the project on understanding root development and architecture in tomato, transgenic lines altered in the expression of genes of the HSF, MYB, WRKY and START domain families are under study for their role in governing primary and lateral root growth and the interaction of different hormones in these processes. Evidences from individual studies demonstrate the roles of ABA, ethylene, strigolactones, and GA in manipulation of tomato root growth through these factors.
- For fruit growth and ripening study in tomato, an interaction between ABA, ethylene, auxin and GA has been uncovered during growth and ripening and is being explored in detail through transgenic manipulation of different genes of the AP2/ERF domain family.

- Two *HSP90 chaperone-like* genes up-regulated during the early ripening stages were used for genome editing. The putative genome-edited plants were screened for mutation and a number of indels were found. The plants were raised for generation advancement and further studies. Detailed phenotypic analysis suggests *HSP90 chaperone-like gene2* edited CRISPR lines were taller and had more leaves, leaf area and stem diameter than the control plants in the early phase (30 days). In contrast, the significance decreased with the onset of maturity (60 days). Metabolome studies show significant changes in secondary metabolite pathways and some phytohormones in various stages of fruit development in the CRISPR-edited lines. Detailed analysis of the metabolome data and ripening studies are in process. Expression analysis of various ripening-related genes is to be done.
- Small RNA related to fruit ripening was identified from fruits of five ripening stages. Their differential expression was confirmed and miPEPs identified from the primary transcript. The peptide assay for miR159 was carried out.
- In the project to understand the molecular basis and hormonal control of abscission in fragrant roses, an interaction between ethylene and other hormones such as jasmonic acid and salicylic acid has been observed. Jasmonic acid delays abscission while SA promotes abscission although at high concentrations. The regulation of these pathways in abscission is currently being studied.

Computational biology and genomics

- In the area of computational biology, the stress tolerance of plants in response to drought, salt, heavy metals and pathogen attack was studied. The transcriptome meta-analysis of the salt and drought-stressed cotton was carried out. The analysis revealed that key regulatory hub genes of drought and salt stress conditions have notable associations with functional drought and salt stress-responsive (DSSR) genes. There were 5,962 and 3,510 differentially expressed genes (DEGs) identified in drought and salt stress data. Total 3,132 and 2,830 up and down regulated genes in drought and 2,265 and 1,245 up and down regulated genes (P-value < 0.05 and log2fold change > 2) in salt stress data. The genome wide analysis of *ATcase* and *OTcase* genes in various fruits showed their involvement in fruit ripening. The role of miRNA and its corresponding miPEP in heavy metal and nutrient deficiency stress was analysed in detail. The study shows that miR408 and miPEP408 regulate the arsenic response through the sulphur assimilation pathway.
- There is a significant chance to find the histone acetylation dynamics essential in response to insect infestation and provide stress tolerance. This study thus proposes the identification of the *HAT* and *HDAC* genes that play a significant role during insect infestation. Transcriptome analysis is done to identify the genes involved in biotic stress response. *HAT* and *HDAC* genes involved in biotic stress were selected from the previously reported transcriptomic data and further validated. Homozygous T-DNA insertion mutant lines were procured from ABRC, and homozygous T-DNA insertional mutants were screened. The selected *HAT* and *HDAC* genes are validated *via* mutant analysis and the functional validation of the genes will be done further.
- Genome sequencing of the Indian Lotus (108 petals) was carried out using PacBioHiFi for long reads and Illumina Hiseq for short reads. The genome assembly indicated 99.3% completeness. A large number of sequence variations were observed between the Indian and China antique genome. Transcriptomic analysis of various accessions collected from different locations was also carried out and differentially expressed genes were identified.
- The transcriptomic analysis of various tissues of *Commiphora wightii* and *Commiphora agalocha* identified key genes related to guggulsterone and germacrone synthesis.
- "Plant Resources of Chambal Ravines (PRCR) – A Digital Flora of Chambal Ravines", a database has been developed and accessible only on institutional LAN.

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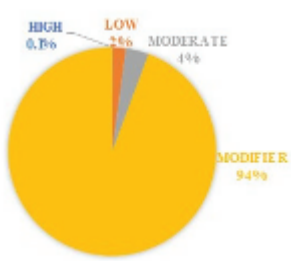
Unraveling molecular details of drought tolerance in cotton

We remapped >380 cotton RNA-Seq data with uniform mapping strategies that span ~400-fold coverage to the genome. We identified stage-specific features related to fiber cell commitment, initiation, elongation, and secondary cell wall synthesis for the specific regulation in fiber development. Thus, our data-mining study reveals several important features related to cotton fiber development and improvement, which were consolidated in the Cotton Express-omics database. Multi-location trial of 320 core germplasms of *G. hirsutum* had been carried out at four locations viz., Abohar, Aurangabad, Hyderabad, and Yavatmal under irrigated and rainfed conditions. We performed the targeted gene sequencing of 320 genotypes and identified approximately 1.30 crore SNPs with high confidence (Fig. 1). The genome-wide associated study (GWAS) by using these SNPs (>5 read map) and phenotypic data may be helpful for agronomically important traits.

Cotton (*Gossypium* sp.) genome editing to develop determinate/semi-determinate sympodial varieties for synchronized fiber yield and quality

The cultivated cotton varieties are perennial; thus, flowering, boll setup, and mature fiber production continues throughout the year. We want to develop a cotton variety that can give the production in one go, and preferably in a shorter time frame. In cotton, the SELF-PRUNING (*GhSP*) and SINGLE FLOWER TRUSS (*GhSFT*) genes have been identified whose local balance (*GhSP* and *GhSFT* ratio) and antagonistic actions in shoots apical meristem regulate growth habit and flowering. Studies showed that the constitutive expression and knockout/down of either *GhSP* or *GhSFT* showed an extreme phenotype which is not beneficial for agricultural purposes. To achieve determinate/semi-determinate growth habits and synchronous flowering in cotton, the genic and promoter regions of SELF-PRUNING (GhSP)



Variants Category	No. of SNPs
Upstream	303866
Downstream	302665
Stop gain	602
Stop loss	205
Start loss	71
Synonymous	18094
Nonsynonymous	32954
Intronic	54274
Intergenic	2266374
Other	252
Total	3179417

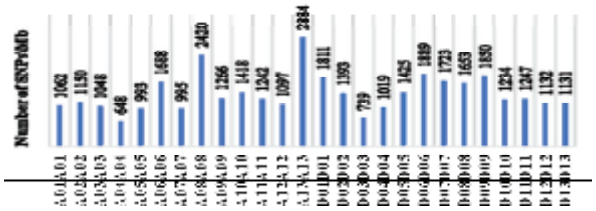


Fig. 1: Genome sequencing of 320 Cotton genotypes.

and SINGLE FLOWER TRUSS (GhSFT) genes have been cloned and sequenced. Several edited lines of GhSP & GhSFT has been developed and confirmed through PCR and sequencing.

A novel male sterility-fertility restoration system for commercial hybrid seed production in cotton

A novel male sterility-fertility restoration system has been developed for hybrid seed production. In this system, a construct comprising a novel *Arabidopsis BECLIN1* gene was expressed under a two-component expression system (ES) to achieve complete male sterility in tobacco. The novel reversible ES in *Nicotiana tabacum* drives high-level and stringent expression of the *AtBECLIN1*gene in post-meiotic tapetal cells rendering them male sterile. The reversible ES principally works on functional complementation of mutated TATA-Box (TGTA) and TATA-binding protein-mutant-3 (TBPm3). In contrast, the fertility of F1-hybrid was restored by limiting TBPm3 availability through Constitutive-photo-morphogenesis-1 (COP1)-mediated degradation of Long Hypocotyle-in-Far-Red1 (HFR1) fused protein HFR1NT131-TBPm3. We introduced this proven ES in cotton by developing male sterility-fertility restoration transgenic lines using somatic embryogenesis methods in the Cocker-312 genotype of *G. hirsutum*. We further explored the detailed phenotypic and molecular characterization of developed transgenic male/ RS (1373), female lines/ MS (1374), and F1-hybrids (RS X MS). The

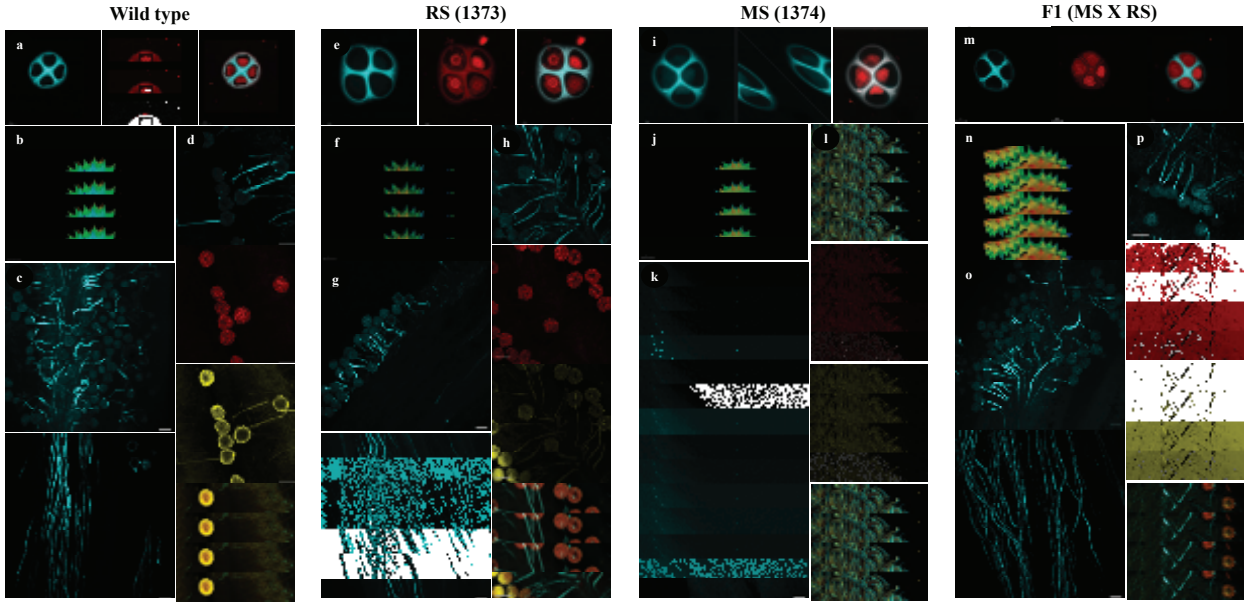


Fig. 2: *In vivo* pollen germination in Wild type, male, female and F1 hybrid (MS X RS) flowers: *AtBeclin1* expression in female flowers showed the normal tetrad as in wild type but due to a defect in tapetum degeneration, pollens become non-viable in later stages of pollen development. (a) Pollen tetrad from WT, (b) Mature well-developed WT pollen, (c-d) WT stigma loaded with germinated pollens, (e-f) Tetrad and mature pollen from Male (1373) flowers (g-h) Male flower stigma loaded with viable and germinated pollens, (i) Female tetrad pollen (j) Non-viable sterile pollen of female (k-l) Stigma from a female flower without pollen and (m-n) Tetrad and mature pollen from F1 hybrid (MS X RS), (o-p) F1 hybrid flower stigma loaded with viable and germinated pollens. The scale bar for tetrad and mature pollen is 20 um, scale bar for germinated pollen is 50 um. MS-male sterile (Female) and RS-restorer (male).

[Tetrad stage pollens were stained with aniline blue and propidium iodide (PI), mature stage pollens stained with acid fuchsin (3D structure) and *in vivo* germinated pollens loaded on stigma stained with aniline blue (blue colored), counterstained with PI (red colored) and auramine o (yellow colored).]

tapetum-specific expression of *Beclin1* in female plant flower anthers leads to abnormal tapetum degeneration and ultimately results in non-viable pollen. However, co-expression of male (1373) and female (1374) expression cassettes in cotton F1- hybrids (MS X RS) causes *Cop1m* mediated abolition of *Beclin1* expression and reverses the male sterility. The F1 hybrids (MS X RS) with restored fertility showed normal pollen viability and germination as in control.

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Role of the IDL gene family in rose petal abscission

The INFLORESCENCE DEFICIENT IN ABSCISSION family has been identified as a key regulator of abscission in *Arabidopsis* and other plants, encoding peptides that interact with receptor-like kinases to activate abscission. Four members of this family were identified in the ethylene-sensitive, early-abscising fragrant rose, *Rosa bourboniana*, of which three, RbIDL1, RbIDL2 and RbIDL4, showed a 3-4 fold increase in transcript levels in petal abscission zones (AZ) during ethylene-induced petal abscission as well as natural abscission. The genes were also expressed in other floral tissues but responded differently to ethylene in these tissues. RbIDL1 and RbIDL4, the more prominently expressed IDL genes, complemented the abscission defect of the *Arabidopsis* ida-2 mutant while promoters of both genes could drive AZ-specific expression in an ethylene-responsive manner in rose as well as *Arabidopsis* petal AZs indicating recognition of their AZ-specific and ethylene-responsive cis elements by the abscission machinery of rose as well as *Arabidopsis* (Fig. 3).

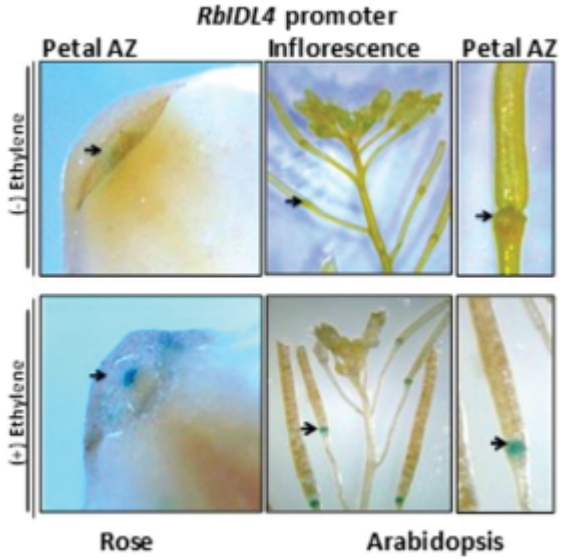

Fig. 3: Histochemical analysis of GUS expression driven by the rose IDL4 promoter in rose petal AZ and *Arabidopsis* inflorescence and petal AZ in presence and absence of ethylene

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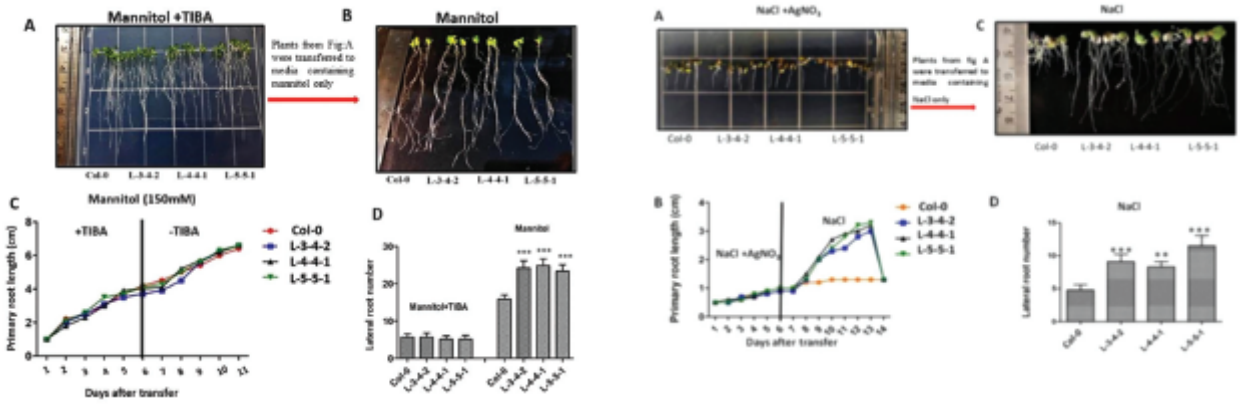
SlWRKY23 enhances salt and osmotic stress tolerance by modulating the ethylene and auxin pathways in transgenic *Arabidopsis*

Osmotic stress is one of the biggest problems in agriculture adversely affecting crop productivity. Plants adopt several strategies to overcome osmotic stresses that include transcriptional reprogramming and activation of stress responses mediated by different transcription factors and phytohormones. We identified a WRKY transcription factor from tomato, SlWRKY23, which is induced by mannitol and NaCl. Over-expression of SlWRKY23 in heterologous system (*Arabidopsis*) affected root growth and lateral root number. In addition, transgenic lines showed better osmotic stress tolerance to mannitol and NaCl. These lines showed reduced electrolyte leakage and higher relative water content upon mannitol and NaCl treatment with respect to Col-0 plants. Lower MDA content and higher proline content than Col-0 in transgenic lines suggested better membrane integrity. Responses to mannitol were governed by auxin as treatment with TIBA (auxin transport inhibitor) negatively affected the osmotic tolerance in transgenic lines by inhibiting lateral root growth (Fig. 4). Similarly, responses to NaCl were controlled by ethylene as treatment with $AgNO_3$ (ethylene perception inhibitor) inhibited the stress response to NaCl by suppressing primary and lateral root growth. Our study showed that *SlWRKY23*, an osmotic stress inducible gene in tomato, imparts tolerance to mannitol and NaCl stress through interaction of the auxin and ethylene pathways.

Phosphomevalonate kinase regulates the MVA/MEP pathway in mango during ripening

Mango is a popular tropical fruit with a great diversity in taste and aroma, contributed



Panel 1 Panel 2

Fig. 4: Panel 1: SlWRKY23 increases the mannitol tress tolerance in transgenic Arabidopsis through auxin mediated pathway. Seedlings of both Col-0 and transgenic lines were placed on ½ MS containing Mannitol(150mM) + TIBA(10nM) (A) and primary root length was measured every day and lateral root number was counted (C), after 6th day seedlings were transferred to media containing mannitol only then primary root length and lateral root data was taken (B-D). Panel 2: SlWRKY23 increases the salt tolerance in transgenic Arabidopsis through ethylene mediated pathway. Seedlings of both Col-0 and transgenic lines were grown on ½ MS containing NaCl (100mM) + $AgNO_3$ (500nM) and primary root length was measured everyday (A and C), after 6th day seedlings from Fig A were transferred to media containing NaCl only and primary root length and lateral root data was taken (B-D). Error bar represents the standard error of 3 independent experiments. *, indicates $P < 0.05$, **, indicates $P < 0.01$, ***, indicates $P < 0.001$.

primarily by terpenoids. Phosphomevalonate kinase (PMK) is a key enzyme for isoprenoid biosynthesis in the mevalonic acid (MVA) pathway responsible for terpenoids. Two cultivars of mango, "Dashehari" and "Banganpalli", showing opposite spatio-temporal patterns of ripening polarity, were investigated for studying the role of MiPMK in aroma production. MiPMK transcription and enzyme activity increased during ripening in both varieties. Polypeptide sequences of the two enzymes showed differences in a few amino acids that were also reflected in kinetic properties such as specific activity and pH optima. Silencing of MiPMK in "Dashehari" fruit by VIGS suppressed the kinase activity and led to changes in relative contributions of the mevalonic acid (MVA) and methylerythritol 4-phosphate (MEP) pathways (Fig. 5). This also altered the fruit metabolite profile with a reduction/disappearance of sesquiterpenes such as geranyl geraniol,trans-farnesol, β-caryophyllene, β-pinene, bisabolene

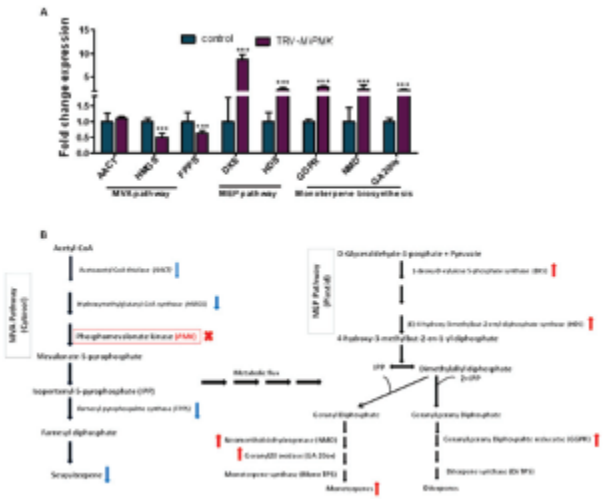


Fig. 5: MiPMK suppression alters the MVA, MEP and monoterpene biosynthesis pathway in mango fruit

and guaiane but the appearance of menthol and d-limonene in silenced fruit. The study shows that MiPMK levels may control downstream metabolite flux of the MVA pathway in mango.

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Characterization of Tma12 as Lytic Polysaccharide Monooxygenase (LPMO)

We employ molecular strategies to safeguard cotton crops from a wide range of insect pests, including chewing and sucking types. By screening ferns and mosses, we unearthed a novel insecticidal protein namely Tma12 from the fern *Tectaria macrodonta* (Fig. 6). Tma12, a 21.68 kDa protein, exhibits potent whitefly toxicity at an LC_{50} of 1.49 µg/ml. Incorporating Tma12 into cotton plants provides effective protection from whitefly. Remarkably, Tma12 structural features share resemblance with a novel enzyme Lytic Polysaccharide Monooxygenases (LPMOs),

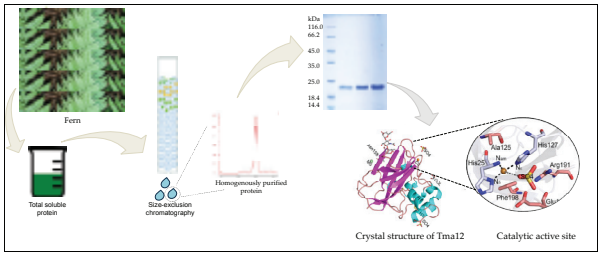

Fig. 6: Purification of Tma12 from fern and its crystal structure with catalytic site. Catalytic site comprises of conserved His (His_{25} and His_{127}) that binds to metal ion.

belonging to class Auxiliary Activities (AA) in the Carbohydrate Active Enzymes (CAZy) database (Fig. 1).

LPMO activity of Tma12 and its role in whitefly toxicity

Whitefly (*Bemisia tabaci*; family Aleyrodidae; order Hemiptera) stands out as one of the most infamous sap-sucking insect pests. Across the world, a multitude of strategies have been devised to effectively combat the menace of the whitefly. Among these, deployment of Tma12 has emerged as a promising solution in the battle against this pest. However, to ensure its safe use in agricultural practices functional characterization of Tma12 is imperative. At the outset, we established the enzymatic activity of Tma12 on both natural and artificial substrates, and subsequently delved into investigation of the correlation between catalytic activity and toxicity.

Tma12 shows strong affinity towards β-chitin and digests its crystalline form (Fig. 7). It also digests β-chitin nanofibers in presence of ascorbic acid and generates oxidized chitin oligosaccharides of DP2-DP7. For artificial substrate hydrocoerulignone, Tma12 shows maximum activity in 25 mM sodium phosphate buffer at pH 7.5. The Km and Vmax values are 22.43 ± 2.45 and 125.96 ± 5.68 respectively. The Km and Vmax value for cosubstrate H_2O_2 is 5.67 ± 1.62 and 121.53 ± 3.22, respectively. Collectively these evidences show that Tma12 is a functionally active LPMO.

Copper-loaded and demetallized Tma12 was modified with DEPC

To understand the role of LPMO activity of Tma12, protein chemistry approach was followed. MS analysis showed that DEPC modifies both the histidine residues (His_1 and His_{103}) present at catalytic active site of demetallized $Tma12_{apo}$ and blocks the copper binding to it. This significantly reduces the LPMO activity of modified $Tma12_{apo}$. While copper-loaded Tma12 remained catalytically active even after DEPC labeling of His_{103}. However, affinity of unmodified and modified Tma12 towards β-chitin was remain unperturbed.

Further, association of LPMO activity with insecticidal function was examined through

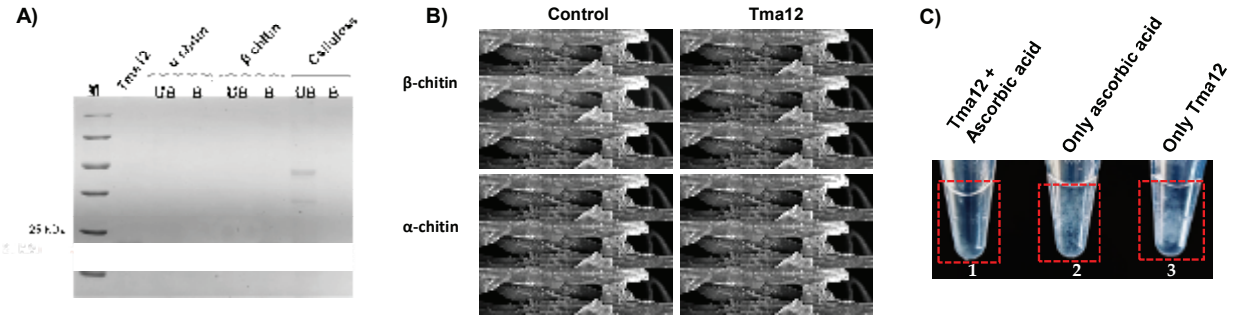

Fig. 7: (A) SDS-PAGE showing affinity of Tma12 to shrimp shell α-chitin, squid pen β-chitin, and cellulose (Avicel 101). (B) SEM analysis of β- and α-chitin digested with Tma12. The surface of β-chitin (upper panel) treated with Tam12 appears rough and disrupted in comparison to the control (no Tma12 in reaction). (C) β-chitin nanofibers are digested with Tma12 in the presence of ascorbic acid; digestion in the absence of Tma12 or ascorbic acid served as control.

