वार्षिक प्रतिवेदन
२०२१-२०२२
Annual Report
2021-2022

सीएसआईआर-केन्द्रीय औषधीय एवं सगंध पौधा संस्थान, लखनऊ
CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow

सीएसआईआर–सीमैप के प्रमुख योगदान

- 3,00,000 हेक्टेयर से अधिक क्षेत्र में मेन्था की खेती का विस्तार, लघु अवधि और उच्च पैदावार वाली किस्मों और बेहतर कृषि और प्रसंस्करण प्रौद्योगिकियों को विकसित किया, जिससे लगभग 6,00,000 किसानो की आय में वृद्धि हुई और भारत को एक मेन्थॉल आयात करने वाले देश से मेन्थॉल मिंट तेल के सबसे बड़े वैश्विक उत्पादक और निर्यातक देश बनाने में मदद मिली।

- आर्टीमिसिया एनुआ की उच्च पैदावार वाली किस्में, निष्कर्षण और आर्टिमिसनिन के व्युत्पन्नकरण के लिए रासायनिक प्रक्रिया के विकास और किसानों में सुधारित किस्मों की खेती को बढ़ावा देकर मलेरिया रोधी दवा आर्टिमिसनिन के 'मेक इन इंडिया' को सुनिश्चित किया।

- वेटिवर (खस) की कम अवधि और उच्च पैदावार वाली किस्मों को विकसित और प्रसारित करके नमक प्रभावित और बाढ़ ग्रस्त तटीय और नदी के किनारे वाले क्षेत्रों में उनका लाभकारी उपयोग।

- बुंदेलखंड, विदर्भ, कच्छ और मराठवाड़ा जैसे कम वर्षा वाले क्षेत्रों में नींबू घास, पामारोजा, अश्वगंधा और तुलसी की खेती की बेहतर किस्मों का विकास और प्रसार।

- आयुर्वेद में वर्णित औषधीय पौधों का उपयोग करके मधुमेह टाइप 2 के प्रबंधन के लिए सफल हर्बल फॉर्मूलेशन (सीएसआईआर– एनबीआरआई के साथ) का विकास।

- किसानों और उद्योगों को सुगंधित फसलों की खेती, प्रसंस्करण, मूल्यवर्धन और विपणन द्वारा सशक्त बनाने के लिए सीएसआईआर एरोमा मिशन में अग्रणी भूमिका।

- भारतीय–महासागर रिम एसोसिएशन (IORA) के सदस्य देशों के बीच औषधीय पौधों के ज्ञान और व्यापार के आदान–प्रदान को बढ़ावा देने हेतु सीमैप में समन्वय केन्द्र की स्थापना।

वार्षिक प्रतिवेदन

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Annual Report

2021-2022

CSIR-Central Institute of Medicinal and Aromatic Plants
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Cover page
Depicts that India has become one of the largest exporter of Lemongrass, mainly due to interventions through CSIR-Aroma Mission, led by CSIR-CIMAP.

Contents

From The Director's Desk....

I am delighted to present the annual report of the CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) for the year 2021-22, which also happens to coincide with the Amrit Mohotav year of Indian independence. CSIR-CIMAP, with its headquarter at Lucknow and research centers at four other agro-climatic zones, viz. Purara, Pantnagar, Bengaluru, and Hyderabad, is a frontier research laboratory of CSIR engaged in conducting world-level competitive and cutting-edge research related to medicinal and aromatic plants (MAPs) and various active and high-value phytomolecules. The institute is engaged in developing improved varieties of MAPs through conventional and advanced-molecular technologies like genome editing and pathway engineering; development of herbal-based products against human disorders and diseases, including COVID-19, and building business models to improve the economy of the farmers and entrepreneurs involved in the cultivation of MAPs. Despite the unprecedented challenges presented by COVID-19 second and third wave, we not only employed measures to provide safety to our scientific and technical staff, research scholars, and other associated people but also managed our ongoing research and development programs with careful fiscal management.

As the nodal laboratory of the CSIR Aroma Mission Phase-II, CSIR-CIMAP has made significant progress to better the income of farmers, aroma-based industries and entrepreneurs. Under this mission, about 4500 hectares of land was successfully covered under aromatic crops, which includes aspirational districts and other regions that are frequently affected by the vagaries of weather like floods, cyclones, and droughts. Furthermore, the unutilized fields are also being cultivated by introducing many stress-tolerant aromatic crops. Our efforts through this mission provided alternative crops to the farmers, especially tribes and other economically weaker sections, to achieve higher incomes even from a small piece of farmland. CIM-Nandi, a high citronella-containing clone of *Eucalyptus citriodora,* was released for commercial cultivation. During this period, the 70 awareness/training-cum-skill development programs organized by us benefitted more than 7900 people, including 1500 women.

CSIR-CIMAP is also leading and participating in many significant R&D programs of the CSIR. As a nodal laboratory of the CSIR Network project on Genome Editing for crop improvement (MLP-07), we were able to obtain low nicotine-containing tobacco plants in addition to standardizing this new generation molecular technique for many medicinal plants. Through our participation in the CSIR network project on biostimulants (MLP-049) and endophytes (MLP-048), we are testing the bioefficacy of several medicinal and aromatic plants and seaweed-based biostimulants and isolated promising bacterial endophytes for improving crop growth and yield in food crops like tomato and many other MAPs. In addition, CSIR-CIMAP has conducted various important R&D studies through other projects, of which 30 (GAP, CNP, and CSIR projects) were sanctioned during FY 2021-22.

One of our research papers published in *Current Molecular Pharmacology* depicts the effect of molecular targets and the antiproliferative effect of citronellal on triple-negative breast cancer cells. Another study published in the *Journal of Advanced Research* reports the promising activity of Neomenthol against human epidermoid carcinoma cells by arresting the G2/M phase and increasing the number of sub-diploid cells. Our plant biotechnologists, through a study published in the Journal of Biology Chemistry, identified the role of a novel UDP-glycosyltransferase (UGT86) in the biosynthesis of labdane diterpenes in *Andrographis paniculata,* and

this knowledge is expected to contribute to developing better plant chemotypes and synthesis of pharmacologically relevant diterpenes. In another high-impact study from the plant biotechnology group published in *The Plant Journal*, a BAHD acetyltransferase was shown to be involved in wound-induced biosynthesis of oleo-gum resin triterpene in *Boswelia serrata*. During this period, bioactive designer molecules, 2-benzylindanocine, 2,3-diarylnaphthofurans, 3-aryl-3H-benzopyrans, and chroman-based triarylethylenes have been identified to exhibit potent anticancer activity via microtubule destabilization effect and estrogen receptors. Standardization of *Kaempferia galanga* L. rhizome and vasorelaxation effect of its key metabolite has been reported. We have developed a green solvent for the isolation of biopolymers from *Mentha arvensis* distilled biomass and saccharification to glucose for the production of methyl levulinate. This study helps to utilize the distilled biomass properly. A study on mentha distilled waste-derived biochar amendment on herbicide-contaminated soil indicated that biochar significantly reduced the herbicide toxicity on soil microbes and immobilized the herbicide. Another work demonstrated that lemongrass-loaded chitosan and cellulose nanofibers could be good options for controlling the indoor air bioaerosol concentration. Further, we have also developed a nondestructive method to determine the nitrogen content in the menthol mint using spectral characteristics of menthol mint. The genetic variability and stable genotype selection over the years in the germplasm of critically endangered Prishanparni (*Uraria picta Desv*.) were made for commercial cultivation in northern Indian plains.

During this period, the institute published 94 research papers in high-impact journals, with a cumulative impact factor of 371.704 (IF 4.04 per paper) and 02 patents were filed. Six technologies have been licensed or commercialized for 8 different industries. CSIR-CIMAP has signed 12 MoUs with various organizations/NGOs/Universities/ State Government/ Corporate Sector/ FPOs etc., in the year 2021-22. The institute has earned ₹ 30.56 Lakhs as premia and ₹ 20.16 Lakhs as royalty. During this year, we renovated tissue culture and biotechnology greenhouse facilities to bring them at par with the global standard.

Our continuous efforts and work have earned accolades from other agencies and bodies. The institute has received various prestigious awards during FY 2021-22, including JC Bose national fellowship (Dr. Prabodh K. Trivedi) by SERB, Govt. of India. Fellow of the National Academy of Sciences, India (Dr. Dinesh A Nagegowda), Sir CV Raman Young Scientist award (Dr. Dinesh A Nagegowda), by Govt. of Karnataka, India, INSA Young Scientist Medal (Dr. Akansha Singh) and Professor K.K. Nanda Memorial Lecture Award-2021 from the Indian Society for Plant Physiology (Dr. Prabodh Kumar Trivedi). In addition, three of our scientists, Dr. Dinesh A Nagegowda, Dr. Suaib Luqman, and Dr. Ram Swaroop Verma, also featured in the list of the world's top 2% scientists database 2021 released by Elsevier BV based on a study conducted by Stanford University, USA.

The strength of our institute lies in our students and during this tenure, 24 students were awarded Ph.D. through AcSIR and JNU Ph.D. programs, and 16 new students enrolled in these Ph.D. programs. This year 01 scientist and 12 other staff have superannuated. I want to take this opportunity to thank all our scientific, technical, and administrative staff and students for their commitment, enthusiasm, and dedication to propel CSIR-CIMAP in the trajectory of a world-class R&D institute in the field of MAPs. I also take this opportunity to extend our sincere gratitude to the Director General, CSIR for rendering us valuable support, encouragement, and guidance in the overall science and technology management of our institute. We are extremely grateful to the chairpersons and members of the Research and Management Councils for showing right direction to research activities of the institute. We are also thankful to all our sponsors, funding agencies, industry partners, collaborators, peers, academia, other supporters, and well-wishers for the generous support and cooperation extended to us directly or indirectly in multiple ways. Hope with their support, our current brigade of scientists, research scholars, and technical and administrative staff will take the institute to a new level.

(Prabodh Kumar Trivedi)

निदेशक की कलम से.....

मुझे सीएसआईआर–केन्द्रीय औषधीय एवं सगंध पौध संस्थान (सीएसआईआर–सीमैप) का वर्ष 2021–22 का वार्षिक प्रतिवेदन प्रस्तुत करते हुए अत्यंत हर्ष का अनुभव हो रहा है, जो संयोग से भारतीय स्वतंत्रता के अमृत महोत्सव का भी वर्ष है।

सीएसआईआर–सीमैप का मुख्यालय लखनऊ में है एवं इसके चार अनुसंधान केन्द्र–पुरारा, पंत नगर, बैंग्लूरू एवं हैदराबाद विभिन्न कृषि–जलवायु क्षेत्रों में स्थित हैं। सीएसआईआर–सीमैप, सीएसआईआर की एक अग्रणी प्रयोगशाला है जो औषधीय व सुगंधित पौधों तथा विभिन्न उच्च मूल्य वाले फाइटोकेमिकल्स से संबंधित विश्वस्तरीय प्रतिस्पर्धी और अत्याधुनिक अनुसंधान करने के लिए विख्यात है। औषधीय व सगंध फसलों की उन्नत किस्मों को हमारा संस्थान पारंपरिक तथा अत्याधुनिक प्रौद्योगिकियों जैसे जीनोम एडिटिंग व पाथवे इंजीनियरिंग के द्वारा विकसित करने में संलग्न है। संस्थान विभिन्न मानव विकारों और बीमारियों के तथा कोविड–19 निवारण हेतु हर्बल उत्पादों का विकास कर रहा है। औस फसलों की उन्नत खेती कर किसानों और उद्यमियों की आर्थिक दशा में सुधार के लिए कई व्यावसायिक मॉडल्स के निर्माण के लिए भी संस्थान निरंतर प्रयासरत है। कोविड–19 की दूसरी और तीसरी लहर के कारण आई अभूतपूर्व चुनौतियों के बावजूद हमने न केवल अपने वैज्ञानिक और तकनीकी कर्मचारियों, शोधार्थियों तथा संबंधित लोगों की सुरक्षा के लिए समुचित उपाय किए वरन् कुशल वित्तीय प्रबंधन के द्वारा अपने अनुसंधान और विकास कार्यक्रमों को भी अनवरत् गति से आगे बढ़ाया।

सीएसआईआर, एरोमा मिशन की नोडल प्रयोगशाला के रूप में सीएसआईआर–सीमैप ने किसानों, सुगंध आधारित उद्योगों और उद्यमियों की आर्थिक स्थिति बेहतर बनाने में उल्लेखनीय प्रगति की है। इस दौरान इस मिशन में लगभग 4500 हेक्टेयर भूमि में सुगंधित फसलों की खेती प्रारंभ हुई। जिसमें विभिन्न महत्वाकांक्षी जिले, अन्य क्षेत्र तथा ऐसे जिले शामिल हैं जो बार–बार बाढ़, चक्रवात और सूखा जैसे प्राकृतिक आपदाओं से प्रभावित होते हैं। इसके अलावा अनुपयोगी क्षेत्रों में प्रतिकूल परिस्थितियों के प्रति सहिष्णुता रखने वाले सुगंधित फसलों की खेती को बढ़ावा देकर उन्हें भी उपयोगी बनाया जा रहा है। इस मिशन के माध्यम से हमारा प्रयास किसानों विशेषतः जनजातियों और आर्थिक रूप से कमजोर वर्गों को कृषि भूमि के एक छोटे टुकड़े से भी उच्च आय प्राप्त करने के लिए, एक वैकल्पिक फसल देना है। इसी क्रम में यूकेलिप्टस सिट्रिओडोरा का एक उच्च सिट्रोनेला युक्त क्लोन सिम–नंदी को व्यावसायिक खेती के लिए विकसित किया। इस दौरान हमारे द्वारा आयोजित 70 जागरूकता/प्रशिक्षण सह कौशल विकास कार्यक्रमों का आयोजन किया गया, जिससे 1500 महिलाओं सहित 7900 से अधिक लोग लाभान्वित हुए।

सीएसआईआर–सीमैप सीएसआईआर के अनेक महत्वपूर्ण अनुसंधान एवं विकास कार्यक्रमों में भी अग्रणी एवं सक्रिय भूमिका निभा रहा है। हमारा संस्थान जीनोम एडिटिंग के द्वारा फसल सुधार की सीएसआईआर की परियोजना (MLP–07) में नोडल प्रयोगशाला है, जिसके तहत कम निकोटीन वाले तंबाकू के पौधों को तैयार करने के साथ–साथ विभिन्न औषधीय फसलों के लिए भी अत्याधुनिक आणविक तकनीकों के मानक स्थापित किए गए हैं। सीएसआईआर की अन्य नेटवर्क परियोजनाओं जैसे बायोस्टिमुलेंट्स (MLP–049) तथा एंडोफाइट्स (MLP–048) में भी हम सहभागी प्रयोगशाला हैं– जिसके माध्यम से हम टमाटर व कई अन्य फसलों की बढ़वार एवं उपज में वृद्धि हेतु कई औषधीय और सुगंधित पौधों तथा समुद्री शैवाल आधारित बायोस्टिमुलेंट्स व उत्कृष्ट और संभावनापूर्ण बैक्टीरियल एंडोफाइट्स के प्रभाव का परीक्षण कर रहे हैं। इसके अलावा सीएसआईआर–सीमैप ने विभिन्न परियोजनाओं के माध्यम से कई महत्वपूर्ण अनुसंधान एवं विकास कार्य किए हैं, जिनमें 30 (GAP, CNP और सीएसआईआर परियोजना) वित्तीय वर्ष 2021–22 के दौरान स्वीकृत हुए। करेंट मॉलिकुलर फार्माकोलॉजी नामक जर्नल में सिट्रोनेलॉल के ट्रिपल नेगेटिव स्तन कैंसर कोशिकाओं पर प्रकाशित हमारे एक शोध पत्र में पड़ने वाले आणविक कारकों और एंटीप्रोलिफेरेटिव प्रभाव को दर्शाया गया है। जर्नल ऑफ एडवांस्ड रिसर्च में प्रकाशित एक अन्य अध्ययन में मनुष्य के एपीडर्माइड कार्सिनोमा कोशिकाओं में G2/1M चरण को बाधित करके एवं उप–द्विगुणित कोशिकाओं की संख्या में वृद्धि करने में नियोमेंथॉल की आशाजनक गतिविधि पाई गयी है। हमारे संस्थान के प्लांट बायोटेक्नालॉजी समूह के द्वारा किया गया एक अन्य शोध जर्नल ऑफ बायोलॉजीकल केमिस्ट्री में प्रकाशित हुआ है, जिसमें एंडोग्राफिस पैनिकुलैटा में लैब्डेनडाईटरपिन्स जैव संश्लेषण में एक नवीन यूडीपी–ग्लाइकोसिलट्रांसफरेज (UGT86) की भूमिका की पहचान की है, जिससे हमें फार्माकोलॉजिकल रूप से संश्लेषित बेहतर कीमोटाइप विकसित करने की आशा है।

इसी समूह का एक अन्य उच्च प्रभाव वाला अध्ययन प्लांट जर्नल में प्रकाशित हुआ है, जिसमें बोस्वेलिया सेरेटा में एक BAHD-एसिटाइल ट्रान्सफरेज का संबंध घाव द्वारा उत्सर्जित ओलियोगम रेजिन ट्राइटरपीन के साथ दर्शाया गया। इस अवधि में बायोएक्टिव डिजाइनर मॉलिक्यूल्स 2–बेंजाइलइनडेनोसिन, 2–3 डायरिलनाफ्थोफ्यूरन्स 3–एरिल–3एच– बेंजोपाइरनस और क्रोमन–आधारित ट्राईएराईलएथलिंस् की पहचान भी की गई, जो सूक्ष्मनलिकाओं को अस्थिर करते हैं तथा शक्तिशाली कैंसररोधक क्षमता भी रखते हैं तथा इस्ट्रोजन रिसेप्टर की भूमिका निभाते हैं। कैम्फेरिया गेलेंगा में राइजोम के मानक स्थापित करना तथा इसके मुख्य मेटाबोलाइट के वासोरिलैक्सेशन प्रभाव के कार्य को भी किया गया है। इसी अवधि में हमने मेंथा आर्वेसिंस के डिस्टिल्ड बायोमास से बायोपॉलिमर निकालकर, ग्लूकोज के सैकैरीफिकेसन के द्वारा मिथाइल लैविनुलेट के उत्पादन के लिए एक हरे रंग के सॉल्वेंट को विकसित किया है। इस अध्ययन से आसवन के बाद बचे हुए जैविक कचरे के समुचित उपयोग में सहायता मिलेगी। एक अन्य अध्ययन में पाया गया है कि खरपतवारनाशक के अत्यधिक प्रयोग से प्रदूषित मिट्टी पर मेंथा के आसवन अवशिष्ट से बनाए गए बायोचार का अच्छा प्रभाव है, जिससे मृदा–जीवाणुओं पर खरपतवार नाशकों के जहरीले दुष्प्रभाव को भी रोका जा सकता है। एक अन्य शोध में प्रदर्शित किया गया है कि आंतरिक वायु बायोएरोसोल एकाग्रता को नियंत्रित करने के लिए लेमनग्रास–लोडेड काइटोसन और सेल्युलोज नैनोफाइबर अच्छे विकल्प हो सकते हैं। इसके अलावा, हमने मेन्थॉल मिंट की वर्णक्रमीय विशेषताओं का उपयोग करके मेन्थॉल मिंट में नाइट्रोजन सामग्री को निर्धारित करने के लिए एक गैर–विनाशकारी विधि भी विकसित की है। गंभीर रूप से विलुप्त पृशनपर्णी (यूरारिया पिक्टा) के जर्मप्लाज्म में वर्षों से अनुवांशिक परिवर्तनशीलता और स्थिर जीनोटाइप को चयनित करके उत्तर भारत के मैदानी इलाकों में व्यवसायिक खेती करने के लिये प्रदान किया गया।

इस अवधि के दौरान, संस्थान ने 371.704 (प्रति पेपर इमपेक्ट फैक्टर 4.04) के संचयी प्रभाव के साथ उच्च प्रभाव वाली पत्रिकाओं में 94 शोध पत्र प्रकाशित किए एवं 02 पेटेंट दर्ज किए गए। 8 विभिन्न उद्योगों के लिए 06 प्रौद्योगिकियों का लाइसेंसिंग व व्यवसायीकरण किया गया है। सीएसआईआर–सीमैप ने वर्ष 2021–22 में विभिन्न संगठनों/एनजीओ/विश्वविद्यालयों/राज्य सरकार/कॉर्पोरेट क्षेत्र/एफपीओ आदि के साथ 12 समझौता ज्ञापनों पर हस्ताक्षर किए हैं। संस्थान ने 30.56 लाख रुपये प्रीमिया के रूप में, और 20.16 लाख रुपये रॉयल्टी के रूप में अर्जित किए हैं। इस वर्ष के दौरान, हमने अपनी ऊतक संस्कृति और जैव प्रौद्योगिकी ग्रीनहाउस सुविधा को वैश्विक मानक के बराबर लाने के लिए पुनर्निर्मित किया।