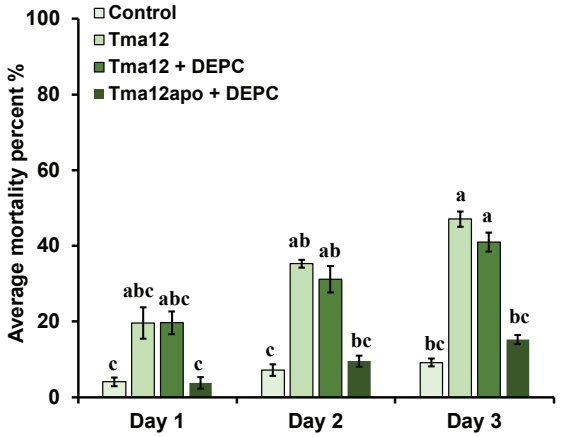

Fig. 8: Toxicity of DEPC modified Tma12 on whitefly. The bar graph shows a significant reduction in the mortality of whiteflies fed on the DEPC labeled $Tma12_{apo}$ while no change in toxicity was observed in modified Tma12. All values represent as mean ± SD of three independent replicates of bioassay (one-way ANOVA, $P < 0.05$, Tukey's test).

whitefly bioassay. Modified and unmodified Tma12 were fed to whitefly and mortality was recorded for 3 days (Fig. 8). DEPC labeled $Tma12_{apo}$ showed significantly reduced toxicity to whitefly in comparison to unmodified Tma12, whereas, toxicity in modified Tma12 was comparable with unmodified Tma12. This establishes that LPMO activity in Tma12 is imperative for its efficacy to whitefly.

Impact of cations such as Cu^{2+}, Zn^{2+} and Mg^{2+} on catalytic and insecticidal activity of Tma12 was also studied. Tma12 showed enzymatic and insecticidal activity only in the presence of Cu^{2+} whereas Zn^{2+} and Mg^{2+} were unable to restore both the functions. This further establishes that Cu^{2+} is essential for catalytic activity as well as whitefly toxicity. Our findings shows that Tma12 not only can be deployed in crops for combating whitefly but also can be used as a powerful enzyme (LPMO) in biorefineries for production of biofuel.

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Co-expression of *Cocculus hirsutus* trypsin inhibitor with Cry protein increases the development of resistance in transgenic tomato

The modified *Cocculus hirsutus* trypsin inhibitor (*ChTI*) was expressed either alone or pyramided with the Bt-toxin Cry1Ab increases the resistance in transgenic against two herbivorous insects, *Helicoverpa armigera* and *Spodoptera litura*, with complete insect mortality. Up to 80% weight loss and reduced larval growth were observed in both the insects challenged with 200 µg of the purified ChTI protein. The ChTI protein trypsin inhibitor activity is up to 5.5 U/mg protein when expressed in *E. coli*, 3.0–3.5 U/mg protein in transgenic *Arabidopsis*, and 2.5–

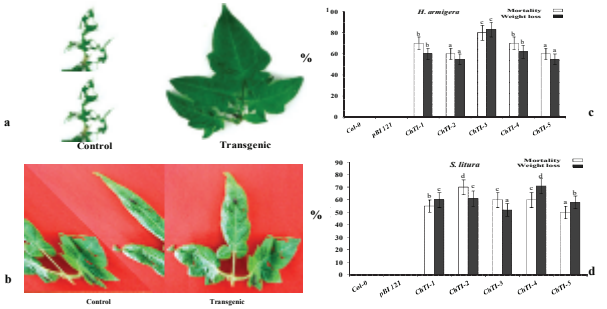

Fig. 9: Characterization of transgenic tomato plants developed with *ChTI*. Insect bioassay of transgenic tomato plants expressing the *ChTI* gene in (a) *H. armigera and* (b) *S. litura*, compared to non-transformed and vector controls. Less leaf damage, higher mortality and weight loss against both insects, (c) in *H. armigera*, (d) in *S. litura*, compared to their control.

3.0 U/mg protein in transgenic tomato plants. Transgenic *Arabidopsis* and tomato plants were developed by pyramiding *ChTI*, and *cry1Ab genes* showed 100% mortality against both insects. In comparison, the transgenic plants expressing the *ChTI* gene alone showed up to 70% mortality without yield penalty (Fig. 9).

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Arsenic (As) risk assessment in vegetable crops in arsenic affected areas and mitigation through microbial consortia containing AsMT activity

We have made a promising discovery by isolating microbes that possess AsMT (arsenic methyltransferase) activity. The finding opens up possibilities for utilizing these microbes in different vegetable crops to effectively reduce and mitigate the accumulation of arsenic (As). By implementing this approach, we can potentially enhance the safety and quality of vegetables, thereby reducing the risk of arsenic exposure to humans.

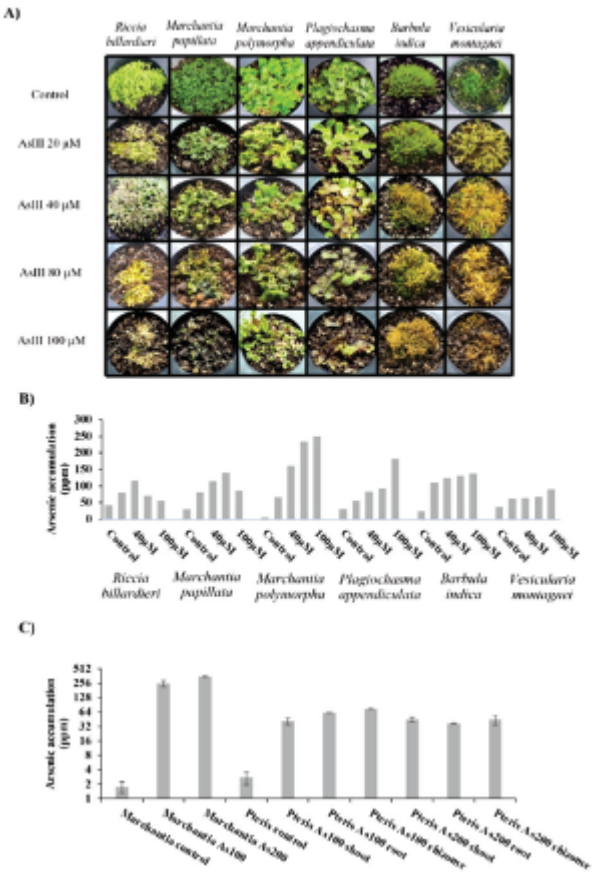

Fig. 10: (A) Phenotypic observation of six bryophyte species- *Riccia billardieri, Marchantia papillata, Marchantia polymorpha, Plagiochasma appendiculata, Barbula indica* and *Vesicularia montagnei* under different arsenite {As (III)} treatment- 20µM, 40µM, 80µM and 100µM respectively after 15 days, (B) Accumulation of total arsenic under the different As (III) concentration- 20µM, 40µM, 80µM and 100µM after 15 days of treatment, (C) Differential accumulation of total arsenic in *Marchantia polymorpha* compared to *Pteris vittata* after 15 days of higher concentration of arsenite (100 and 200µM) treatment.

Arsenic stress tolerance in some bryophyte species collected from West Bengal

Although the bryophytes are one of the most diverse groups of land plants, alongside the angiosperms. These plants are among the most ancient lineage and have amazing capabilities to cope up with wide range of harsh environmental conditions. Humanity is facing many health-related problems due to excessive pollution through heavy metal poisoning, particularly arsenic. So, to assess the arsenic tolerance capability in bryophytes, we have studied six species, namely- *Riccia billardieri, Marchantia papillata, Marchantia polymorpha, Plagiochasma appendiculata, Barbula indica,* and *Vesicularia montagnei*. The results suggest that *Marchantia polymorpha* accumulates the highest level of arsenic among all the species studied when treated with varying concentration of AsIII for different time durations (accumulates higher arsenic when compared to *Pteris vittata*) (Fig. 10). Transcriptome studies were performed to understand the molecular mechanism behind the tolerance capabilities of *Marchantia polymorpha* under AsIII stress condition. The results of this study would be highly beneficial in understanding the genes responsible for arsenic stress tolerance mechanism in lower group of plants and also in generating transgenic plant varieties with greater arsenic stress tolerance capabilities.

Micropropagation of *Hoya carnosa, H. karri, H. parasitica,* and *H. longifolia* using tray-based floating and stationary hydroponic systems

Hoya is a wild ornamental plant with medicinal

properties that have been extensively exploited from its natural habitat, causing a reduction at an alarming rate. The current study is aiming to fabricate an affordable and simple-to-use hydroponic system for the conservation and mass production of four *Hoya* species (*H. carnosa, H. karri, H. parasitica, and H. longifolia*). Tray-based floating and stationary hydroponic systems consist of *Hoya* plants (cuttings) inserted in a thermocol sheet and suspended in MS nutrient solution (Fig. 11). Cuttings derived from mature plants were subjected to full MS (Murashige and Skoog), 1/2 MS, 1/3 MS, and 1/4 MS nutrient media for growth optimization. Subsequently, the ½ MS nutrient medium was further augmented with different concentrations (0.5, 1.5, 2.5, 3.5, and 4.5 µM) of auxins like NAA, IBA and IAA for rooting. A combination of 1/2 MS + IBA (2.5 µM) proved to be the optimal medium for rooting in *Hoya* species when compared to all other treatments.

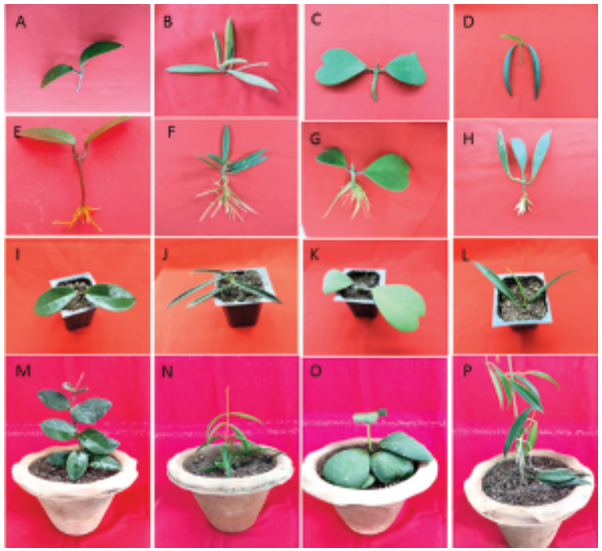

Fig. 11: Tray-based floating and stationary hydroponic systems for four Hoya species- (A) *Hoya carnosa*, (B) *Hoya parasitica*, (C) *Hoya kerrii*, (D) *Hoya longifolia*

Further, improvements in root number were recorded with augmentation of 25, 50, 100, 150, and 200 µM of Zinc Sulphate ($ZnSO_4$). Half MS nutrient solution with 2.5 µM IBA and 100 µM $ZnSO_4$ resulted in a maximum of 15 roots in *H. carnosa*, 20 in *H. parasitica*, 38 in *H. kerrii*, and 19 in *H. longifolia*. The effect of 5.0 µM GA_3 (Gibberellic acid) was also evaluated on bud break in rooted plants. Foliar spray of GA_3 on acclimatized plants subsequently reduced the bud break time, and the highest reduction of time was observed from 21 d to 7 d in *H. longifolia*. Transfer of hydroponically raised plantlets come under stress when transferred to field conditions from hydroponic conditions. Our results based on stress marker activities suggest that the plantlets were able to overcome the stress when transferred to field from hydroponic conditions. The present study proposed a reliable protocol for the conservation and mass propagation of most of the Hoya species (Fig. 2).

Apart from this research, Plant Tissue Culture Division, is working on *in vitro* establishment and propagation of Carnation (Kiliyosh, Liberty, Purple, Master, and Pink); Gerbera (Silvester, Balance, Dune, Ankur, Dana Allen, and Pink); Gladiolus (Tiger, Amethyst, Prosperity, Blue Isle, Yellow stone, Kalima, and Melody) and Chrysanthemum (Himani, Kundan). Thousands of tissue culture-raised plants were transferred to the beneficiary farmers of Uttar Pradesh, India.

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Genomics and transcriptomics of Indian Lotus

Lotus (*Nelumbo nucifera*) belongs to the family Nelumbonaceae and is an aquatic plant of high medicinal and nutritional value. The flowers are generally white or pink and the number of petals vary from 16-160. It is considered sacred in both Indian and Chinese cultures. All parts of the plant (rhizome, leaf, fruit and seed) are used for ayurvedic as well as Chinese medicines.

The Indian Lotus varieties have not been explored in detail. The genome sequence of the

Indian lotus was carried out and various SNPs as compared to the Chinese Lotus were identified. The SNPs were mapped on the chromosomes and showed distribution in all the chromosomes. Various accessions of Lotus were collected from different parts of India and the transcriptome sequencing of rhizome, leaf, seed and flower tissues were carried out. The analysis revealed several differences in gene expression pattern of Lotus plants collected from different regions, indicating diversity amongst them. The rhizome of Lotus plant is of high economical value and is generally consumed as vegetable, pickle and has high nutritive and medicinal value. The carbohydrate synthesis and metabolism genes expressed in the rhizomes of different varieties were analysed and differences observed (Fig. 12).

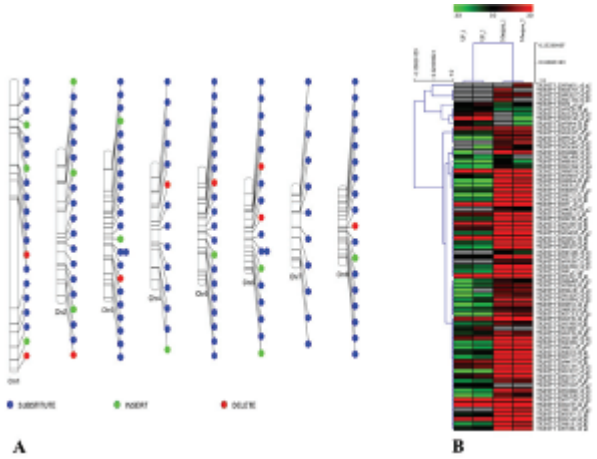

Fig. 12: A Polymorphisms identified in the genome sequence of Indian Lotus vis a vis China Antique Lotus. **B** Differential expression of carbohydrate metabolism genes in rhizomes of lotus plants collected from UP and Manipur.

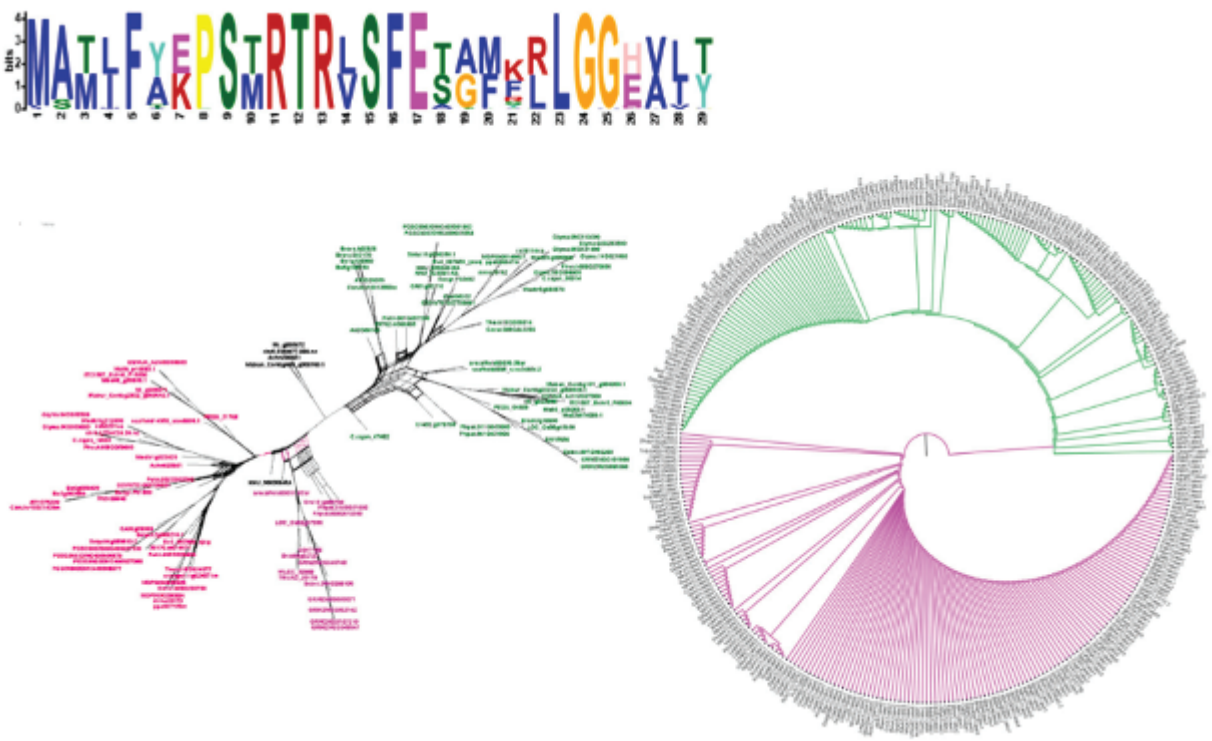

Fig. 13: The logo representation of conserved motif in Atcase domain of plant groups and phylogeny and network of the same, representing the signature distribution of 2 different classes of Atcase: Aspartic Atcase (Pink) and Ornithine Atcase

Genome and transcriptome-wide study of carbamoyltransferase genes in major fleshy fruits: a multi-omics study of evolution and functional significance

The carbamoyltransferase or ATCase/OTCase, is an evolutionary conserved protein family, which contains 2 genes, aspartate carbamoyltransferase (ATCase) and ornithine carbamoyltransferase (OTCase). The ATCases catalyses the committed step in the synthesis of UMP from which all pyrimidine molecules are synthesized. The second member OTCase, catalytically regulates the conversion of ornithine to citrulline. This study traces the evolution of the carbomoyltransferases genes in the plant kingdom and their role during fruit ripening in fleshy fruits. These genes are highly conserved throughout the plant kingdom and except for the melon and watermelon do not show gene expansion in major fleshy fruits. In the present study, 393 carbamoyltransferase genes were

identified in the plant kingdom including 30 fleshy fruit representatives. Their detailed phylogeny, evolutionary patterns with their expression during the process of fruit ripening was analysed. The ATcase and OTcase genes were conserved throughout the plant kingdom and exhibited lineage specific signatures (Fig. 13). The expression analysis of the ATcase and OTcase genes during fruit development and ripening in climacteric and non-climacteric fruits showed their involvement in fruit ripening irrespective of the type of fruits

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CRISPR/Cas9 mediated genome editing in tomato for manipulating fruit shelf-life

One of the most important agronomical factors affecting fruit quality in post-harvest marketing is the shelf life of ripe fruits. Tomato is the second most produced commodity after potato, and India is the second largest producer of tomato. Tomato fruits easily deteriorate because of excessive and rapid fruit softening, thus

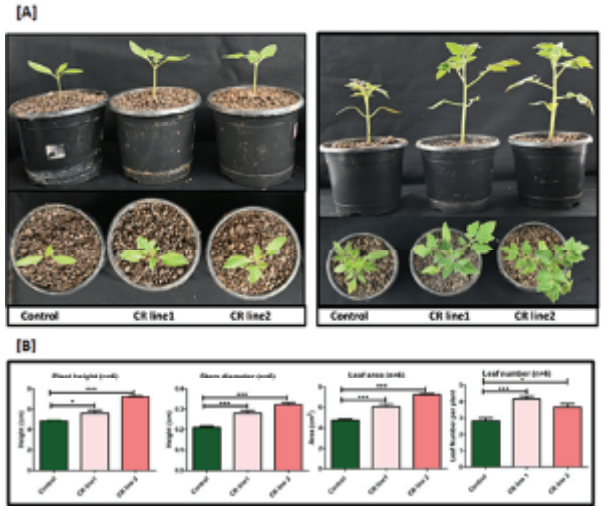

Fig. 14: [A] Genome-edited plants (15 days and 30 days old plants). [B] Phenotypic variation in genome-edited plants w.r.t. control plants.

attracting microbial infection, thereby leading to the loss of vital nutrients. A substantial amount, i.e., 20-40% of the total produce, is exhausted in post-harvest losses due to improper storage and transportation conditions. Here, in this study, we are targeting various ripening-related genes with genome editing technology (CRISPR/Cas9.) We targeted two HSP90 chaperone-like genes up-regulated during the early ripening stages. The putative genome-edited plants were screened for mutation and a number of indels were found. The plants were raised for generation advancement and further studies. Detailed phenotypic analysis suggests HSP90 chaperone-like gene2 edited CRISPR lines were taller, and had more leaves, leaf area, and stem diameter than the control plants in the early phase (30 days, Fig. 14). Various phenotypic, biochemical, and ripening studies on other CRISPR lines are also under progress.

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Elevated CO_2 induced methylation pattern differs in low and high elevation population of *Arabidopsis thaliana*

Understanding plant response towards changing environment still remains to be the goal of plant biologists. This has become more important considering the present and expected future climate change scenario and demand to feed the growing world population. The accelerated climate change may force plants to adapt to the changing environment. Until now, only genetic factors were considered to reveal the underlying mechanisms involved in plant adaptation. We focus on exploring

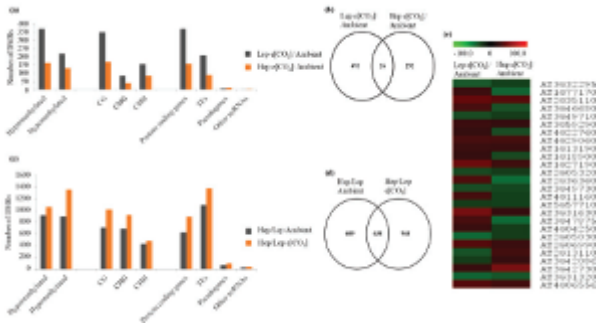

Fig. 15: Differentially methylated regions (DMRs) and their distribution patterns with respect to growth and population. Number of growth (a) and population specific (c) DMRs, their methylation status (hyper-or hypo-methylated), distribution patterns in different sequence (CG, CHG and CHH) and genomic contexts of the Lep and the Hep. Venn diagrams representing growth specific (b) and population specific (d) common and unique DMGs between the Lep and the Hep. Heatmap of methylation status of growth specific common DMGs are between the Lep and the Hep (e). Higher color intensity of red to green corresponds to the level of hyper-methylation and hypo-methylation, respectively.

epigenetic factors by studying the natural populations of *Arabidopsis thaliana*, especially those growing along steep altitudinal gradient ranging from 600 to 3400 m amsl in the Himalayas.

We investigated the methylome, of the two *Arabidopsis thaliana* populations evolved at high (3400 m amsl) and low elevation (700 m amsl) zones to elevated [CO_2] (e[CO_2]). Seeds of these two populations were sown in plastic pots containing Soilrite Mix. Ten days post-germination, pots were transferred to a Free Air CO_2 Enrichment (FACE) ring as well as to a control ring without supply of CO_2 (ambient~400±10 ppm) commissioned at the institute. Whole genome bisulfite sequencing was carried out to determine the methylation pattern. Differentially methylated sites (DMSs) and differentially methylated regions (DMRs) between different combination of samples were identified. Global gene expression was analysed by transcriptome sequencing of the samples.

We identified differentially methylated regions (DMRs) in a tilling window of 100 bp with an overlap of five bases as well as differentially methylated region related genes (DMGs) (Fig. 15). Gene having DMRs within the genic region or its 1 kb upstream sequence was considered as DMR-related gene (DMG). Like DMSs, the DMRs were also > two-fold higher in the lower elevation population (Lep) than the higher elevation population (Hep). The proportion of hyper-methylated DMRs were more in the Lep (62.9%) while the Hep exhibited almost equal proportion of hyper- and hypo-methylated

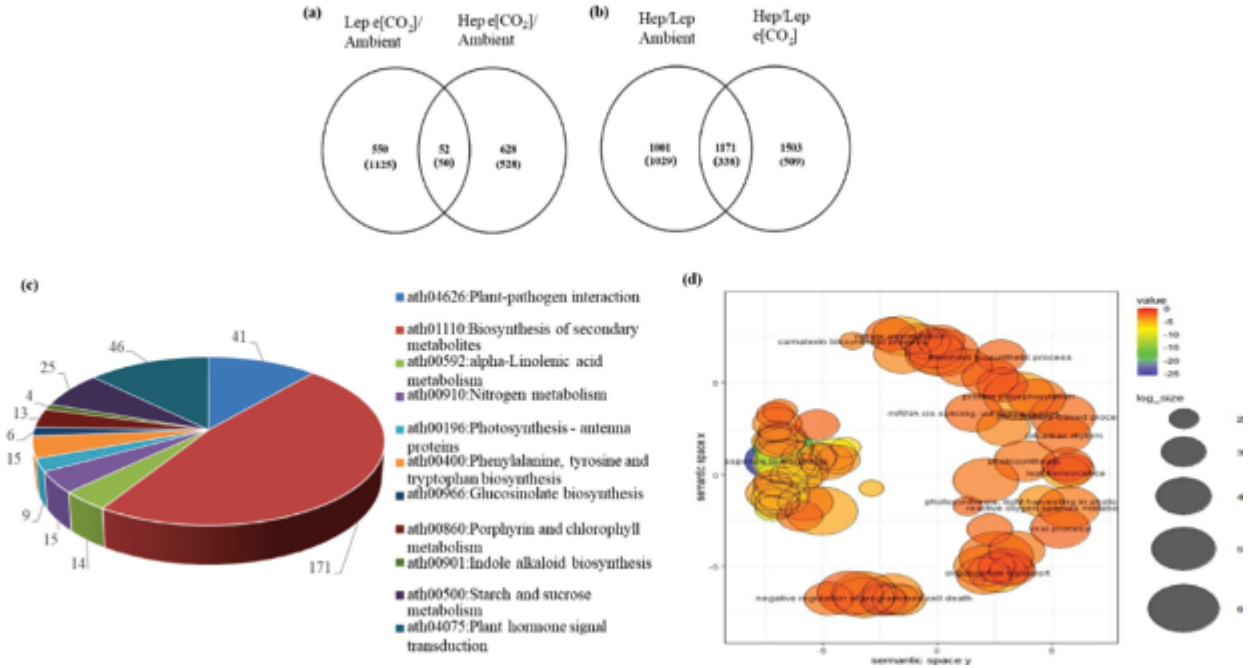

Fig. 16: Growth and population specific differential gene expression and KEGG pathway and GO analyses of CO_2 responsive genes. Venn diagram showing number of significantly differentially expressed growth specific (a) and population specific (b) genes in the Lep and in the Hep ($P \leq 0.05$). KEGG pathway analysis of genes showing differential expression of e[CO_2] responsive genes at FDR ≤ 0.05 (c).GO enrichment analysis [CO_2] responsive genes analysed using REViGO at FDR ≤ 0.05 (d). The disc color gradient (blue to red color) indicates the degree of GO enrichment corresponding to log10 p-value, while the disc size is proportional to the frequency of the GO term in underlying GO annotation database.

DMRs (Fig. 15a). The CG-DMRs were dominated in both the populations (Lep 59.5%, Hep 58.2%), followed by CHH- (Lep 26.3%, Hep 28.4%) and CHG-DMRs (Lep 14.0%, Hep 13.3%,) (Fig. 15b). In both the Lep and the Hep, a higher proportion of DMRs (63.1% and 56.1%, respectively) were associated with protein coding genes followed by TEs (35.5% and 38.0%, respectively), pseudo-genes and other non-coding RNAs (Fig. 15c). Finally, we identified a total of 519 and 278 DMGs in the Lep and in the Hep, respectively and 26 common DMGs between the two. Most of the common DMGs were either hypo- or hyper-methylated in both the populations while a few of them exhibited contrasting patterns (Fig. 1d). Thus, it was evident that methylation remodeling mostly occurred in protein coding genes in both the populations and more so in the Lep than the Hep.

The population specific DMRs was 32.8% higher under e[CO_2] as compared to ambient condition and the hypo-methylated DMRs were more than the hyper-methylated ones. However, under ambient condition, the proportion of the hypo- and the hyper-methylated DMRs was more or less equal (Fig. 1e). The proportion of CG-, CHG- and CHH-DMRs was 38.7% and 42.0%, 37.6% and 38.1%, 23.5% and 19.8% under ambient and e[CO_2], respectively. Further, in contrast to growth specific DMRs, under both the conditions a higher proportion of the DMRs (60.8% and 57.3%) were associated with TEs followed by protein coding genes (33.9% and 37.0%). Finally, we identified a total of 1247, 1586 and 638 DMGs under ambient, e[CO_2] and common to both the conditions, respectively (Fig. 2). Most of the common DMGs exhibited similar methylation pattern, while a few showed contrasting methylation patterns between the two populations.

The Lep exhibited more number of significant DEGs (1877) (both up- and down- regulated) than the Hep (1258) under e[CO2]. The proportion of down-regulated DEGs was more in the Lep (68%) than the Hep (45%) (Fig. 16). On the other hand the population specific gene expression showed nearly equal proportion of DEGs under ambient (51.13%) and e[CO_2] (49.87%) and DEGs due to interaction between treatment and population (PxT) were about 21.3% (Fig. 2).

Thus, the two populations of *A. thaliana* adapted at different climatic conditions responded differentially in terms of molecular plasticity towards e[CO_2]. This may partly be driven by genetic differences of the two populations but spontaneous local variations in DNA methylation variants between the two were also obvious.

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Data mining of transcriptional biomarkers at different cotton fiber developmental stages

Advancement of the gene expression study provides comprehensive information on pivotal genes at different cotton fiber development stages. Through data mining and statistical approaches, we identified and validated the transcriptional biomarkers for stage specific differentiation of fiber. With the unique mapping read matrix of ~ 200 cotton transcriptome data and sequential statistical analysis, we identified several important genes that have a deciding and specific role in fiber cell commitment, initiation and elongation, or secondary cell wall synthesis stage.

For the identification of transcriptional biomarkers at initiation, elongation, and secondary cell wall-specific stages, the total 171 online submitted RNAseq datasets were processed through data mining approaches (Fig. 17A). Multi-step procedures identified 50 important features that were classified for the initiation and elongation/SCW-specific biomarkers (Fig. 17B). Based on the importance score and validation analysis the identified top 20 important transcriptional biomarkers include different types of superfamily like alpha/beta hydrolases, peroxidases, HAD-like, pectin lyase-like and NAD-like superfamily. Different transcriptional biomarkers annotated as superfamily protein suggest their importance at different cotton fiber development stages

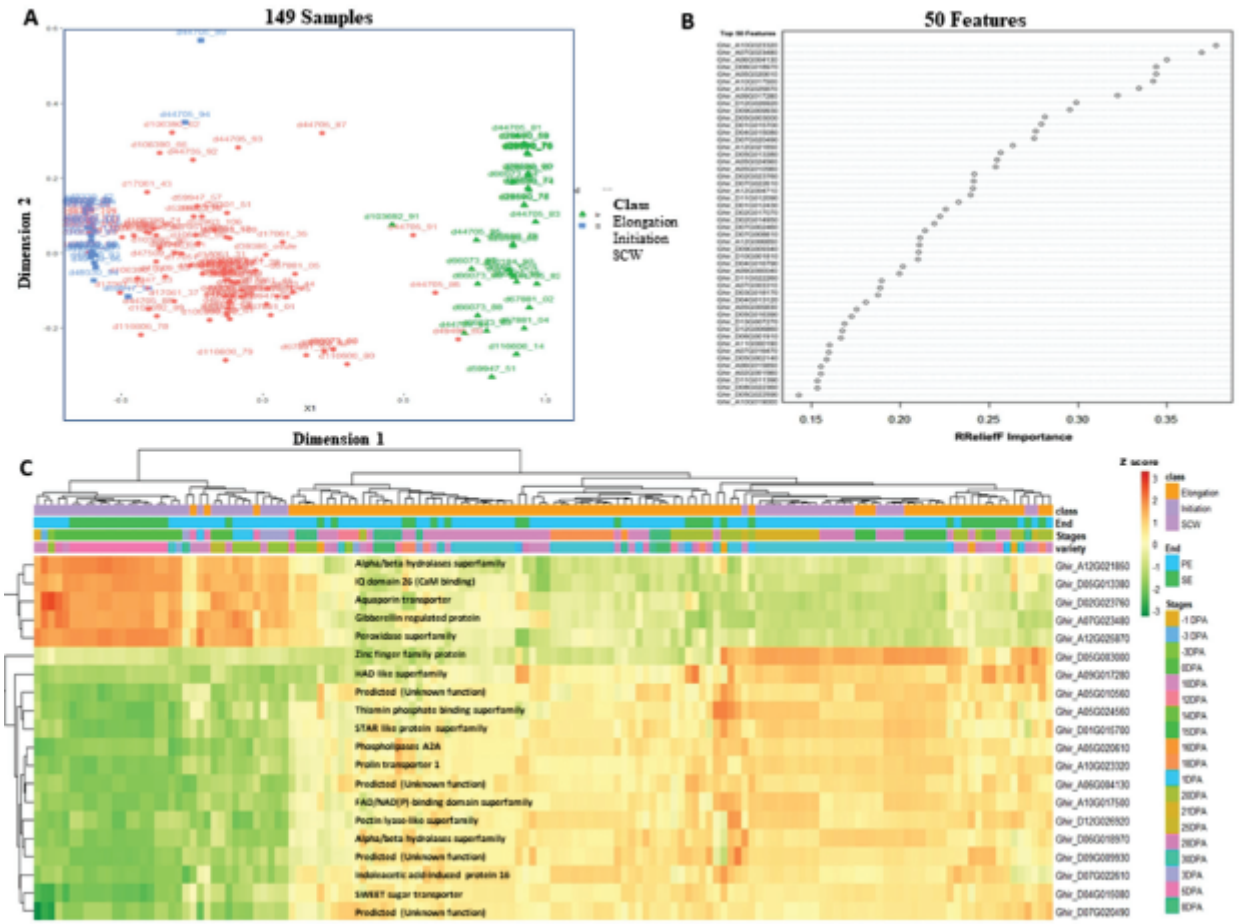

Fig. 17: Mining of Transcriptional Biomarkers in cotton **A**. Multidimensional scaling plot of filtered and normalized RNAseq sample for initiation, elongation and secondary cell wall (SCW) synthesis-fiber developmental stage based on the most informative features **B**. Dot chart plot of the top-ranked 50 genes based on the RReliefF score **C**. Expression matrix of top 20 highly scored features among the different DPA. The normalized Z-score value was represented in the form of an expression matrix. The green color represents the lowest expression value while the orange color represents the highest expression value. The putative function of each gene is mentioned along each row of genes

(Fig. 17C). Using different multi-omic approaches or the integration of gene editing programs could help us to identify their role in crop improvement through different fiber developmental stages. Real-time expression analyses validated that Ghir_A06G004130 and Ghir_D09G009930, expressed at fiber elongation stage. The accuracy of predicted transcriptional biomarkers can be utilized for the cotton breeding program, Similarly, through the RNAseq data of − 3 DPA, − 1 DPA and 0 DPA of 26 samples, we predicted the commitment specific transcriptional biomarker before the day of anthesis (− 3 DPA and − 1 DPA) and on the day of anthesis (0 DPA). These genes are represented as transcriptional biomarkers that provide a base for molecular characterization for cotton fiber development which will ultimately determine the high yield.

Taken together, all these identified and validated genes/features have the potential to act as transcriptional biomarkers for cotton fiber initiation and elongation/SCW-specific stages. This could be a major breakthrough for cotton researchers and breeders, where they can use these biomarkers for screening purposes for different cotton fiber developmental stages.

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Transcriptome analysis of *Fusarium* infected root xylem tissues to decipher genes involved in chickpea wilt resistance

Fusarium wilt is the most destructive soil-borne disease that poses a major threat to chickpea production. Plant resistance towards Fusarium wilt is a very complex phenomenon. In a compatible interaction, the main interface between the host and fungus is the root xylem vessels. The resistant plants known for early pathogen perception triggered molecular reprogramming leading to the activation of downstream defense responses for pathogen restriction. To comprehensively understand the interaction between chickpea and *Fusarium oxysporum*, the xylem-specific transcriptome analysis of wilt-resistant (WR315) and wilt-susceptible (JG62) genotypes at an early time point (4DPI) was investigated. Differential expression analysis showed that 1,368 and 348 DEGs responded to pathogen infection in resistant and susceptible genotypes, respectively. Both genotypes showed transcriptional reprogramming in response to Foc2, but the responses in WR315 were more severe than in JG62 (Fig. 18). As a result of KEGG pathway analysis, most of the DEGS in both genotypes showed enrichment in metabolic pathways, secondary metabolite biosynthesis, plant hormone signal transduction, and carbon metabolism. Genes such as thaumatin-like protein 1b, cysteine-rich receptor-like protein kinases, MLP-like proteins,

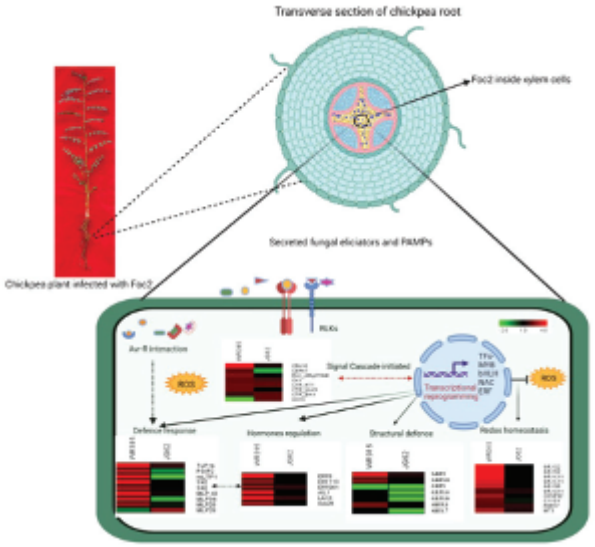

Fig. 18: Model illustrating the cascade of molecular events in the root xylem of wilt contrasting chickpea genotypes at an early stage of Foc2 infection based on transcriptome data. Heat map showing the expression level of genes in the xylem of resistant 'WR315' and susceptible 'JG62' genotypes. Colour scale of log2 fold-change values is shown at the top. Figure created with BioRender.com.

polygalacturonase inhibitor 2-like, ethylene-responsive transcription factors, glycine-rich cell wall structural protein-like, beta-galactosidase like, subtilisin-like protease, thioredoxin-like protein, chitin elicitor receptor kinase-like, proline transporter-like, non-specific lipid transfer protein and sugar transporter were mostly up-regulated in resistant as compared to susceptible genotypes. This study's result may contribute to identifying disease resistance genes, which would help in understanding the Foc resistance mechanism in chickpea.

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Unravelling of unknown components of temperature sensing and signalling in plants

To identify critical genes involved in high temperature adaptation, we will use QTL approach in tomato. For this, we have screened tomato germplasms (70) for their high temperature tolerance potential.

Tomato accessions are growing in the field to know response of heat stress. Some tomato accessions display better performance under high temperature in field conditions.

Based on available QTL mapping, we have identified a set of genes those may play an important role in enhancing fruit size in tomato. Further, studies are under progress.

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Identification of Canna viruses and their management

Our group has identified the mixed infection of canna yellow mottle virus (CaYMV), bean yellow mosaic virus (BYMV), and cucumber mosaic virus (CMV) in Black Knight cultivar of Canna exhibiting severe yellow streak and mottling symptoms. The ability of callogenesis and organogenesis from the ovary, stalk, and rhizome explants was tested for the development of virus-free plants. Performance of rhizome explants was excellent and 33.33±1.67 rhizomes showed callus development on ME medium (MS with 0.8 mg/L TDZ and 0.25 mg/L NAA) and further on a refined M4 medium (MS with 4.0 mg/L BAP, 1.0 mg/L NAA and 50 mg/L Ads) and produced 4.06±0.16 shoots per explant. The development of virus-free plants was attempted by *in vitro* chemotherapy using ribavirin. In the presence of 40 mg/L ribavirin in the ME medium, rhizomes developed about 3.78±0.68 shoots per explant. The elimination of coinfection of all three viruses from rhizome explants of 0.5 cm^2 of the Black Knight cultivar was attempted. Consequently, a total of 53.33% of plants free from all three viruses (48 out of the 90 plants developed) were obtained when screened by RT-PCR and PCR for their absence (Fig. 19).

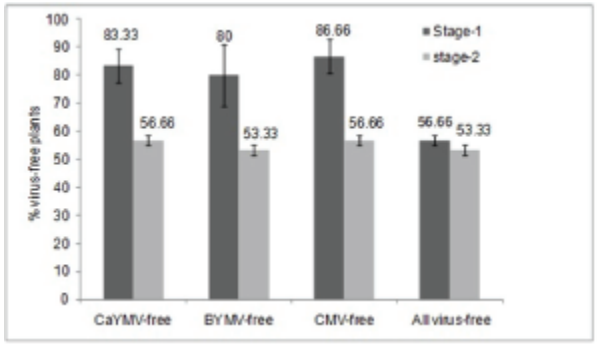

Fig. 19: The percent of individual CaYMV, BYMV, CMV free along with all three virus-free Canna cv. Black Knight plants, as tested by the PCR/RT-PCR assays in two different stages (after 30 days and 90 days of chemotherapy). Data represents the average number of shoots obtained from 90 explants with standard error

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Unravelling plant fitness in challenging environments: the molecular dynamics of steroid hormones

Our research is focused towards finding innovative solutions to enhance stress resilience in plants while preserving yield and nutritional quality.

Brassinosteroids (BRs), are steroid hormones that govern growth and enable adaptation to changing environmental conditions. Most work on brassinosteroid has been centred around the ubiquitous BRI1-mediated pathway. We are investigating cell- and tissue-specific BR-response pathway components responsible for mediating plant adaptation to challenging growth conditions such as temperature fluctuations, light variations, water scarcity, and CO_2 changes. BRI1-LIKE1, 2 and 3 (BRLs) are proteins belonging to the LEUCINE-RICH REPEAT RECEPTOR-LIKE KINASES (LRR-RLKs) family and have been shown to be expressed specifically in the vascular tissues and stem cells. Our initial results show these BRLs are involved in regulating plant response to elevated CO_2 besides other environmental stressors such as high temperature and water limitation. Since these are vascular specific kinases, we are further studying their role in long-distance signaling and resource partitioning in plants.

Roots serve as a versatile system crucial for plant survival. Edaphic stresses such as soil sodicity, alkalinity and acidity can have major impact on the availability of essential nutrients like Ca, Mg, and K, Fe, Zn and Cu etc., which are essential for human health and mainly obtained by the nutrient content of food-grain crops. Chickpea is an important food-grain crop and a rich source of iron in vegetarian diet. Chickpea performs well in sodic soils compared to other crops, such as wheat and barley, but its productivity can still be negatively affected if the soil pH is too high. We are working towards understanding the relationship between soil sodicity, root growth and nutrient content (specifically Iron) in chickpea seeds. Our goal is to identify novel molecular regulators that enhance plant root system growth, nutrient acquisition, and resource allocation in the face of challenging edaphic conditions.

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Genetic variability and evolution of Potato Virus S

Potato is an important staple crop worldwide, but suffer from various virus diseases that cause substantial yield losses. *Potato virus S* (PVS), a highly contagious and globally distributed Carlavirus. However, limited research has been conducted on PVS due to its mild characteristics, leading to insufficient knowledge about its strains. In our laboratory, 129 PVS isolates were genetically analyzed, including two complete genome sequences from India. The overall nucleotide diversity of the PVS genome was 0.11, with the replicase gene showing the highest diversity among the ORFs at 0.12. The replicase and coat protein genes exhibited significant polymorphism. Phylogenetic analysis identified six major groups (G1-G6) and two recombinant isolates, with Indian PVS isolates belonging to G5 (Fig. 20). The lowest nucleotide identity of 93.6% between G5 and G6 can be used to distinguishing PVS strains. The study also indicated that the genetic diversity of PVS isolates is likely determined by the host rather than geographic origin. This study enhances our understanding of PVS genetic diversity and evolution, facilitating the development of effective management strategies against the virus.

Lab Members:

(L to R): Dr. Yogita Maheshwari, Ms. Swati Bhuria, Mrs. Abhilasha Singh, Ms. Niranjana Prema. M, Mr. Chinnakaruppam. M

Fig. 20: Evolutionary analysis of 129 full length Potato Virus S (PVS) genome sequences. The two PVS isolates from this study is underlined.

R&D-05: PLANT GENETIC RESOURCES AND IMPROVEMENT

Area Co-ordinator

Dr. CS Mohanty, Senior Principal Scientist

Scientific Staff

- Dr. HK Yadav, Senior Principal Scientist
- Dr. SN Jena, Senior Principal Scientist
- Dr. Arvind Jain, Senior Principal Scientist

Technical Staff

- Mr. Rajiv Kumar, Senior Technical Officer
- Dr. KN Maurya, Senior Technical Officer

R&D Area Research Scholars Statistics

Sr. No.	Position Name	Numbers
1.	JRF/SRF	12
2.	Project Staff	19

Aims and Objectives

- The group aims for the genetic improvement of economically important and lesser-known crops through genomics, mutation breeding, molecular genetics and cytogenetics.
- The major objectives of the group are, development and deployment of genetic and genomic resources for marker assisted breeding, mutation breeding, association mapping, pathway engineering for specific metabolites and agronomic traits of underutilized industrial crops especially Winged bean, Linseed, *Amaranthus*, Cotton, Guggul, *Lithocarpus* and other floricultural crops are underway.

Major R&D Highlights

- Specific regulatory miRNAs and their functional role in Proanthocyanidin biosynthesis was elucidated in the underutilized legume *Psophocarpus tetragonolobus*.
- Phenotypic characterization of recombinant inbreeding lines (RILs) mapping population of linseed has been carried out through specific agronomic traits. Three bi-parental mapping populations for elite quantitative traits of linseed progressed to F_5 generation has been developed.
- Large mutant lines of linseed have been evaluated. A core set consisting 300 accessions of grain amaranths have been evaluated for various phenotypic traits. 63 K and 50 K SNP array-based high-density genetic mapping and QTL analysis for productivity and fiber quality traits in cotton was developed.
- *De novo* hybrid assembled draft genome of guggul; and complete chloroplast genome sequence of *Lithocarpus dealbatus* and its comparative study with family Fagaceae for phylogeny, was carried out.
- A significant progress has been made in the area - 'Development of new floricultural varieties and registration'. The identified new mutant lines, hybrids (inter-varietal involving 'standard' types) and dwarf/photo-insensitive selections of *Chrysanthemum morifolium* were raised from suckers and later multiplied through cuttings. The new ornamentals were characterized further as per DUS parameters and guidelines.

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Identification and manipulation of molecular factors in underutilized legume winged bean (*Psophocarpus tetragonolobus*) for mainstreaming

The presence of condensed tannins (CT) or proanthocyanidins (PA) in the underutilized legume *Psophocarpus tetragonolobus* and its various parts limit its acceptance. Histochemical staining confirmed the presence of CT in several tissues, with the evidence that, catechin and epicatechin is the primary monomeric components responsible for CT biosynthesis. Employing virus-induced gene silencing (VIGS), successfully lowered the biosynthesis of CT. Additionally, the identification of *P. tetragonolobus* lines with varying PA content and miRNA profiling of their leaf tissues provided insights into the regulatory mechanisms of PA production. The miRNAs responsible for PA biosynthesis on seed coat and leaves of *P. tetragonolobus* were reported in contrasting PA-containing lines of *P. tetragonolobus* i.e., High Proanthocyanidins Winged Beans (HPW) and Low Proanthocyanidins Winged Beans (LPW)

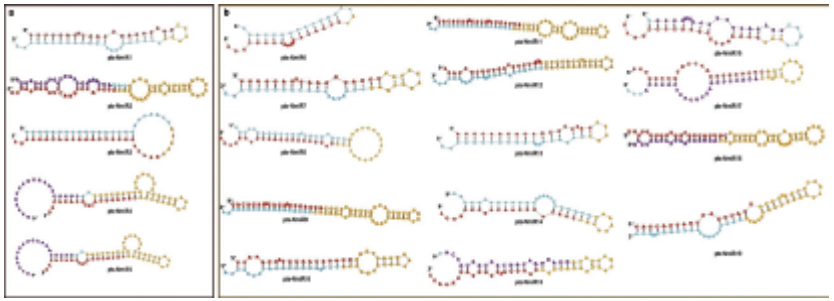

Fig. 2: Secondary structure illustrations of predicted novel miRNAs of *P. tetragonolobus* from a HPW and b LPW sequenced Illumina library. Provisional IDs were assigned to predicted novel miRNAs in a sequential manner with "pte-NmiR" prefixes. Star nucleotide sequences in miRNA secondary structures are represented in red colour

(Fig. 1). Differentially expressed miRNAs with probable role in PA biosynthesis were identified and validated. Functional validation of miR172 indicated that, the biosynthesis of PA is regulated by targeting APETALA2 transcription factor (Fig. 2). The precursor miR172 was cloned from *Glycine max* for further validation in *P. tetragonolobus*. The molecular investigation of the root-tuber of this plant through transcriptomes of the root-tuber and nodules of *P. tetragonolobus* is underway. It resulted in the identification of the underlying molecular factors responsible for controlling the process of tuberization and nodulation in *P. tetragonolobus*.

Fig. 1: Target visualisation of differentially expressed (DE) miRNAs in HPW and LPW lines of *P. tetragonolobus* for (**a**) miR894, (**b**) miR319p, (**c**) miR4414b, (**d**) miR862a, (e) miR9726, (**f**) miR396, (**g**) miR4416-c3p, and (**h**) miR396-5p. Pink colour (node) represents the DE miRNAs, and the targets are represented on edges with turquoise-coloured *Glycine max* Gene ID. TFs are displayed through the brown rectangular boxes, while secondary metabolite-related genes are shown in pink boxes. The yellow-colored edges are the literature-based validated targets of the corresponding miRNA.

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Genetic and genomic resources in linseed for varietal development

Linseed (*Linum usitatissimum*) or 'Flax' is among the first domesticated crops of the old world. Every part of the linseed plant is utilized commercially, either directly or after processing. In consideration with the facts, integration of traditional breeding approaches and molecular breeding techniques were used to develop genetic and genomic resources for genetic improvement of linseed. For genetic resource development, two bi-parental mapping populations (RILs) were evaluated for phenotypic characters during cropping season of 2022-23 (Fig. 3). The RIL population 1 developed from cross of RKY-14 (high oil~40%) x KL-213 (Low oil ~33%) for tagging QTLs associated with oil and other traits. The oil content for these RILs was found to vary from 23.1% to 42.1% with an average of 33.1±0.4%. The RIL population 2 was developed from cross of Padmini (Early flowering/maturity) x KL-213 (Late flowering/maturity) for tagging QTLs for flowering and maturity traits. The days to 50% flowering varied from 61.3 to 108.3 days with an average of 87.7±1.0 days in RIL population against the parental variation of 81 days (RKY14) and 93 days (KL213). The days to maturity showed variation from 125.7 to 143.7 days with an average of 136.0±0.9 days in RIL population against the parental variation of 130 days (RKY14) and 136 days (KL213).

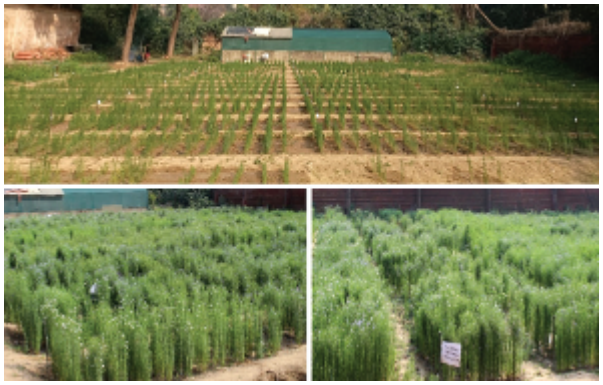

Fig. 3: Field view of linseed RILs population grown at CSIR-NBRI

In addition, two other bi-parental mapping populations developed for elite quantitative traits have been progressed to F_5 generation leading towards formation of RILs. Three hundred linseed germplasm lines were grown, single plant harvested and maintained at PGRI division. To generate new genetic variability six parent diallel F_1 crosses were grown and data were recorded on various traits viz. days to 50% flowering, days to maturity, plant height, primary branches/plant, secondary branches/plant, capsules/plant, capsule weight/plant, seeds/capsule, seed weight/plant, biological yield/plant, husk weight/plant, test weight, harvest index and oil content. For development of NAM (Nested Association Mapping)

Table 1: Estimation of phenotypic and genotypic coefficient of variation, heritability, genetic advance, and genetic gain of 298 Grain Amaranth core accessions for 9 quantitative traits.