हमारे निरंतर प्रयासों और कार्यों ने अन्य एजेंसियों और निकायों से प्रशंसा अर्जित की है। संस्थान ने वित्तीय वर्ष 2021–22 के दौरान विभिन्न प्रतिष्ठित पुरस्कार प्राप्त किए हैं, जिसमें एसईआरबी, भारत सरकार द्वारा जेसी बोस राष्ट्रीय फेलोशिप (डॉ. प्रबोध के. त्रिवेदी) शामिल हैं। इनमें प्रमुख हैं – राष्ट्रीय विज्ञान अकादमी, नासी फेलो (डॉ. दिनेश ए नागेगौड़ा), कर्नाटक सरकार द्वारा सर सीवी रमन यंग साइंटिस्ट अवार्ड (डॉ दिनेश ए नागेगौड़ा), इंसा युवा वैज्ञानिक पुरस्कार (डॉ आकांक्षा सिंह) और इंडियन सोसाइटी फॉर प्लांट फिजियोलॉजी की ओर से प्रोफेसर के.के. नंदा मेमोरियल लेक्चर अवार्ड–2021 (डॉ. प्रबोध कुमार त्रिवेदी)। इसके अलावा, हमारे तीन वैज्ञानिक, डॉ. दिनेश ए नागेगौड़ा, डॉ. शोएब लुकमान, और डॉ. राम स्वरूप वर्मा, स्टैनफोर्ड यूनिवर्सिटी, यूएसए द्वारा किए गए एक अध्ययन के आधार पर एल्सेवियर बीवी द्वारा जारी दुनिया के शीर्ष 2% वैज्ञानिक डेटाबेस 2021 की सूची में भी शामिल किये गये हैं।

हमारे संस्थान की मजबूती हमारे छात्रों में है। इस कार्यकाल के दौरान 24 छात्रों को एसीएसआईआर पीएच.डी. और जेएनयू पीएच.डी. कार्यक्रमों में डिग्री प्रदान की गयी है। इसके अलावा 16 नए छात्रों का भी नामांकन इन कार्यक्रमों में किया गया है। इस वर्ष 01 वैज्ञानिक और 12 अन्य कर्मचारी भी सेवानिवृत्त हुए हैं। मैं इस अवसर पर अपने सभी वैज्ञानिक, तकनीकी और प्रशासनिक कर्मचारियों और छात्रों को MAPs के क्षेत्र में एक विश्व स्तरीय शोध संस्थान के रूप में सीएसआईआर–सीमैप को आगे बढ़ाने के लिए उनकी प्रतिबद्धता, उत्साह और समर्पण के लिए धन्यवाद देना चाहता हूँ। मैं इस अवसर पर हमारे संस्थान के समग्र विज्ञान और प्रौद्योगिकी प्रबंधन में हमें बहुमूल्य समर्थन, प्रोत्साहन और मार्गदर्शन प्रदान करने के लिए महानिदेशक, सीएसआईआर के प्रति अपनी कृतज्ञता व्यक्त करता हूँ। संस्थान की अनुसंधान गतिविधियों को सही दिशा देने के लिए हम अनुसंधान और प्रबंधन परिषदों के अध्यक्षों और सदस्यों के बहुत आभारी हैं। हम अपने सभी प्रायोजकों, फंडिंग एजेंसियों, उद्योग भागीदारों, सहयोगियों, साथियों, शिक्षाविदों, पूर्व वैज्ञानिकों एवं अन्य समर्थकों और शुभचिंतकों के भी आभारी हैं, जिन्होंने हमें प्रत्यक्ष या अप्रत्यक्ष रूप से उदार समर्थन और सहयोग दिया है। आशा है कि उनके सहयोग से, वैज्ञानिकों, शोधार्थियों और तकनीकी और प्रशासनिक कर्मचारियों की हमारी वर्तमान टीम संस्थान को एक नए स्तर पर ले जाएगी।

प्रबोध

(प्रबोध कुमार त्रिवेदी)

R & D Activities

PHYTOCHEMISTRY

HIGHLIGHTS

Phytochemistry division has actively been involved in the various phytochemical aspects of Medicinal and Aromatic Plants (MAPs) such as phytochemical investigation, bioactivity guided isolation of molecules, structure elucidation, down-stream processing, supercritical fluid extraction technology, enantiomeric separation of chiral aromatics, quality assurance, C^{14}-dating based tool for authentication of plant secondary metabolites, chemical ecology, target based synthesis of designer molecules, new chemical processes, value addition etc. The faculties of the Phytochemistry division have collaborations within the institute and with other research organisations. Chemical Central Facility (CCF) of the division has different sophisticated instruments and serves analytical support to internal projects, external sample from farmers, industry and academics.

The division is significantly contributing to CSIR mission project i.e. Aroma Mission-II (HCP-007). The faculties of the division could earn five consultancy projects (CNP), nine Govt. Aided Projects (GAP392, GAP-410, GAP415, GAP432, GAP-444, GAP460, GAP-465, GAP-471, & SSP-433) and two CSIR-funded projects (MLP-09 & MLP-10) etc. which have been successfully executed during this period.

In Aroma Mission Phase-II, Phytochemistry division extended support for efficient distillation processing and also developed efficient process technologies for high demand aroma molecules, namely ambrox, *cis*-3-hexenol, vanillin, menthone and isomenthone, thymol, *p*-methane-3,8-diol. In addition, efficient processes have been developed for the isolation of lutein from marigold flowers (*Tagetes erecta* L.) and biotransformation of castor oil to (+)-gamma-decalactone. A method for the production and enhancement of lipids in oleaginous yeasts has also been optimized using *Prosopis Cineraria* (L.) Druce pod aqueous waste as natural inhibitor.






Scientists of Phytochemistry Divisional Unit

Upper Panel (L to R) : Dr. Ratnasekhar CH, Dr. Kapil Dev, Dr. CS Chanotiya, Er. Ashween D Nannaware, Dr. Ram Swaroop Verma, Dr. PK Rout, Dr. A. S. Negi, Dr. Sudeep Tandon, Dr. Karuna Shanker, Dr. Hariom Gupta and Dr. Atul Gupta

Lower Panel (L to R) : Ajayakumar PV, Er. G. D. Kiran Babu, Dr. J. Kotesh Kumar, Dr. RC Padalia, K.V.N. Satya Srinivas and Dr. V S Pragadheesh

The phytochemical investigation of some promising medicinal plants has been carried out. Five marker chemicals namely withaferin A, 27-deoxy-17-hydroxywithaferin A, withanone, 5β,6β-epoxy-4β-hydroxy-1-oxo-witha-2,24-dienolide, 17-Hydroxy withaferin A, have been isolated from leaves of *Withania somnifera* (L.) Dunal. Four marker chemicals have been isolated and characterized from *Cupressus torulosa* D. Don. Further, seven compounds have been isolated and characterised from *Oroxylum indicum* (L.) Benth. Three compounds namely, astridecane-1-ol, 17-*β*-sitosterol and *epi*-betulinic acid have been isolated from the ethyl acetate fraction of leaf extract of *Indigofera cordifolia*. Quercetin-3-O-rhamnoside and daucosterol were isolated from the leaf extract of *Getonia floribunda*. Investigation on bark of the *Putranjiva roxburghii* Wall. led to the isolation of five known triterpenoids *viz.* friedlein, methylputranjate, putrone, roxburghonic acid, putranjivadione and a novel triterpene roxburghonol. The roxburghonol has shown the antiplosmodial action (IC_{50}=4.1±1.75 µg/ml). Moreover, standardization study of *Kaempferia galanga* L. for vasorelaxation effect has been reported for the first time.

In aromatic plant chemistry, species and variety specific metabolic profiling of Indian medicinal herb *Ocimum* has been accomplished. A new myrcene rich essential oil was identified from aerial parts of *Glossocardia bosvallia* (L.) DC. The volatile signatures of specific chemotype of *Ocimum kilimandscharicum* collected from Kumaun region has been performed with unique aroma and introduced at field gene bank of CIMAP Pantnagar. Essential oil composition of *Artemisia pallens* (Davana) from tarai region of Uttarakhand, India has been established. Essential oil yield and composition of CIM-Sukhda variety of *Ocimum basilicum* L. at different phenological stages, plant density and post-harvest drying periods have been done. Twelve aromatic compounds have been isolated from species of *Cymbopogon* and *Curcuma*. Nineteen aromatic compounds have been identified as primary marker chemicals for the analysis of aromatic oil by Gas Chromatography. An optimization of distillation parameters of turmeric oil has been done.

During this period, many novel chemical transformations such as improved total synthesis of an investigational anticancer molecule named indanocine, conversion of bicyclic monoterpene hydrocarbons to terpinyl acetate, bornyl acetate and fenchyl acetate using 1%Pd-β-Zeolite in solvent free medium have been achieved. In the area of bioactive designer molecules, 2-benzylindanocine, 2,3-diarylnaphthofurans, 3-aryl-*3H*-benzopyrans and chroman based triarylethylenes have been identified to exhibit potent anticancer activity via microtubule destabilization effect and estrogen receptors. Additionally, different forskolin-indole-triazole conjugates have also been prepared as anticancer agents. Further, several mannich bases and triazole-chalcone derivatives were prepared as eugenol hybrids. MAPs mediated synthesis of zinc oxide nanostructures and surface modification for enhanced dye separation application has also been explored. Doped zinc oxide nanostructures have been prepared. New designed solar distillation apparatus both centralised and decentralized types have been developed for essential oil extraction.

Furthermore, analytical techniques have been developed for quality assurance and to study molecular interactions. Under these activities, a radiocarbon dating method for detection of synthetic citral in genuine lemongrass essential oils has been established. It will help in differentiating the lemongrass oil of natural origin or declared to be derived synthetically from citral. Enantiomers of chiral aromatics present in essential oil of *Ocimum* species have successfully been identified in Gas chromatography (GC) using cyclodextrin columns. A thermo-gravimetric based method has been developed for quantification of high boilers in patchouli essential oils. NMR based studies of cyclodextrin and mupirocin incusion complex and pi-pi stacking interactions in butylidine-linked pyridazinone-based system have been done. An efficient HPLC method has been developed for the quantification of vasicine and Vasicinone in *Adhatoda vasica* (L.).

In this period, Phytochemistry division earned thirty three research publications in SCI journals and four new GAP projects. The faculties of the division delivered nine invited talks at the dignified forums. In analytical support, more than eighteen thousand samples of GC, GC-MS, LC-MS, HPLC and HPTLC were served. Dr. Karuna Shanker has been elected as a Fellow of Royal Society of Chemistry (FRSC) and also won second prize for prestigious PD Sethi Award.

Dr. Arvind Singh Negi Mk vjfon flg uxh

An improved synthesis of indanocine and antiproliferative activity of 2-benzyl-indanocine *via* microtubule destabilization

Indanocine is an anticancer investigational drug of National Cancer Institute-USA. The present synthetic methodologies applied for the synthesis of indanocine require improvements. With this objective, we developed a new improved total synthesis of indanocine. It is a simple, efficient and straight-forward process which offers improved product yield by two fold (double yields) than previously reported yields.

Further, we prepared close analogues of indanocine as possible antiproliferative agents. Some of the benzylidene and 2-benzyl derivatives with free rotation at C2 position exhibited potential cytotoxicities against various human cancer cell lines HCT-116 (colon), MIA PACA-2 (pancreas), SW 620 (colon) and A549 (lung). Five of these analogues exhibited potential antiproliferative effect against HCT-116 and MIA-PACA-2 cell lines. Benzylindanocine induced microtubule destabilization by occupying colchicine binding pocket of β-tubulin. It also exhibited antiinflammatory activity by down-regulating proinflammatory cytokines, IL-6 and TNF-α. In *in-vivo* efficacy experiment *via* Ehrlich ascites carcinoma model, benzylindanocine reduced 78.4% of EAC tumour in Swiss albino mice at 90 mg/kg dose intraperitoneally. In *in-vivo* safety studies, benzylindanocine was found to be safe to rodents up to 1000 mg/kg dose. The concomitant anticancer and antiinflammatory activity of benzylindanocine is distinctive which suggests its further optimization for better efficacy and druggability (Fig.). Study also enlightens that increase in flexibility at 2-benzylidene system does not necessarily enhance the tubulin binding and hence the efficacy.

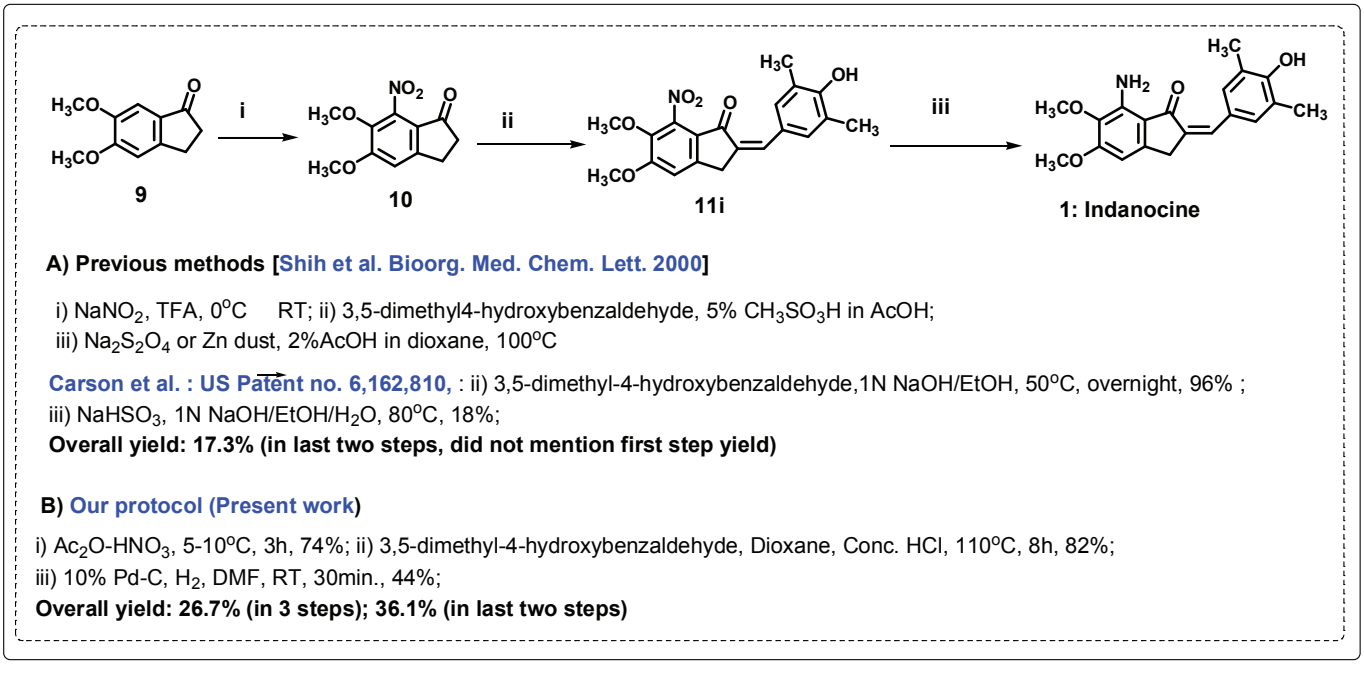


Fig. Schematic presentation of total synthesis of indanocine

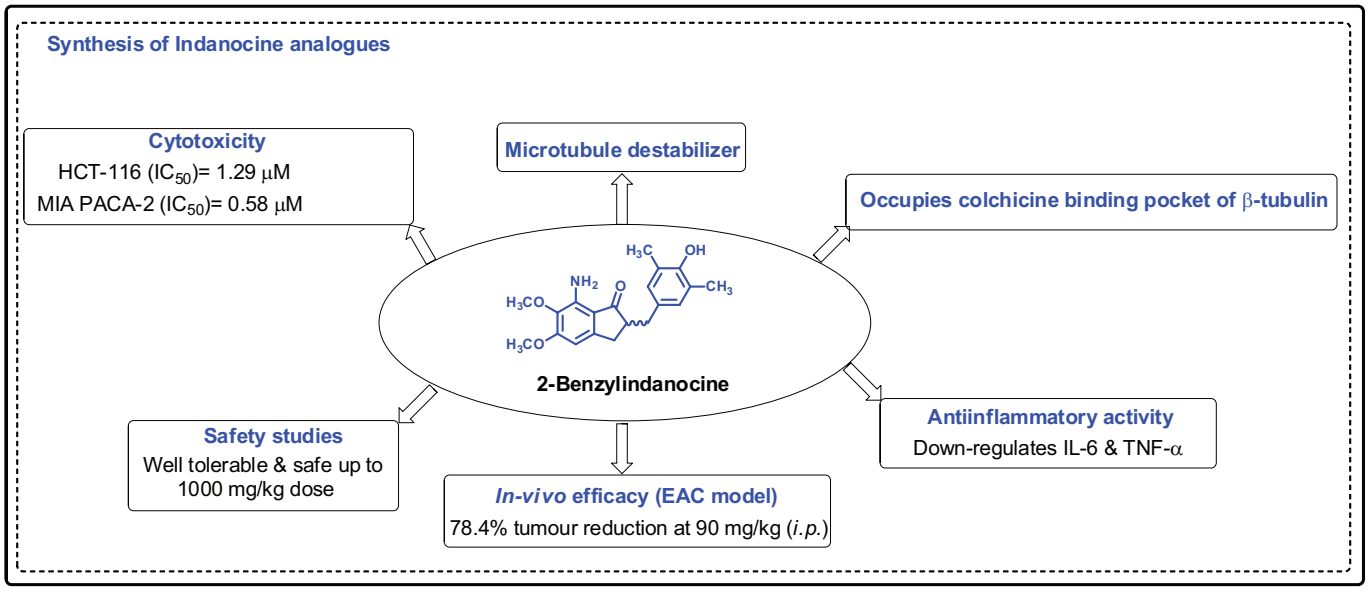


Fig. Anticancer activity of benzylindanocine

Antiproliferative activity of diaryl-naphthofurans *via* microtubule de-stabilization

Breast cancer is the most common cancer diagnosed in women. It is a multifactorial disease with diverse morphology and complications. This study deals with designing of a pharmacophore based on 'Fragment Based Drug Discovery' approach. Two series of compounds were synthesized and evaluated for antiproliferative activity against human cancer cell lines by sulphorhodamine assay, target studies *via* tubulin kinetics, *in-silico* predictions of binding pocket and druggability and safety studies by acute oral toxicity in mice model. Out of twenty four varied analogues, seven compounds exhibited significant antiproliferative activity against both hormone dependent and hormone independent breast cancer cell lines.

Among these, most active representative compounds, **1** and **2** showed potential antiproliferative activity against MDA-MB-231 with IC_{50} at 10.04 μM and 10.70 μM and significant antitubulin effects (Fig.). In molecular docking studies, both the compounds occupied colchicine binding pocket at β-tubulin with high binding energies of -8.3 Kcal/mol and -7.9 Kcal/mol respectively. Both the identified investigational

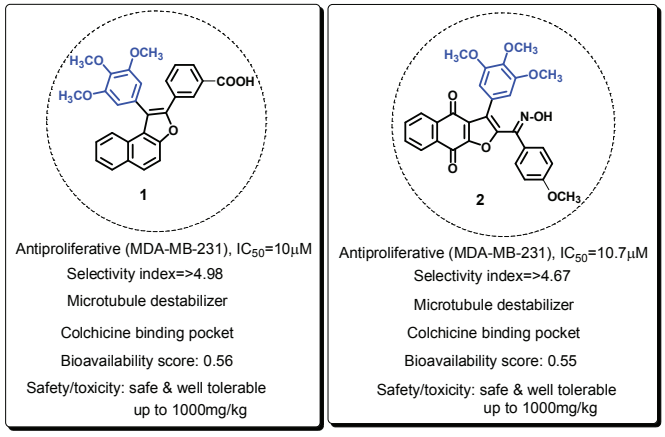


Fig. Anticancer activity of most active representative compounds 1 and 2

leads were found to be safe and non-toxic in rodent model up to 1000 mg/kg oral dose. Optimization of these lead compounds may yield some better candidates in future.

Dr. Arvind Singh & his team

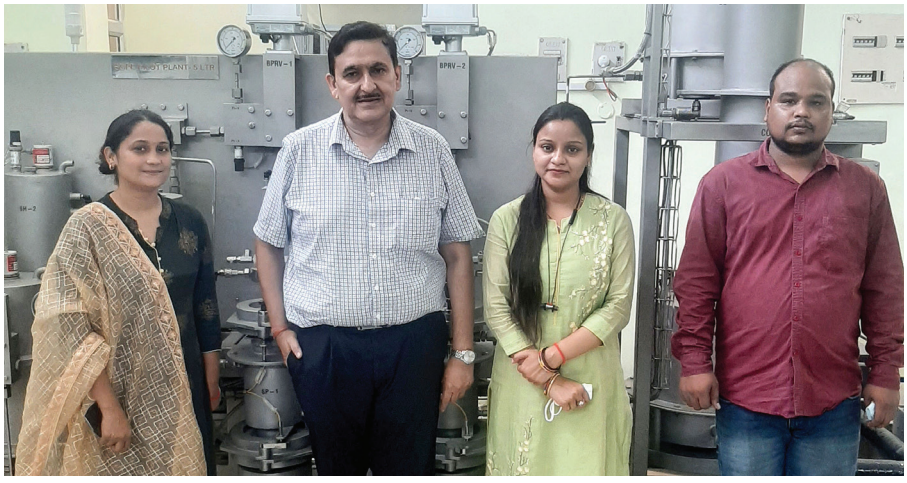
Dr. Sudeep Tandon Mk- lpnhi VMu

Studies on the variation of the yield and chemical composition of clary sage (*Salvia sclarea* L.) essential oil and absolute produced on pilot scale by different extraction techniques

Studies were carried out to evaluate the variation in the yield and chemical composition of the essential oil of clary sage (*Salvia sclarea* L) produced on a pilot scale by different distillation techniques, *viz*. steam-distillation using high-pressure steam, water-steam distillation at atmospheric pressure, and condensate recycling methods at atmospheric pressure, and to that of absolute prepared by solvent extraction technique (**Table**). The essential oil yield obtained by the recycling technique was observed to be higher (0.134±0.0025%) as compared to the water-steam distillation (0.113±0.005%) and steam-distillation processes (0.080±0.0025%). The absolute yield obtained by the solvent extraction method was observed to be 1.30±0.047%. The chemical composition of the essential oils obtained by different distillation techniques was dominated by linalool (9.9–36.6%) and linalyl acetate (27.7–55.5%). However, the absolute was exclusively characterized by the presence of sclareol (86.3%). The improved distillation technology, wherein the condensate was recycled back into the still through a packed column, also termed as cohobation technique, enhanced the recovery by almost 60% over conventional steam-distillation methods, which can highly benefit the farmers cultivating clary sage.