S. No.	Characters	Mean±SD	Range	GCV	PCV	$h^2B\%$	GA
1	Plant height (cm)	109.20±2.83	30.63-203.56	37.51	37.70	99	76.87
2	Number of branches	6.96±0.40	0.26-26.67	45.75	46.17	98	93.40
3	Inflorescence length (cm)	35.68±1.15	14.07-90.34	40.75	40.91	99	83.60
4	Lateral inflorescence length (cm)	25.56±0.39	8.18-52.59	27.28	27.34	99	56.09
5	Seed yield plant (g)	27.10±0.73	0.35-60.97	45.73	45.83	99	93.99
6	Stem Thickness (mm)	13.53±0.40	3.59-25.9	29.74	29.91	99	60.90
7	Protein content (mg/ml)	16.65±1.19	6.42-26.00	22.10	23.70	87	42.44
8	Days to flowering	96.27±1.22	73.67-117.67	9.50	9.61	98	19.35
9	Days to Maturity	135.74±0.86	116-153	5.35	5.39	98	10.92

Where, GCV= Genotypic coefficient of variance, PCV= Phenotypic coefficient of variance, h2B= Broad sense heritability, GA= Genetic advance as % mean

Fig. 4: Representative image of extracted linseed fibre showing variability in fibre length and quantity.

population crosses were made using variety T-397 as male parent and 11 lines as female parent. The seed for F1s have been harvested and stored. Furthermore, considering high demand for fibre lines linseed (flax type), fibre from 25 selected lines have been extracted (Fig. 4) and evaluated for fibre traits. The accessions VIKING, LC2023, GP2892 and RLU were found to be promising lines for fiber. These lines will be utilised further for genetic improvement and development of mapping population.

Exploitation of grain amaranth genetic resources for accelerated genetic improvement

Agro-morphological trait analysis can be very useful to characterize genetic diversity present among the grain amaranth accessions. A set of 300 core accessions of grain amaranth was evaluated for various phenotypic traits. These includes 9 quantitative traits - plant height, number of branches per plants, inflorescence length, lateral inflorescence length, stem thickness, seed yield per plant, protein content, days to 50% flowering, and days to maturity; 8 qualitative traits - seed color, inflorescence color, inflorescence shape, inflorescence spininess, leaf color, stem color, stem surface and plant growth habitat. Wide range of variability was observed for all the characters. The plant height ranged from 30.63 to 203.56 cm with a mean height of 109.20 cm. Number of branches per plant ranged from 0.26 to 26.67 with a mean of 6.96. Inflorescence length ranged from 14.07 to 90.34 cm with a mean of 35.68 cm. Lateral inflorescence length ranged from 8.18 to 52.5 cm with a mean of 25.56 cm. Seed yield per plant ranged from 0.35 to 60.97 g with a mean of 27.10 g. Stem thickness ranged from 3.59 to 25.9 mm with a mean of 13.53 mm. Protein content (grains) ranged from 6.42 to 26% with a mean of 16.65 % (Table 1). The analysis of variance (ANOVA) and other genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability ($h^2B\%$), and genetic advance as percentage of mean (GA%) were estimated (Table 1). Analysis of variance showed significant differences among the tested accessions for all traits indicating presence of considerable variation. The mean performances, GCV, PCV, heritability, GA, and GA as % of mean of 298 accessions for 9 quantitative traits are summarized.

Lab Members:

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63 K and 50 K SNP array-based high-density genetic mapping and QTL analysis for productivity and fiber quality traits in cotton

We focused on study for productivity and fiber quality traits in cotton using high-density genetic mapping and quantitative trait locus (QTL) analysis. The research employed two SNP (Single Nucleotide Polymorphism) arrays, one with 63,000 SNPs and another with 50,000 SNPs, to genotype a population of cotton plant. The objective of the study was to gain a deeper understanding of the genetic factors underlying productivity and fiber quality in cotton. By utilizing SNP arrays with high marker density, we aimed to construct detailed genetic maps and identify specific genomic regions associated with these traits. The research involved genotyping the cotton population using the two SNP arrays, which allowed for simultaneous genotyping of numerous SNPs across the cotton genome. This data was then utilized to construct high-density genetic maps that provided a comprehensive representation of the genetic architecture related to productivity and fiber quality traits in cotton (Fig. 5). Subsequently, QTL analysis was performed on the genetic maps to identify specific QTLs associated with the studied traits. The identification of QTLs helps in understanding the genetic control of productivity and fiber quality traits in cotton. We reported the discovery of several QTLs linked to productivity and fiber quality traits

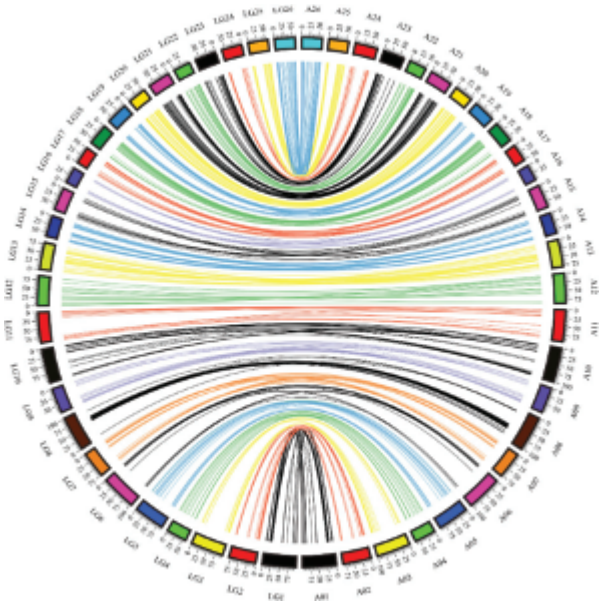

Fig. 5: Collinearity of genetic map (LG=Linkage group) with physical map (the nomenclature of chromosomes in physical map is shortened from AD_chr. to A for convenience)

in cotton, thereby providing valuable insights into the genetic basis of these important traits. The information obtained from the QTL analysis and high-density SNP arrays can be utilized in cotton breeding programs to develop improved varieties with enhanced productivity and fiber quality. This study demonstrates the utility of high-density genetic mapping and QTL analysis using SNP arrays for investigating productivity and fiber quality traits in cotton. The findings contribute to advancing our understanding of the genetic mechanisms underlying these traits and offer potential applications for cotton breeding programs aimed at improving crop productivity and fiber quality.

De novo hybrid assembled draft genome of guggul *Commiphora wightii*

The study aimed to understand the genetic basis of phytosterol biosynthesis in *Commiphora wightii* by identifying key enzymes involved in this process from the *de novo* assembled genome. Phytosterols are a group of plant-derived compounds that have important role in plant growth and development, as well as potential health benefits for humans. *Commiphora wightii* is known to accumulate high levels of phytosterols, making it a valuable resource for phytosterol production and studying their biosynthesis. To achieve this, we employed a *de novo* hybrid assembly approach to generate a draft genome of *Commiphora wightii*. By analyzing the draft genome, we identified key enzymes involved in the biosynthesis of phytosterols in *Commiphora wightii*. We report here the discovery of specific enzymes responsible for important steps in phytosterol biosynthesis, shedding light on the genetic machinery involved in the production of these compounds in *Commiphora wightii* (Fig. 6). These findings contribute to our understanding of the metabolic pathways and regulatory mechanisms associated with phytosterol biosynthesis. Understanding the genetic basis of phytosterol biosynthesis can facilitate the development of strategies to enhance phytosterol production in plants or engineer plants with altered phytosterol profiles for various purposes, including pharmaceutical and nutraceutical applications. The findings provide valuable insights into the genetic basis of phytosterol accumulation in this medicinal plant species, opening avenues for further research

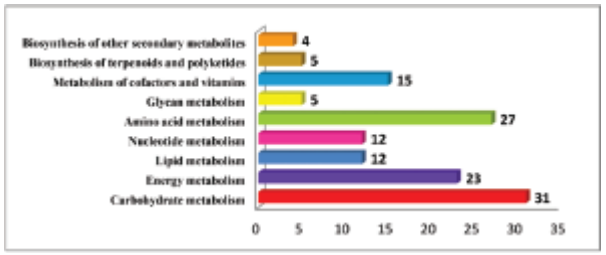

Fig. 6: Major metabolic pathways identified in the genome of *C. wightii*. Number of genes associated with each pathway are shown adjacent to each bar.

and applications in the field of phytosterol production and utilization.

Complete chloroplast genome sequence of *Lithocarpus dealbatus* and comparative study in Fagaceae for phylogeny

The chloroplast genome of *Lithocarpus dealbatus* a species of tree in the family Fagaceae, has been studied to determine its evolutionary history and identify regions of high mutation rate. The research findings establish that the *Lithocarpus* is of monophyletic origin, meaning it descended from a common ancestor and does not have any close relatives outside of its own lineage. The chloroplast is an organelle found in plant cells responsible for photosynthesis, and its genome provides valuable information for studying plant evolution and genetic diversity. By comparing the chloroplast genome of *Lithocarpus dealbatus* with those of other related species, we determined the species' evolutionary relationships and confirm its monophyletic origin. This finding suggests that *Lithocarpus dealbatus* has evolved independently from other species and has a unique genetic lineage. Additionally, the study identified mutational hotspots within

the chloroplast genome of *Lithocarpus dealbatus*. Mutational hotspots are regions of the genome that are prone to accumulating mutations at a higher rate compared to the rest of the genome. These hotspots may have implications for the species adaptation to its environment or other evolutionary processes. Overall, the research on the chloroplast genome of *Lithocarpus dealbatus* provides insights into the evolutionary history of the species and sheds light on the genetic diversity and mutational patterns within its chloroplast genome.

Lab Members:

(L to R): Dr. Rajeev Kumar, Dr. Pankajni Bal, Dr. Gopal Ji Tiwari, Dr. Rahul G. Shelke, Dr. Vartika Srivastava, Ms. Padma Tamang, Ms. Babita Joshi, Dr. Geeta Prasad, Ms. Shruti Rai, Mr. Tushar Sinha, Mr. Sudeepta Mishra, Ms. Debabrata Mohanty, Ms. Sweta Tripathi, Ms. Anindita Das, Ms. Ankita Tripathi, Mr. Revanna Swamy KM

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Development of new floricultural varieties

The identified new mutant lines, hybrids (inter-varietal involving 'Standard' types) and dwarf/photo-insensitive selections of *Chrysanthemum morifolium* were raised from suckers and later multiplied through cuttings. The new ornamentals were characterized further as per DUS parameters and guidelines. PCR conditions were optimized using different molecular markers for detection of polymorphisms among mutant lines vis-à-vis somatic parent. Whole transcriptomic sequencing from floral tissues of a set of mutants and respective control have been done and further analysis is under process.

Through targeted breeding of chosen Gladiolus varieties earlier this year, we have been able to generate numerous inter-varietal hybrid seeds which were harvested and stored under optimum conditions during the period. Further, we have also been able to successfully grow inter-varietal hybrid seedlings (237 nos) and generated Ist year corms for next season (Fig. 7).

For registration of our institutionally developed Chrysanthemum & Gladiolus varieties with ICAR-AICRP on Floriculture, rooted cuttings and corms, respectively have been submitted to different AICRP centres.

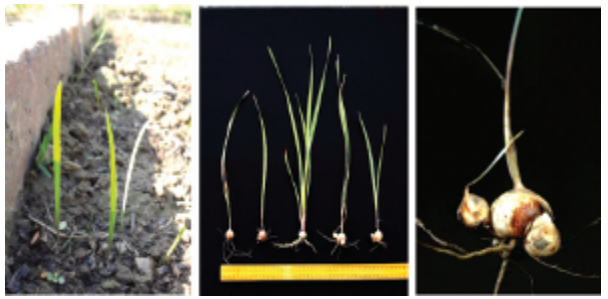

Fig. 7: Some Gladiolus inter-varietal seedlings and harvested Ist year corms

Marigold seeds and seedlings were given colchicine and oryzalin treatments to induce polyploidy for ornamental improvement.

In mutation breeding of narcotic crops i.e. *Papaver somniferum*, M_3 population has been raised which shall be screened for high oripavine content in the next season.

New rose varieties introduced

Rose varieties viz. 'Honest Red', 'Veteran's Honor', 'Jadis', 'Raktima' and 'Sugandha' were successfully introduced at Botanic Garden for breeding purposes.

Lab Members:

(L to R): Dr. Bologam Ravikumar, Ms. Neha Gupta

R&D-06: BOTANIC GARDEN AND PLANT CONSERVATION & AGRO-TECHNOLOGY

Area Coordinator

Dr. SK Tewari, Chief Scientist

Scientific Staff

- Dr. Devendra Singh, Principal Scientist
- Dr. Lal Bahadur, Principal Scientist
- Dr. RC Nainwal, Principal Scientist
- Dr. KJ Singh, Senior Scientist
- Dr. Bikarma Singh, Senior Scientist

Technical and Support Staff

- Dr Shankar Verma, Pr. Technical Officer
- Dr. Daya Shankar, Sr. Technical Officer
- Dr. Atul Batra, Sr. Technical Officer
- Dr. Rajeev Kumar, Sr. Technical Officer
- Mr. Girdhari Sharma, Sr. Technical Officer
- Mr. Bhagwan Das, Sr. Technical Officer
- Dr. SK Sharma, Technical Officer
- Dr. Satish Yadav, Technical Officer
- Dr. Shweta Singh, Technical Officer
- Dr. MG Prasad, Technical Assistant
- Mr. NP Yadav, Senior Technician
- Mr. Ram Karan, Senior Technician

R&D Area Research Scholars Statistics

Sr. No.	Position Name	Numbers
1.	Post-Doc Fellows	02
2.	Research Associate	02
3.	JRF/SRF Fellow	02
4.	Project Staff	14

Aims and Objectives

- The Botanic Garden of CSIR-NBRI is a repository of diversified groups of plants with special reference to rare, and threatened plants. The major objectives include enriching the germplasm collection, domestication of wild plant species of ornamental significance, developing new and novel cultivars of ornamental plants, and awareness and education on garden-related activities. The major attractions are the conservation of plants in specially designed houses. The group also organizes Flower Shows and visits by school/college students. The training/skill development programs in various gardening and floriculture areas are very popular.
- The main purpose of the Plant Conservation and Agro-technologies group is to develop an agronomic package for sustainable development and economic utilization of sodic wastelands. The group has developed improved varieties of *Bixa* and *Curcuma*.

R&D Highlights

- Morphological characterization of ten reference varieties of Bougainvillea, namely Red Triangle, Suvarna, Mrs. Butt, Enid Walker, Thimma, Filoman, Spring Festival, Vishakha, Camarillo Fiesta, and Cherry Blossom was done. Additionally, the division's efforts extended to the preparation of 792 new samples of Bougainvillea varieties for germplasm maintenance.
- The field experiments revealed the effect of Carbon dots (CDs) on the yield of agricultural crops and their respective biomass showed a strong positive correlation with the increase in CDs dosages. The combined effect of seed treatment (ST) and foliar spray (FS) is more pronounced and has the maximum additional benefit in paddy grain yield was 24.00% over control. The overall maximum yield increase was 22.5% in the wheat crop and 16.31% for chickpea.
- Field experiments conducted to assess the response of zeolites on growth and yield performance of agricultural crops (paddy, wheat, chickpea) revealed that the supplementary application of zeolite (2%) along with the recommended dose of fertilizer was much more effective and more pronounced as a growth booster for increasing the growth and yield attributes of agricultural crops. Zeolite showed a strong positive correlation with yield parameters.
- Under CSIR Aroma Mission Phase-II, the dissemination of turmeric have reached 256 ha in different states. We have provided turmeric rhizomes/seed (27 qt) among 37 farmers who act as seed farmers. We have organized 09 awareness/ training programmes at different locations of India for popularization of turmeric cultivation & Nagarmotha and trained about five hundred farmers.
- Evaluation of 15 germplasm of quinoa was done under sodic wasteland conditions for their commercial cultivation in second year. Stem colour, leaf colour, flower colour and seed colour were treated as qualitative traits.

- Eighty-five accessions of Nagarmotha were collected from different localities of Madhya Pradesh, Rajasthan, and Uttar Pradesh. Agronomic character and oil evaluation will be done. Accessions are being conserved and multiplied at the Banthra Research Station for distribution in Farmers.
- Turmeric is a very important spice and medicinal plant in India. In the present study, different locally grown turmeric varieties were collected from highly As contaminated sites of West Bengal. Arsenic, macro elements *viz*., Na, K, Ca and micro elements (trace elements) such as Fe, Zn, Cu, Co, Mo, Pb, Cd and Cr were showed variation in the collected turmeric varieties. Difference in the level of metal contents is possibly due to the variation in environmental conditions, varietal differences and soil characteristics. Among ten collected varieties, two varieties (IT8 and IT10) are in the range of permissible limit for As.
- On the basis of growth attributing parameters, As accumulation, macro and micro elements in rhizome, the high and low As accumulating turmeric varieties were screened. Among ten turmeric varieties, IT8 and IT10 showed less As accumulation which lie in the safer standard limit of As in turmeric. Varieties, IT8 and IT10 also showed better growth in terms of rhizome length, diameter and rhizome weight in comparison to other collected turmeric varieties. IT8 and IT10 turmeric varieties were also found enriched with macro (Na, K, and Ca) and micro nutrient elements (Fe, Zn, Cu, Co and Mo). Additionally, IT8 and IT10 varieties also showed lesser accumulation of another toxic heavy metals i.e. Pb and Cd. Thus, on the basis of present findings, IT8 and IT10 turmeric varieties were screened as a low As accumulating turmeric varieties collected from highly As contaminated areas of West Bengal. Interestingly, IT4 and IT9 turmeric varieties that showed higher content of As accumulation, also were found exceptionally good in growth attributing parameters as well as in accumulation of macro and micro nutrient elements. Thus, IT4 and IT9 were screened as high As accumulating turmeric varieties out of the collected locally grown turmeric varieties in As contaminated areas of West Bengal. The selected low and high As accumulating turmeric varieties will further be evaluated for growth, yield and quality (curcumin content) performance during As stress under natural field conditions. Evaluation on the basis of curcumin content is must as curcumin is the main active component of turmeric and also have potential role in amelioration of As stress.
- Enriched 09 *Aloe* species, acclimatization and multiplication of 11 *Aloe* species, and evaluating 23 Aloe species under different categories of sodic soil.
- The five *Aloe* species, *A. cameronii, A. chabaudii, A. trinervis, A. vera* and *A. vera* × *A. chabaudii* were found more tolerance with sodicity up to 9.2 pH.
- To identify the sodicity tolerance critical limit for cultivation under of 'Kesari' an experiment was conducted. The variety was also found sodicity tolerance to other varieties. The result indicated that the critical limit for the cultivation of the turmeric was ESP- 9.45, pH-8.40, EC-0.39 dS m^{-1}.

Facility created

Extension/upgradation of the Open Air Interpretation Centre

Upgradation of open-air interpretation centre has been done in the Botanic Garden campus.

Skill satellite Center

For the development of Dehydrated Floral Craft products, Skill Satellite Center has been developed in the Botanic Garden.

Future Prospects

The future prospects of research in these areas at CSIR-NBRI are very promising. The institute has a strong team of scientists with expertise in a wide range of plant science disciplines. It also has access to a wealth of plant germplasm and other resources. The institute is well-positioned to make significant contributions to the conservation of plant diversity, the development of new agro-technologies, and the promotion of botanic gardens.

Some specific examples of future research projects include the development of new methods for the conservation of endangered plant species, the development of new agro-technologies to improve the productivity of crops grown in marginal environments and the development of new botanic gardens that are designed to conserve plant diversity and promote public education.

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- The yield and quality evaluation of *Bixa orellana* and *Curcuma longa* were continued to search for the best germplasm for sodic soils. The turmeric variety 'Kesari' is being popularized under CSIR-Aroma Mission for leaf essential oil for doubling the farmer's income.
- Turmeric with good leaf oil content and high yield accessions were sown in the Botanic Garden for further screening.
- CSIR-NBRI is DUS Test Centre of PPV&FRA for Bougainvillea, Canna and Gladiolus. Characterizations by recording morphological characters (both vegetative and floral) of some varieties/ cultivars of Gladiolus have been done to identify the range of morphological variations.
- Different turmeric varieties were collected from highly As contaminated sites of West Bengal. Arsenic, macro elements *viz*., Na, K, Ca and micro elements (trace elements) such as Fe, Zn, Cu, Co, Mo, Pb, Cd and Cr showed a variation or range of accumulation in collected turmeric varieties. The difference in the level of metal contents is possibly due to the variation in environmental conditions, varietal differences and soil characteristics. Among ten collected varieties, two varieties (IT8 and IT10) lies in the range of permissible limits for As. These varieties also showed better growth in terms of rhizome length, diameter and weight in comparison to other tested turmeric varieties. IT8 and IT10 turmeric varieties were also found enriched with macro (Na, K, and Ca) and micronutrient elements (Fe, Zn, Cu, Co and Mo). Additionally, IT8 and IT10 varieties also showed lesser accumulation of toxic heavy metals i.e. Pb and Cd.

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CSIR Aroma Mission

- Under Aroma Mission Phase-II, agro-technology for cultivating turmeric for essential leaf oil was shared with farmers in various Indian states, including Karnataka, Jharkhand, Uttar Pradesh, Bihar, Uttarakhand, Odisha, and Maharashtra. The area under cultivation was expanded by 256 hectares. Additionally, 37 farmers received 27 quintals of the promising turmeric variety 'Kesari'. More than 500 farmers participated in awareness and training programs held at different locations across India, aimed at promoting turmeric cultivation for essential oil and Nagarmotha (Fig. 1).
- The project focused on collecting, conserving, evaluating, and propagating plant species under partially sodic waste land conditions to generate income for farmers through commercial cultivation. In this regard, 15 accessions of Quinoa were studied under sodic waste land conditions. Qualitative traits such as stem color, leaf color, flower color, and seed color were analyzed as growth parameters. Significant differences were observed in the length of inflorescence among the quinoa accessions. The tallest and shortest plants ranged from 125 cm to

Fig. 1: Plant Conservation and Agro-technologies (Distant Research Centres, Banthra)

75 cm in height, while inflorescence length varied from 36 cm to 21 cm. The grain yield also showed variations, ranging from 43.34 to 14 g per plant.

- A total of 85 accessions of Nagarmotha (*Cyperus scariosus*) were collected from various locations in Madhya Pradesh, Rajasthan, and Uttar Pradesh. The objective was to explore their potential for commercial cultivation and extraction of essential oil under sodic waste land conditions. Studies are being conducted to evaluate growth parameters, yield, and other relevant factors.

Propagation of new dwarf cultivars of Neem with early maturity and higher Limonoids yield

Different morpho descriptors of all cultivars were characterized for evaluation in different agroforestry models. Multi-location trials of these cultivars were performed at 05 different agroclimatic zones *viz*., North East (Shillong); North Central (Lucknow); North (Chandigarh); South (Bangalore) and East (Bhubaneshwar). Comparative evaluation of these cultivars is under process.

Outreach Programmes/ Extension Activities

To popularize CSIR-NBRI green technologies, various extension/outreach activities/training programmes were organized. More than 500 individuals including farmers, entrepreneurs were trained under the programmes. The field visits were organized at Distant Research Centre (Banthara) for students and teachers from various schools and Colleges. More than 200 individuals were visited the Distant Research Centre (Banthara) during the year.

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Enrichment of *Aloe* germplasm collection and evaluation on sodic soil

Nine species of *Aloe* were successfully acclimatized and 11 species were multiplied at Distant Research Centre, Banthara (Fig. 2). Evaluation of 23 species on sodic soil were undertaken. The five *Aloe* species viz. *A. cameronii*, *A. chabaudii*, *A. trinervis*, *A. vera* and *A. vera* × *A. chabaudii* were found more tolerant

Fig. 2: *Aloe* field on sodic soil at Distant Research Centre, Banthara

Table 1. *Aloe* species and their relation to gel and leaf yield in normal soil

S. No.	Aloe species	Gel weight / Leaf (g)	Leaf weight (g)	Gel (%)
1	*Aloe vera* × *A. chabaudii*	260.5	372.53	70.00
2	*Aloe trinervis*	245.2	426.53	57.48
3	*Aloe vera*	220.6	387.50	56.92
4	*Aloe chabaudii* × *A. ammophila*	176.4	240.07	73.47
5	*Aloe saponaria*	144.6	252.87	57.18
6	*Aloe ammophila*	125.8	248.80	50.59
7	*Aloe maculata* × *A. ammophila*	120.4	178.93	67.28
8	*Aloe chabaudii*	119.3	172.40	69.22
9	*Aloe maculata*	85.2	149.80	56.87
10	*Aloe ammophila* × *A. immaculata*	66.1	111.00	59.60
11	*Aloe immaculata*	62.3	110.94	56.19
12	*Aloe aagedonta*	41.5	90.10	46.05
13	*Aloe cameronii*	24.2	62.00	39.03
14	*Aloe camperi*	19.8	26.27	75.37
15	*Aloe swynnertonii*	15.9	33.60	47.32
16	*Aloe stiriata*	11.7	20.90	55.98
17	*Aloe nobilis*	11.5	33.27	34.62
18	*Aloe ellenbeckii*	9.9	19.53	50.84
19	*Aloe nyeriensis*	9.6	33.07	29.21
20	*Aloe arborescens*	4.1	70.80	5.90
21	*Aloe ciliaris*	3.3	10.67	31.21

with sodicity up to 9.2 pH. A ranking of *Aloe* species for their respective tolerance to sodic soil was also prepared.

Evaluation of *Aloe* species for gel yield

At DRC, gel yield evaluations were conducted on 21 *Aloe* species. Among them, *Aloe chabaudii* × *A. ammophila*, *A. saponaria*, *A. trinervis*, and *A. vera* × *A. chabaudii* exhibited high gel yield per leaf (Table 1).