Table: Oil recovery under different modes and scales of distillation

S. no.	Mode of Distillation	Weight of flower spikes (kg)	Oil Recovery (mL)	Percentage of Oil (v/w)	Mean (± S.D.)
1.	Steam Distillation	20.0	16.6	0.083	0.080 ± 0.003
		30.0	24.0	0.080	
		40.0	31.4	0.078	
2.	Water-Steam Distillation	20.0	23.8	0.119	0.113 ± 0.005
		30.0	33.4	0.111	
		40.0	43.2	0.108	
3.	Distillation with Cohobation	20.0	28.0	0.140	0.134 ± 0.003
		30.0	41.5	0.138	
		40.0	54.2	0.135	



Dr. Sudeep Tandon & his team

Er. G.D. Kiran Babu b t h- t h- Mh- fdj.k ckc

Kinetic studies on hydro-distillation of *Curcuma longa* (L.) leaf oils

Twenty thousand hectares of land is presently under cultivation of Turmeric in the Telangana State which amounts to approximately 50,000 ton of agro-waste (aerial part). This agro-waste can produce 500 ton of essential oils worth Rs 25 crores. Efforts have been made to add value to this agro-waste by distilling the leaves to produce essential oil. *Curcuma longa*, cultivated in the village Issipetaof Parkal Mandal, Bhupalapalli, Telangana, was harvested in January 2022 when the leaf was ripe and dried (brown in colour). One thousand two hundred and fifty grams of dried brown *C. longa* leaves were charged along with 10 lit tap water into the Clevenger-type apparatus to study the kinetics of essential oil distillation. Volume of oil collected at different interval of time was recorded. The distillation was continued for 360 min for complete recovery of turmeric leaf oil. A total of 22ml oil was collected during the distillation. The samples were dried over anhydrous sodium sulphate and analysed by GC.

Mathematical models are useful in development of up-scaling procedures from laboratory to pilot and industrial scales. Such models are also used to generalise the experimental results and allow a rational approach to the extraction problems besides enabling to fit some experimental data for process simulation. To select an appropriate mathematical model for process simulation, knowledge on essential oil distribution in plant materials and experimental results on production kinetics can beused. While dealing so, aspects on solid material structure, locationof the compounds to be extracted, interaction of solutes with thesolid matrix, broken-intact cell structures and shape of particles need to be taken into account. Production of essential oil from Turmeric dry leaf by hydrodistillation was assumed to be a rate process.

First order rate kinetics

The rate of vaporization of oil during hydro-distillation depends on the solubility of its components in steam instead of their relative volatility. Production of essential oil from Turmeric dry leaf by hydro-distillation was assumed to be a rate process. Oil removed *per* unit time was directly proportional to oil remaining in the foliage. The simple rate equation was given by first order kinetics.

$$\frac{-dm}{dt} = km \text{ ---------- (1)}$$

Minus (−) sign signifies the decrease in the oil concentration as distillation proceeds. Equation (1) can be written as.

$$-\frac{dm}{m} = k.dt \text{ ---------- (2)}$$

on integrating the equation (2),

$$ln\frac{m_0}{m} = k.t \text{ ---------- (3)}$$

Equation (3) can be written as

$$ln\frac{1}{1-y} = kt \text{ ---------- (4)}$$

$$y = \frac{weight\ of\ the\ oil\ distilled\ till\ time\ t}{cumulative\ weight\ of\ oil\ distilled}$$

If the above model holds good, the plot of ***ln* (1/1-*y*)** versus ***t*** shall produce a straight line passing through the origin (Fig.) and the slope of straight line gives the rate constant, *k*.

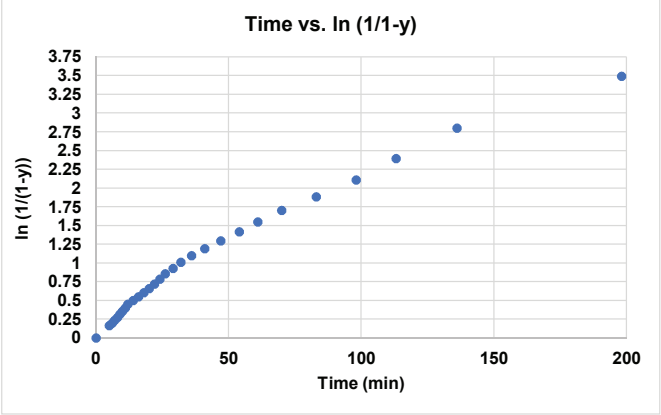


Fig. A plot of distillation time (t, min) vs ln(1/1-y)

A plot of ln(1/1 − y) versus t showed that the oil produced by hydro-distillation followed the first order kinetic model having 'k' values ranged from 0.02435 to 0.02912 min^{-1} for the set of experiments

designed in this study. A comparison of experimental data points with the data points calculated by first order kinetic model for different 'k' values is depicted in the graph. From the graph (Fig.), it is can be concluded that the rate constant (k) having values ranging from 0.02435 to 0.02912 min^{-1} suitably fits the experimental data to simulate the turmeric leaf oil distillation process.

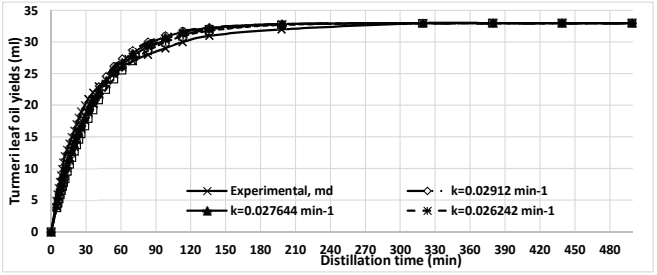


Fig. Turmeric Leaf oil Production: Comparison of Experimental *vs* Calculated (different first order rate constant 'k' values)

Variation in chemical composition of individual fractions of turmeric leaf essential oils

The turmeric leaf essential oil fractions collected during the above distillation experiment were analysed by GC and found that terpinolene is the major constituent followed by 1,8-cineol+lemonene, *p*-cymene and α-phellandrene (Fig.). The concentration of terpinolene in the individual fractions collected in different intervals of time has gradually increased initially from 50.3 to 63.1% *i.e.*, from fraction 1 to 13 *i.e.*, the fractions collected up to first 29 min. Thereafter, its concentration started decreasing from fraction 14

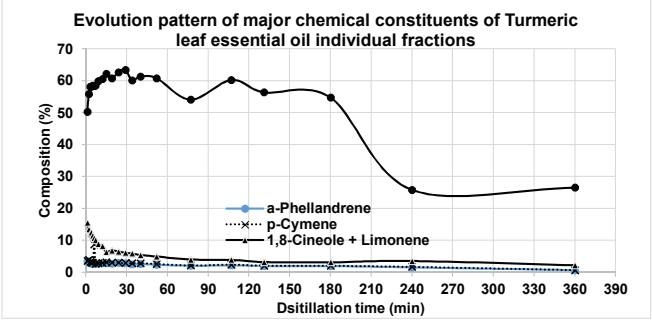


Fig. Variation in concentration of major chemical compounds in the *C. longa* leaf essential oil's individual fractions as hydro-distillation proceeds.

to 22 (60.2% to 26.5%) *i.e.*, from 34 min to 360 min as distillation proceeded. However, the concentration of 1,8-cineole+limonene steadily decreased from fraction 1 to 22 *i.e.*, from 15.6% to 2.2%. Similarly, the composition of α-phellandrene (from 3.5% to 0.7%) and *p*-cymene (from 3.9% to 0.7%) also decreased as distillation proceeded.

Variation in chemical composition of cumulative turmeric leaf essential oils fractions

The individual fractions, as obtained in the above experiment, were mixed sequentially from the beginning till the hydro-distillation is proceeded *i.e.*, from fraction 1 to 22, and cumulative fractions, thus obtained, were analyzed by GC to predict the chemical composition of these fractions.

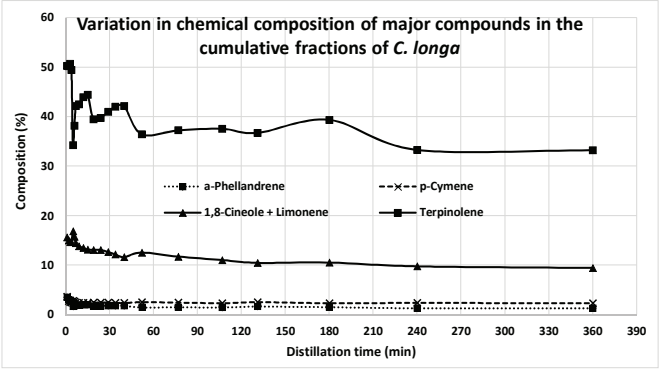
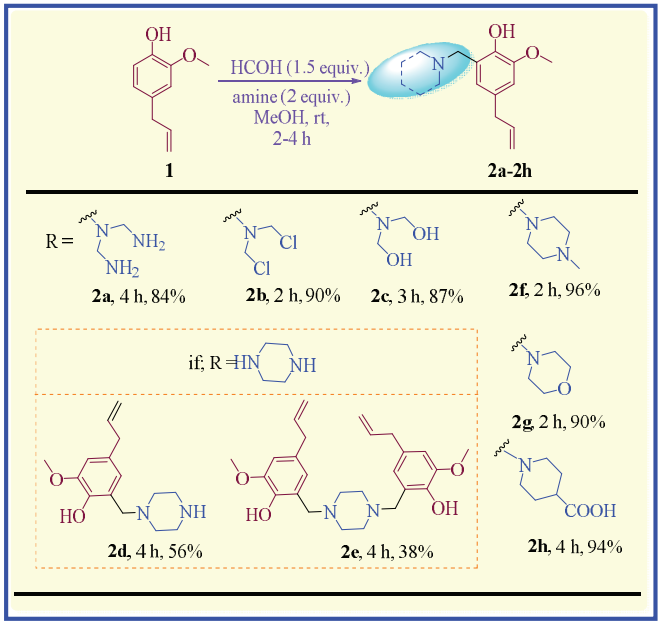


Fig. The composition of cumulative fractions of *C. longa* oil during hydro-distillation.

The concentration of all the major constituents decreased as distillation proceeded. The highest concentration of terpinolene (about 50%) was found the in the oils distilled in the beginning *i.e.*, the first four fractions distilled up to 1 min, 2 min, 3 min and 4 min. Thereafter, as the distillation time increased, the concentration of terpinolene decreased to 33.3% at the end of the distillation. Similarly, 1,8-cineole+limonene content was recorded high (16.9% to 14.4%) in the cumulative oils distilled up to 7 min. Further increase in distillation time, reduced the concentration of the 1,8-cineole+limonene content from first 9 min (13.8%) distillation to first 3h (10.5%). The concentration of the 1,8-cineole+limonene further

decreased, if the consolidated oil collected at 4h (9.7%) and at 6h (9.4%). However, not much variation was recorded in the *p*-cymene content throughout the distillation. The concentration of α-phellandrene gradually decreased from 3.5% to 1.3%.

Er. G.D. Kiran Babu & his team



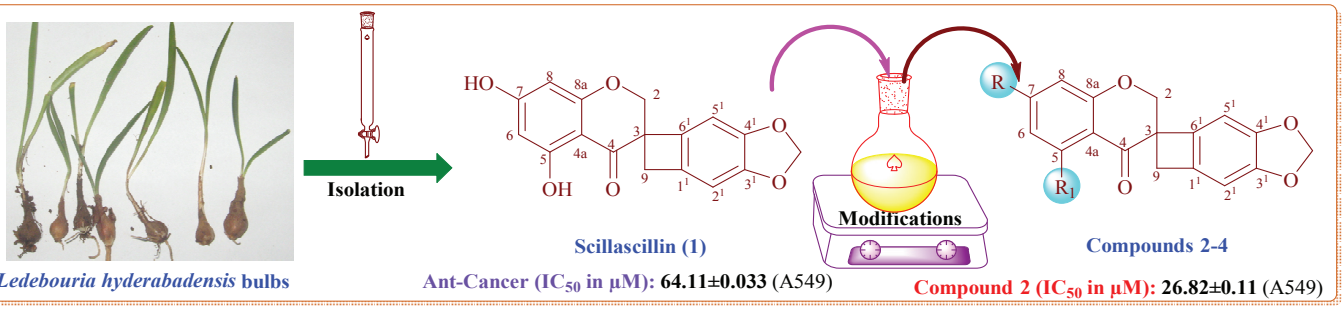
Dr. J Kotesh Kumar Mk- t- dkVs'k dqekj

Synthesis and bioactive evaluation of eugenol hybrids

Design, synthesis, and bioactivity evaluation of novel mannich bases (**2a-2j**) and triazole-chalcone derivatives (**7a-7k**) of eugenol (**1**) were reported. Among all the derivatives tested for antiproliferative activity, di-amine manich derivative **2b** and 4-methoxy-chalcone triazole derivative **7d** significantly inhibited hepatocellular carcinoma (HepG2 cells) at IC_{50} 32.92 µM and 33.05 µM, respectively, when compared to the standard doxorubicin (IC_{50}37.29 µM). The synthesized analogues were also tested for anti-diabetic and antiobesity potentials. Compounds **2f** (55.50%), **2c** (54.34%), **7g** (55.5%), and **2a** (55.5%) showed moderate inhibitory potential toward intestinal α-glucosidase enzyme as compared to the standard Acarbose (72.86%). Likewise, compounds **7d** (82.95%), **7f** (76.19%), **7g** (74.81%), **7e** (74.81%), and **2g** (72.50%) showed significant to moderate inhibitory potential toward pancreatic lipase enzyme as compared to the standard orlistat (91.10%).[***J. Heterocyclic Chem.*** **2021;**58(11), 2078-2089]

Synthesis of novel anticancer derivatives of a rare phytocompound scillascillin from a new species *Ledebouria hyderabadensis* (M.V. Ramana, Prasanna & Venu)

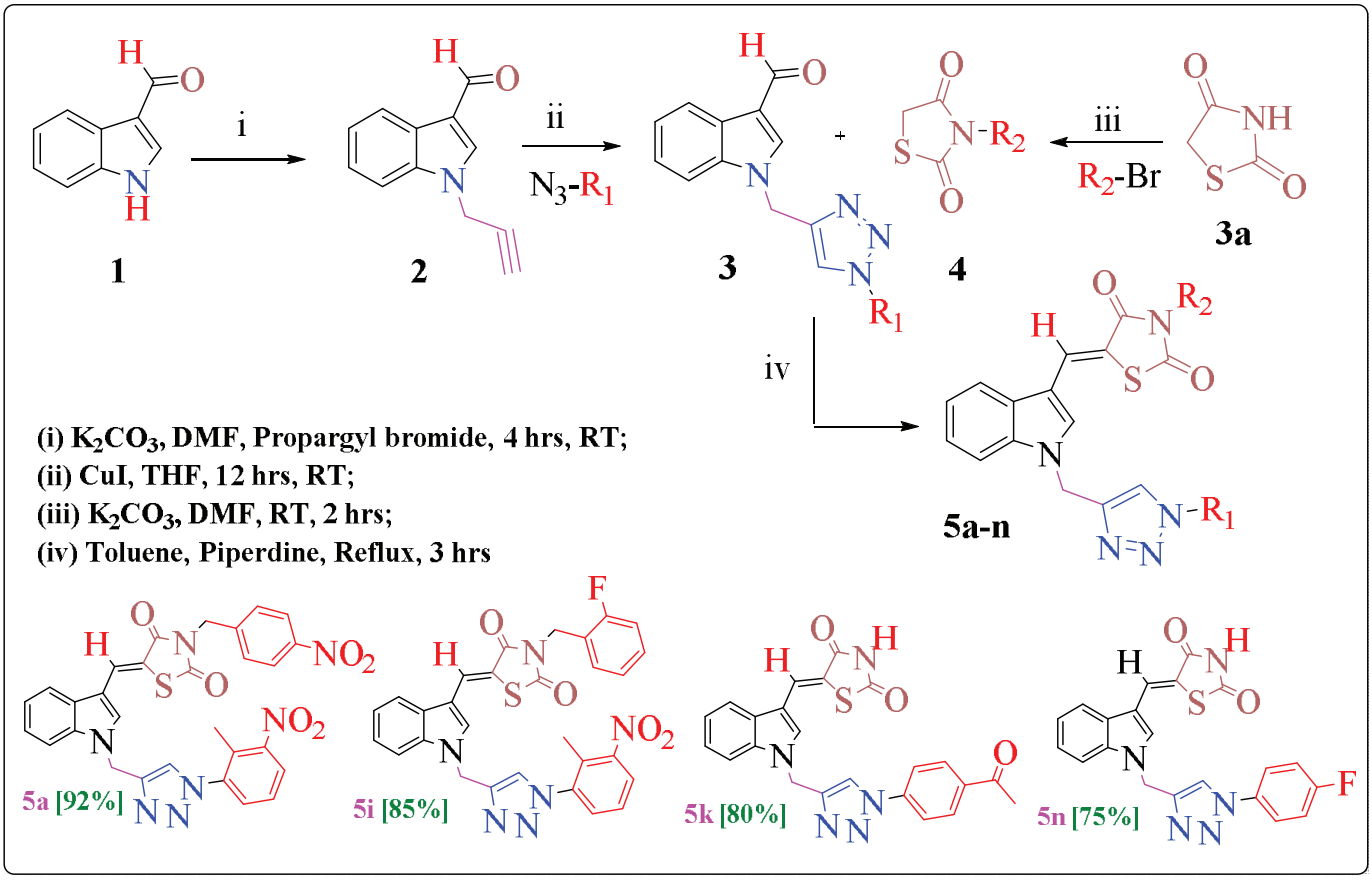
Ledebouria is a genus of deciduous or weakly evergreen bulbs in the Hyacinthaceae family. This is recognized as the first collection made of the new taxon *Ledebouria hyderabadensis*. The compound



scillascillin (**1**) is a rare and novel benzocyclobutene ring containing homoisoflavanone, isolated for the first time from *L. hyderabadensis*. Compound **1** and its semi-synthetic derivatives were evaluated for *in vitro* anticancer activity against human cancer cell lines Amongst all the compounds, **4** showed better anticancer activity against hepatocellular carcinoma HepG2 (IC_{50}: 61.34 ± 0.31 µM) as comparedtothe parent scillascillin (**1**, IC_{50}: 244.69 ± 0.01 µM).[***J.Med. Arom. Pl. Sci.*** **2021**, 43 (1-2), 200-204]

Synthesis of potential Lipase & α-glucosidase inhibiting novel hybrids of thiazolidinedione-triazoles.

Novel thiazolidinedione-triazole analogs (**5a-5n, 6**) were synthesized and screened for pancreatic lipase and intestinal α-glucosidase inhibitory activity. Analogs with nitro- and fluoro-benzyl substitutions at thiazolidinedione moiety, *i.e.* **5a** (IC_{50} 28.571 µM) and **5i** (IC_{50} 29.929 µM) and analogs with fluoro- and acetyl- phenyl substitutions at triazole moiety, *i.e.***5k** (IC_{50} 29.796 µM) and **5n** (IC_{50} 31.980 µM) demonstrated good lipase inhibitory activity. Similarly, compounds with bromo- and nitrile- benzyl substitutions, *i.e.***5c** (IC_{50} 23.502 µM) and **5d** (IC_{50} 24.840 µM) showed good α-glucosidase inhibitory activity. *In silico* docking studies of the compounds with human pancreatic triacylglycerol lipase (PDB: 1LPA) revealed good docking score and binding affinity in the range of 120.299–137.658, as compared to orlistat (155.391). The docking study of compounds with the enzyme, α-glucosidase (PDB: 2QMJ) showed docking scores in the range of 100.332–107.645 as compared to acarbose (123.536).[***Indian J. Heterocyclic. Chem.,*** **2021**, 31, 565-574]

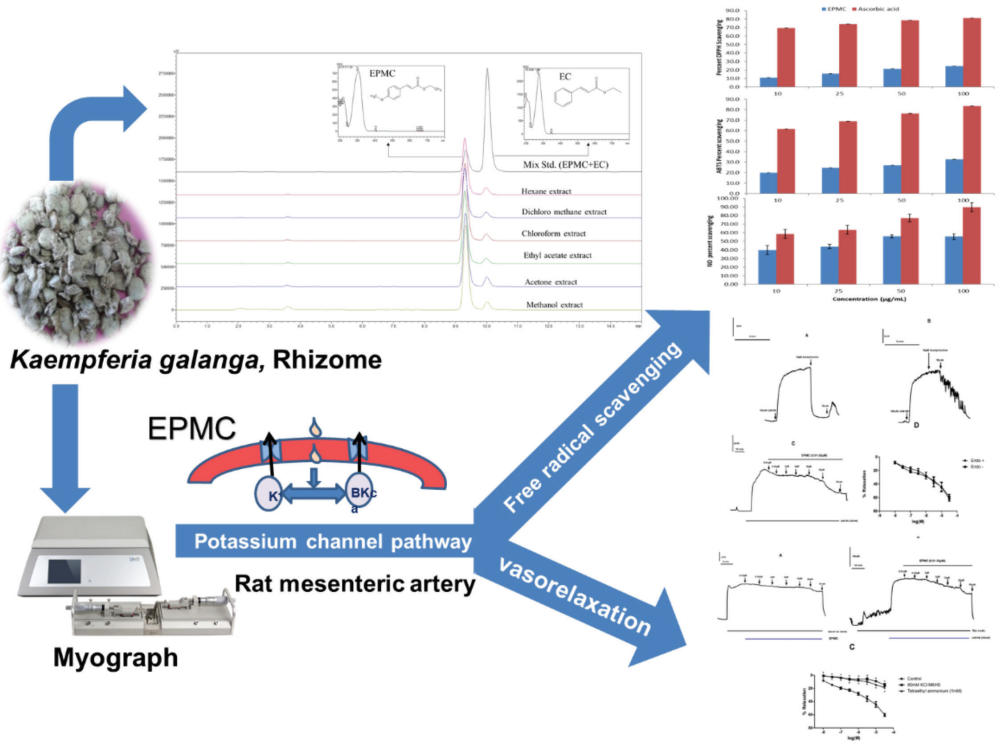


Dr. Karuna Shanker Mk- d : .kk 'kdj

Standardization of *Kaempferia galanga* L. rhizome and vasorelaxation effect of its key metabolite

Kaempferia galangal L. rhizome (KGR) is part of more than sixty-one *Ayurvedic* formulations and commonly known as '*Chandramula*'. KGR is widely used in traditional Indian medicines to treat fever (*Jwar*), rheumatism (*Amavata*), respiratory (*Shwasa*), hypertension (*Vyanabala vaishamya*) and cardiovascular disorders (*Vyanavayu Dushtijanya Hrudrog*). Although ethnomedicinal properties have extensively been demonstrated in traditional medicines of south-east countries i.e. China, India, Indonesia, and Malaysia, the chemico-biological validation are still lacking. The main objective of the present study was to establish the Chemico-biological standardization of KGR with respect to its vasorelaxation potential. Accordingly, a HPLC method was developed and validated for the quality assessment of KGR using its two major phytochemicals i.e. ethyl-*p*-methoxycinnamate (EPMC) and ethyl cinnamate (EC) in KGR. Present validated HPLC method facilitates simultaneous quantitation of EPMC and EC faster than classical GC techniques. The vasorelaxation effect of major phytochemicals of KGR was evaluated on the Main Mesenteric Arteries (MMA) isolated from male Wistar rats. Specific BKca channel blocker tetraethylammonium (TEA), receptor antagonist, nitric oxide scavenging capacity, and antioxidant potential were also evaluated to establish their plausible mechanism.