Evaluation of promising turmeric variety 'Kesari' under sodic condition

The promising turmeric variety 'Kesari' developed by CSIR-NBRI was evaluated at sodic soil condition. The variety was also found sodicity tolerant as compared to other varieties. The critical threshold limit for Sodicity tolerance was found to be at ESP- 9.45, pH-8.40, EC-0.39 dS m^{-1}. The growth parameters such as plant height, leaf length & width, no. of leaves and fresh weight were taken while evaluating the Sodicity tolerance.

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Application of Carbon Dots (CDs) as growth enhancers in agriculture system

Field experiments revealed a strong positive correlation between CD dosages and crop biomass. The combined effect of seed treatment (ST) and foliar spray (FS) is more pronounced and has the additional benefit in paddy grain yield which was 24.00% over control. The overall maximum yield increase was 22.5% in the wheat crop and 16.31% for chickpea.

Synthesis of zeolites from fly ash for agriculture application

Field experiments conducted to assess the response of zeolites on growth and yield performance of agricultural crops (paddy, wheat, chickpea) revealed that the supplementary application of zeolite (2%) along with the recommended dose of fertilizer was much more effective and more pronounced as a growth booster for increasing the growth and yield attributes of agricultural crops. Zeolite showed a strong positive correlation with yield parameters.

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IUCN threat assessment of *Cycas nayagarhensis*

Cycas nayagarhensis, a gymnosperm species endemic to Odisha, India, has been classified

Fig. 3: *Cycas nayagarhensis* in natural habitat

as Critically Endangered under 'CR B1ab (iii,v)' according to the IUCN Redlist (https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T103632199A103632290.en). The species' localities were heavily impacted by various human activities, including excessive harvesting of leaves for religious and cultural rituals, leading to damage to stems, disruptions in the reproductive cycle, and endangerment of the plant's population. Presently, *C. nayagarhensis* is limited to just three elevated areas in the Nayagarh district, where only a few plants remain. The expansion of Nayagarh city has further deteriorated the species' habitat, resulting in a significant decline in its population. Illegal mining activities and the cultivation of cash crops like rubber further exacerbate the threats (Fig. 3).

Typification of Asian conifers

The study provided nomenclatural notes of *Abies delavayi*, *Picea brachytyla* (Pinaceae) and *Nageia wallichiana* (Podocarpaceae) with their lectotypification. It is a part of the ongoing revision of gymnosperms of Indian subcontinent.

Enrichment of Botanic Garden germplasm collection

Cycas nathorstii, *Phlogacanthus jenkinsii*, *Hedychium coccineum*, Orchids (*Coelogyne* sp., *Dendrobium devonianum, D. primulinum, D. fimbriatum*), *Frerea indica, Caralluma adscendens, Boucerosia umbellata, Kalanchoe bhidei, Codariocalyx motorius, Coryphantha elephantidens*, floricultural crops such as Carnation, Gypsophila, several varieties of lotus, waterlilies and canna were successfully introduced in the Botanic Garden.

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Species diversity, phenology, and conservation status of coniferous plant communities in Bhallesa Hills, Pir Panjal Mountain, Jammu & Kashmir, India

We conducted plant diversity studies in the Coniferous forests of Bhallesa Hills in Jammu and Kashmir's Pir Panjal Mountain region during the years 2018 to 2022. We used 25 replicated plots, each measuring 50 × 50 m, at Chilli, Kahal, Chanwari, and Gandoh to assess species diversity, phenology, life forms, and leaf size spectra of the coniferous plant communities. Native and non-native plant species were distinguished based on scientific literature. In total, 328 plant species were identified from different locations, with approximately 68.51% being native and 31.49% non-native. Dicotyledon species, especially from the family Asteraceae (38 species), dominated the plant community. Chamaephytes accounted for 29% of the species, followed by therophytes at 28% and phanerophytes at 21%. The study showed the presence of threatened species like *Taxus wallichiana* Zucc., *Picrorhiza kurroa*, *Trillium govanianum*, *Aconitum heterophyllum*, and *Euphorbia obovata*.

Fig. 4: Characterization of Bougainvillea cultivars

Characterization of *Bougainvillea* germplasm

Characterization of 10 reference varieties of *Bougainvillea*, viz. Red Triangle, Suvarna, Mrs. Butt, Enid Walker, Thimma, Filoman, Spring Festival, Vishakha, Camarillo Fiesta, and Cherry Blossom were undertaken during the reporting period (Fig. 4). Various characteristics such as stem color, thorn size and shape, leaf shape and size, bract color, and flower size and color were analyzed as per DUS guidelines. Additionally, the efforts were made to preparation of 792 new samples of *Bougainvillea* varieties for germplasm maintenance.

Outreach and Skill Development Programmes

A series of training programs on various topics including home gardening, bonsai, and dehydrated floral crafts were conducted during the reporting period. More than 1200 participants have benefited from the training programs.

Lab Member:

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R&D OUTPUTS

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Book Chapters

1. *In:* Bio-actives and Pharmacology of Medicinal Plants Vol. 2 (Ed. T. Pullaiah), *CRC press, Taylor & Francis*: 9:
   - Kumar S, Singh B. 2022. Phytochemical and pharmacological profile of *Rauvolfia verticillata* (Lour.) Baill.: 9
   - Kumar S, Singh B. 2022. An overview on bioactives and pharmacology of *Rauvolfia vomitoria* Afzel.: 10
2. *In:* Plant Ionomics: Sensing, Signaling and Regulation (Eds. VP Singh, MS Siddiqui), John Wiley & Sons:
   - Bisht N, Joshi H, Chauhan PS. 2023. Nutrients regulation and abiotic stress tolerance in plants: 209
   - Joshi H, Bisht N, Chauhan PS. 2023. Regulation of phytohormonal signaling by nutrients in plant: 191
3. Anand V, Kaur J, Srivastava S, Dharmesh V, Bist V, Maheshwari A, Yadav S, Srivastava, S. 2023. Plant-microbe synergism for arsenic stress amelioration in crop plants. *In:* Genomics Approach to Bioremediation: Principles, Tools, and Emerging Technologies (Eds. V Kumar, M Bilal, LFR Ferreira, HMN Iqbal), *John Wiley & Sons, Inc.*: 69-87.
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5. Boopathi NM, Jena SN, Joshi B, Premalatha N, Mahalingam L, Rajeswari S. 2022. Resilient cotton for abiotic stresses: realizing genetic gains through translational genomics. *In:* Genomic Designing for Abiotic Stress Resistant Technical Crops, *Springer International Publishing*: 71-98
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8. Giri VP, Pandey S, Singh SP, Kumar B, Zaidi SFA & Mishra A. 2022. Medicinal plants associated microflora as an unexplored niche of biopesticide. *In*: Biopesticides, *Woodhead Publishing*: 247-259
9. Gupta A, Rastogi A, Singh M. 2022. Ethylene Implication in root development. *In:* Ethylene in Plant Biology (Eds. S Singh, T Husain, VP Singh, DK Tripathi, SM Prasad, NK Dubey). *John Wiley & Sons Ltd*:1-16
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11. Khan Z, Srivastava R, Bag SK, Verma PC. 2022. Plant pectin methylesterase: an insight into agricultural and industrial applications. *In:* Agricultural Biocatalysis: Enzymes in Agriculture and Industry (Eds. P Jeschke, EB Starikov). *Jenny Stanford Publishing*: 49-53.
12. Kumar A, Sharma P, Srivastava R, Verma PC. 2023. Demystifying the role of transcription factors in plant terpenoid biosynthesis. *In:* Plant Transcription Factors (Eds. V Srivastava, S Mishra, S Mehrotra, SK Upadhyay), *Academic Press*: 233-249.
13. Kumar V, Sanyal I. 2022. Co-transport mechanism in plants for metals and metalloids. *In:* Plant Metal and Metalloid Transporters (Eds. K Kumar, S Srivastava). *Springer Nature, Singapore*: 305-330.
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15. Marwa N, Gupta SK, Saxena G, Pandey V, Singh N. 2023. Proteomic regulation during arsenic stress. *In:* Arsenic in Plants: Uptake, Consequences and Remediation Techniques, First Edition. (Eds. PK Srivastava, R Singh, P Parihar, SM Prasad), *John Wiley & Sons*: 173-184.
16. Mishra N, Chauhan P, Verma P, Singh SP, Mishra A. 2022. Metabolomic approaches to study-plant interactions. *In*: Advances in *Trichoderma* Biology for Agricultural Applications, *Springer, Cham*: 281-302.
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25. Verma P, Chauhan P, Kumar N, Mishra, N., Pandey S, Bajpai R, Yadav JK, Sahay R, Bahadur L, Mishra A. 2023. Microbial biofilm approaches in phytopathogen management. *In:* Microbial Biomolecules, *Academic Press*: 77-96.

26. Verma P, Paswan SK, Chandra G, Gupta A, Rao ChV. 2022. Hydro alcoholic extract of *Holarrhena antidysenterica* L. induced toxicity research in experimental animals. *In:* Emerging Trends in IoT and Computing Technologies (Eds. SL Tripathi, D Agarwal, SB Verma, S Dwivedi, KB Prakash, BK Singh), *Taylor & Francis*: 212-218.

27. Verma S, Verma PK, Chakrabarty D. 2023. Plant transcription factors: important factors controlling oxidative stress in plants. In: Plant Transcription Factors (Eds. Srivastava et al.), *Elsevier*: 383-417.

PATENTS GRANTED/ FILED

Patents Granted (India)

Sr. No.	Title	Inventors	Application No.	Grant Date	Patent No.
1.	An herbal insecticidal composition for controlling stored grain insect pests and a process for the preparation thereof	HM Behl, V Kumar, C Krishnappa, A Lehri, N Singh, OP Sidhu, J Bajpai, VK Shukla	0287DEL2008	26 August 2022	404656
2.	A cost-effective method of producing high density *Trichoderma* based formulation	Poonam C Singh, CS Nautiyal	1986DEL2011	13 September 2022	406461
3.	Tri-methoxy-tetra-hydrobenzo-dioxolo-iso-chromene compound and pharmaceutical composition comprising same for management of inflammation	R Roy, OP Sidhu, N Chattopadhyay, T Tripathi, YA Khan, ChV Rao, SK Barik	201911011647	07 October 2022	408571
4.	A process for preparation of a novel insecticidal chitinase toxic against whiteflies, it's encoding nucleotides and application there off	PK Singh, SK Upadhyay, C Krishnappa, S Saurabh, R Singh, Preeti Rai, Harpal Singh, Manisha Mishra, AP Singh, PC Verma, KN Nair Rakesh Tuli	3851DEL2011	22 December 2022	415132
5.	Novel health promoting functional foods fortified with herbs	P Pushpangadan, AKS Rawat, ChV Rao, SK Srivastava, R Govindarajan	2506DEL2004	22 December 2022	415113
6.	A wound inducible expression constructand a method of its preparation	AP Sane, SP Pandey, AP Singh	3865DEL2014	22 December 2022	415119

Patents Filed (India)

Sr. No.	Title	Inventors	Application No.	Filed Date
1.	An herbal oil-based composition for management of dandruff and method of preparation thereof	SK Srivastava, SP Singh, Ankita Misra, Bhanu Kumar, ChV Rao, SK Barik	202311007302	02 February 2023

HUMAN RESOURCE DEVELOPMENT

Training Received by Individual

Sr. No.	Name of Person (s)	Subject of Training/Course	Organizer/ Place	Date/ Period
1.	Mr. Ajay Mishra, Mr. Tushar A. Lohit, Mr. Vairavan R., Ms. Pratibha Sharma & Ms. Nimisha Shukla	Workshop on Botanical Nomenclature	Botanical Survey of India, Dehradun	February 06-10, 2023
2.	Dr. Mahesh Pal	Training Programme on 6th PTP/ RMP Conclave-2022 at Bengaluru	National Accreditation Board for testing and Calibration Laboratories (NABL) Gurugram	August 24-27, 2022
3.	Dr. Alok Lehri, Dr. Subha Rastogi, Dr. Anju Patel, Dr. Anil Kumar, Dr. Abhishek Niranjan	Proficiency Testing Provider (PTP) Awareness Program	National Accreditation Board for Testing and Calibration Laboratories (NABL), at Lucknow	May 20, 2022
4.	Dr. Pankaj Kumar Srivastava	Training Course on ISO/IEC 17043: 2010	National Accreditation Board for Testing and Calibration Laboratories (NABL), New Delhi	February 13-17, 2023
5.	Dr. Yogita Maheshwari	International Workshop cum Training on Plant Microbiomes: Theory and Application	IARI, New Delhi, India	February 20-March 03, 2023
6.	Dr. Susheel Kumar and Dr. Vijay Anandraj S	Ethics in Research and in Governance	CSIR-HRDC, Ghaziabad	October 17-21, 2022
7.	Dr. Richa Rai	Biological Mass Spectrometry	Banaras Hindu University, Varanasi	June 27-July 01, 2023
8.	Dr. Richa Rai	Bridging the Climate Change Research and Policy Gap for Enhanced Local Climate Action in Uttar Pradesh	Directorate of Environment, U.P.	December 29, 2022
9.	Dr. Soumit K Behera	3rd International Workshop on 'Biodiversity and Climate Change - Sustainable Development Perspective, BDCC-2013'	IIT Kharagpur, West Bengal	February 16-19, 2023
10.	Dr. Aditi Gupta and Ms. Shalini Pandey	Basics of Intellectual Property	Virtual Programme by National Intellectual Property Awareness Mission (NIPAM)	March 29, 2023
11.	Dr. Manish Tiwari	Induction Programme of Newly Recruited Scientists	CSIR-HRDC, Ghaziabad at CSIR-IHBT, Palampur	February 13-18, 2023
12.	Dr. Amber Srivastava, Ms. Anisiya Naorem, Mr. Anoop Shakya, Mr. Prakhar Tripathi	Botanical Nomenclature Course	Botanical Survey of India, Northern Regional Centre, Dehradun	February 06-10, 2023

Trainings Imparted to Groups

Trainings organized by Botanic Garden, CSIR-NBRI, Lucknow

Sr. No.	Subject of Training	No. of Participants	Date/Period
1.	Home Gardening	26	July 18-20, 2022
		15	February 20-22, 2023
2.	Bonsai Technique	31	July 21, 2022
		13	February 23, 2023
3.	Dehydrated Floral Craft	24	July 22, 2022
		13	February 24, 2023
		19	June 24-September 23, 2023
		15	March 01-29, 2023

Other Group Trainings Imparted

Sr. No.	Name of the Co-ordinator	Subject/Title	No. of participants	Place	Date
1.	Dr. Vivek Pandey, Dr. Nandita Singh and Dr. RD Tripathi	Environmental Education and Climate Change Adaptation: Science of Pollution Tolerant and Climate Resilient Plants	45	CSIR-NBRI	October 20-21, 2022
2.	Dr. PK Srivastava and Dr. Anju Patel	Training of Technical staff of Dept. of Agriculture, U.P. under the National Project on Soil Health and Fertility on "Atomic Absorption Spectrophotometry with reference to monitor Soil Health and Fertility"	75	CSIR-NBRI	January 09-13, 2023
3.	Dr. Priyanka Agnihotri	Retrospects and Prospects in Angiosperm Systematics under Scientific Social Responsibility Policy of SERB, New Delhi	25	NBRI	January 24-25, 2023
4.	Dr. Sanjeeva Nayaka	"Lichens in an ecosystem" Workshop for faculties, under Scientific Social Responsibility Policy of SERB, New Delhi	25	NBRI	February 06-07, 2023
5.	Dr. KJ Singh	Two Day Workshop on Cycad Biology (Diversity, Distribution, Reproduction, Ethnobotany and Conservation) under SERB-SSR sponsored by DST-SERB	25	NBRI	December 19-20, 2022

6.	Dr. PS Chauhan/RKVY	Biofertilizer awareness cum training programme	265	Dabugoan, Nabarangpur District, Odisha	June 06, 2022
			280	Kosagumda, Nabarangpur District, Odisha	June 07, 2023
			55	Koraput, Odisha	June 08, 2023
7.	Dr. Devendra Singh	Training programme on Neem for Sustaniable Agriculture	37	DRC, CSIR-NBRI	May 05, 2023

Trainings Imparted Under CSIR Floriculture Mission

Sr. No.	Title	No. of Participants	Place	Date
1.	Preparation of Herbal gulal	50	HESCO, Dehradun (Uttarakhand)	June 01-02, 2022
		70	HCL Foundation, Hardoi (UP)	July 27, 2022
		72	RSPL Foundation, Kanpur (UP)	October 10, 2022
		60	Vidarbha Industries Association (VIA), Nagpur (Maharashtra)	October 17-18, 2022
		100	Indian Science Congress, Nagpur	January 03-07, 2023
		75	Indian Flowers Auction Centre, Bangalore	January 09-12, 2023

Trainings imparted under CSIR Aroma Mission

Sr. No.	Subject: Cultivation of turmeric for essential oil extraction from senescing leaves		
	Place	Date/Duration	Number of Participants
1.	IFTM University, Lodhipur Rajpoot, Moradabad	May 05, 2022	35
2.	DRC, Banthra, CSIR- NBRI, Lucknow	June 08, 2022	09
3.	DRC, Banthra, CSIR- NBRI, Lucknow	May 11, 2022	33
4.	DRC, Banthra, CSIR- NBRI, Lucknow	September 29, 2022	73
5.	DRC, Banthra, CSIR- NBRI, Lucknow	November 18, 2022	52
6.	DRC, Banthra, CSIR- NBRI, Lucknow	January 06, 2023	51
7.	Sirsiyanpurwa, Bahraich	January 19, 2023	85
8.	DRC, Banthra, CSIR- NBRI, Lucknow	February 21, 2023	134

Skill Development Programmes Conducted under CSIR- Integrated Skill Initiative

Sr. No.	Name of the Programme	Date/period	Number of the candidates
1.	Biofertilizer Production for Quality Control	August 08, 2022	25
2.	Phytochemicals Analysis Technician	June 06-July 15, 2022	08
		December 19-30, 2022	16
		January 02-13, 2023	17
3.	Bioinoculant Producer for Agriculture Application	September 17-14, 2023	02
		December 19-30, 2023	16
4.	Quality Analysts for herbal Industry	January 02-13, 2023	16
5.	Certificate course on Advance Bioinformatics	November 15-30, 2022	15
6.	Training Programme on Improved Composting	December 27, 2022	06
7.	Atomic Absorption Spectrophotometer Operation	December 19-30, 2023	75

HONOURS/AWARDS/DISTINCTIONS

Honours/Awards/Recognitions Received by Individual

Sr. No.	Name of the Person	Designation	Award (s)
1.	Dr. Aradhana Mishra	Principal Scientist	Selected in top ten women achievers of lab compendium 'CSIR Women Achievers in STEM'
2.	Dr. Debasis Chakrabarty	Senior Principal Scientist	• Elected Fellow of West Bengal Academy of Science and Technology (WAST) • Featured in the List of World's Top 2% scientist database 2022 released by Elsevier BV based on study conducted by Stanford University
3.	Dr. PK Srivastava	Principal Scientist	Fellow-National Environmental Science Academy, New Delhi
4.	Dr. Richa Rai	Senior Scientist	NESA (National Environmental Science Academy) Environmentalist of The Year Award 2022
5.	Dr. Sharad Srivastava	Senior Principal Scientist	Fellow of Royal Society of Chemistry (FRSC), London, UK
6.	Mr. RA Lone	Research Scholar	Young Research Scholar Award in International Conference on New Generation Horticulture for prosperity
7.	Ms. Pratima Debnath	SRF	EMBO Fellowship 2022

Member, Editor, Referee, Expert, Reviewer, Judge etc. (selected, recognized, enrolled, empaneled, nominated)

Sr. No.	Name of the person	Details
1.	Dr. Aradhana Mishra	Member of the Biotech Research Society (BRSI) and Indian Science Congress Association (ISCA), Kolkata.
2.	Dr. Aditi Gupta	• Guest editor/topic editor/review editor for *Frontiers in Plant Sciences* • Reviewer board member for *Plants* • Reviewer for *Physiologia Plantarum*, *Plant Cell Reports*, *Plant Science.*
3.	Dr. Anju Patel & Dr. Richa Rai	Life Membership of National Environmental Science Academy, New Delhi
4.	Dr. BN Singh	• Editor of *Frontiers in Fungal Biology*, *Surgery Insights*, *Cancer Biology Journal, Ocean Journal of Biotechnology & Bioengineering* • Fellow of Indian Lichenological Society
5.	Dr. Debasis Chakrabarty	Academic Editor, *Frontiers in Plant Science*
6.	Dr. CS Mohanty	Editor of *Vegetos* and *Indian Journal of Plant Genetic Resources*
7.	Dr. Dibyendu Adhkari	Member, Society for Ethnopharmacology (SFE-India), Kolkata, India
8.	Dr. KJ Singh	• Member of IUCN Species Survival Commission: Cycad Specialist Group, Conifer Specialist Group & Western Ghats Specialist Group • Member, International Waterlily & Water Gardening Society • Member, Royal Horticulture Society • Member, Indian Society of Ornamental Horticulture, Delhi • Member, Bougainvillea Society of India • Editor, Cycads (IUCN/SSC Cycad Specialist Group) • Associate Editor, Asian Journal of Conservation Biology • Subject Editor, *Journal of Threatened Taxa* • Subject Editor, *Journal of Economic and Taxonomic Botany*
9.	Dr. Manjoosha Srivastava	• Invited as subject expert (Chemistry) in a Ph.D. defence examination at Lucknow University and for recruitment/ selection committee at Poorvanchal University, Jaunpur • Invited as Judge in Elocution event Chemovation, at Lucknow University on January 19, 2023.
10.	Dr. Manish Tiwari	Review Editor for *Frontiers in Plant Sciences*
11.	Dr. Poonam C Singh	• Associate Editor, *BMC Microbiology* • Member, Association of Microbiologists of India
12.	Dr. Suchi Srivastava	Member of the Biotech Research Society (BRSI)
13.	Dr. SK Behera	Elected as Vice President of Indian Fern Society for the year 2022-2023
14.	Dr. Sanjeeva Nayaka	• Invited as Expert in Selection Committee for recruitment of Junior Scientists (Scientist B) in the area of Taxonomy of Cryptogams at KSCSTE – Malabar Botanical Garden and Institute for Plant Sciences, Kozhikode, Kerala • Fellow of Indian Lichenological Society (ILS) • Member of IUCN Species Survival Commission (SSC) Lichen Specialist Group 2021-2025
15.	Dr. Sharad Srivastava	• Co-Chairman, Millet Mission, DST • Member, Joint Working Group (JWG) for Inter-Ministerial Cooperation between Ministry of AYUSH, ICAR and CSIR • Member of State Medicinal Plant Board, UP. • Member of expert panel for TRIFED committee. • Member of expert panel for CODEX committee.
16.	Dr. Susheel Kumar	Review editor in *Advances in Bioscience and Bioengineering*
17.	Dr. Subha Rastogi	Member of the Institutional Ethics Committee, State Ayurvedic College and Hospital, Lucknow
18	Dr. Vijay Anandraj S	Reviewer Editor of *Frontiers in microbiology*

PHDs AWARDED AND SUBMITTED

Ph.D Theses Awarded

Sr. No	Name of the Student	Title of Thesis	Guides	University
1.	Ms. Amrisha Srivastava	Synthesis of silver nanoparticles from mixed/ monoculture of bacteria and its potential applications in agriculture	Dr. PS Chauhan, Principal Scientist/Dr. Rachna Singh	Amity University, Lucknow
2.	Ms. Arpita Singh	Study on quorum sensing mechanism of stress tolerant plant growth promoting rhizobacteria for improving *Zea mays* productivity under drought stress	Dr. PS Chauhan, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
3.	Ms. Avitri Ranjan	Functional characterization of stress responsive Galactinol synthase, AtGolS1, under arsenic stress in *Arabidopsis thaliana*	Dr. PK Trivedi, Former Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
4.	Ms. Deeksha Singh	Functional characterization of factor(s) regulating flavonoid biosynthesis in *Nicotiana tabacum*	Dr. PK Trivedi, Former Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
5.	Ms. Meenakshi	Functional validation of *CAMTA* gene against drought stress in chickpea.	Dr. Indraneel Sanyal, Senior Principal Scientist/ Prof. Veena Pande	Kumaun University, Nainital
6.	Mr. Mithlesh Singh	Analysis of transgenic cotton lines expressing *Tma12* under control of inducible promoters	Dr. PK Singh, Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
7.	Mr. Mudasir Nazir Bhat	Studies on floristic composition and medicinal wealth of *Lolab* and *Bungus* valleys of district Kupwara (Jammu and Kashmir)	Dr. Bikarma Singh, Senior Scientist/Dr. Sabhajeet	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
8.	Ms. Nikita Bisht	Plant growth promoting rhizobacteria mediated nutrient stress management in *Oryza sativa* L.	Dr. PS Chauhan, Principal Scientist/Dr. Poonam C Singh, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
9.	Ms. Priti Prasad	Data mining of fiber specific features in cotton at different cotton fiber development stages	Dr. SV Sawant, Chief Scientist/Dr. SK Bag, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
10.	Ms. Priyanka Chauhan	Deciphering the protective role of endophytic biomaterial against *Macrophomina phaseolina*	Dr. Aradhana Mishra, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
11.	Ms. Priyanka Upreti	Physiological and biochemical performance of Guar (*Cyamopsis tetragonoloba* (L.) Taub) plant varieties in response to drought stress	Dr. PA Shirke, Chief Scientist/ Dr. LM Pandey	Kumaun University, Nainital
12.	Mr. Ravi Shankar Kumar	Identification and functional characterization of arsenic stress-responsive miRNA(s) in *Arabidopsis thaliana*	Dr. PK Trivedi, Former Chief Scientist/Dr. MH Asif, Senior Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.