EPMC showed a dose-dependent relaxation in rat main mesenteric arteries (MMA) contracted by U46619 with an E_{max} of 58.68±3.31%. Similarly, in endothelium-denuded MMA rings, relaxation was also observed (E_{max} of 61.83±3.38%). Moreover, relaxation response to EPMC was strongly inhibited (E_{max} 14.76±2.29%) when the tissue exposed to depolarizing high K^+containing buffer for the contraction. The point correlation dimension (pD2) values were also significantly decreased in high K^+treated arterial rings compared to control. Interestingly, when MMA rings incubated with a specific BK_{ca} channel blocker (TEA, 1 mM), the relaxation response to EPMC was significantly blocked. For the first time, this study demonstrated chemical standardization of *K. galanga* rhizome and EPMC is responsible for its vasorelaxation potential as demonstrated by the endothelium-independent response mediated by Ca2+ dependent potassium channel.[*J. Ethanopharmacol*. **2021**, 271, 113911]

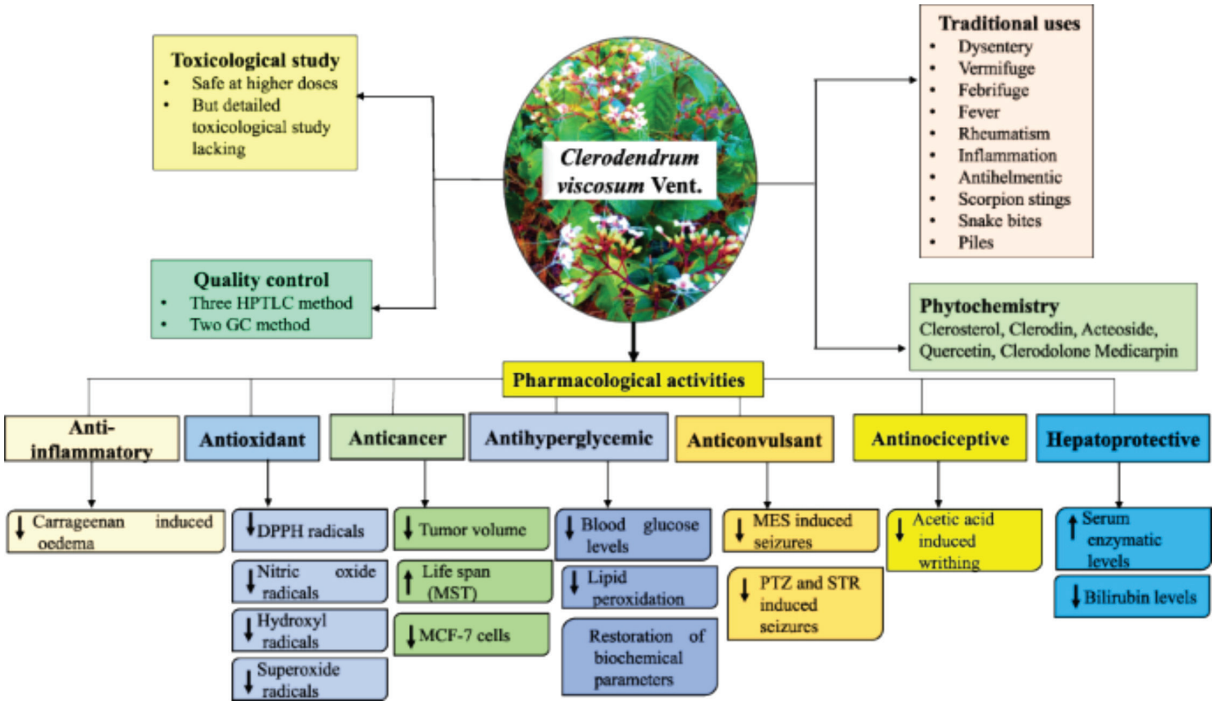


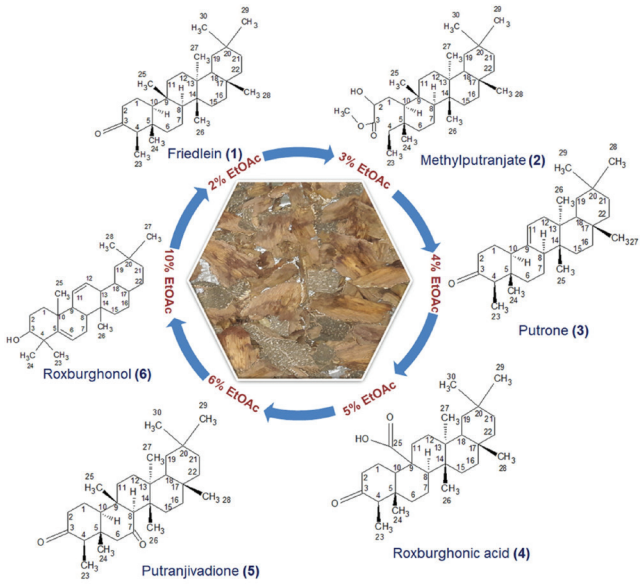
Systematic and comprehensive update on the phytochemistry, pharmacology, quality assurance, and safety data of *Clerodendrum viscosum* Vent.:A plant used in Dashamularishta

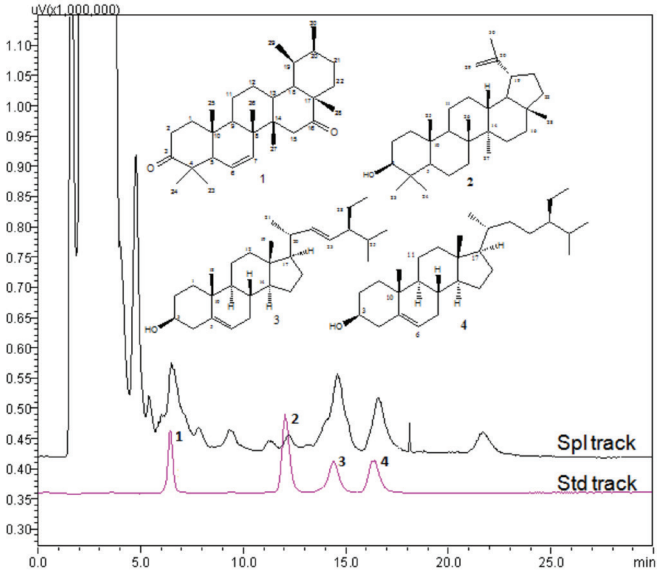
Clerodendrum viscosum Vent. is used in different indigenous systems of medicine by Asian ethnic communities. Significant advances in the validation of ethnomedicinal claims of *C. viscosum* are driving unprecedented opportunities for plant-based therapeutics leads and utilization of secondary metabolites for the mode of action studies. This study covered an updated and comprehensive review of the medicinal uses in traditional medicines, pharmacology, phytochemistry, and safety of C. viscosum. Extracts and phytoconstituents of *C. viscosum* have demonstrated a wide range of pharmacological effects such as anti-inflammatory, antioxidant, antidiabetic, anticancer, immunomodulatory, antibacterial, and hepatoprotection. More than fifty phytochemicals representing diverse class of secondary metabolites of both physiological and phytopharmaceutical significance have been reported from *C. viscosum*. The molecules with terpenoids, flavonoids, steroids, and the glycosylated chemical scaffold and biological activities of *C. viscosum* have demand in the pharmaceutical industry. An overview of the mechanism of action of prominent compounds has also been collated for future research on *C. viscosum*-based therapeutics. [*Med. Chem. Res.* **2021**, 30, 2145-2167]

Novel bioactive compound from the bark of *Putranjiva roxburghii* Wall

Putranjivah (Putranjiva roxburghii Wall, family – Putranjivaceae) is an Indian native medicinal plant used to treat many diseases such as treatment of mouth and stomach ulcers, hot swellings, smallpox, burning sensation and ophthalmopathy. The study of chemical constituents in the bark of *P. roxburghii* resulted in a new triterpene (**6**) along with five known triterpenoids (**1–5**). The chemical characterisation was based on ^{1}H, ^{13}C, 2D-NMR experimentation, and ESI-MS data. The anti-plasmodial activity was investigated by measuring parasite-specific lactate dehydrogenase (pLDH) based *in vitro* assay. The IC_{50} value results







showed that friedlein (2.40±0.70) and roxburghonol (4.10±1.7 µg/ml) possessed better anti-plasmodial activity than other isolated triterpenes (**2–5**) but not as potent as chloroquine (0.023±0.002 µg/ml) against chloroquine-sensitive *Plasmodium falciparum* (3D7) strain. [*Nat. Prod. Res.* **2021**, 35, 10, 1738-1740, **DOI:** https://doi.org/10.1080/14786419.2019.1633650]

x|.koÙkk fu;=.k d| fy, ,pih,ylh&ok"ih-dj.kh; çdk'k çdh.k¼**HPLC&ELSD**½ fof/k }kjk ,jM ¼***Ricinus communis***½ dh tM+ esa cg&t|o lfØ; inkFkk| dk fu/kkj.k

पहली बार, एचपीएलसी (HPLC–ELSD) एक सरल और विश्वसनीय विधि को ट्राइटरपीन्स और फाइटोस्टेरॉल एरंडोन (1), ल्यूपियोल (2), स्टिग्मास्टेरॉल (3) और साइटोस्टेरॉल (4) रिसिनसकम्युनिस (एरंड) रूट के एक साथ निर्धारण के लिए स्थापित किया गया। यह भारतीय प्रणाली में इस्तेमाल होने वाला एक महत्वपूर्ण पारंपरिक औषधीय पौधा है। क्रोमैटोग्राफिक पृथक्करण एक Phenonemex Luna–C18 (4.6 मिलीमीटर 50 मिलीमीटर, 3 माइक्रोमीटर) पर एसीटोनिट्राइल में 1: एसिटिक एसिड और पानी में 1: एसिटिक एसिड का उपयोग करके किया गया। विविध विधि सत्यापन पैरामीटर, जैसेकि रैखिकता (r^2 > 0.999), संवेदनशीलता (LOD और LOQ), सटीकता, दोहराव और प्रतिलिपि प्रस्तुत करने के लिए सफलतापूर्वक प्राप्त किए गए। एकनएडाइकीटोनपेंटा साइक्लिकट्राइटरपीन (एरंडोन) सहितये चार फाइटोकेमिकल्स (1–4) भौगोलिक–पर्यावरण गीय संपर्क के कारण आर. कम्युनिस की गुणवत्ता और इसकी रासायनिक संरचना में भिन्नता के मूल्यांकन के लिए मार्कर यौगिकों के रूप में क्षमता दिखाते हैं। [J. Med. Arom. Pl. Sci, 2021, 43 (1-2). 1-8].

Dr. Karuna Shanker & his team

Dr. R.C. Padalia Mk- vkj- lh- iMkfy ;k

Volatile signatures of specific chemotype of *Ocimum kilimandsharicum*

The essential of *O. kilimandsharicum* with unique aroma collected from Kumaun region and introduced at field gene bank of CSIR-CIMAP, Pantnagar, was studied. The essential oil composition was studied in half bloom, full bloom and seed setting stage of this chemotype of *O. kilimandsharicum*. The essential oil is mainly composed of eugenol (34.7-45.4%), methyl chavicol (10.8-11.5%) and 1,8-cineole (9.5-12.3%) (**Fig.**). Comparative results showed that this sweet smelling chemotype is the most widespread chemotype of basil in Kumaun regions and grown for medico-religious purpose in household.

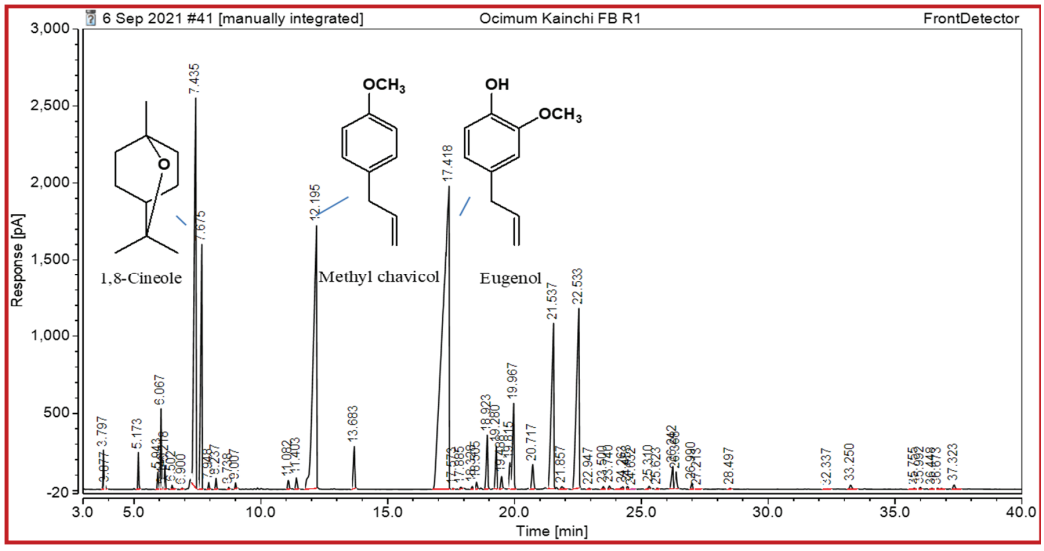


Fig. Gas chromatographic profile of Eugenol / Methylchavicol chemotype of *O. kilimandsharicum*

Essential oil composition of *Artemisia pallens* (Davana) from foothills tarai region of Uttarakhand, India

Davana a member of the daisy family, Asteraceae is used for its sweet fragrance and various other medicinal values. Its fragrant herb is indigenous to southern part of India. In present study, davana is cultivated at foothills climatic condition (Tarai region) of Uttarakhand and the essential oil composition of its fragrant herb was studied. The major constituents identified in the essential oil of fresh herb in flowering stage were *cis*-davanone (45.39%), bicyclogermacrene (10.92%), davana ether (6.33%), davanol acetate (4.90%) davanol (3.99%) (**Fig.**); while its flower essential oil contains *cis*-davanone (70.56%), bicyclogermacrene (4.92%), davana ether (3.82%), and davanol acetate (2.21%).

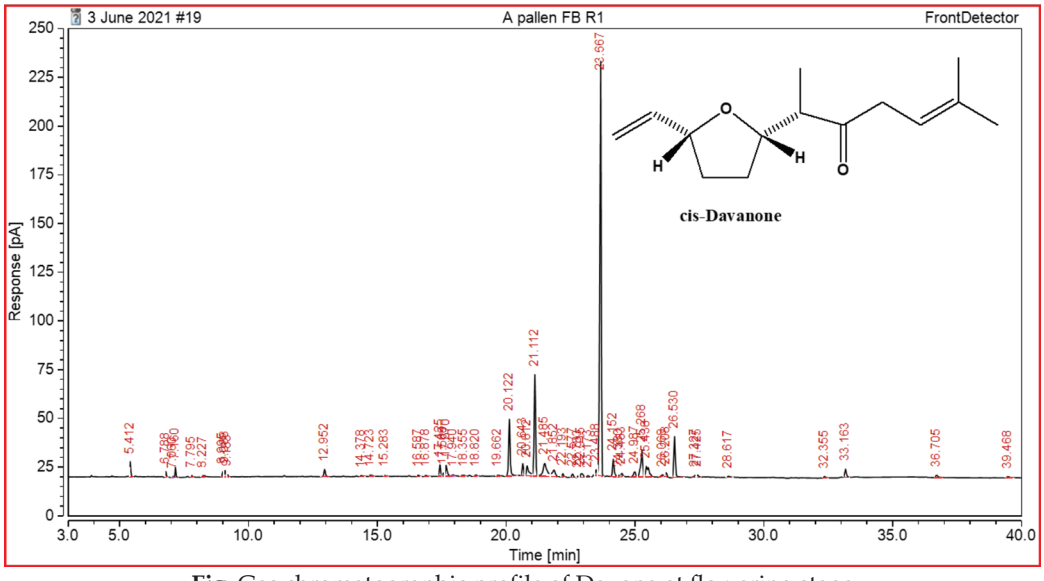


Fig. Gas chromatographic profile of Davana at flowering stage

Essential oil yield and composition of *Ocimum basilicum* L. at different phenological stages, plant density and post- harvest drying periods

The impact of phenological stages and plant density on productivity of quality essential oil of CIM-Sukhda variety of *O. basilicum,* as well as the effect of drying procedures on essential oil quality, were investigated. Four plant spacing (45cm×30cm, 45cm×40cm, 45cm×45cm, 45cm×60cm), four growth stages (vegetative, half bloom, full bloom and seed setting) and drying up to one month were compared in present study. Total 20 compounds were identified by GC and GC-MS, and linalool (66.9-84.2%), geranial (1.1-9.0%), neral (0.8-7.0%) and 1,8-cineole (0.5-3.4%) were identified as the major constituents. The results showed that both plant density and growth stages affecting herb yields and essential oil yields. Herb yield of plants is better in flowering and seed setting stages. Highest fresh herb yield (227.35q ha^{-1}) was observed in plant spacing 45cm×30cm followed by (188.82 q ha^{-1}) in spacing of 45cm×40cm. CIM-Sukhda is a linalool rich cultivar of basil. Higher yield of essential oil is produced in full bloom stage (106.2 kg ha^{-1}) with >75.0% of linalool. Linalool possess floral scents in nature and used in various fragrant products. Therefore, the presence of significance content of linalool (>70.0%) and essential oil yield potential (unto 106.2 kg ha^{-1}) offer promise for cultivation of this crop in tarai agroclimatic conditions of Uttarakhand.