13.	Ms. Shobha Singh	Phytochemical investigation of Sesbania seed with emphasis on modification and functional properties of its gum	Dr. Manjoosha Srivastava, Principal Scientist/Dr. Karuna Shanker	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
14.	Mr. Sumit Singh	Floristic inventory through eco-taxonomy and ethno-botanical studies in Bani valley and Sarthal hill of Kathua district (J&K)	Dr. Bikarma Singh, Senior Scientist/Dr. Rajendra Bhanwaria	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
15.	Ms. Venita Tomar	Search for potential anticancer leads from different *Cassia* species	Dr. Manjoosha Srivastava, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
16.	Mr. Vijay Kant Dixit	Characterization of plant growth promoting Rhizobacteria Isolated from degraded soil for stress amelioration and enhancing crop productivity (*Zea mays*)	Dr. PS Chauhan, Principal Scientist/ Prof. Namita Joshi	Gurukul Kangri University, Haridwar

Ph.D. Theses Submitted

Sr. No.	Name of the student	Title	Guides	University
1.	Ms. Adity Majee	Characterization of heat shock transcription factor, *SLHSFB3*a from tomato (*Solanum lycopersicum*)	Dr. Vidhu A Sane, Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
2.	Ms. Alka Srivastava	Development of transgenic cotton (*Gossypoum hirsutum* L.) expressing a pectin methyl esterase gene for broad spectrum resistance against insects	Dr. Praveen C Verma, Principal Scientist/Prof. RS Dubey	Banaras Hindu University, Varanasi
3.	Ms. Annu Lata	Assessment of genetic and chemotypic diversity in Wood Apple (*Limonia acidissima* L., Rutaceae)	Dr. KN Nair, Former Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
4.	Ms. Ankita Yadav	Functional characterization of miRNA(s) involved in plant-PGPR interaction for drought stress tolerance in chickpea (*Cicer arietinum* L.).	Dr. Indraneel Sanyal, Senior Principal Scientist/ Dr. Shashi Pandey Rai	Banaras Hindu University, Varanasi
5.	Ms. Anshu	Study on the mechanisms of abiotic stress tolerance in *Trichoderma* spp.	Dr. Poonam C Singh, Principal Scientist/Dr. Kumkum Mishra	Lucknow University, Lucknow
6.	Ms. Komal Tiwari	Bio-molecular approaches of carbon and nitrogen metabolism of guar (*Cyamopsis tetragonaloba)* under drought conditions.	Dr PA Shirke, Chief Scientist/Prof. Veena Pande	Kumaun University, Nainital
7.	Ms. Kriti	Phytoremediation approaches for management of toxicants produced due to e-wastes	Dr. Shekhar Mallick, Senior Principal Scientist/ Prof. Kusum Mishra	Lucknow University, Lucknow
8.	Mr. Narender Kumar	Systematic and phylogenetic studies on *Betula* L. (Betulaceae) in India	Dr. TS Rana, Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
9.	Ms. Prateeksha Singh	Impact of elevated ozone on *Leucaena leucocephala*	Dr. Vivek Pandey, Chief Scientist/Dr. Ashish Tewari	Kumaun University, Nainital

10.	Mr. Sanket Kumar	Development of phyto-synthesized nanoparticles with enhanced anti-quorum sensing and anti-biofilm activities against *Pseudomonas aeruginosa* PA01	Dr. BN Singh, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
11.	Mr. Sanoj Kumar	Functional characterization of Metallothionein (*MT1*) gene against drought stress response in chickpea (*Cicer arietinum* L.).	Dr. Indraneel Sanyal, Senior Principal Scientist/ Dr. Sudhakar Srivastava	Banaras Hindu University, Varanasi
12.	Ms. Saumya Raizada	Role of Map Kinases in mango fruit ripening	Dr. Vidhu A Sane, Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
13.	Mr. Shiv Narayan	Elucidation of anatomical and physio-molecular mechanism involved in Guar under drought	Dr. PA Shirke, Chief Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
14.	Ms. Shruti Srivastava	Identification and characterization of early wound responsive WRKY gene from chickpea	Dr. AP Sane, Chief Scientist/ Prof. Veena Pande	Kumaun University, Nainital
15.	Mrs. Touseef Fatima	Isolation, characterization, and application of rice endophytes in upland rice cultivation under abiotic stress conditions	Dr. Poonam C Singh, Principal Scientist/ Dr. Swati Sharma	Integral University, Lucknow
16.	Mr. Udit Yadav	Comparative study of chemical and bio-fungicide on tomato plant endophytes and its implications on plant defense	Dr. Poonam C Singh, Principal Scientist	Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, U.P.
17.	Ms. Upasana Pandey	Identification, characterization and biological screening of endolichenic fungi against some plant pathogens	Dr. BN Singh, Principal Scientist/Prof. Veena Pande	Kumaun University, Nainital

MD Thesis Submitted

Sr. No	Name of the Student	Title	Guides	University
1.	Dr. Mamta Ojha (Dravyguna) (2019-2022)	Determination of Ras of some Extra-pharmacoepial Drugs used in local health traditions in Pilibhit district of Uttar Pradesh.	Dr. SK Ojha, Senior Principal Scientist/ Dr. HS Mishra & Dr. RK Tewari	PG Department of Dravyaguna, L.H.S.P.G. Ayurveda College and Hospital, Pilibhit
2.	Dr. Neetu Verma (Dravyguna) (2019-2022)	Pharmacognostical Studies on *Euphorbia fusiformis* (Adhoguda)	Dr. SK Ojha, Senior Principal Scientist/ Dr. HS Mishra & Dr. Ram Milan	PG Department of Dravyaguna, L.H.S.P.G. Ayurveda College and Hospital, Pilibhit

R&D-07: S&T SUPPORT SERVICES

Vivek Srivastava
vivek@nbri.res.in

Head, Planning, Monitoring and Evaluation

The division plays key role in R&D management of the institute including management of R&D projects, issues concerning Intellectual Property, technical queries and technical/performance audits and facilitate for Management Council (MC) and Research Council (RC) meetings. Major activities of the division are as follows:

- Facilitate the submission of R&D proposals to various funding agencies & International collaborations.
- Data collection and management of R&D Project Reports.
- Management and Updation of R&D Project Database.
- Budgetary management of various R&D projects.
- Scrutiny and Registration of all externally & in-house funded projects.
- Compilation of R&D Reports for CSIR-HQ and CSIR-Data Infographics System(C-DIS)
- Mapping of R&D Projects CSIR ERP System

During 2022-23, A total of 103 projects were implemented including the CLP (01), CNP (01), GAP (58), HCP (05), MLP (26), NWP (01), OLP (10), SSP (01).

Projects initiated during 01 April 2022 to 31 March 2023

S.N.	Project Number	Project Title	Funding Agency	Principal Investigator / Co-Principal Investigator / Coordinator / Mentor	Duration
1	HCP 0047	Phenome India- CSIR Health Cohort Knowledgebase	CSIR-IMD, New Delhi	Dr. ChV Rao	w.e.f. 03-08-2022 to 31-03-2027
2	MLP 0055	Unraveling the post-translational control of ripening by the MAP kinase pathways in mango	CSIR	Dr. Vidhu A Sane	w.e.f. 25-05-2022 to 31-03-2024
3	MLP 0056	Preparation of Certified Reference Material of important phytomolecules	CSIR	Dr. Manjoosha Srivastava	w.e.f. 18-08-2022 to 31-07-2024
4	MLP 0057	Optimization of Beta 1.3 glucan production using heterotrophic microalga	CSIR	Dr. S K Ratha	w.e.f. 18-08-2022 to 31-07-2024
5	CNP 3048	Preparation of biodiversity management plan for nongtrai limestone mine of Lafarge umiam mining Pvt. Ltd. in Meghalaya	Holtec Consulting Private Limited (HPCL), Gurgaon, Haryana	Dr. Dibyendu Adhikari	w.e.f. 14-07-2022 to 13-10-2022
6	GAP 2542	EIACP Programme centre RP at National Botanical Research Institute (NBRI), Lucknow on Indicators of Plants & Pollution	MoEF&CC, New Delhi	Dr. PK Srivastava	w.e.f. 01-04-2022 to 31-03-2026
7	GAP 3512	Development of high laccase producing mutants of *Trichoderma asperellum* strain NBRI-K14 using gamma ray mutagenesis	BRNS, DAE, Mumbai	Dr. PC Singh	w.e.f. 19-05-2022 to 18-05-2025

8	GAP 3513	Rapid and on-site diagnostic for viruses and viroid infecting apple	SERB, New Delhi	Dr. PS Chauhan (Mentor)/ Yogita Maheshwari (PI)	w.e.f. 29-04-2022 to 23-07-2023
9	GAP 3514	Establishment of Amrut Biodiversity Park at New Delhi	DDA, New Delhi	Dr. KJ Singh	w.e.f. 18-08-2022 to 17-08-2029
10	GAP 3515	Characterization of cotton fiber-specific microRNA-encoded peptides (miPEPs)	DBT, New Delhi	Dr. SV Sawant	w.e.f. 26-09-2022 to 25-09-2025
11	GAP 3516	Exploring roles of tissue specific circadian clock in regulating plant organogenesis and adaptive growth	DBT, New Delhi	Dr. SV Sawant (PC)/ Dr. Manjul Singh (PI)	w.e.f. 01-09-2022 to 31-08-2027
12	GAP 3518	Mapping nitrogen pollution in Gangetic Plains utilizing lichens as bioindicators	UPCST, Lucknow	Dr. Sanjeeva Nayaka	w.e.f. 20-12-2022 to 19-12-2025
13	GAP 3519	Biotechnological Interventions for management of protected areas	DBT, New Delhi	Dr. Dibyendu Adhikari / Dr. SN Jena / Dr. Soumit Kumar Behera	w.e.f. 17-02-2023 to 16-02-2026
14	GAP 3520	Identification of adulterants/substitutes for Ayurveda plant raw material in trade using pharmacognostic and phytochemical parameters	CCRAS, New Delhi	Dr. Sharad Srivastava	w.e.f. 18-03-2023 to 17-03-2026
15	GAP 3521	Mechanistic studies in elucidation of shodhana for nine poisonous medicinal plants of E1 schedule	CCRAS, New Delhi	Dr. Sharad Srivastava	w.e.f. 24-03-2023 to 23-03-2026

Deputation of CSIR-NBRI Personnel Abroad during 2022-23

Sr. No.	Name	Purpose of Visit	Place of Visit	Deputation Period
1	Dr. Gaurav Kumar Mishra, Scientist	To study the systematic and molecular phylogeny of the pyrenocarpous lichen genus *Trypethelium* using morphological as well as molecular markets which help in enhance my skills on modern techniques of molecular taxonomic studies on lichens	The field Museum Chicago, USA	November 04, 2022 to May 04, 2023

Team Members:

Dr. RN Gupta, Mrs. Sandhya Srivastava, Mr. VK Gupta, Mr. Shubham Tandon

Manish Bhoyar
manish.bs@nbri.res.in

Head, Technology Transfer & Business Development

The division is interface of the institute for bridging the gap between R&D at lab and stakeholders. It identifies key inventions for intellectual property right protection. Scientists are helped for prior art search and patent drafting. The division interacts with industry for information dissemination by participating in various exhibitions, putting up information on web site and interacting and exchanging information by various mode of communication. Various agreements viz., consultancy, secrecy, sponsored, technical services, with project funding agencies, with academia for joint R&D work are also facilitated.

The division has been facilitating training/ dissertation programme each year for post graduate students of various universities and colleges which entail updating the skills and knowledge of the outside students and faculty in the core competences of the institute.

Technologies Transferred

Sr. No.	Name of Technology	Client	Date
1.	Certified Reference Materials (CRM) - Aromatic (L-Carvone, Eugenol, Geraniol, (-) Enthol) & Medicinal (Mangiferin)	M/S Aashvi Technology, LLP, Ahmedabad	11 May 2022
2.	Licensing agreement signed for knowhow transferred of Microbial Bio-fertilizer technology	M/S Uma Sankar Sabuja Dunia Ltd., Nabarangpur, Odisha	10 June 2022
3.	Licensing agreement signed for knowhow transferred of Bio-available Curcumin (CROMA-3)	M/S Techno Chemical Industries Ltd., Kerala	26 September 2022

MoUs/MoAs/MTAs/MoCs/ CDA / NDA/Secrecy Agreement Signed

Sr. No.	Details	Client	Date
International			
1.	For procuring the plasmid (*Pmre-Tn7-152*)	ADDGENE, USA	11 August 2022
2.	For joint research and academic activities	The Central University of Punjab, Bathinda	09 November 2022
3.	For the procurement of plasmid (*pRGEB31*)	ADDGENE, USA	17 January 2023
National			
4.	To promote and develop academic, cultural and research co-operation between both the institutions and mutual benefits.	University of Science & Technology, Meghalaya	11 May 2022
5.	For the evaluation of developed Bio-formulation for crop productivity	Timco Agro India Private Limited, Chennai	16 June 2022
6.	To work jointly for promoting the R&D works related to plant sciences	Global Indo Scientists and Technocrats Forum (GIST), New Delhi	25 June 2022
7.	For plant biodiversity management	Holtec Consulting Pvt. Ltd., Gurugram, Haryana	11 July 2022
8.	For academic research	Chaudhary Charan Singh University, Meerut	04 August 2022

9.	For collaborative and academic research	Kerala Forest Research Institute, Peechi, Kerala (KFRI)	10 August 2022
10.	For procuring the germplasm lines of Pearl millet against insect pests	ICRISAT, Hyderabad	11 August 2022
11.	For collaborative and academic research	Green Ahalia, Ahalia International Foundation, Kerala	12 August 2022
12.		M.S. Swaminathan Research Foundation, Kerala (MSSRF)	16 August 2022
13.		Malabar Botanical Garden and Institute for Plant Sciences, Calicut, Kerala (MBGIPS)	
14.	For evaluation of URO-5, NBRMAP-DB, Topical Herbal Anti Candida Gel and Dentogel	Mascot Health Series Private Limited, New Delhi	23 August 2022
15.	MTA & Reciprocal Confidentiality agreement	Kumarappa National Handmade Paper Institute, Jaipur	23 August 2022
16.	For collaborative and academic research	Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala (JNTBGRI)	26 August.2022
17.	For academic research	North – Eastern Hill University, Shillong (NEHU)	05 September 2022
18.	For genomic data analysis generated on cotton crop by ICAR-IASRI	ICAR-Indian Agricultural Statics Research Institute (IASRI), New Delhi	27 September 2022
19.	For the project "Development of transgenic cotton varieties through marker assisted event pyramiding for broad spectrum insect resistance"	ICAR-Central Institute for cotton Research, Nagpur - 440010	30 September 2022
20.	For joint research and academic activities	Chhatrapati Shahu Ji Maharaj University (CSJMU), Kanpur - 208012	31 October 2022
21.	For jointly work on Bioprospection and product development towards diseases like diabetes, neurodegenerative disorders based on genetic diversity	Regional Plant Resource Centre, Bhubaneswar – 751015, Orissa	31 October 2022
22.	For collaboration between National Laboratory and Society in terms to dedicate shelf for Journal of Indian Botanical Society in the Library of CSIR-NBRI.	Indian Botanical Society, Department of Botany, CCS University, Merrut.	11 November 2022
23.	For procurement of chickpea seeds (*Cicer arietinum)* for research work.	ICAR-IIPR, Kanpur	21 November 2022
24.	For joint research and academic activities	Sambalpur University, Burla, Orissa	14 December 2022
25.	For the collaborative work on "Identification of adulterants / substitutes for Ayurveda plant raw material in trade using pharmacognostic and phytochemical parameters."	Central Council for Research in Ayurvedic sciences (CCRAS), New Delhi	14 March 2023
26.	For academic research and collaborative work	Mahatma Gandhi Central Univrsity Motihari, Bihar	19 March 2023
27.	Tripartile MoU for the collaborative work on "Mechanistic studies in elucidation of shodhana for nine poisonous medicinal plants of E1 schedule."	Central Council for Research in Ayurvedic sciences (CCRAS), New Delhi & Sambalpur University, Odisha	21 March 2023
28.	For the procurement of germplasm (seeds) of *Lotus japonicas*	ICAR-NBPGR, New Delhi - 110012	28 March 2023

Trainings, Outreach Programmes, Exhibitions

Participated & showcased technologies & products developed by CSIR-NBRI in following events/ programmes:

- International knowledge sharing workshop on cross-border innovation, acceleration and challenges in international transfer of technologies organized by CSIR and DSIR in association with (APCTT) of the UN-ESCAP at CSIR Science Centre, New Delhi during 14-15 November, 2022.
- Government Achievement & Scheme Expo-2022 at Pragati Maidan, New Delhi during 17-19 June, 2022.
- Gramoudhay Mela and Sharad Utsav, at Deendayal Research Institute, Chitrkoot during 9-12 October, 2022.
- 13th Agro-Vision 2022 at Nagpur during 25-28 November, 2022.
- Science exhibition at Government Jubilee Inter College, Near City Station, Lucknow on 28 December, 2022.
- Indian Science Congress' 2023 at RTM University, Nagpur during 3-7 January, 2023.

Glimpses of the exhibition, training programmes participated during the reporting peroid

- India International Science Festival 2022 at Bhopal during 21-24 January, 2023.
- Shhak Bhaji Avom Pushp Pradarshini at Governor house, Lucknow during 17-20 February, 2023.

Training for Post Graduate Students

During the reporting period 89 students were imparted research trainings in different disciplines of the plant and applied sciences.

A revenue of Rupees Fourteen Lakh Eighty-Two Thousand was generated as training fee during the year 2021-22.

School Visits

Education visits of Students and teachers of 53 schools of Lucknow and nearby districts were coordinated by the division. A total number of 3023 individuals including students, teachers, researchers, general public visited the institute and its facilities during the reporting period.

Team Members:

(L to R): Mrs. Swati Sharma, Mr. BL Meena

NBRI JIGYASA 2.0

Mission Objective

- To develop novel and interesting content for the students in the area of plant science.
- Scientist-Students and Scientists-Teachers interaction programmes.
- To develop scientific temperament among students.

Mode of Engagements

Under the Jigyasa programme, CSIR-NBRI has provided quality exposure to promote scientific temperament among the students under following models:

- School visit on CSIR Foundation Day
- Lab specific activities / Visits of students
- Online Programmes for School Children
- Popular Lecture Series
- Scientists as Teachers and Teachers as Scientists
- Important Awareness Days like: Environment Day, World Health Day, National Science Day etc.

Major Activities

Sr. No.	Name of the programme	Place	Date	No. of participants
1.	World Youth Skill Day-2022	Kendriya Vidyalaya (KV), Gomti Nagar	July 15, 2023	16
2.	World Nature Conservation Day	Rajkiya Kanya Inter College (Choti Jubilee), Nabiullah Road, Lucknow	July 28, 2023	34
3.	NASI workshop on 'Nurturing Young Minds for a Career in Science'	CSIR-NBRI, Lucknow	September 07, 2022	130
4.	Scientist–students interaction programme	CSIR-NBRI, Lucknow	September 29, 2023	20
5.	Scientist–students interaction programme	CSIR-NBRI, Lucknow	October 17, 2022	45
6.	Scientist–students interaction programme	CSIR-NBRI, Lucknow	November 15, 2022	95
7.	Lecture on A Role of the Urban Forest in Mitigation Air Pollution and Climate Changes issues	Kednriay Vidyalaya, Hardoi	December 08, 2022	85
8.	Scientists–Teachers interaction programme	CSIR-NBRI, Lucknow	January 17, 2023	08
9.	Scientist–Students interaction programme	CSIR-NBRI, Lucknow	January 27, 2023	50
			January 31, 2023	102
10.	Lecture on 'Plant diversity exploration, herbarium technique, importance of various plants and other relevant topics'	Kendriya Vidyalaya, Shivgarh, Raebareli	February 20, 2023	158
11.	Lecture on "Mission Life"	Kendriya Vidyalaya, Bamrauli, Prayagraj	February 25, 2023	65
		Kendriay Vidyalay, Cant. Prayagraj	February 25, 2023	50
12.	Scientist–Students interaction programme	CSIR-NBRI, Lucknow	March 24, 2023	120
13.	IPR Awareness Programme under NIPAM	Online	March 29, 2023	70

Virtual Contents Developed

Under Jigyasa initiative, CSIR-NBRI created following interactive contents for the students during the year 2022-23.

Animated Videos

Bio-inoculants and Genome Editing

Team Members:

Dr. SK Tewari, Dr. SV Sawant, Dr. VA Sane, Dr. PK Singh, Dr. CS Mohanty, Dr. ChV Rao, Dr. Sanjeeva Nayaka, Dr. SK Ojha, Dr. Aradhana Mishra, Dr. Pankaj Srivastava, Dr. SK Bag, Dr. Sribash Roy, Dr. Lal Bahadur, Dr. VV Wagh, Dr. KM Prabhukumar, Dr. KJ Singh, Dr. Richa Rai, Dr. Sandip K Behra, Dr. Manish Bhoyar, Dr. Aditi Gupta, Dr. Anju Patel, Dr. Vinay Sahu, Dr. KK Rawat, Dr. DK Purshottam, Mr. Harendra Pal, Mr. RR Rastogi, Mr. BL Meena, Mrs. Swati Sharma

Glimpses of programmes organized under the Jigyasa 2.0

INFORMATION, PUBLICATION AND EXPOSITION DIVISION

Highlights and Activities

The division function as one of the important S&T support systems of the Institute and primarily manages the scientific publication work, effective dissemination of the R&D achievement through print and electronic media. The division also manages the organization of different scientific events, press meets, celebration of various national and international days designated for scientific, technological and strategic importance to nation. It also bears the public relation to the press and media for promoting and showcasing institute's achievements to the science community and the public.

Its primary function is publication of the research and development outcomes and outputs of the Institute in the form of Annual Report, and other science and popular books, bulletins on different themes of topical interests on plants, environment, biotechnology, agro-technology, ornamental horticulture, etc.

Publication Works

CSIR-NBRI Annual Report for the year 2021-22 was compiled and released on the occasion of Annual Day of the Institute on October 20, 2022. The calendar for the year 2023 with a special theme ' Lotus germplasm collections at CSIR-NBRI Botanic Garden' was compiled and released on National Science Day (February 28, 2023).

Progress report of important R&D projects was compiled with respect to CSIR-NBRI, which covered significant contributions of CSIR-NBRI in the areas of Science & Technology, HRD activities, Awards and Distinctions, Patents Filed & Granted and sent to CSIR HQ for inclusion in the CSIR Annual Report 2021-22.

Sale of Publications: Rs. 9095/-

Parliament Questions: Twenty Nine parliament questions received from CSIR HQ were answered.

Section-In-charge

Dr. ChV Rao

Chief Scientist

Email ID: info-nbri@nbri.res.in

Team:

- Dr. KN Nair, Chief Scientist
- Mr. Yogendra Nath, Principal Technical Officer
- Mr. AC Little, Principal Technical Officer
- Mr. Rajat Raj Rastogi, Technical Assistant

LIBRARY-KNOWLEDGE RESOURCE CENTRE (KRC)

The Knowledge Resource Centre (KRC/Library) of CSIR-NBRI was established in 1953. The KRC provides services and facilities to meet the S & T knowledge requirements of the Institute's R& D activities.

The prime objective of this division is to organize various types of knowledge resources and disseminate them to its user at the right time. Most of the in-house operations in KRC are fully automated, supporting the Information System created with the help of Library Management Software.

KRC facilitates online access to Electronic Resources like e-journals, and databases to the end users. It also conducts training programs and workshops from time to time on how to use e-resources for the benefit of the scientists, technical staff, researchers and students of the Institute. Every year, especially on the occasion of the Hindi Pakhwada, KRC organizes an exhibition of Hindi Books.

Library Classification Scheme: Dewey decimal classification (D.D.C)

Cataloguing Code: Anglo-American Cataloguing Rules-2(AACR-2)

Library Software: LibSys

Library Holdings and Reprography Services

KRC currently holds a total of 29626 books and 31525 bound journals. It currently subscribes to a total of 469 journals, including 58 print and 411 online journals covering diverse fields of Plant Sciences. The Botanical Archive in the library of the Institute was established on 16th August 1991 by Dr. P.V. Sane, former Director of CSIR-NBRI.

A Botanical Archive is maintained in the KRC, which houses rare and hand-written manuscripts in Persian and Arabic languages, illustrations of plants dating back to 18th century and other original botanical literature and files containing biographic details, signatures, and important documents of eminent botanists/ scientists and institutions/ societies.

CSIR-NBRI KRC Collection
Books: 29626
Journal Bound Volumes: 31525
Total No. of Books and Bound Journals: 61151
Thesis • AcSIR-149 • Other Universities-83
Annual Reports • CSIR Institute-44 • Other Organization-137

Additions in KRC holding during the year 2022-23
Books : Purchased-32
Bound Journals: 643
Total Number of books and bound journals added during 2021-22 : 675
Current Periodicals Subscribed • Print only-58 (Indian) • Print + Online-03 (Indian) • Online Subscribed directly by CSIR-NBRI- 07 (E-journals) • Online Subscribed through CSIR Consortium (NKRC) on share basis-411
Total Number of Periodicals (Titles): 498
Databases Subscribed • Subscribed direct by KRC, CSIR-NBRI-02 • Subscribed through CSIR Consortium (NKRC) on share basis-03
Database Services NBRI-KRC serves the research community of CSIR-NBRI by subscribing the following databases: • Global Plants JSTOR • TAIR • Web of Science • iThenticate • Grammarly

Training Imparted and Special Demonstration programmes held

KRC provides one year Apprentice Training to 6 students in Library Science every year under the Apprentice Scheme of Government of India. In the current year training was imparted to 2-degree holder apprentice.

Sectional In-charge

Dr. ChV Rao

Chief Scientist

Email ID: chvrao72@nbri.res.in

Team:

- Mr. Yogendra Nath, Principal Technical Officer
- Mrs. Leena Wahi Gupta, Senior Technical Officer

CENTRAL INSTRUMENTATION FACILITY (CIF)

Objectives

The facility is established with primary objective of plant based analytical testing services to the industries / organization / universities / individuals.

- Development of different projects in public private partnership mode
- Creating Joint IPR with industries.
- Instrumental and infrastructural support to R&D activities of institutes.