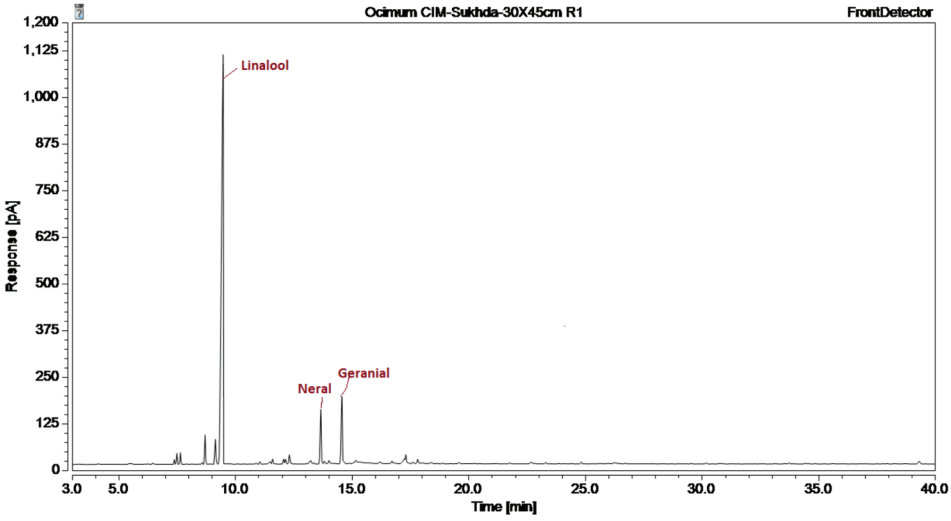


Fig. Gas chromatographic profile of *O. basilicum* var. CIM-Sukhda

Dr. R.C. Padalia & his team

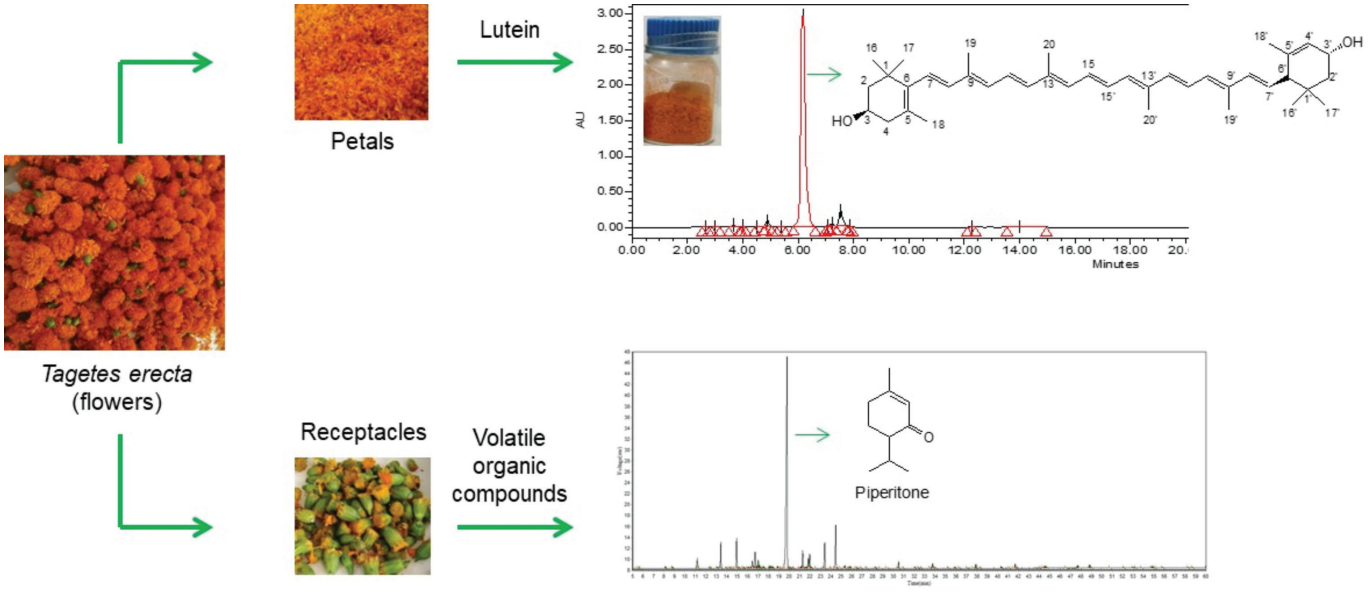
Dr. Ram Swaroop Verma Mk- jke Lo : i oek

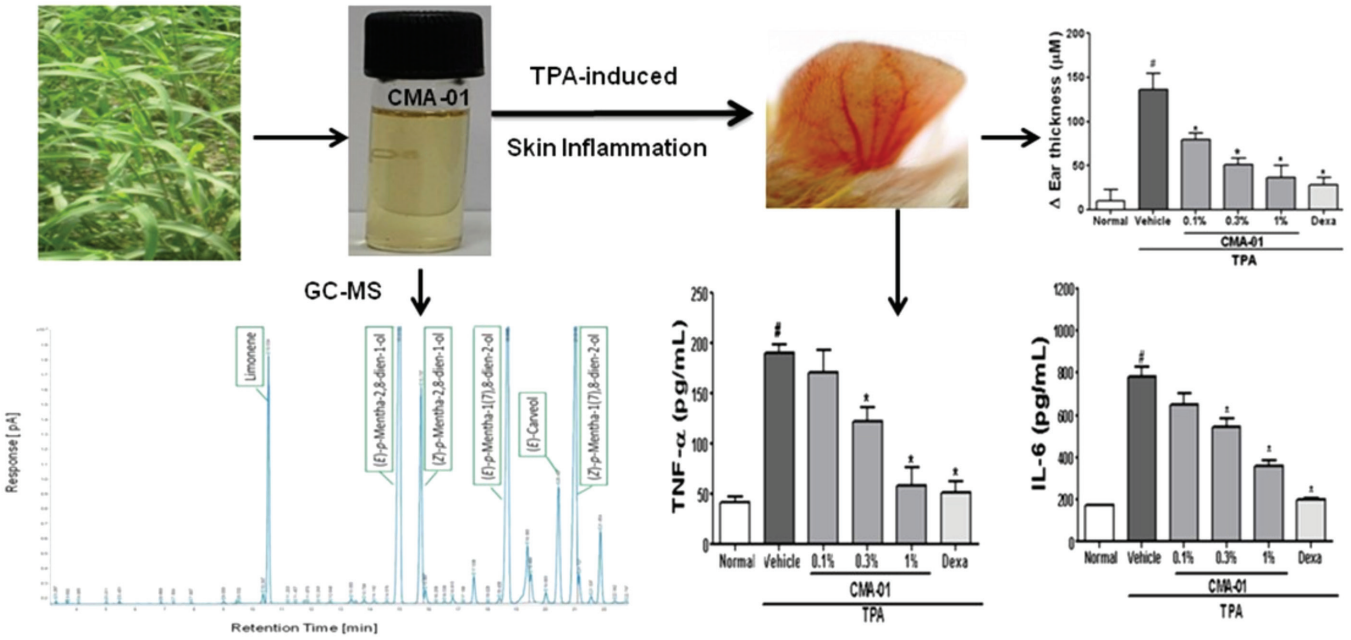
An efficient process for the extraction of lutein and chemical characterization of other organic volatiles from marigold (*Tagetes erecta* L.) flower

Marigold (*Tagetes erecta* L.) petals are the primary industrial source of lutein, which is used as a colouring agent and nutrient supplement to foods. This research extracted marigold petals using different solvents, covering conventional and non-toxic green solvents. The oleoresin, free lutein, and recrystallized lutein yields varied from 8.47-16.67%, 2.56-9.62%, and 1.11-1.61%, respectively. The purity of lutein was achieved up to 92.57% and 97.64% in conventional and newly established green methods, respectively. The present study described an efficient green process to isolate lutein with significantly improved yield (2.56%) and purity (97.33%) over the conventional methods. Based on the results, 2-methyltetrahydrofuran could be a practical green alternative to the traditional toxic solvents for the processing of lutein. Further, the chemical analysis of the essential oil of the residual receptacles obtained after removing petals revealed the presence of important organic volatiles, including piperitone (54.7%) and piperitenone oxide (6.5%), indicating its usefulness for value-addition. (***Food Chemistry, 2022***, *396, 133647, https://doi.org/10.1016/j.foodchem.2022.133647*).

p-Menthadienols rich essential oil from *Cymbopogon martini* ameliorates skin inflammation

Cymbopogon martini variety *sofia,* commonly known as ginger-grass, is an important aromatic crop used by perfumery, medicinal and cosmetic industries worldwide. The study explores the chemical and possible pharmacological profile of hydro-distilled essential oil of *C. martini* variety *sofia* against skin inflammation.The essential oil extracted by the hydrodistillation process was analyzed by gas chromatography (GC), gas chromatography-mass spectrometry (GC-MS) and nuclear magnetic resonance spectroscopy (NMR) to identify its constituents and coded as CMA-01 for further *in-vitro* and *in-vivo* pharmacological study related to skin inflammation. Chemical fingerprint revealed that CMA-01 oil has (*E*)-*p*-mentha-2,8-dien-1-ol (21.0%), (*E*)-*p*-mentha-1(7),8-dien-2-ol (18.1%), (*Z*)-*p*-mentha-1(7),8-dien-2-ol (17.4%), (*Z*)-*p*-mentha-2,8-dien-1-ol (9.0%), limonene (7.7%), and (*E*)-carveol (5.7%) as





major components. The pre-treatment of CMA-01 showed significant inhibition of pro-inflammatory markers in activated HaCat cells without cytotoxic effect. The *in-vivo* study revealed the ameliorative impact of CMA-01 against skin inflammation induced by TPA in mouse ears as evidenced by reduction of ear oedema, pro-inflammatory mediators (IL-6, TNF-α), lipid peroxidation and histological changes in ear tissues without any skin irritation response on rabbit skin. These findings suggest the suitability of CMA-01 as a valuable therapeutic candidate for the treatment of skin inflammation. (***Infammopharmacology, 2022**, 30, 895–905*).

Dr. Ram Swaroop Verma & his team

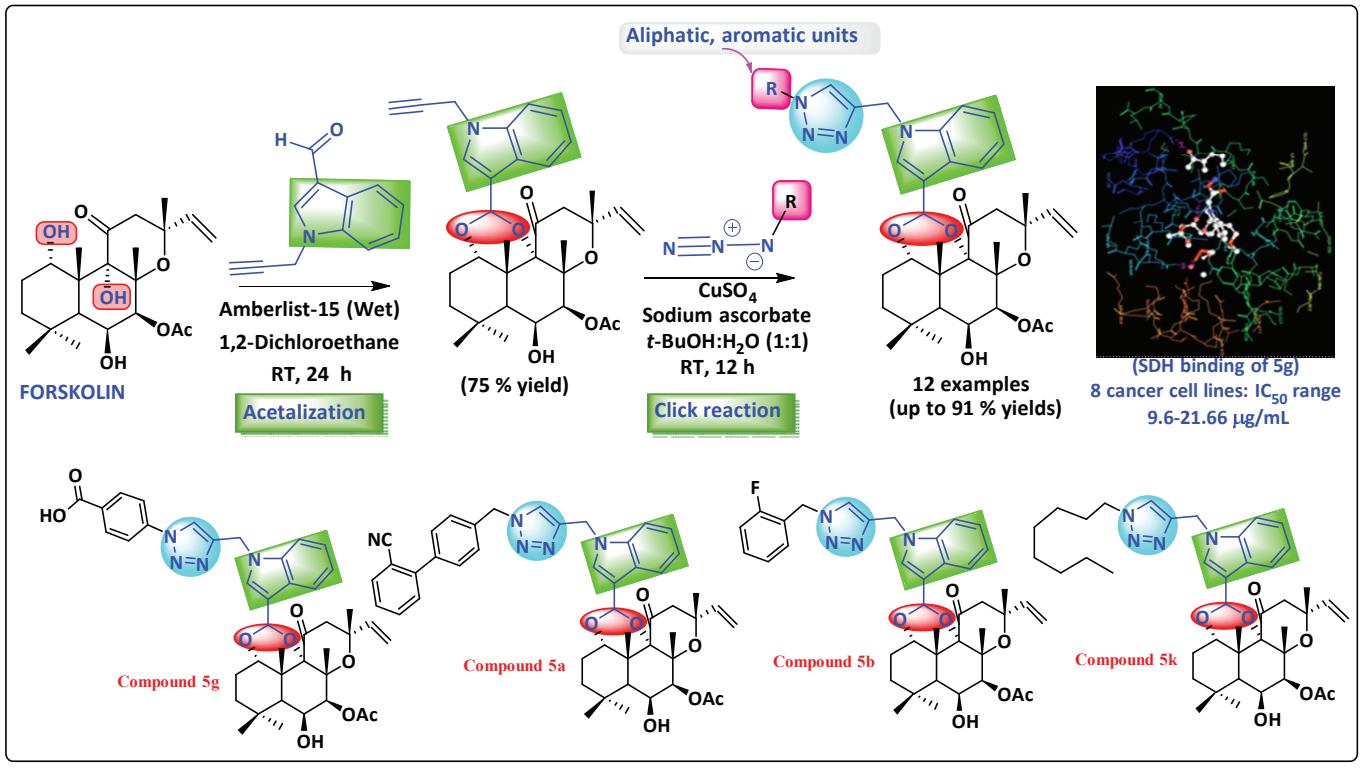
K.V.N. Satya Srinivas d-oh-,u- lR;k Jhfuokl

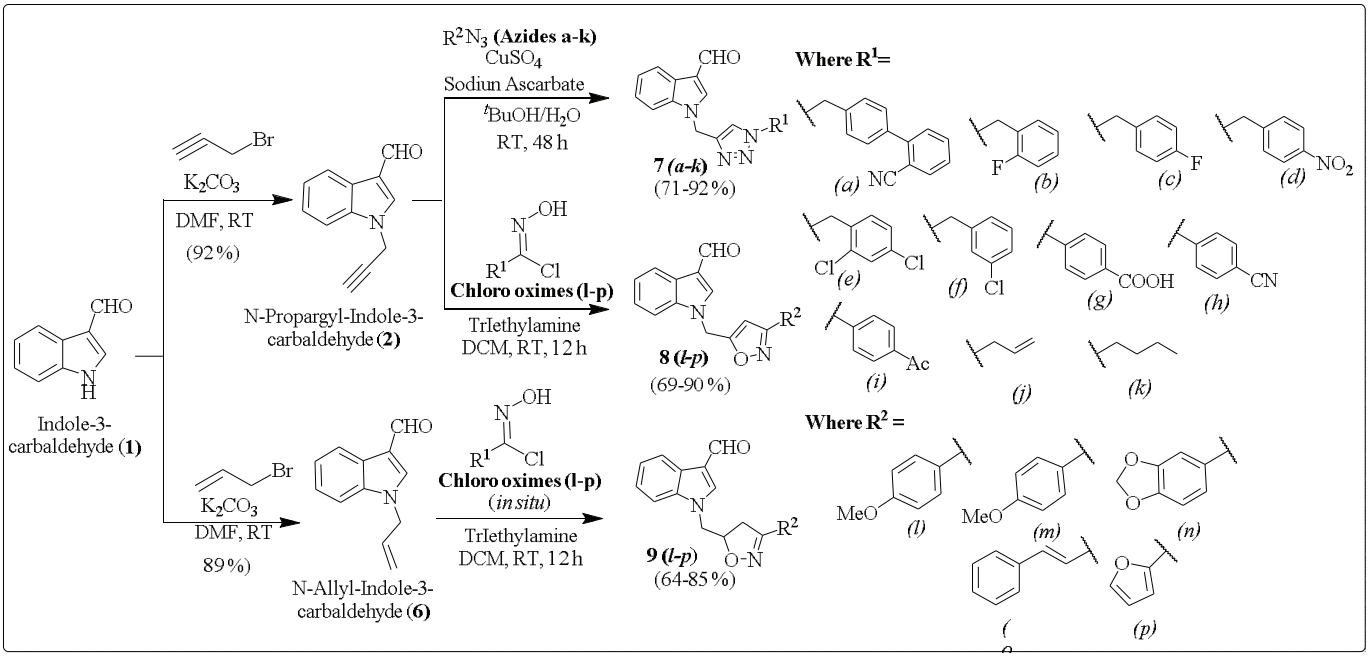
Synthesis of novel forskolin-indole-triazole conjugates, activity screening and *In-silico* studies

Three different biologically important pharmacophores *viz* forskolin, indole and 1,2,3-triazoles were coupled to synthesize novel series of forskolin-indole-triazole conjugates **(5a-5l)**. The synthesized compounds were evaluated for *in vitro* anticancer activity against PC-3, MCF-7, MDA-MB-231, COLO-205, HeLa, WRL-68, RAJI, CHANG and RAW-264.7 cell lines. Compound **5g** was found to be the most potent in all the tested cell lines except COLO-205, within IC_{50} range 9.6–21.66 µg/ml. Compounds **5a, 5b** and **5k** exerted its effect only against WRL-68 (IC_{50} range 27.69-48.18 µg/ml). In these experiments, doxorubicin and forskolin were used as standard for comparison which had IC_{50}value within the of range 0.42–3.16 µg/ml and > 100 µg/ml for doxorubicin and forskolin, respectively (tested concentrations 10–50 µg/ml). Erythrocyte fragility test showed compound **5g** with mean erythrocyte fragility i.e., MEF_{50} 0.57µg/ml, was found non-toxic to human erythrocytes as compared to control (MEF_{50} 0.60µg/ml) at tested concentration (50 µg/ml). *In silico*-based succinate dehydrogenase inhibition showed that the synthesized compounds had potent binding affinity compared to forskolin. Predictive ADMET and toxicity risk assessment analysis revealed that most of the compounds were complying with the standard limit of Lipinski's rule of five for oral bioavailability. [***J. Heterocyclic Chem.* 2021**; 58(11), 2090-2101]

Synthesis of novel indole substituted heterocyclics

Based on the importance of indole, 1,2,3-triazole, isoxazole and isoxazoline pharmacophore, a series of twenty-one novel hybrid molecules was synthesized using indole-3-carbaldehyde attached to triazole/ isoxazole/ isoxazoline moieties having various aromatic/benzylic/aliphatic substitutions.



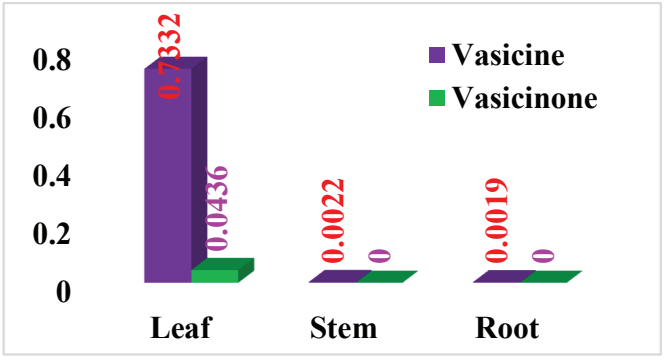


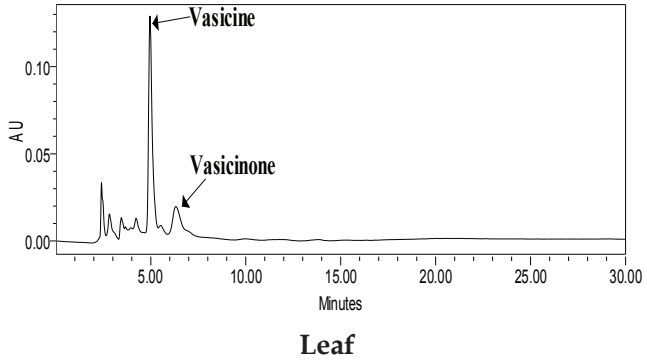
These compounds were synthesized *via* 1,3-dipolar cycloaddition between azide/ nitrile oxide (dipole) and indole substituted alkyne/ alkene (dipolarophile). [***Indian J. Chem.-B 2022,*** 61, 51-59]

HPLC method for analysis of marker compounds of *Adhatoda vasica* (L.)

A HPLC method for analysis of medicinal plant *Adathoda vasica* (L.) was developed. Methanol was used for the sample preparation. The mobile phase consists of (A) Acetonitrile : Methanol [50 : 50] and (B) Water in Gradient elution over 30 min. The flow rate was set to 1.0 mL/ min. A Phenomenex Sphereclone ODS (**2**) was used for the analysis and spectral acquisition was performed at 271 nm.

The leaf, stem and root parts were analysed by HPLC. The marker compounds vasicine is more in the leaf part compare to stem and root. Similarly, another compound vasicinone was present only in the leaf.





Leaf

Dr. CS Chanotiya Mk- lh-, l- pukfV;k

Identification, characterization of terpenoids and phenylpropanoids in selected aromatic plants and evaluation of their biological activities

a. *Antimicrobial and anti-inflammatory activities of patchouli (Pogostemon cablin) var. CIM-Utkrisht essential oil and its major constituents*

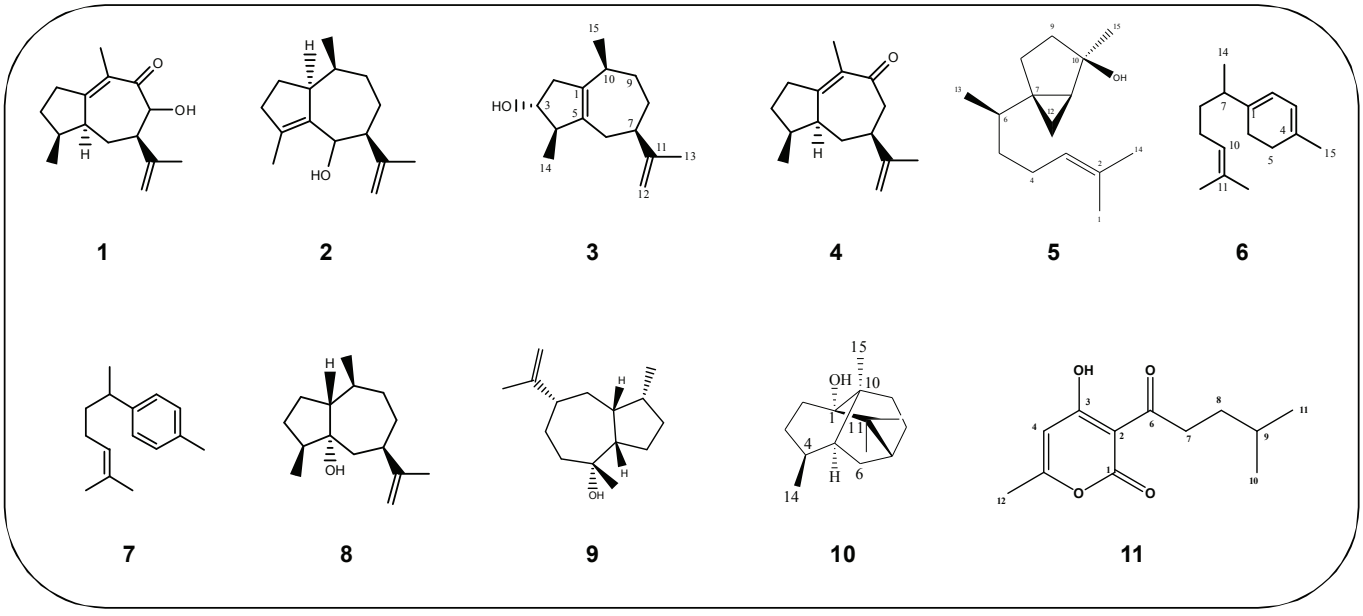
Post harvest drying pattern in *Pogostemon cablin* were investigated. Drying interval of a minimum of twenty one days yield the maximum oil content (>1%). Essential oil obtained in fourteen days of drying inhibits *M. furfur* growth. Oils distilled in 7, 14, 21 and 28 days of drying exhibited significant *In-vitro* antimicrobial activity against five selected microorganism's viz., *C. albicans*, *S. typhimurium*, *S. aureus*, *E. coli*. Total seven sesquiterpenoids, including three undescribed guaiane-type (**1-3**) and one known sesquiterpenoid (**4**), one sesquisabinane-type (**5**), and two bisabolane-type (**6-7**), together with four known sesquiterpene derivatives (**8-11**) were isolated from *Pogostemon cablin* (Blanco) Benth. var. CIM-Utkrisht. Bisabolanes were the key markers of *P. cablin* (Blanco) Benth. var. CIM-Utkrisht. The essential oils as well as ar-curcumene **7**, pogostol **9**, and patchouli alcohol **10** significantly reduced TNF-α ($p < 0.05$) in treated cells.

Based on NMR interpretation, it may be suggested that a ketonic group at C-9 and -OH at position C-8 in compound (**1**) is a new guaiane-type sesquiterpenoid identified from patchouli. The identification of 7-epi-*cis*-sesquisabinene hydrate (**5**) is the first report from the Lamiaceae family.

b. Chemical composition of phenylpropanoid rich chemotypes of *Ocimum basilicum* L. *and their antimicrobial activities*

Highlights

- Two phenylpropanoid rich *O. basilicum* chemotypes were investigated.
- Camphor has been reported in *O. basilicum* essential oil first time.
- *O. basilicum* chemotypes biosynthesize (*R*)-(+)-camphor and (*R*)-(-)-linalool.
- *meta*-Eugenol was isolated and characterized first time in Genus *Ocimum*.
- Essential oils showed bacteriostatic property against Gram-positive bacteria.



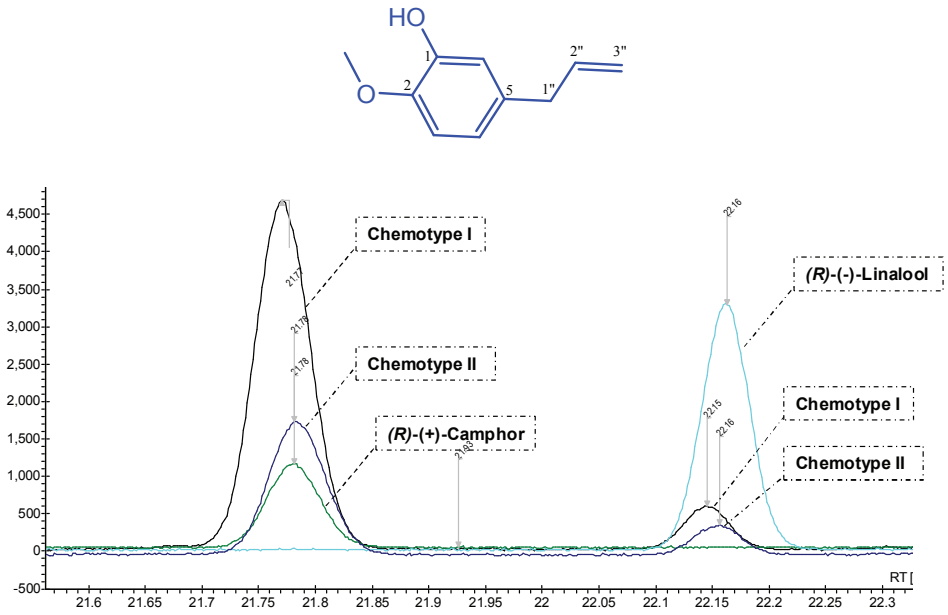


Fig. Chiral gas chromatographic separation of marker chiral constituents in chemotype I and II a using β-cyclodextrin stationary phase.

Table: Marker enantiomers identified in *Ocimum basilicum* L. chemotypes

Enantiomers	RRI	Chemotype I				Chemotype II			
		A	B	C	*ee* (%)	A	B	C	*ee* (%)
(*S*)-(+)-camphor	1188	18.6 ± 1.6	14.5 ± 4.0	17.3 ± 1.4	>99	6.6 ± 0.4	6.0 ± 0.9	5.1 ± 0.6	>99
(*R*)-(-)-linalool	1195	4.3 ± 1.0	20.7 ± 30.9	5.8 ± 3.0	>99	0.8 ± 0.4	0.7 ± 0.5	0.9 ± 0.4	>99
Sum of enantiomers		22.9	35.2	23.1		7.4	6.7	6.0	

Table: ^{1}H-NMR (500 MHz) and ^{13}C-NMR (125 MHz) spectroscopic data for *meta*-eugenol in $CDCl_3$ D: DEPT (135°, 90° and 45°)

Carbon No.	δ_C	DEPT	δ_H
1.	145.59	Q	-
2.	144.97	Q	
3.	110.72	CH	6.77 (m, 1H)
4.	119.81	CH	6.65-6.67 (m, 1H)
5.	133.49	Q	-
6.	114.87	CH	6.78 (m, 1H)
1"	39.58	CH_2	3.28 (d, *J*=6.72 Hz, 2H)
2"	137.63	CH	5.88-5.98 (m, 1H)
3"	115.48	CH_2	5.02-5.08 (m, 2H)
-OCH_3	56.04	CH_3	3.86 (s, 3H)

*δ in ppm; J in Hz; measured at 125 MHz for ^{13}C-NMR and 500 MHz for ^{1H}-NMR in CDCl3, Q; quaternary carbon; s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad)

Method development for detection of high boilers in essential oils

Detection & demonstration of adulteration and thermo-stability pattern in patchouli essential oils using Simultaneous Thermo-gravimetric Analyzer (STA)

Patchouli essential oil is the most frequently adulterated commodity in modern times. It makes a homogenous solution with chemicals like diethyl phthalate, castor oil, or other solvents. Therefore, genuine essential oils are very prone to misbranding or adulteration. Some of the most common adulterants are castor oil, liquid paraffin, vegetable oils, gurjun balsam, hercolyn D, etc. For the quality control comparison, pure essential oil, one high boiler (castor oil as adulterant), and three deliberately spiked patchouli essential oil samples at 5, 10, 15% level with castor as adulterant were subjected to Thermogravimetric Analysis (Fig.). A high boiler (castor oil) showed thermal stability up to 350°C but showed complete weight loss (Delta Y=99.572%) above 500°C. In contrast, when subjected to TGA analysis, high-quality genuine patchouli essential oil showed complete mass loss (Delta Y=99.286%) at 200°C. Notably, when analyzed as individual samples, both the high boiler and essential oil revealed a single-stage decomposition pattern. The result obtained for each essential oil sample obeys the sigmoid shape curve except for the high boiler or castor oil.

Interestingly, the samples deliberately spiked with adulterant invariably followed an efficient two-stage decomposition pattern. The first derivative of mass loss vs. degradation temperature of a 15% spiked sample was noticed at 200°C (Delta Y=84.152%)

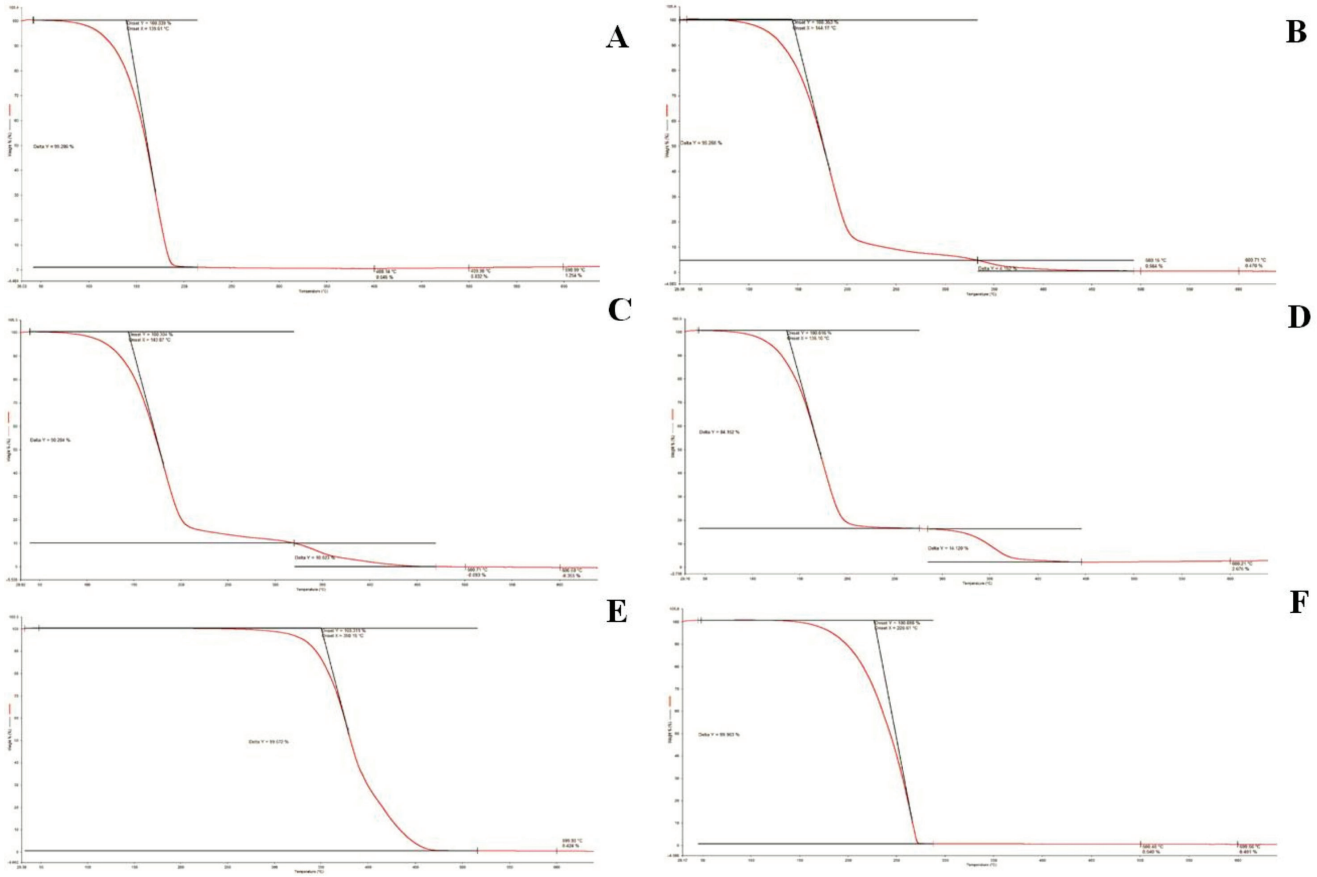


Fig. Thermogravimetric Analysis of genuine and spiked patchouli essential oils: (**A**) authentic patchouli essential oil; (**B**) 5% spiked patchouli oil with castor oil; (**C**) 10% spiked patchouli oil with castor oil; (**D**) 15% spiked patchouli oil with castor oil; (**E**) pure castor oil; and (**F**) pure liquid paraffin as adulterant. The weight loss pattern in each curve is reported as percent.

for essential oil and 400°C (Delta Y=14.12%) for spiked adulterant, respectively. Likewise, a 10% spiked sample is differentiated in the form of two separate weight losses, as Delta Y=90.24%, which corresponds to essential oil, and Delta Y=10.02% represents the spiked part of the sample. Moreover, the high-end model of PerkinElmer STA 8000 can provide an exact quantitative percentage of both ingredients in a single run. Therefore, the proportion of adulterants can be easily estimated in minimum time duration without running a time-consuming chromatographic technique. As the spiking percent increased or decreased, degradation temperature shifted accordingly. Due to several advantages and the ability to detect non-volatile adulterants quantitatively in a sample, the Thermogravimetric Analysis is found to be complementary to other sophisticated techniques such as FT-IR, IR-MS, GC-MS, etc. as one of the powerful tool for quality control authentication of patchouli and its derived products, worldwide.

C^{14} radiocarbon dating of essential oils/ chemcals for determination of modern carbon

The work on radiocarbon carbon dating has entered into second year in collaboration with Inter-University Accelerator Centre for C^{14} analysis work at IUAC, New Delhi (Ref. IUAC/XIII.3A of dated August 01, 2019 and BTR 70108; Ref: IUAC/XIII.3A/) of dt. July 1, 2021). We have utilized the XCAMS (Compact Accelerator Mass Spectrometry System) for recording of radioactive carbon signature in samples of natural origin.

Out of the total approved 40 samples for C^{14} radiocarbon dating (Ref: IUAC/XIII.3A/) of dt. July 1, 2021), 10 samples comprising of lemongrass, isopulegol, menthol and gamma-decalactone have been completed and results have been critically analyzed and interpreted with the help of collaborator at IUAC.

Dr. CS Chanotiya & his team

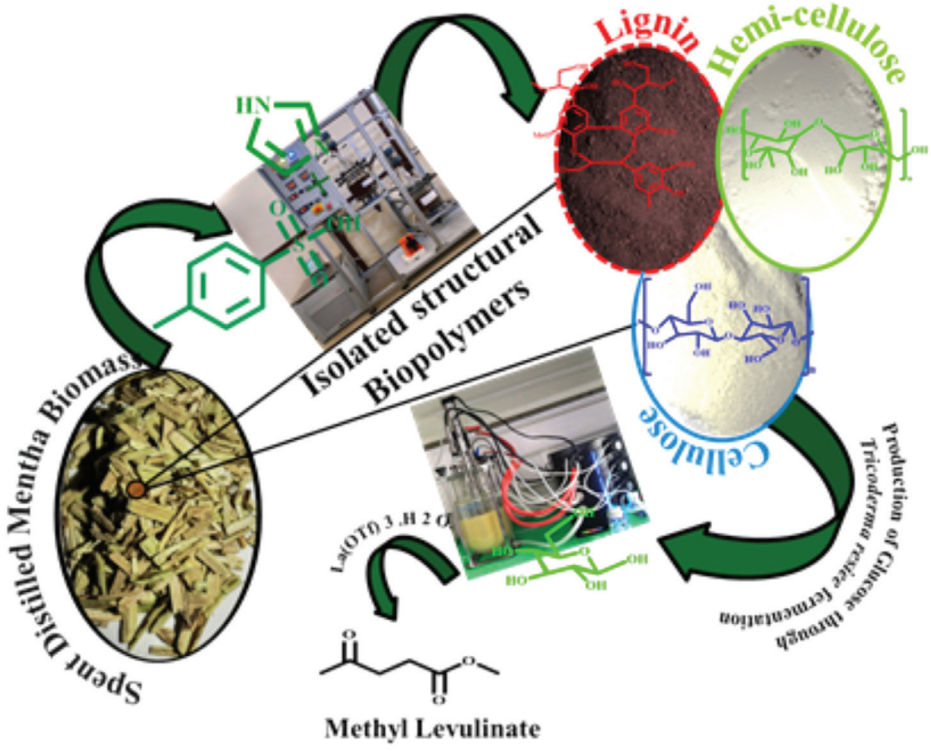
Dr. PK Rout Mk- ihdu jkmr

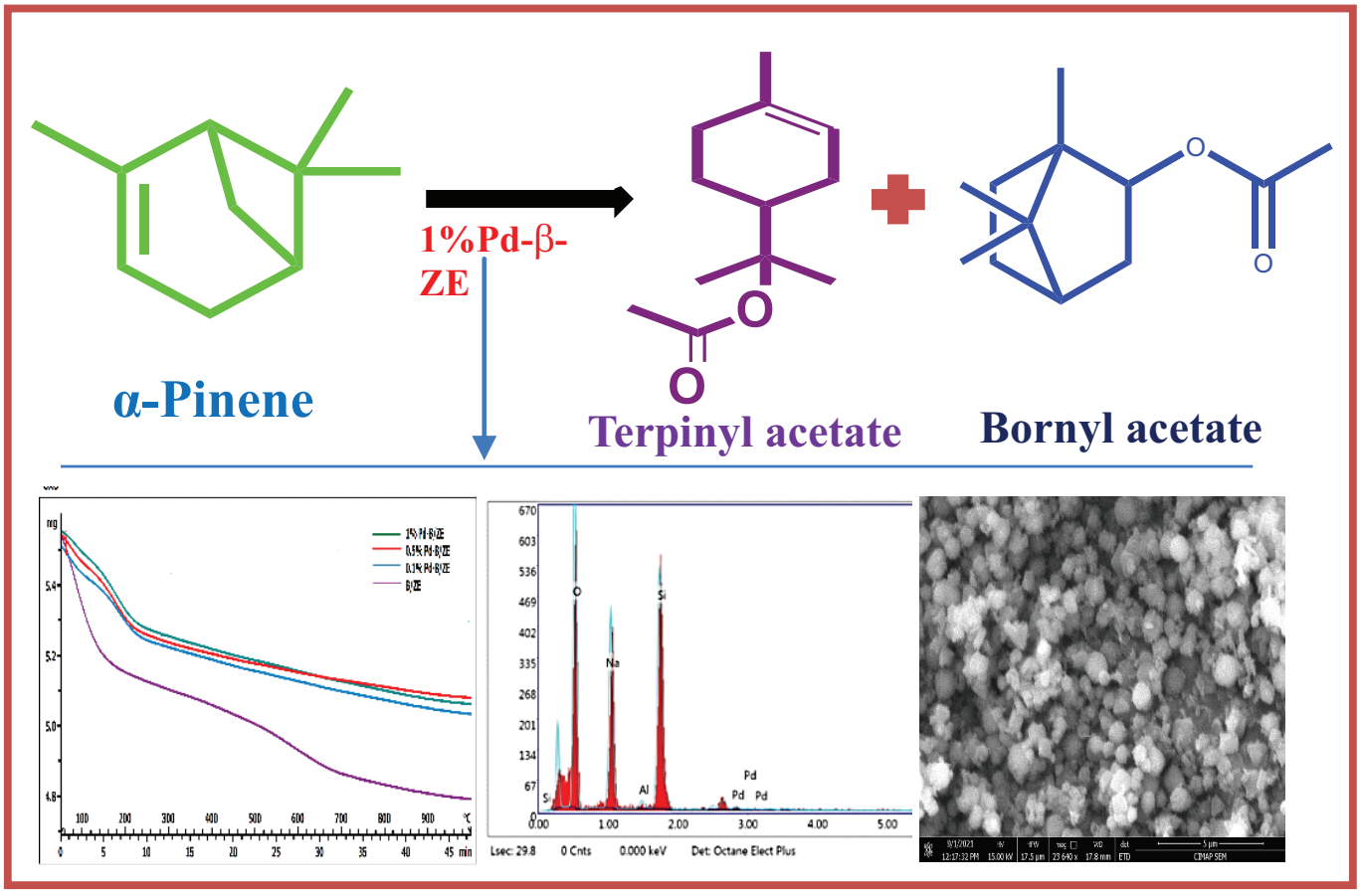
Valorisation of distilled Mentha biomass

Cornmint (*Mentha arvensis*) is cultivated to produce essential oil. Fresh biomass is hydro-distilled to obtain essential oil (1%), and the rest of the pre-treated biomass (99%) is generated as waste. A novel, green and economical two-step process has been developed using a mixture of imidazole (IM: 1 M)-*p*-toluene sulfonic acid (*p*TSA: 1.2 M), and IM (0.2 M)-20%NH_3 for the separation of lignin and hemicellulose, respectively. The lignin and hemicellulose were isolated from the respective solution by precipitation, and final undissolved solid residue was obtained as cellulose. This process was scaled-up to recover cellulose (38%), hemicellulose (27%), and lignin (14%) using 5 L double jacketed reactor. The processing parameters such as temperature, solvent ratio, and time were optimized using single factorial design mathematical model for the isolation of biopolymers. Further, cellulose was enzymatically biotransformed to glucose through submerged and solid-state fermentation (SSF) using *Trichoderma reesei, T. harzianum (TH, TH10)*, and *T. atroviride*. Isolated cellulose produced 61.5% of glucose at 30°C, pH 5 in 72 h through SSF process using *TH10* strain. This glucose solution was transformed to methyl levulinate (74%) under aqueous-methanol (5:1) solvent system for 2 h at 160°C using$La(OTf)_3.H_2O$ catalyst.

Valorisation of bicyclic monoterpene hydrocarbons to oxygenated terpenoids

Monoterpene hydrocarbons are the unwanted, off-smelling fractions in most of the essential oils. Due to the absence of functional groups in monoterpene hydrocarbons, it is difficult to solubilize in common solvents such as water, ethanol, etc. Hence, this fraction is removed from the essential oil in deterpenation process before their application in the formulations. Pinene (α-,β-), the monoterpene hydrocarbons are found in most of the essential oils. In the present work, pinene isomers are esterified to valuable compounds such as terpinyl acetate, bornyl acetate and fenchyl acetate. They are widely used as fragrance ingredients in various food and cosmetic

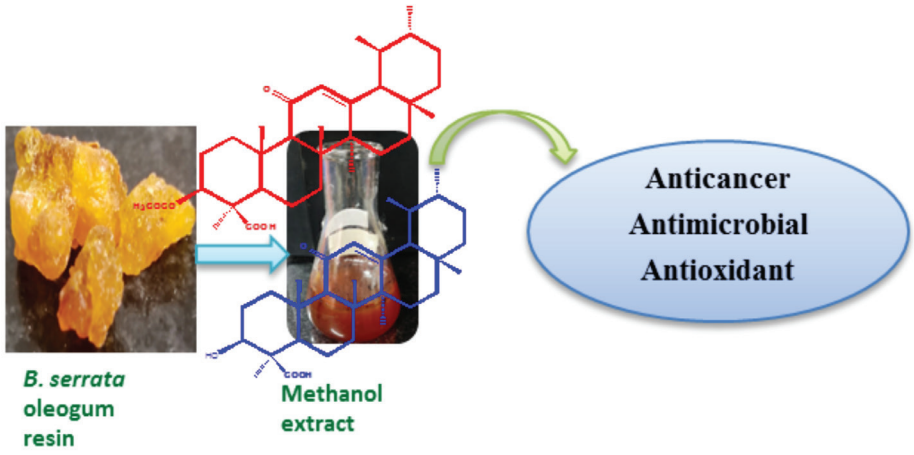




products with improved organoleptic profiles. Hence, a solvent-free process has been developed for the selective conversion of pinene to terpinyl acetate and bornyl acetate using 1%Pd-*β*-Zeolite (ZE) at room temperature (30°C). The different percentage of Pd loading over β-ZE was studied on the transformation of α-pinene. It was attained 98% of conversion with the selectivity to 54.2% of terpinyl acetate, and 34.8% of bornyl acetate at 30°C in 2 h using 1%Pd-*β*-ZE. Similarly, the synthesized catalyst (1%Pd-*β*-ZE) has been shown excellent activity for α-pinene esterification under the 50 psi N_2 at 50°C to give 83% selectivity towards bornyl acetate. The esterifications of monoterpene hydrocarbons-rich essential oils (salaiguggul, guggul, black pepper, rosemary, and nutmeg) were carried out at 30°C with 1%Pd-*β*-ZE for selective transformation to bornyl acetate, terpinyl acetate, and fenchyl acetate. Since the reactions are carried out without any additional use of organic solvents, hence, makes the overall process quite attractive. This study will help to develop an eco-friendly strategy for the valorization of bicyclic monoterpene hydrocarbons-rich essential oils.