Scientist In-charge

TN Khoshoo Block

Dr. Alok Lehri
Chief Scientist

KN Kaul Block

Dr. Vivek Pandey
Chief Scientist

Team:

- Dr. Anil Kumar, Senior Technical Officer
- Dr. Sanjay Dwivedi, Senior Technical Officer
- Dr. Abhishek Niranjan, Senior Technical Officer
- Dr. Babita Kumari, Senior Technical Officer
- Dr. GG Sinam, Senior Technical Officer
- Mr. Jai Chand, Technical Officer
- Mr. Dileep Singh, Technician
- Mr. Pawan Kumar, Technician

Highlights and Major Activities

Analytical Testing Services Provided (2022-23)	
External Samples	• No. of samples analyzed-61 • Revenue generated- Rs. 1,27,440.00
No. of industries/organizations /entrepreneurs/individual benefitted	20
Internal Samples	• No. of samples analyzed-6261 • Estimated revenue generated-Rs. 37,74,000.00 @ 50% of current testing charges
Maintenance and repairing of instruments	• Number of jobs of maintenance and repairing of instruments -200
NABL/Other similar Accreditation Status	• NABL Accreditation of the Institute • NABL-Gurugram after reassessment audit held in October 2021 recommends for continuation of NABL-Accreditation of the institute up to Jan. 2024. • Certificate Number: TC-7972; Validity- 17.01.2024 • Scope: Ayush Product, Cosmetics & Essential Oils, Food & Agriculture Products, Pesticide Formulation, Pollution & Environment, Residues in Water, Chemical Water • Institute is also NABL Accredited as reference material producer based on the requirement of ISO 17034:2016 since 31.03.2021 and valid up to 30.03.2023
Training Imparted and Special Demonstration programmes Held	• Skill development programmes organized –04 • No of individuals trained-55
New Facility Established	Flash Chromatography (Isolation of molecules/compounds from medicinal plants)

ENVIRONMENTAL INFORMATION AWARENESS, CAPACITY (EIACP) PROGRAMME CENTRE

The EIACP (Environment Information, Awareness, Capacity Building and Livelihood Programme) centre of CSIR-National Botanical Research Institute is working on the themes of Plants and Pollution. A total of 34 EIACP Centres across India are working as the Programme Centres of the Ministry of Environment, Forest & Climate Change, Govt. of India. These programme centres of the EIACP are being hosted by different institutes/ universities/ organizations on specific themes of environment and forest sectors.

Objectives

- To build up a repository and dissemination centre in Environmental Science and Engineering.
- To gear up the modern technologies of acquisition, processing, storage, retrieval and dissemination of information of environmental nature.
- To support and promote research, development and innovation in environmental information technology.

Major Activities

An online database of emerging pollutants has been created. ENVIS-NBRI Newsletters (Vol. 18 Issues 02, 03, 04 in the year 2022 & Vol. 19 Issue 01 in the year 2023) has been published.

The NBRI EIACP programme centre organized/ participated following events/awareness programmes during the reporting year:

- World Earth Day 2022 on 22nd April 2022 at Kendriya Vidyalaya, CRPF Bijnaur, Lucknow
- International Day of Biological Diversity 2022.
- World Environment Day 2022 at the Department of Botany, University of Lucknow.
- Hariyali Saptah 2022 during July 01-09, 2022.
- Participated in a National Workshop on Mission LiFE conducted at Paryavanran Bhawan of Ministry of Environment, Forest and Climate Change, Govt. of India on January 30, 2023.

- Five-Day Training Programme On "Atomic Absorption Spectrophotometry with Reference to Monitor Soil Health and Fertility" under the umbrella of CSIR Integrated Skill Initiative & CSIR-EIACP sponsored by Department of Agriculture, Government of Uttar Pradesh.
- Awareness programme on Mission LiFE among students Central School Gomti Nagar in collaboration with CSIR-Jigyasa held on 27th January 2023.
- Awareness programme on Mission LiFE among students of KVS Prayagraj in collaboration with CSIR-Jigyasa held on 25th February 2023.

Team:

Dr. Pankaj Kumar Srivastava, Senior Principal Scientist & Coordinator

Dr. Anju Patel, Scientist & Co-coordinator

राजभाषा कार्यान्वयन समिति

lLFkku e jkt Hkk"kk dk;kUo;u lfefr d rRok/kku e o"k 2022&2023 e dh x;h ie[k xfrfof/k;k fuEufyf[kr g&

1- संस्थान में राजभाषा विभाग, गृह मंत्रालय, भारत सरकार द्वारा जारी दिशा–निर्देशों के अनुसार राजभाषा के प्रगामी प्रयोग संबंधी निगरानी हेतु राजभाषा कार्यान्वयन समिति की चार तिमाही बैठकों का आयोजन किया गया।

2. संस्थान के अधिकारियों तथा कर्मचारियों द्वारा हिंदी के प्रगामी प्रयोग में और भी अधिक वृद्वि लाने हेतु संस्थान के निदेशक महोदय द्वारा व्यक्तिशः आदेश जारी किये गये।

3. समय–समय पर कार्यालय ज्ञापन व सूचनाएं जारी की गयी, जिससे संस्थान के अधिकारियों व कर्मचारियों द्वारा कार्यालयी कार्य हिंदी में करने में वृद्वि हुई है। राजभाषा अधिनियम 1963 की धारा 3(3) के अंतर्गत जारी किये जाने वाले समस्त दस्तावेज द्विभाषी जारी करने हेतु कार्यालय ज्ञापन जारी किये गये।

4. संस्थान से हिंदी के प्रगामी प्रयोग संबंधी त्रैमासिक व छमाही रिपोर्टें तैयार कर सीएसआईआर–मुख्यालय, नई दिल्ली, सचिव, नगर राजभाषा कार्यान्वयन समिति जीएसआई, लखनऊ एवं क्षेत्रीय कार्यान्वयन कार्यालय उत्तर क्षेत्र–2 गाजियाबाद को प्रेषित की गईं तथा सभी त्रैमासिक रिपोर्टें राजभाषा विभाग के सूचना प्रबंधन प्रणाली पोर्टल पर भी अपलोड की गयी।

5. संस्थान में हिंदी को प्रोत्साहित करने हेतु निम्नलिखित हिंदी कार्यशालाएं एवं हिंदी वैज्ञानिक व्याख्यान आयोजित किये गए :

Jherh yhukokgh xIrk] rduhdh vf/kdkjh if'k{kfFk;k dk iLrdky; l lcf/kr tkudkjh inku djrh gb

दिनांक 25/05/2022 को हिंदी प्रशिक्षण कार्यक्रम के अंतर्गत श्री आनंद प्रकाश, वरिष्ठ प्रधान वैज्ञानिक, श्रीमती लीनावाही गुप्ता, तकनीकी अधिकारी एवं श्री बिजेन्द्र सिंह, हिंदी अधिकारी ने नवयुग कन्या महाविद्यालय, राजेन्द्र नगर, लखनऊ की 33 छात्राओं को एक दिवसीय प्रशिक्षण दिया जिसमें हिंदी के प्रसार एवं विकास की गति को बढ़ाने हेतु हिंदी बोले और लिखे जाने एवं राजभाषा से संबंधित क्षेत्र में शामिल राज्य/संघ राज्य क्षेत्र क, ख, एवं ग के बारे में सम्पूर्ण जानकारी प्रदान की गई।

दिनांक 30/08/2022 को हिंदी कार्यशाला में डॉ. चन्द्र मोहन नौटियाल, सेवानिवृत्त प्रधान वैज्ञानिक, बीरबल साहनी पुराविज्ञान संस्थान एवं रेडियोकार्बन प्रयोगशाला प्रमुख द्वारा व्याख्यान दिया गया। जिसमें 10 अधिकारियों एवं 125 कर्मचारियों ने प्रतिभाग किया।

दिनांक 05/08/2022 को डॉ. सचित्र कुमार रथ, प्रधान वैज्ञानिक, ने शैवालों से संबंधित वैज्ञानिक व्याख्यान दिया। जिसमे 15 अधिकारियों एवं 58 कर्मचारियों ने प्रतिभाग किया गया।

दिनांक 22/09/2022 को हिंदी कार्यशाला का आयोजन किया गया जिसमें संस्थान के वरिष्ठ प्रधान वैज्ञानिक व आयुर्वेद चिकित्सक, डा. संजीव कुमार ओझा, ने व्याख्यान में बताया कि मुधमेह के बढ़ने का मुख्य कारण मोटापा, ज्यादा मीठा खाना है जिससे शरीर में ग्लूकोज की मात्रा अधिक हो जाती है। अतः खाने में शक्कर वाले व्यंजन से बचना चाहिए।

दिनांक 30/12/2022 को हिंदी कार्यशाला का आयोजन किया गया जिसमें संस्थान के डॉ. कृष्ण कुमार रावत, सदस्य सचिव, रा. का. स. एवं डॉ. श्रीकृष्ण तिवारी, उपाध्यक्ष, रा. का. स. द्वारा संस्थान के कर्मचारियों एवं शोधार्थियों को हिंदी लेखन एवं अनुवाद में आने वाली समस्याओं एवं उपाय के संबंध में जानकारी दी गई। इसके अतिरिक्त पृथ्वी विज्ञान मंत्रालय के 7 सूत्री चार्टर के अनुपालन में शोध थीसिस के सारांश को द्विभाषी रूप में तैयार करने संबंधी जानकारी प्रदान की गई जिसमें 120 लोगों द्वारा भाग लिया गया।

fgnh dk;'kkyk e 0;[;ku nr g, Mk- ltho dekj vk>k] ,o mifLFkr vf/kdkjh] depkjhx.k

दिनांक 23/02/2023 को हिंदी कार्यशाला में श्री रामबदल, भण्डार एवं क्रय अधिकारी द्वारा हिंदी कार्यशाला में अपने व्याख्यान में ''सरकारी ई मार्केट प्लेस (जेम) से खरीद'' पर विस्तार से चर्चा की गई जिसमें 10 अधिकारियों एवं 45 कर्मचारियों ने प्रतिभाग किया गया।

6. संस्थान ने नगर राजभाषा कार्यान्वयन समिति कार्यालय उत्तर क्षेत्र–2 भारतीय भू–सर्वेक्षण उत्तरी क्षेत्र, लखनऊ द्वारा समय–समय पर आयोजित बैठकों में प्रतिभागिता की।

7. संस्थान की राजभाषा कार्यान्वयन समिति के तत्वाधान में दिनांक 16/09/2022 से 29/09/2022 तक हिंदी पखवाड़ा कार्यक्रम का आयोजन किया गया। हिंदी पखवाड़े के अंतर्गत निम्नलिखित कार्यक्रमों का आयोजन किया गया–

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दिनांक 16/09/2022 को हिंदी पखवाड़ा' के उद्घाटन कार्यक्रम के अंतर्गत संस्थान के पुस्तकालय में हिंदी पुस्तक प्रदर्शनी का आयोजन किया गया। जिसका उद्घाटन मुख्य अतिथि डॉ. चन्द्र मोहन नौटियाल सेवानिवृत्त, वरिष्ठ वैज्ञानिक एवं रेडियोकार्बन प्रयोगशाला प्रमुख, बीरबल साहनी पुराविज्ञान संस्थान लखनऊ द्वारा किया गया। इस अवसर पर मुख्य

'fgnh i[kokMk* dk;Zdze dk mn?kkVu lekjkg esa e[; vfrfFk] vf/kdkjh ,oa deZpkjhx.k

fgnh i[kokMk dk;Zdze esa 0;[;ku iLrqr djrs gq,, e[; vfrfFk

fgnh i[kokMk dk;Zdze ds vrxZr fofHkUu izfr;kfxrk,a

अतिथि द्वारा संस्थान के कर्मचारियों को संबोधित किया गया। हिंदी पखवाड़ा' कार्यक्रम के अंतर्गत संस्थान के वैज्ञानिकों/अधिकारियों / कर्मचारियों / शोधार्थियों हेतु विभिन्न प्रतियोगिताओं जैसे हिंदी वर्ग पहेली प्रतियोगिता, बच्चों के लिए निबन्ध प्रतियोगिता, हिंदी टिप्पण/आलेखन प्रतियोगिता एवं हिंदी ज्ञान प्रतियोगिता का आयोजन किया गया जिसमें बड़ी संख्या में प्रतिभागियों ने भाग लिया।

fgnh i[kokMk ds dk;Zdze dk lekiu lekjkg dk vk;kstu&

दिनांक 29/09/2022 को आयोजित हिंदी पखवाड़े के कार्यक्रम समापन के अवसर पर श्री राकेश कुमार ओझा, पूर्व

आईएएस मुख्य अतिथि के रूप में आमंत्रित थे। इस अवसर पर विभिन्न प्रतियोगिताओं में विजेता प्रतिभागियों को पुरस्कार वितरण किया गया। मुख्य अतिथि ने अपने व्याख्यान में कहा कि हिंदी के प्रचार, प्रसार एवं उत्थान में भारत की विश्व में बढ़ती ख्याति एवं आर्थिक संबंधों का भी बड़ा योगदान है। सबसे अधिक बोली जाने वाली हिंदी भाषा के माध्यम से अधिक से अधिक लोगों तक पहुंच बनाई जा सकती है।

वर्ष 2022-23 के दौरान आयोजित कार्यक्रम

दो दिवसीय बोगनविलिया उत्सव एवं ग्रीष्म कालीन पादप विज्ञान महोत्सव

¼vçy 12&13] 2022½

वै.औ.अ.प.–एनबीआरआई, लखनऊ में दो दिवसीय बोगनविलिया उत्सव एवं ग्रीष्म कालीन पादप विज्ञान महोत्सव का आयोजन अप्रैल 12–13, 2022 के मध्य किया गया। कार्यक्रम का उदघाटन 12 अप्रैल 2022 को उत्तर प्रदेश सरकार के माननीय उप–मुख्यमंत्री श्री ब्रजेश पाठक के द्वारा किया गया। इस अवसर पर श्री असीम अरुण, पूर्व आईपीएस एवं उत्तर प्रदेश सरकार के माननीय राज्य मंत्री (स्वतंत्र प्रभार) एवं एसजीपीजीआईएमएस, लखनऊ के निदेशक प्रो. आर के धीमान, विशिष्ट अतिथि के रूप में मौजूद थे।

ckxufofy;k mRlo ,oa xh"e dkyhu ikni foKku egkRlo dh dqN >yfd;k

बोगनविलिया उत्सव में विशेषज्ञों की विशेष बैठक में देश के कई वैज्ञानिकों एवं विशेषज्ञों ने बोगनविलिया पर अनुसंधान एवं विकास कार्य आगे बढ़ाने के लिए अपने अपने विचार रखे। संस्थान द्वारा एक सम्पूर्ण बोगनविलिया प्रदर्शनी के आयोजन से सम्बंधित गाइडलाइन्स पर भी चर्चा की गयी। इस उत्सव में संस्थान द्वारा विकसित बोगनविलिया की किस्मों जैसे 'बेगम सिकंदर'; 'शुभ्रा'; 'डा० बी० पी० पाल'; 'अर्जुना'; 'अर्चना'; 'मेरी पाल्मर स्पेशल'; 'लॉस बनोस वैरिगेटा'; 'अरुणा'; 'डा० पी० वी० साने' को प्रदर्शित किया गया था। विज्ञान फेस्टिवल में विभिन्न वैज्ञानिक प्रतियोगिताएं आयोजित की गयी जिनमे डिजिटल फोटोग्राफी, मौखिक व्याख्यान, पोस्टर प्रस्तुतियां शामिल थी। संस्थान के लगभग 300 शोधार्थियों द्वारा इस फेस्टिवल में प्रतिभाग किया गया।

राष्ट्रीय प्रौद्योगिकी दिवस-2022

सीएसआईआर–एनबीआरआई में 11 मई, 2022 को राष्ट्रीय प्रौद्योगिकी दिवस समारोह का आयोजन किया गया इस अवसर पर किंग जॉर्ज चिकित्सा विश्वविद्यालय, लखनऊ के कुलपति ले. जन. (डॉ.) बिपिन पुरी मुख्य अतिथि के तौर पर उपस्थित थे। कार्यक्रम के मुख्य अतिथि डॉ. बिपिन पुरी ने अपने व्याख्यान में मानव शरीर में पाए जाने वाले सहजीवी सूक्ष्मजीवाणुओं के बारे में चर्चा की। इस अवसर पर संस्थान द्वारा सन्दर्भ सामग्री (सीआरएम) उत्पादन हेतु विकसित तकनीकी को अश्वी टेक्नोलॉजी, अहमदाबाद को हस्तांतरित किया गया। इसके साथ साथ संस्थान द्वारा यूनिवर्सिटी ऑफ साइंस एंड टेक्नोलॉजी, मेघालय के साथ पूर्वोत्तर भारत में अनुसंधान एवं विकास कार्य को बढ़ावा देने हेतु एक समझौते पर भी हस्ताक्षर किये गये।

विश्व पर्यावरण दिवस-2022

वै.औ.अ.प.–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ एवं इंटरनेशनल सोसाइटी ऑफ एनवायर्नमेंटल बॉटनिस्ट्स (आईएसईबी), लखनऊ द्वारा आज दिनांक 6 जून 2022 को विश्व पर्यावरण दिवस समारोह आयोजित किया गया इस अवसर पर प्रो. रेनी एम. बोर्जेस, सेंटर फॉर इकोलॉजिकल साइंसेज, भारतीय विज्ञान संस्थान, बेंगलुरु मुख्य अतिथि के रूप में उपस्थित थी।

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अंतर्राष्ट्रीय योग दिवस-2022

अन्तर्राष्ट्रीय योग दिवस के अवसर पर आयुष मंत्रालय, भारत सरकार द्वारा जारी दिशा निर्देशों एवं सामान्य योग अभ्यासक्रम (प्रोटोकॉल) के अंतर्गत वै.औ.अ.प.–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ द्वारा दिनांक 21 जून, 2022 को संस्थान के के.एन. कौल ब्लाक में एक योग शिविर का आयोजन किया गया। इस अवसर पर लखनऊ में प्रशिक्षित योग विशेषज्ञों ने विभिन्न योगासनों का अभ्यास कराया गया। इस शिविर में संस्थान के वैज्ञानिकों, विद्यार्थियों, स्टाफ एवं अन्य लोगों ने इस योग शिविर में भारी संख्या में उत्साह के साथ भाग लिया।

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51 वाँ शांति स्वरुप भटनागर मेमोरियल (चतुर्थ जोनल) फुटबॉल टूर्नामेंट

वै.औ.अ.प.–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ एवं सीएसआईआर–खेल संवर्धन बोर्ड, नई दिल्ली द्वारा संयुक्त रूप से 9–11 सितम्बर, 2023 के मध्य 51वें शांति स्वरूप भटनागर मेमोरियल (चौथे क्षेत्रीय) फुटबॉल टूर्नामेंट का आयोजन किया गया। कार्यक्रम का उदघाटन समारोह के मुख्य अतिथि एवं द्रोणाचार्य अवार्डी (बैडमिंटन) एवं राष्ट्रीय कोच, भारतीय पैरा बैडमिंटन टीम, श्री गौरव खन्ना के द्वारा किया गया। इस टूर्नामेंट में सीएसआईआर परिवार के चार प्रयोगशालाओं की फुटबॉल टीमें–सीएसआईआर–एनपीएल, नई दिल्ली, सीएसआईआर–आईआईपी देहरादून, सीएसआईआर–सीएमईआरआई, दुर्गापुर और सीएसआईआर– सीबीआरआई, रुड़की भाग ले रही हैं।

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विज्ञान एवं तकनीकी द्वारा उद्यमिता विकास पर दो दिवसीय एक विशेष कार्यक्रम

सीएसआईआर–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ एवं राष्ट्रीय विज्ञान अकादमी, भारत (नासी) प्रयागराज एवं बायोटेक कंसोर्टियम इंडिया लिमिटेड, नई दिल्ली द्वारा सयुंक्त रूप से सितम्बर 12–13, 2023 के मध्य विज्ञान एवं तकनीकी द्वारा उद्यमिता विकास पर दो दिवसीय एक विशेष कार्यक्रम का आयोजन किया गया। कार्यक्रम का मुख्य उद्देश्य विज्ञान एवं तकनीकी द्वारा उद्यमियों को आत्मनिर्भर बनाने हेतु को प्रोत्साहित करना था। कार्यक्रम का उदघाटन प्रो. मंजू शर्मा,

राष्ट्रीय विज्ञान अकादमी, भारत की चेयरमैन एवं पूर्व सचिव, जैवप्रौद्योगिकी विभाग, भारत सरकार के द्वारा किया गया।

पारिस्थितिकी सुधार एवं जैव विविधता संरक्षण पर राष्ट्रीय सम्मेलन

राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ एवं क्लीन एंड ग्रीन एनवायर्नमेंटल सोसाइटी, लखनऊ के संयुक्त तत्वाधान में पारिस्थितिकी सुधार एवं जैव विविधता संरक्षण पर दो दिवसीय राष्ट्रीय सम्मेलन का आयोजन सितम्बर 17–18, 2023 के मध्य किया गया। सम्मेलन का उदघाटन उत्तर प्रदेश सरकार के मुख्य सचिव एवं कार्यक्रम के मुख्य अतिथि श्री दुर्गा शंकर मिश्र, आईएएस ने किया। राष्ट्रीय विज्ञान अकादमी, इंडिया के वरिष्ठ वैज्ञानिक, इंसा फेलो प्रो. रूप लाल कार्यक्रम में विशिष्ट अतिथि के रूप में मौजूद थे। इस राष्ट्रीय सम्मेलन में देश भर से करीब 130 प्रतिभागी शामिल हो रहे है इन दो दिनों में विभिन्न शोधार्थियों एवं वैज्ञानिकों द्वारा 60 पोस्टर प्रस्तुतियां एवं 50 मौखिक व्याख्यान प्रस्तुत किये गए।

81वां सीएसआईआर स्थापना दिवस-2022

सीएसआईआर – राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ द्वारा अपनी पैतृक संस्था वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद, नई दिल्ली के 81वां स्थापना दिवस समारोह का आयोजन आज दिनांक 27 सितम्बर, 2022 को किया गया। इस अवसर पर डॉ. हिमांशु पाठक, सचिव, कृषि अनुसंधान एवं शिक्षा विभाग एवं महानिदेशक, भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली मुख्य अतिथि के रूप में समारोह में ऑनलाइन जुड़े थे।

इस अवसर पर संस्थान के निदेशक प्रो. एस के बारिक ने 25 वर्ष की सेवा पूरी करने वाले नौ कर्मचारियो एवं विगत दो वर्षों में सेवानिवृत होने वाले 31 कर्मचारियो को स्मृति चिन्ह देकर सम्मानित भी किया। स्थापना दिवस के अवसर पर कर्मचारियों के बच्चों हेतु आयोजित विज्ञान निबंध एवं चित्रकारी प्रतियोगिता में विजयी बच्चों को पुरस्कार एवं प्रमाण पत्र देकर सम्मानित भी किया गया।

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69वां वार्षिक दिवस समारोह-2022

सीएसआईआर– राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ ने 29 अक्टूबर, 2022 को अपना 69वां वार्षिक दिवस मनाया। इस अवसर पर डॉ. एकलब्य शर्मा, पूर्व उप–महानिदेशक, इंटरनेशनल सेंटर फॉर इंटीग्रेटेड माउंटेन डेवलपमेंट, काठमांडू मुख्य अतिथि के रूप में उपस्थित थे एवं उन्होंने भारतीय उप–महाद्वीपों के पारिस्थिकी तंत्रों के संरक्षण एवं सुधार पर अपना व्याख्यान प्रस्तुत किया। इस अवसर पर कार्यक्रम में संस्थान की वार्षिक रिपोर्ट 2021–22 जारी की गयी। संस्थान के निदेशक प्रो एस के बारिक ने अतिथियों का स्वागत करते हुए वर्ष 2020–21 की अवधि के दौरान वार्षिक प्रगति की जानकारी प्रस्तुत की। मुख्य अतिथि डॉ. एकलब्य शर्मा ने इस अवसर पर 'पुष्पांगदन बायोडाइवर्सिटी एक्सेस एंड बेनेफिट शेयरिंग अवार्ड' के विजेताओं की भी घोषणा की। यह पुरस्कार आदिवासी कल्याण हेतु किये गये विशिष्ट कार्य हेतु प्रदान

किया जाता हैं। इस पुरस्कार के अंतर्गत कैश अवार्ड, सम्मान पत्र एवं स्मृति चिन्ह प्रदान किया जाता हैं। वर्ष 2021 के लिए केरल विश्वविद्यालय के अंतर्गत स्थापित स्टार्टअप के निदेशक, डॉ. टी पी लिजनु, एवं डॉ. अंकिता मिश्र, महिला वैज्ञानिक, सीएसआईआर–एनबीआरआई को चुना गया।

वार्षिक गुलदाउदी एव कोलियस पुष्प प्रदर्शनी-2022

सीएसआईआर–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ द्वारा वार्षिक दो दिवसीय गुलदाउदी एवं कोलियस प्रदर्शनी का आयोजन दिसम्बर 10–11, 2022 के मध्य किया गया। इस वर्ष प्रदर्शनी में कुल 72 प्रदर्शकों द्वारा 569 प्रविष्टियों को प्रदर्शित किया गया। प्रदर्शनी का समापन 11 दिसम्बर 2022 को किया गया इस अवसर पर प्रो. आलोक कुमार राय, कुलपति, लखनऊ विश्वविद्यालय, लखनऊ समापन समारोह में मुख्य अतिथि के तौर पर उपस्थित थे जबकि डॉ. संदीप तिवारी, मुख्य चिकित्सा अधीक्षक, ट्रामा सेंटर, केजीएमयू, लखनऊ समारोह में विशिष्ट अतिथि के रूप में मौजूद थे।

इस प्रदर्शनी में श्रीमती रंजीता अग्रवाल, मदन मोहन मालवीय मार्ग, लखनऊ कुल छह कप/शील्ड/ट्रॉफियॉ जीतकर प्रथम स्थान पर रहीं। श्रीमती सुमन अग्रवाल मदन मोहन मालवीय