Valorisation of *Boswellias errata* oleo-gum-resin

Boswellia serrata oleo-gum resin was obtained from distinct topographical origins of India. Physical, chemical, and bioactive properties of crude samples, methanol extracts, and essential oils were evaluated. Neemuch collection (BS-N2) was contained higher essential oil (10.7%), including α-thujene (69.8%) and α-pinene (4.6%). It was displayed the antifungal (MIC: 0.1-0.02 µg/mL) and DPPH-scavenging (44.6% at 20 µg/mL) activities. The methanol extract of BS-N2 (70.1% yield) contained the highest amounts (8.4%) of 3-hydroxy-11-keto-β-boswellic acid (KBA). It's antiproliferative (IC_{50}: 6.8-11.75 µg/µL), antimicrobial (MIC: 2.4-312 µg/mL), and antioxidant (DPPH-77%, $ABTS^+$ 87.6% at 100 µg/mL) activities has been shown significant. The activity-guided isolation revealed



that KBA is the most active biomolecule, having antimicrobial (MIC: 31.25 µg/mL) activity, time-kill kinetic, and ethidium bromide efflux pump inhibitory assays. In combination study, it synergizes with oxacillin against drug-resistant clinical isolates (FICI: 0.325-0.450 µg/mL). KBA exhibits anti-proliferative (4.10-37.9 µg/mL), antiplasmodium (sensitive strain, IC_{50}: 4.5±0.6 µg/mL; resistant strain, IC_{50}:6.25±1.02 µg/mL) activities. KBA inhibits heme detoxification pathways, and it is non-cytotoxicity to VERO cells. In acute oral toxicity studies at 2000 mg/kg body weight, KBA did not exhibit any abnormality in the serum biochemistry of animals. The enriched extract containing potent bioactive compounds (KBA and 3-acetyl-11-keto-β-boswellic acid (AKBA) were prepared for value-addition of oleo-gum resin. Total boswellic acids (BAs) content increased by 44% in the enriched extract (BSPE), and bioactive compounds KBA and AKBA increased by >50% (HPLC analysis). Moreover, antifungal activity against *Candida albicans* was also improved after enrichment of BAs in BSPE with MIC of 2.5 µL/mL. In the utilization of spent marc obtained from BAs enrich extract, natural gum (BSG) was prepared and characterized. It was estimated that the BSG content ash (2.35%), moisture (5%), carbohydrate (28.2±6%), and protein (19.3±22%). It has shown good thermal stability at 200-210°C with semi-crystalline microstructure in nature. Further, entire valorization of *B.serrta* oleo-gum resin by successive isolating of (i) volatiles by liquid-CO_2, (ii) bioactive compounds in methanol, and (iii) gum from marc biomass.

Dr. PK Rout & his team

Dr. Atul Gupta Mk- vr;y xIrk

In-vivo efficacy, mechanistic study and synergistic interaction of precocene II with norfloxacin against methicillin-resistant *Staphylococcus aureus*

Ageratum conyzoides L. (Asteraceae) possesses wound healing, antimicrobial, and anti-inflammatory activities. Traditionally, this plant is used in skincare. The essential oil (EO) of *A. conyzoides* aerial parts contains the chromenes precocene I (**1**) and precocene II (**2**) as major constituents (**Fig.**). This study evaluated precocene II (**2**) for its *in-vivo* efficacy, mechanistic analysis, and synergistic interaction with norfloxacin against methicillin-resistant *Staphylococcus aureus* (MRSA). The study showed that **2** interacted synergistically (Fractional Inhibitory Concentration Index, FICI≤0.5) with norfloxacin and oxacillin and reduced their MIC values significantly. These observations were further validated using the mice model and showed a significant reduction in bacterial load at much lower doses of **2** and norfloxacin without toxicity at 200 mg/kg body weight. Mechanistic studies revealed that **2** regulates bacterial resistance against clinical isolates of *S. aureus* through membrane disturbance

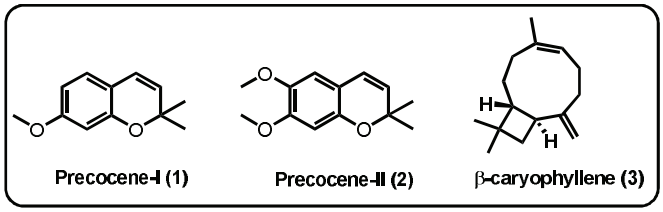


Fig. Structure of Precocene-I (1), Precocene-II (2) and β-caryophyllene (3)

in a dose- and time-dependent manner. Further, precocene II (**2**) damaged the membrane of the bacteria, as observed from the increased membrane depolarization and uptake of propidium iodide (**Fig.**). It also displayed high selectivity towards *S. aureus* over mammalian cell lines. The *in-vitro* results highlighted the synergistic activity of **2** through the cell membrane damage without any detrimental effect on mammalian cells. *In-vivo* results showed that **2** in combination with norfloxacin significantly reduced bacterial load at much lower concentrations through synergistic interaction without apparent toxicity. [***Chemistry and Biodiversity*, 2022**, 202100906]

Structural modification of natural chromene-precocene-I isolated from *Ageratum conyzoides* L. for value addition

Ageratum conyzoides L. is an herbaceous plant belongs to family Asteraceae. It is commonly known

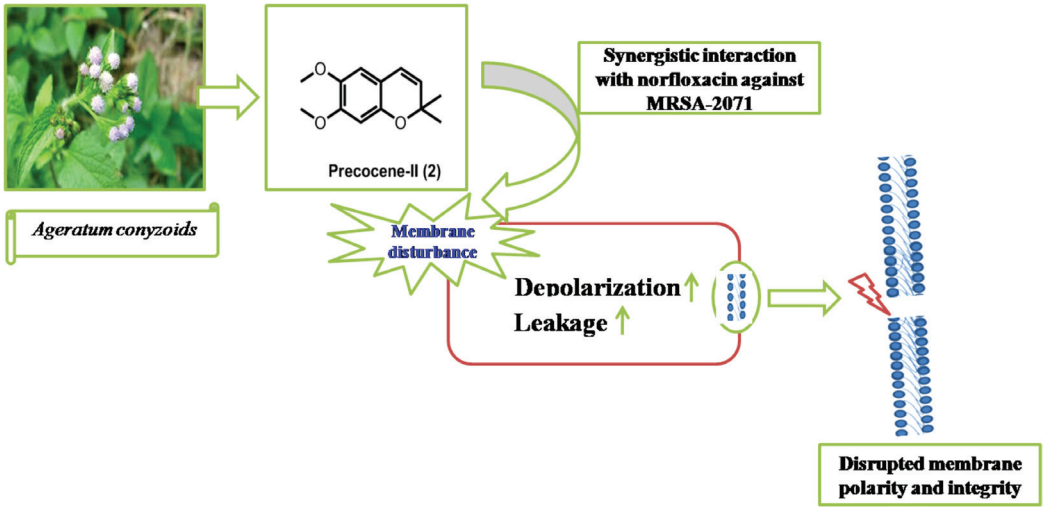


Fig : Synergistic activity of Precocene II with Norfloxacin against Methicillin-Resistant *Staphylococcus aureus*

as goatweed and abundantly found in India. It is popular for its chromene repository along with some flavonoids. In this study, precocene I, a chromene was isolated from *Ageratum conyzoides* L. and was structurally modified to substituted chroman based triarylethylenes (**Fig.**). The target compounds were made through simple and efficient chemistry. The target compounds were evaluated for their *in vitro* anticancer activity in estrogen receptor positive and triple negative breast cancer cells (in MCF-7 and MDA-MB-231 cell lines, respectively). Biological results showed that compounds possessed impressive anticancer activity within the IC_{50} 12-18 µM (in MCF-7) and 6-15 µM (in MDA-MB-231). The stereo-chemical characterization of compounds revealed that core nucleus of these molecules bear phenyl rings in a *Trans*-stilbenoid system and had good structural correlation with 17β-estradiol. *In silico* study about the compounds showed their structural complementarities with the LBD of estrogen receptor (ER) which indicated possible ER mediated activity of compounds.

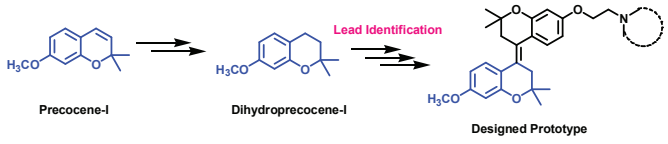


Fig. Modification of precocene I into target oriented chroman based triarylethylenes

Synthesis of amide derivatives of 3-aryl-*3H*-benzopyrans as osteogenic agent concomitant with anticancer activity

This study reports a series of 3-arylbenzopyran based amide derivatives as osteogenic agent concomitant with anticancer activity (Fig.). The target compounds showed good osteogenic activity at 1 pM and 100 pM concentrations. One of the potential molecule effectively induced ALP activity and expression of mRNA genes at 1 pM and bone mineralization at 100 pM concentrations. Besides their osteogenic potential, molecules presented significant cytotoxicity in osteosarcoma (MG63), estrogen-dependent (ER+), and -independent (ER-) breast cancer cells (MCF-7 and MDA-MB231 cells, respectively). The most active compound inhibited the growth of the above-mentioned cancer cells within the range of IC_{50} 10.45-12.66 µM. The mechanistic studies about most active derivative showed that it was able to induce apoptosis via activation of caspase-3 enzyme and inhibition of cell migration. In silico molecular docking study revealed the possible interaction of compounds with ER-β for their biological activities.

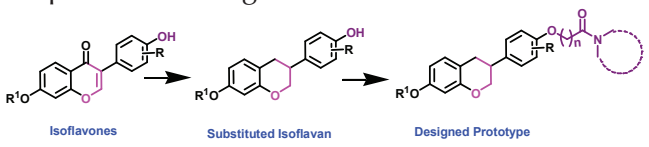


Fig. Modification of isoflavone derivatives into target oriented amide derivatives of 3-aryl-*3H*-benzopyrans

Dr. Atul Gupta & his team

Er. Ashween D Nannaware b|th v'fou Mh- uUukoj|

New design centralized solar distillation apparatus for essential oil extraction

A new environmental friendly solar aroma distillation apparatus is designed and developed for producing controlled distillation of essential oil crops. This new distillation apparatus is developed by use of solar panels connected to a steam generation assembly to provide a renewable solar energy for uniform steam generation (1.5 bar to 2.0 bar). In this, the solar energy generated steam uniformly penetrates into the pores of plant matrix kept in distillation tank, heating it efficiently and homogeneously. This causes vaporization of volatile materials which increases internal pressure within the cell and finally ruptures the cell to release the active volatile compounds. The resulting volatile essential oil vapor mixture is then pass through the packed column for removing the unwanted dust dirt impurities from the oil vapor mixture and directing the pure oil mixture to pass through the condenser. The vapor mixture condense is then collected in a new oil separator having a recirculation line. Based on the density of the essential oil being collected, this new oil separator is partitioned into two sections, top glass section allow for drainage of oil having lighter density than water through top oil discharge line and the bottom glass section for oil with higher density than water through bottom discharge line. The extraction studies have successfully been carried out on different aromatic plants using this new solar steam aroma distillation unit prototype. It has been found to be very effective with respect to time reduction, yield and purity of essential oil. This new design solar distillation unit facilitates the aromatic crops growing farmers with higher oil yield and also allow the farmers to have the complete visibility of essential oil obtained from aromatic plants during distillation operation. Using this new design distillation, farmers can easily see the quality and yield of the essential oil obtained. This technology will help to introduce the agriculture industry about the various uses of solar energy in a very simple and effective way. This solar distillation technology will also curtail the farmer's dependency on fossil resources in modern agriculture practice using renewable source of energy. The innovative solar distillation work will open a new landmark in rural development of India. This new solar distillation unit was successfully demonstrated to various scientists and farmers in Kisan Mela-2022 [*Renewable energy*, **2022**, 191,345-356].

Decentralized mobile solar distillation apparatus for essential oil extraction

We have designed an innovative environmental friendly decentralized mobile solar aroma distillation prototype for highly regions farmers for distilling the valuable volatile fractions from aromatic and medicinal plants. This new design mobile solar distillation unit will be environmentally safe, easy to take to the farmers field and will facilitates the aromatic crops growing farmers with higher oil yield. Using this new design distillation unit, farmers dependency on wood will be reduces and will also allow the farmers to have the complete visibility of essential oil obtained from aromatic plants during operation. (Patent work is under progress)

Er. Ashween D Nannaware & his team

Dr. Hariom Gupta Mk- gjhvke xIrk

NMR investigation for stacking interaction in butylidine-linked pyridazinone-based systems

^{1}H–^{1}H 2D-NOESY NMR based dipolar coupling technique was used as tool for structural and conformational characteristics of stacking interaction in butylidine-linked pyridazinone-based systems. The molecule may exist in various conformations, as the molecular rotations are very fast at room temperature, but the equilibrium is greater around the stable conformation. The presence of NOE peaks was a direct confirmation that interacting protons were below 5 A in space. The observed cross peaks clearly give the idea that the peaks in the chemical shift region δ 5 and δ 5.45 were interacting with the ring protons. Selected NOEs, which support the face-to-face stacking of compounds 2CN and 1CN, are C20H and C5H. Other signals that reinforced the U-turn of the butylidine spacer were C18H and C5H, C18H and C38H, C21 and C38, C18H and C34H, C18H and C5H, and C21H and C1H in 2CN; C18H and C36H, C21H and C36H, and C21H and C5H in 1CN (**Fig.**). Hence, 2D-NOESY supported the fact that both compounds were folded in solution state. [**New J. Chem., 2022,** 46, 5830.]

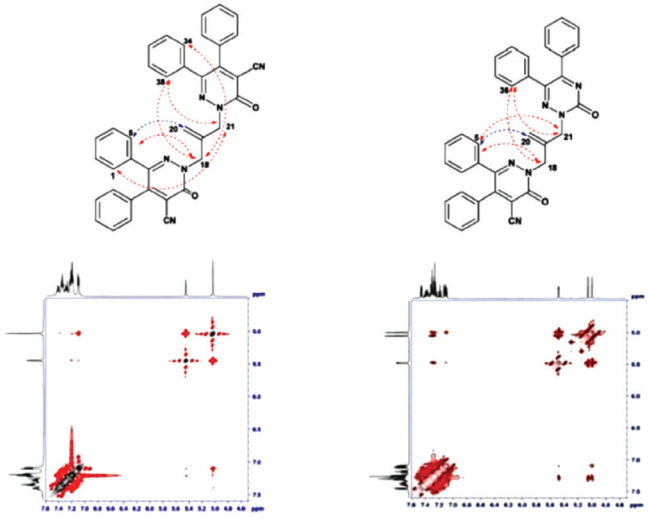


Fig.: The structures and 2D NOE spectra of compounds 2CN (right) and 1CN (left) exhibiting noncovalent interactions

Plant mediated synthesis of nano-structure of different morphology

Surface and morphology of the particles at nanoscale plays an important role to perturb the particle properties. It can be modulated with nucleation rate and surface modifications which can be achieved through mediation of synthesis matrix. Zn based nanostructures of different morphology such as flower like and spongy ball, are prepared with medicinal plant mediation as characterized which are represented below (**Fig.**). Further characterization and application studies for these prepared materials are in progress.

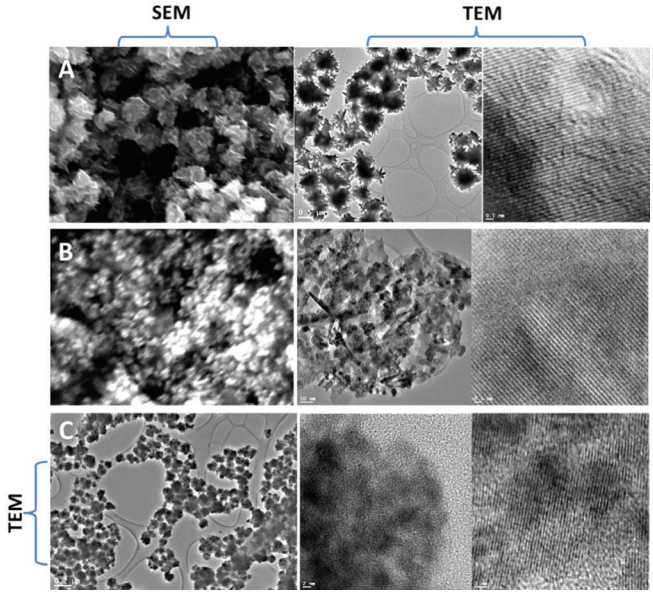


Fig. SEM and TEM images of different morphology of Zn-based crystalline Nanostructures

Docking of crystalline nanostructure with protein and dye molecules

Zinc based nanostructure have shown an excellent potential in cosmetic, biomedical, agriculture and separation & degradation of dyes. A molecular docking is one of important computation tool to screen the characteristics of pharmaceutical molecules and it can also be strongly useful for crystalline nanomaterials.

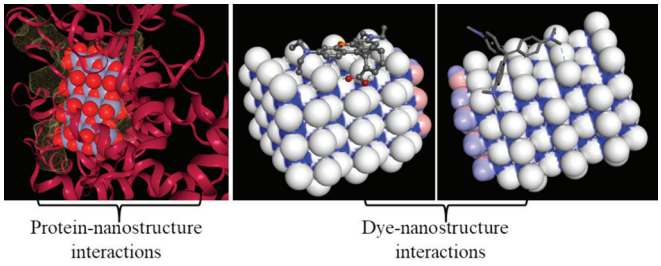
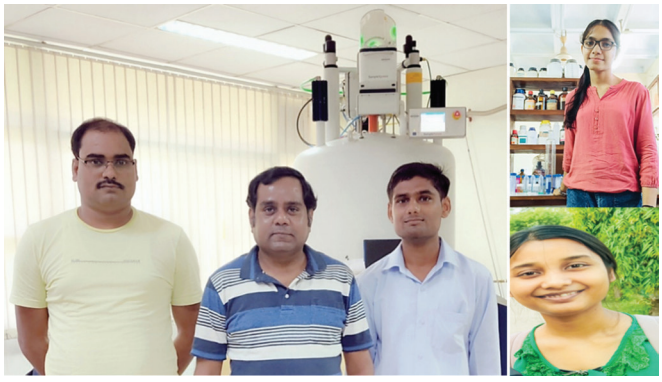


Fig. Molecular Docking results of ZnO nanostructure with protein and crystal violet dye

A docking analysis for crystalline nanostructures is performed for better understanding of nanostructure interaction with protein and dye molecules. One of the results represented a significant binding of ZnO crystalline nanostructure with crystal violet dye in comparison to other dyes (Fig.). Similar trend of interaction performance is observed in experimental results of dye separation studies carried out with prepared nanostructures of similar crystalline phase.



Dr. Hariom Gupta & his team

Dr. Kapil Dev Mk- dfiy no

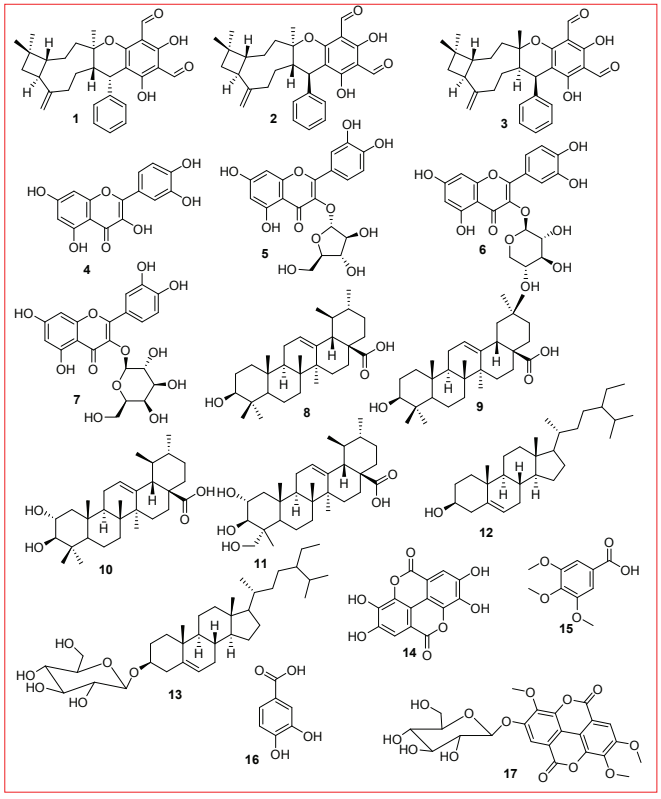
Chemical investigation of *Psidium guajava* L. leaves

Psidium guajava L. (commonly known as guava), belongs to family Myrtaceae and cultivated for its fruits in tropical and subtropical regions of the world. In Ayurveda, it is considered as tridoshnashak *i.e.*vata, pitta and kapha. Previous preclinical studies found that *guava* leaves and its isolates have potentials as anti-cancer, antioxidant, anti-inflammatory, antibacterial, antidiabetic, and hypolipidemic activities etc.