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मार्ग, लखनऊ, ला मार्टिनीयर कॉलेज, हजरतगंज, लखनऊ, एवं अंचल ग्रीन एम्पायर, एल्डिको उद्यान–2, रायबरेली रोड, लखनऊ तीन–तीन कप/शील्ड/ट्रॉफियॉ जीतकर द्वितीय स्थान एवं निदेशक, सीएसआईआर–सीमैप, लखनऊ व हेड क्वार्टर, सेंट्रल कमांड, कैंट, लखनऊ ने दो–दो कप/शील्ड/ट्रॉफियॉ जीत कर तृतीय स्थान प्राप्त किया।

इस वर्ष दिए गए 380 कुल सामान्य पुरस्कारों में श्रीमती रंजीता अग्रवाल, मदन मोहन मालवीय मार्ग, लखनऊ कुल 32 पुरस्कार (17 प्रथम,10 द्वितीय तथा 5 सान्त्वना) जीतकर प्रथम स्थान पर रही। ला मार्टिनीयर कॉलेज, हजरतगंज, लखनऊ कुल 34 पुरस्कार (16 प्रथम, 8 द्वितीय तथा 10 सान्त्वना) जीतकर द्वितीय तथा हेड क्वार्टर, सेंट्रल कमांड, कैंट, लखनऊ 24 पुरस्कार (12 प्रथम, 05 द्वितीय तथा 07 सान्त्वना) जीतकर तृतीय स्थान पर रहे।

वार्षिक गुलाब एवं ग्लेडियोलस प्रदर्शनी-2023

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सीएसआईआर –राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ द्वारा जनवरी 21–22, 2023 के मध्य दो दिवसीय गुलाब और ग्लैडिओलस प्रदर्शनी का आयोजन किया गया इस प्रदर्शनी में विभिन्न सरकारी, अर्द्ध सरकारी विभाग, स्वायत्त निकाय, व्यक्तिगत उत्पादक, महिलायें, नर्सरियों के लोग एवं मालियों से विभिन्न वर्गो में प्रतिभागिता हेतु 50 प्रदर्शकों से कुल 329 प्रविष्टियॉ प्राप्त हुईं। एनबीआरआई द्वारा प्रदर्शनी में मुख्य आकर्षण के रूप में एक विशेष पवेलियन को भी लगाया गया जिसमे संस्थान के गुलाब एवं ग्लेडियोलस के संग्रह की चुनिंदा किस्मों को विभिन्न वर्गों एवं कट फ्लावर्स के रूप में प्रदर्शित किया गया। इसके साथ साथ ग्लेडियोलस एवं गुलाब की कृषि से संबंधित तकनीकी जानकारी को भी अलग से प्रदर्शित किया जा रहा हैं। आमजन हेतु पवेलियन में गुलाब की विभिन्न रंगों एवं रूपों की चुनिंदा किस्मों को (75 किस्में गमलों में एवं 90 किस्मे फूलदान में) रखा गया। पुरस्कार वितरण समारोह में लखनऊ जिले के नगर आयुक्त श्री इंद्रजीत सिंह, सीएसआईआर–सीडीआरआई, लखनऊ की निदेशक डॉ. राधा रंगराजन एवं सीएसआईआर–आईआईटीआर, लखनऊ के निदेशक डॉ. भास्कर नारायण विशिष्ट अतिथि के रूप में उपस्थित थे। कुल 24 रनिंग चौलेंज ट्रॉफी/शील्ड/कप एवं विभिन्न विजेताओं को 171 पुरस्कार (प्रथम–68, द्वितीय–52 एवं सांत्वना–51) वितरित किये गए।

भारत में जर्मनी के राजदूत, विज्ञान परामर्शदाता, जर्मन दूतावास का संस्थान भ्रमण

भारत में जर्मनी के राजदूत महामहिम डॉ. फिलिप एकरमैन ने भारत में जर्मन दूतावास के विज्ञान सलाहकार श्री कास्पर मेयर के साथ 23 जनवरी, 2023 को सीएसआईआर–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ का भ्रमण किया। डॉ. प्रबोध कुमार त्रिवेदी, निदेशक, सीएसआईआर–राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ और डॉ. भास्कर नारायण, निदेशक, सीएसआईआर–भारतीय विष विज्ञान अनुसंधान संस्थान, लखनऊ ने संस्थानों में की जा रही अनुसंधान एवं विकास गतिविधियों के बारे में विस्तार से बताया। इस अवसर पर विज्ञान और समाज के प्रति दोनों संस्थानों के योगदान और उपलब्धियों के बारे में भी जानकारी दी गई। उक्त गणमान्य व्यक्तियों ने संस्थान के वनस्पति उद्यान का भी भ्रमण किया तथा सीएसआईआर–एनबीआरआई परिसर में रुद्राक्ष (*एलियोकार्पस एंगुस्टिफोलियस*) और सीता अशोक (*सराका असोका*) के पौधे लगाए। उन्होंने दोनों संस्थानों के वरिष्ठ वैज्ञानिकों के साथ विज्ञान की उन्नति तथा समाज के कल्याण के लिए पादप विज्ञान, विष विज्ञान तथा पर्यावरण अनुसंधान के क्षेत्र में भविष्य में परस्पर सहयोग की संभावनाओं पर चर्चा की।

dk;Øe dh dN >yfd;k

लैंगिक जागरूकता एवं कार्यस्थल पर महिला यौन उत्पीड़न विषय पर व्याख्यान

सीएसआईआर–एनबीआरआई, लखनऊ द्वारा दिनांक 06 फरवरी, 2023 को लैंगिक जागरूकता एवं कार्यस्थल पर महिला यौन उत्पीड़न विषय पर एक विशेष जागरूकता कार्यक्रम का आयोजन किया गया। इस अवसर पर सीएसआईआर–आईआईटीआर, लखनऊ की पूर्व मुख्य वैज्ञानिक डॉ. पूनम कक्कड़ ने अपना व्याख्यान प्रस्तुत किया। संस्थान की आंतरिक शिकायत समिति की अध्यक्षा डॉ. विधु साने ने कार्यक्रम के बारे में सभी को अवगत कराया। उन्होंने बताया कि कार्यस्थल पर महिला उत्पीडन के प्रति जागरूकता एवं बचाव के लिए समय समय पर समिति द्वारा विभिन्न कार्यक्रम आयोजित किये जाते हैं।

डॉ. पूनम कक्कड़ ने लैंगिक जागरूकता की आवश्यकता पर चर्चा आरम्भ करते हुए कहा कि उत्पीडन एवं यौन उत्पीड़न के बीच एक महीन सा अंतर होता है जिसको समझने की नितांत आवश्यकता है। डॉ. कक्कड़ ने अपने व्याख्यान में महिलाओं के कार्यस्थल पर लैंगिक उत्पीड़न (रोकथाम, निषेध और निवारण) अधिनियम, 2013 के बारे में चर्चा करते हुए कहा कि यौन उत्पीड़न किसी भी व्यक्ति के मूल अधिकारों के साथ साथ बराबरी के अधिकार, सामान रोजगार के अधिकार, पेशा चुनने के अधिकार, जीवन एवं स्वतंत्रता के अधिकार आदि का भी उल्लंघन करता है।

राष्ट्रीय विज्ञान दिवस समारोह-2023

सीएसआईआर–एनबीआरआई, लखनऊ द्वारा फरवरी 28, 2023 को संस्थान में राष्ट्रीय विज्ञान दिवस समारोह का आयोजन किया गया। इस अवसर पर पद्म भूषण डॉ. राजेंद्र सिंह परोदा, संस्थापक अध्यक्ष, ट्रस्ट फॉर एडवांसमेंट ऑफ एग्रीकल्चरल साइंसेज, नई दिल्ली; भूतपूर्व महानिदेशक, भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली एवं भूतपूर्व सचिव, कृषि अनुसंधान एवं शिक्षा विभाग, भारत सरकार समारोह के मुख्य अतिथि के रूप में आमंत्रित थे। डॉ. परोदा ने 'हमारी कृषि जैव विविधता का प्रबंधन' विषय पर प्रो. के. एन. कौल स्मृति व्याख्यान प्रस्तुत किया। इस वर्ष के विज्ञान दिवस का थीम 'वैश्विक कल्याण के लिए वैश्विक विज्ञान' था।

अंतर्राष्ट्रीय महिला दिवस-2023

सीएसआईआर–एनबीआरआई, लखनऊ आज दिनांक 10 मार्च 2023 को अंतर्राष्ट्रीय महिला दिवस समारोह का आयोजन किया गया। इस अवसर पर सीएसआईआर–सीडीआरआई, लखनऊ की निदेशिका डॉ. राधा रंगराजन मुख्य अतिथि के रूप में मौजूद थी। मुख्य अतिथि डॉ. राधा रंगराजन ने अपने 'जेंडर एंड साइंसः नेवीगेटिंग दी इंटरसेक्शन' विषयक सम्बोधन में कहा कि प्राचीन इतिहास में विज्ञान क्षेत्र में महिलाओं के योगदान सही पहचान नहीं मिल पाई थी उन्होंने भारतीय विज्ञान क्षेत्र की अग्रणी महिला वैज्ञानिकों जैसे डॉ. मुत्तुलक्ष्मी रेड्डी, डॉ. असीमा चटर्जी आदि के वैज्ञानिक योगदान एवं उनके संघर्ष के बारे भी बताया। संस्थान द्वारा अंतर्राष्ट्रीय महिला दिवस समारोह के अंतर्गत 03 मार्च से 10 मार्च, 2023 के मध्य विभिन्न कार्यक्रमों जैसे महिलाओं हेतू योग शिविर आदि का आयोजन किया गया।

दो दिवसीय पुष्प कृषि मेला एवं बोगनविलिया उत्सव

सीएसआईआर–एनबीआरआई, लखनऊ द्वारा दो दिवसीय पुष्प कृषि मेला एवं बोगनविलिया उत्सव का आयोजन 19–20 मार्च 2023 के मध्य किया गया। उद्घाटन समारोह में उत्तर प्रदेश सरकार के कृषि, कृषि–शिक्षा एवं अनुसंधान विभाग के अपर मुख्य सचिव डॉ. देवेश चतुर्वेदी मुख्य अतिथि के रूप में उपस्थित थे जबकि महात्मा गाँधी केन्द्रीय विश्वविद्यालय, मोतिहारी, बिहार के कुलपति डॉ. आनंद प्रकाश एवं आचार्य नरेन्द्र देव कृषि एवं प्रौद्योगिकी विश्वविद्यालय, अयोध्या के कुलपति डॉ. बिजेन्द्र सिंह समारोह के विशिष्ट अतिथि के रूप में उपस्थित थे। बोगनविलिया उत्सव के अंतर्गत संस्थान द्वारा विकसित बोगनविलिया की दो दर्जन से ज्यादा किस्मों जैसे 'बेगम सिकंदर'; 'शुभ्रा'; 'डा० बी० पी० पाल'; 'अर्जुना'; 'अर्चना'; 'मेरी पाल्मर स्पेशल'; 'लॉस बनोस वैरिगेटा'; 'अरुणा'; 'डा० पी० वी० साने' आदि को प्रदर्शित किया गया साथ ही बोगनविलिया पौधों को आकर्षक बनाये गये विभिन्न स्वरूपों जैसे बोन्साई, टोपिअरी कला आदि में भी प्रदर्शित किया गया।

इस दो दिवसीय कार्यक्रम में देश के विभिन्न राज्यों के 24 कृषि समूहों से 500 से अधिक किसानों एवं कृषि उद्यमियों द्वारा भाग लिया गया। इन सभी प्रतिभागियों को 10 लाख से अधिक की संख्या में रोपण सामग्री (बल्ब एवं बीज) तथा सूचनापरक कृषि साहित्य का वितरण भी किया गया जिसको वे उन्नत कृषि तरीकों के माध्यम से उगा कर लाभ उठा सकें। समापन समारोह में उत्तर प्रदेश सरकार सरकार के कृषि राज्य मंत्री माननीय श्री बलदेव सिंह औलख मुख्य अतिथि के रूप में उपस्थित थे जबकि केन्द्रीय औषधीय एवं संगंध पौधा संस्थान, लखनऊ के डॉ. पी. के. त्रिवेदी एवं डॉ शक्ति विनय शुक्ला, फ्रेगरेंस एंड फ्लेवर डेवलेपमेंट सेंटर, कन्नौज समारोह के विशिष्ट अतिथि के रूप में उपस्थित थे।

ACADEMY OF SCIENTIFIC & INNOVATIVE RESEARCH (ACSIR)

Established in 2011 as an 'Institution of National Importance' (interim operations started in June, 2010), the Academy of Scientific and Innovative Research (AcSIR) has adopted the mandate to create and train some of the best of tomorrow's Science & Technology leaders through a combination of innovative and novel curricula, pedagogy and evaluation. AcSIR's focus will be on imparting instruction and providing research opportunities in such areas that are not routinely taught in regular academic universities in India. Department of Scientific and Industrial Research (DSIR), Ministry of Science & Technology, Government of India has recognized AcSIR as a Scientific and Industrial Research Organization (SIRO).

RM Module Courses (AcSIR-25-RM)		
Sr. No.	**Course Name**	**Expert Name**
1.	Research Methodology Module 1 & 2	Dr. TS Rana & Dr. AP Sane
2.	Research Methodology Module 3	Dr. SK Tewari, Dr. RC Nainwal, Dr. KJ Singh
3.	Research Methodology Module 4 & 5	Dr. Vivek Srivastava, Dr. Manish Bhoyar
4.	Research Methodology Module 6	Dr. PK Singh, Dr. Alok Lehri, Dr. Abhishek Niranjan, Dr. Sandip Behra
RPE Course (AcSIR-25-RPE)		
1.	Research Publication & Ethics	Dr. Vivek Srivastava, Dr. S. Rath, Dr. Manish Bhoyar
1 Credit Courses		
1.	Basic chemistry for biologist (AcSIR-25-ID-001)	Dr. ChV Rao, Dr. BN Singh, Dr. Manjoosha Srivastava, Dr. Mahesh Pal
2.	Cell and tissue engineering (AcSIR-25-ID-002)	Dr. PC Verma and Dr. Manoj Kumar
3.	Climate change and plants (AcSIR-25-ID-003)	Dr. PA Shirke, Dr. Vivek Pandey Dr. S Behera, Dr. Richa Rai
4.	Introduction to bioinformatics (AcSIR-25-ID-005)	Dr. MH Asif, Dr. SK Bag
5.	Soil fertility and nutrient management (AcSIR-25-ID-007)	Dr. SK Tewari, Dr. Lal Bahadur, Dr. Suchi Srivastava, Dr. Shekhar Mallick, Dr. Devendra Singh, Dr. KJ Singh
3 Credit courses		
1.	Agro-Horticulture Technology (AcSIR-25-BS-AD-001)	Dr. SK Tewari, Dr. Arvind Jain, Dr. Lal Bahadur, Dr. RC Nainwal, Dr. D Singh, Dr. KJ Singh
2.	Cell Signaling (AcSIR-25-BS-AD-002)	Dr. AP Sane, Dr. VA Sane, Dr. Aditi Gupta, Dr. Manjul Singh
3.	Developmental Biology-Plants (AcSIR-25-BS-AD-003)	Dr. Indraneel Sanyal, Dr. Debasis Chakrabarty, Dr. CS Mohanty, Dr. SV Sawant, Dr. Manish Tiwari
4.	Environmental Biochemistry and Biotechnology (AcSIR-25-BS-AD-004)	Dr. RD Tripathi, Dr. Shekhar Mallick, Dr. Pankaj Srivastava, Dr. Anju Patel, Dr. Sanjay Dwivedi
5.	Genomics and Epigenomics (AcSIR-25-BS-AD-005)	Dr. Samir V. Sawant, Dr. Sribash Roy Dr. Manish Tiwari
6.	Plant Biodiversity and Systematics (AcSIR-25-BS-AD-007)	Dr. Sanjeev Nayaka, Dr. AP Singh, Dr. VV Wagh, Dr. Priyanka Agnihotri, Dr. D. Adhikari, Dr. SK Rath, Dr. Bikarma Singh, Dr. SN Jena, Dr. KM Prabhu, Dr. Gaurav Mishra
7.	Plant Microbe interaction (AcSIR-25-BS-AD-008)	Dr. Suchi Srivastava, Dr. PS Chauhan, Dr. P Singh, Dr. Aradhana Mishra, Dr. Susheel Kumar, Dr. S Vijay Anandraj
4 Credit Courses		
8.	CSIR 800 Project Work (Societal Programme)	Dr SK Tewari (Program Coordinator)

Number of Students enrolled for Ph.D until March 31, 2022	170
Ph.Ds. awarded during 2022-23	12
Ph.Ds. theses submitted during 2022-23	07

Coordinator

Dr. Vidhu A Sane, Senior Principal Scientist

Executive Consultant

Ms. Harshita Nag

RESEARCH COUNCIL (AS ON 31.03.2023)

1.	**Prof. Paramjit Khurana** Head, Department of Plant Molecular Biology University of Delhi South Campus Benito Juarez Marg, New Delhi - 110 021	Chairman
2.	**Dr. SK Apte** DST J C Bose National Fellow & Distinguished Professor, University of Mumbai-Department of Atomic Energy-Centre of Excellence in Basic Science, Vidyanagari, Mumbai - 400 098	Member
3.	**Prof. Madhoolika Agarwal** Professor & Head, Department of Botany, Banaras Hindu University, Varanasi - 221 005	Member
4.	**Prof. SR Yadav** Department of Botany, Shivaji University, Kolhapur - 416 004	Member
5.	**Dr. Anil Prakash Joshi** Himalayan Environmental Studies & Conservation Organization (HESCO), Dehradun - 248 001	Member
6.	**Dr. Usha Barwale Zehr** Director and Chief Technology, Mahyco Private Limited Jalna - Aurangabad Road, Post Box No. 76, Dawalwadi	Member
7.	**Dr. KV Prasad** Director, ICAR-Directorate of Floriculture, College of Agriculture Campus Shivajinagar, Pune - 411 005	Member (Agency Representative)
8.	**Dr. Utpal Nath** Associate Professor, Department of Microbiology and Cell Biology, Indian Institute of Science, Bangalore - 560 012	DG's Nominee
9.	**Dr. Zabeer Ahmad** Director, CSIR-Indian Institute of Integrative Medicine Canal Road, Jammu - 180 001	Member (Sister Laboratory)
10.	**Dr. Ajit Kumar Shasany** Director, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001	Member
11.	**Dr. Vibha Malhotra Sawhney** Head, Technology Management Directorate, (Socio-economic Ministry Interface) CSIR-HQ, Rafi Marg, New Delhi - 110 001	Member (CSIR HQ Invitee)
12.	**Dr. PK Srivastava** Principal Scientist, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001	Member -Secretary

MANAGEMENT COUNCIL (AS ON 31.03.2023)

Dr. Ajit Kumar Shasany Director CSIR-National Botanical Research Institute Lucknow - 226 001	Chairman
Dr. Radha Rangarajan Director CSIR-Central Drug Research Institute Lucknow-226031	Member
Dr. Vivek Srivastava Senior Principal Scientist CSIR-National Botanical Research Institute Lucknow - 226 001	Member
Dr. KN Nair Chief Scientist CSIR-National Botanical Research Institute Lucknow - 226 001	Member (Upto July 2022)
Dr. Samir V Sawant Chief Scientist CSIR-National Botanical Research Institute Lucknow - 226 001	Member
Dr. Suchi Srivastava Principal Scientist CSIR-National Botanical Research Institute Lucknow - 226 001	Member
Dr. BN Singh Principal Scientist CSIR-National Botanical Research Institute Lucknow - 226 001	Member
Dr. Abhishek Niranjan Senior Technical Officer CSIR-National Botanical Research Institute Lucknow - 226 001	Member
CoFA/Finance & Accounts Officer CSIR-National Botanical Research Institute Lucknow - 226 001	Member
CoA/AO CSIR-National Botanical Research Institute Lucknow - 226 001	Member Secretary

EXPENDITURES AND EARNINGS 2022-23

I. EXPENDITURE	Figure in Lakhs of Rupees	
	Projects	Non-Projects
A. GIA-Salaries		
1. Salary & Salary Linked Allowances		3047.175
2. Other Allowances		
a. Reimbursement of Medical Expenses/CGHS/Medical Charges		113.053
b. Overtime Allowance		
c. Honorarium		0.765
d. Leave Travel Concession		19.204
e. Travel Allowances (India)	78.519	25.000
f. Travel Allowances (Foreign)		
g. Professional Update Allowance		
h. Total Other Allowances (a to g)	78.519	158.022
A. Total Salaries (1+2)	**78.519**	**3205.197**
3. P-04 Contingencies	84.516	560.000
4. P-05 H.R.D.		
5. P-06 Lab. Maintenance	97.181	535.195
6. P-701 Staff Qrs. Maintenance		60.000
7. P-07 Chemical/Consumables & Other Research Expenses	2475.386	665.000
8. P-804 Pension & Other retirement benefits		3777.722
9. P-906 Advance		
10. Other Heads		
i. P-801 and P-62 ISTADS		
ii. P-803 PPD/TNBD		
iii. P-805 HRD		
iv. P-80508 RAB		
v. P-807 Publicity & Exhibition		
vi. P80804 Grant to other Sci. Organisations		
vii. P80805 CSIR Guest House (Science Centre)		
viii. P80806 Celebrations		1.135
11. P-16 IPTM-Revenue		
12. P-61 NIMTLI-Revenue		
13. ITR (Innovation Complex) Revenue		
B. Total GIA-General (4 to 14)	**2657.083**	**5599.052**
C. Grant for Creation of Capital Assets		
14.P-50 Land Cost		
15. (i) P-50 Works & Services/Electrical Installations (Lumpsum)	26.829	74.000
(ii) P-50 Works & Services/Electrical Installations (Other)		
16. P-50 App. & Equip./Computer Equipments	49.659	719.300
17. P-50 Workshop Machinery		
18. P-50 Office Equipments		
19. P-50 Furniture & Fittings		25.000
20.P-50 Library (Books/ Journals/ e-Journal)		27.000
21. P-50 Model & Exhibits		
22. P-50 Vehicles		
23. P-50 Tools & Plants		
24. P-50 Software development/procurement/LAN/WAN		
25. P-26 -ICT		
26. (i) P-702 Staff Quarters (Construction) (Lumpsum)		26.000
(ii) P-702 Staff Quarters (Construction) (Other)		
27. P-16 IPTM Capital		
28. P-62 NIMTLI Capital		
29. ITR (Innovation Complex) Capital		
C. Total Creation of Capital Assets	**76.488**	**871.300**
Total A+B+C	**2812.090**	**9675.549**

II. Earnings	
RECEIPTS	
Donation	
Contribution	
Miscellaneous Receipts	3.671
Recovery of Advances	
Sales and Services	6.866
License Fees	3.535
TOTAL	**14.073**
R071 LAB RESERVE	
Royalty Premia	15.94162
Testing & Analytical Charges	11.35291
Other Technical Service	
Job Work	21.5285
Rest of R 071 heads	29.544
Total Lab Reserve(R-071)	**121.732**
R909 EXTERNAL CASH FLOW	
Government departments/Bodies (Central)	525.081
Government departments/Bodies (State)	92.053
PSUs (Central)	
PSUs (State)	
Foreign government/agencies	
International Bodies	97.042
Private Agencies	28.270
TOTAL ECF	**742.446**
Royalty & Premia for distribution (R907)	

PERSONNEL (AS ON 31.03.23)

Director
AK Shasany

Chief Scientists
PA Shirke
SK Tewari
TS Rana
Samir V Sawant
Vivek Pandey
AP Sane
Vidhu A Sane
PK Singh
Alok Lehri
ChV Rao

Sr. Principal Scientists
Anand Prakash
Sharad K Srivastava
Sanjeeva Nayaka
Mahesh Pal
SK Ojha
Vivek Srivastava
Indraneel Sanyal
Subha Rastogi
Debasis Chakrabarty
CS Mohanty
HK Yadav
MH Asif
PK Srivastava
PS Chauhan
Shekhar Mallick
SK Behera
SN Jena
PC Verma
Manjoosha Srivastava
Sribash Roy
Arvind Jain

Principal Scientists
SK Bag
Suchi Srivastava
AP Singh
Aradhana Mishra
Poonam C Singh
Dibyendu Adhikari
SK Rath
Priyanka Agnihotri
BN Singh
VV Wagh
Devendra Singh
Lal Bahadur
RC Nainwal

Senior Scientists
Manoj Kumar
KM Prabhukumar
KJ Singh
Bikarma Singh
Richa Rai
Manish Tiwari
SK Behera
Manish Bhoyar
Susheel Kumar
Aditi Gupta

Scientists
GK Mishra
Anju Patel
S Vijay Anand Raj

Pr. Technical Officers
AC Little
D K Purshottam
Shankar Verma

Sr. Tech. Officers (3)
R K Tripathi
Lalit K Srivastava
Daya Shanker
Sanjay Dwivedi
Abhishek Niranjan
Bhagwan Das
Atul Batra

Sr. Tech. Officers (2)
Sushma Verma
RN Gupta
Rajeev Kumar
Girdhari Sharma
Harendra Pal
Vinay Sahu
Kiran Toppo
MM Pandey

Sr. Tech. Officers (1)

MK Shukla
Surjit Kumar
Swati Sharma
Leena Wahi Gupta
SK Sharma
KN Maurya
Babita Kumari
GG Sinam
Sumit Yadav
KK Rawat
Somanath Swain

Technical Officers
Satish Kumar
Prashant Srivastava
Jai Chand
Shweta Singh
Rameshwar Prasad
Rekha Kannaujia
SK Mishra
Komal K Ingle
Bharat Lal Meena
Vivek K Gupta

Technical Assistants
RR Rastogi
Devranjan
Vandana Tiwari
MG Prasad

Administration
Pradip Kumar, CoA
Hare Ram Kushwaha, AO
Nitu Kumari, SO
Dheeraj Pathak, SO
Anil Kumar Upadhyay, SO
SK Pandey, Security Officer
Bijendra Singh, Hindi Officer
Manjot Kaur, ASO
Devashish Abrol, ASO
Deep Chandra, ASO
Arun Kumar, ASO
Surendra S Yadav, ASO
Sibtain Jafar, ASO
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