Fig. Chemical structure of the isolated compounds

Previous chemical investigations led to the isolation of terpenoids, phenolics, meroterpenoids, carotenoids, steroids, and anthocyanins.

As a part of our drug discovery programme, the leaves of the *Psidium guajava* were collected from CSIR-CIMAP research farm, Lucknow and dried under shade. The shade dried leaves were powdered and extracted with alcohol to get alcoholic extract. The alcoholic extract was further fractionated with *n*-hexane, acetone, and



n-butanol to yield corresponding fractions. The purification of the fractions was carried out on silica gel column chromatography which yielded seventeen compounds (**1-17**). The structure of the purified compounds was established by using 1D and 2D-NMR spectral data. All the isolated and characterized compounds as guajadial(**1**), psidial A (**2**), psiguajadial G (**3**), quercetin (**4**), avicularin (**5**), guaijaverin (**6**), hyperin (**7**), ursolic acid (**8**), oleanolic acid (**9**), corosolic acid (**10**), asiatic acid (**11**), β-sitosterol (**4**), β-sitosterol-D-glucoside (**13**), ellagic acid (**14**), gallic acid (**15**), protocatechuic acid (**16**), and 3,3',4'-trimethylellagic acid 4-O-glucoside (**17**) (Fig.). The Isolated compounds were evaluated for vasorelaxant activity.

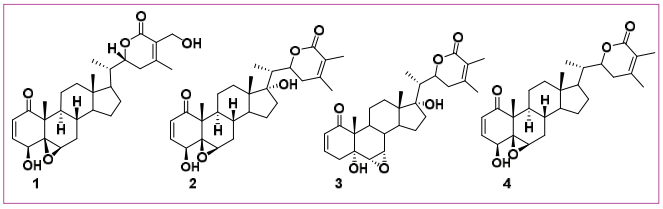


Fig.: Chemical structure of the isolated compounds

Phytochemical investigation of *Withania somnifera* (L.) Dunal leaves

Withania somnifera(L.) Dunal (Solanaceae), popularly known as Ashwagandha has been extensively used as herbal medicine in Indian traditional system. It is designated as the "Sattvic Kapha Rasayana" in Ayurveda. Ashwagandha has been tremendously used as astringent, anti-stress, narcotic, diuretic, and against nervous breakdown, insomnia, constipation, andimmunity booster etc. The roots of the plant that have been extensively used in Unani and Ayurvedic systems of medicine. Chemically, it contained 28-carbon steroidal lactones in the skeleton of ergostane type compounds which further categorized as withanolides. The phytochemical investigation of leaves of the plant yielded four withanolides named as withaferin A (**1**), 27-deoxy-17-hydroxywithaferin A (**2**), withanone (**3**), 5β,6β-epoxy-4β-hydroxy-1-oxo-witha-2,24-dienolide (**4**) (Fig.). Further purification work is in progress. The isolated compounds will be evaluated for osteogenic activity.

Dr. Kapil Dev & his team

Dr. V S Pragadheesh Mk- oh ,l ix/kh'k

Glossocardia bosvallia (L.f.) DC. essential oil: A new source for β-myrcene

Glossocardia bosvallia (L.f.) DC. is a herb with yellow flowers, needle like leaves and raw mango like aroma, found in the waste and cultivated lands in many part of the Indian sub-continent. The chemical profile of hydro-distilled essential oil from the aerial parts and flowers of *G. bosvallia* was analysed using GC, chiral GC, GC-MS and NMR spectroscopy. GC analysis depicted β-myrcene as the major compound in both the essential oils, aerial parts containing 61.59% and flowers constitutes 44.86%. Occurrence of β-myrcene was also confirmed using ^{1}H, ^{13}C and DEPT 135° NMR spectroscopy. Chiral GC illustrated the enantiomeric composition of monoterpene hydrocarbons, in which (1*S*)-(-)-β-pinene, (-)-sabinene and (4*S*)-(-)-limonene were the major enantiomers. The present study reports the essential oil composition and enantiomeric composition of β-myrcene rich *G. bosvallia* essential oil for the first time. *G. bosvallia* essential oil can be a good source of β-myrcene, a compound with wide range of biological properties (Fig.).

Chemical ecology of selected nocturnal flowers: Chemical characterization of their fragrance for insect preference

Flowers generally contain highly volatile compounds and their chemical compositions are unique to every flower. Floral scent has several functions in attracting pollinators, repelling florivores and other herbivores and survive with anti-microbial properties. Due to this reason, most flowers have highly diverse chemical profile. Further qualitative and quantitative variations of chemicals are reported in the flower scent due to many biotic and abiotic factors. Besides, nocturnal flowers show a completely different chemical profiles to attract the nocturnal pollinators like moths, thrips, etc. in the dark where chemical cues are the only choice. It is important to identify the key compounds which attracts the pollinators in the

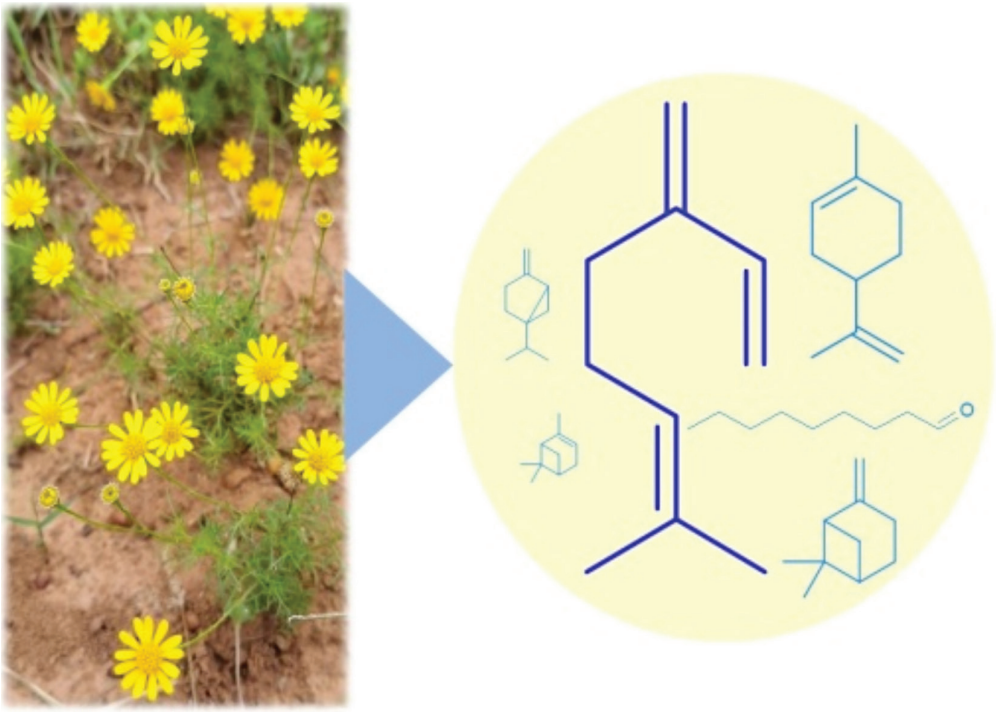


Fig. *β*-Myrcene rich essential oil from *Glossocardia bosvallia* (L.f.) DC.

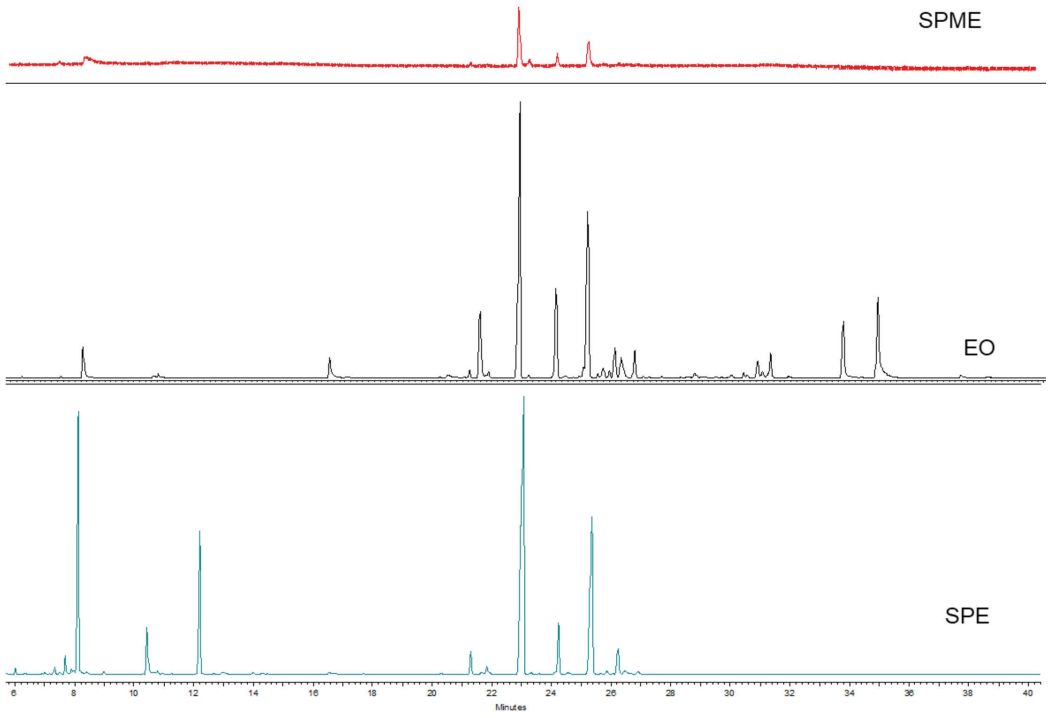


Fig.: Comparison different sampling methods (SPME: Solid-Phase Micro-Extraction, EO: Essential Oil, SPE: Solid-Phase Extraction) of the floral scent of *C. odorata*

fragrant extracts of the nocturnal flowers employing behaviour assay assisted chemical analysis. Selecting an appropriate sampling methods and optimizing the parameters to identify the key compounds are very essential in this process. Thus, we optimised the volatile sampling techniques for floral volatiles of *Cananga odorata* (Lam.) Hook. f. & Thomson, and found that the solid-phase extraction method is giving best results in comparison with essential oils and solid-phase micro-extraction (PDMS).

Dr. V S Pragadheesh & his team

Dr. Ratnasekhar CH Mk- jRu'k[kj lh,p

Comprehensive metabolite profiling identifies *Ocimum* species and variety specific variation

Comprehensive metabolomics of eight different species and varieties of *Ocimum* was performed using liquid chromatography-mass spectrometry and gas chromatography mass spectrometry (Fig.). Chemometric models built using mass spectrometry data correctly predicted nearly 100% of species and varieties with very good classification (R2 >0.9, Q2 > 0.9, Accuracy > 0.98) and identified marker metabolites for classification. Mass spectrometry based untargeted metabolite profiling of samples can classify different species and verities of *Ocimum*.

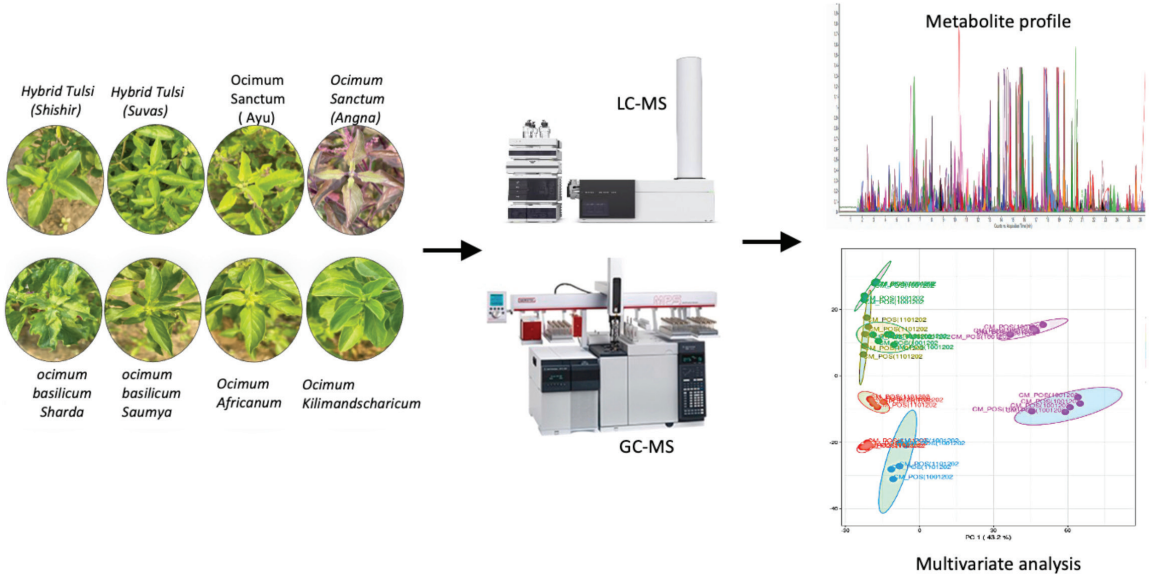


Fig. Schematic of the untargeted metabolomics of *Ocimum* using LC-MS and GC-MS

Dr. Ratnasekhar CH & his team

Bio-Prospection & Product Development

HIGHLIGHTS

According to UNDP (United Nations Development Programme), Biodiversity prospecting or bioprospecting (or Bioprospection) is the systematic search for biochemical and genetic information in nature in order to develop commercially valuable products for pharmaceutical, agricultural, cosmetic and other applications.

The present focus of Bioprospection group is on infectious diseases, metabolic disorders and safety evaluation of MAPs using modern tools. Research activities at Bioprospection and Product Development (DU) are aimed at 'Bioprospecting natural resources for novel bioactive molecules and value-added products for a better health and life." Efforts are focussed at finding the solutions for infective agents (bacteria, fungi, malaria parasite) and some of the metabolic disorders such as diabetes, hepatoprotection, pain, fever, inflammation, arthritis, immuno-modulation, cancer, hypertension etc. The efforts are also directed towards finding the safety limits of herbal preparations/ products.

Some of the major highlights have been the study of the host pathogen interaction through medicinal and aromatic plants for immunity boosting activity and anti-malarial activity.

Eighty percent of the immune system is in the gut lining- that is the eighty percent of our body's defence system, which makes the gut a really important organ. Studies on the validation of traditional medicinal plants on gut immunity and related immune cells have been lacking and hence we considered working on this area by utilizing various *in-vitro* and *in-vivo* models for proving the innate and the adaptive arms of the immune system. The recently concluded project of phytochemically characterized '**Triphala'** formulation through typhoid rodent model validated its role in stimulating the humoral immunity.

Scientists of Bio-prospection and Product Development Divisional Unit

(L to R) : Dr. Suaib Luqman, Dr. D. Chanda, Dr. D Saikia, Dr. Abha Meena, Dr. DN Mani, Dr. Anirban Pal, Dr. N. P. Yadav, Dr. DU Bawankule

Malaria remains one of the major health concerns due to resistance in Plasmodium species towards existing drugs warranting an urgent need of new antimalarials. The anti-plasmodial activity of extracts fractions or derivatives against chloroquine sensitive (NF-54) and resistant (K1) strains of *Plasmodium falciparum* were being undertaken with their *in-vivo* validations through rodent models of *P. berghei* and *P. yoelii nigeriensis*. We have recently reported the potent anti-malarial activity of 4-Chlorothymol and also found it to perturb the redox balance by modulating the glutathione transferase and glutathione reductase, increasing the mean survival time in rodent models. It also showed synergy with chloroquine against chloroquine- resistant *P. falciparum* [Frontiers of Pharmacology (2021) 12, 93]. Similarly, we also reported the synergistic activity of 4-Chloroeugenol with artesunate by increasing the reactive oxygen and nitrogen species besides affecting the macromolecules in terms of DNA damage, protein carbonylation and lipid peroxidation [Biomedicine and Pharmacotherapy (2021), 137, 11131].

Another highlight is the assessment of essential oils/constituents such as Lavender essential oil and its major components linalool and linalyl acetate in imiquimod-induced mice model for anti-psoriatic effect. This is perhaps the first report for scientific validation of any essential oil for psoriasis, although essential oils are in use for aromatherapy long back. Use of a skin analyzer as an alternative method for the PASI score in psoriasis is also innovative.

Also, to mention an emergent area being explored by scientists in our division is the exploration of the anti-hypertensive activity of medicinal plant derived molecules and extracts using *ex-vivo*, *in-vitro* and *in-vivo* models. Hypertension associated ion channels modulation by phytomolecules like lignans, scopoletins, benzimidazoles and naphthoquinone are explored considering their great scope for cardiovascular research.

Area of Research

1. Bioprospecting anti-infective agents active against sensitive and drug resistant strains (bacterial, fungal, malarial parasite).
2. Bioprospecting crude drug/extracts/molecules for metabolic and other life style related disorders.
3. Development of herbal formulations based on identified scientific leads and traditional knowledge base.
4. Toxicity and Safety evaluation of MAPs and their products.

Major scientific outputs/technologies

1. Identification of phyto-extracts/fractions/molecules those are active against harmful microbes/pathogens and cancer cells.
2. Translation of research in to products for general healthcare utilizing medicinal and aromatic plants (MAPs) based research leads.
3. Transfer of technologies for their commercial utilization promoting new entrepreneurships and start-ups.
4. Validation of the Concepts of Gut Immunity Through Traditionally Known Medicinal Plants.
5. Standardization of Chemical Induced Arthritis on small animal model to screen MAPs for RA (*Amavata*).
6. Cliv-92-Loaded Glycyrrhetinic Acid-Modified Chitosan Nanoparticles for Enhanced Hepato-protection–Preparation, Characterization, and *in vivo* Evaluation.
7. Suppression of molecular targets and antiproliferative effect of citronellal on triple-negative breast cancer cells.
8. Acacetin and pinostrobin as a promising inhibitor of cancer-associated protein kinases.
9. Baicalin mediated regulation of key signaling pathways in cancer.
10. Flavonoid display ability to target microRNAs in cancer pathogenesis
11. Purpurin: A natural anthraquinone with multifaceted pharmacological activities.
12. Citronellal, an acyclic monoterpene suppresses the activity of ornithine decarboxylase in hypopharyngeal carcinoma cells.
13. p-Menthadienols-rich essential oil from Cymbopogon martini ameliorates skin inflammation.

14. Rutin ameliorates malaria pathogenesis by modulating inflammatory mechanism.
15. New Insights into the Chemical Composition, Pro-Inflammatory Cytokine Inhibition Profile of Davana (Artemisia pallens Wall. ex DC.) Essential Oil and cis-Davanone in Primary Macrophage Cells.
16. Ameliorative Effects of Dietary Ellagic Acid Against Severe Malaria Pathogenesis by Reducing Cytokine Storms and Oxidative Stress.
17. Generated preclinical oral safety data using acute, sub-acute and sub chronic toxicity testing of medicinal plant molecules, standardized extracts and products and dermal safety data of essential oils, molecules and products.
18. Reported antihypertensive activity in a potent anti-diabetic medicinal plant and identified new medicinal plant molecule as a vasorelaxant.

Patents

Novel composition of essential oil-based formulation for its use as room disinfectant and room freshener. Filed Indian Patent, Application No. 0174NF2021; Dated: 13.10.2021

Skill Development

1. Successfully organized the 5-days training module on *Pre-Clinical Development of Medicinal and Aromatic Plant-based Leads* through online and offline mode under **CSIR-Skill Initiative Program.**
2. Successfully organized **5-days online training program** on Herbal Drug Development Technologies under CSIR-Skill Initiative Program**.**
3. Successfully organized **2-days training program** on "**Entrepreneurship Development Hands on Training Program**" under CSIR-Skill Initiative Program**.**

Research Facilities

1. Biosafety level I-II containment facility for *in-vitro* drug testing
2. CPCSEA approved breeding and research facility (animal house) for small animals.
3. NABL accredited Microbiology Laboratory for Medicinal and Aromatic Plants
4. Technology Business Incubation Centre (**TBIC**), having manufacturing License of research based Herbal formulation under The Department of Ayurveda, U.P. Govt.
5. **GMP** facility for Herbal extract manufacturing, by the Department of Ayurveda, U.P. Govt
6. Animal cell culture facility
7. Mosquito culture facility
8. Herbal Formulation Facility,
9. Nano-formulation development
10. Anoxomat mark II system for anaerobic microbes
11. All relevant and modern instruments needed for bio-evaluation of MAPs and product formulation are available in our DU, some of them as mentioned below--

Instruments

Spectrofluorometer, UV-Vis-spectrophotometers, ELISA plate reader, Ultra Centrifuge and High speed refrigerated centrifuge, Animal isolators for in-vivo drug testing, cryo-microtome, Plethysmometer, animal physiograph, dual chamber wire myograph, non-invasive and invasive measurement of hemodynamics, rodent ECG, smooth muscle cell culture etc., Inverted microscope, Upright fluorescent microscope, Bectec-MGIT, HPLC, Chemi-luminescent imager, Bio-safety Cabinet, CO2 Incubator, Water bath, Hot plate Analgesiometer, Rota rod apparatus, Passive avoidance apparatus, Water Maze, fluorescence based intracellular calcium and potassium imaging, Mindray BC 3000Plus [Complete Blood Counter], Biochemical test analyzer, Mosquito repellent chamber.

Instruments for Product formulation

MISPA VIVA Manual Capsule filling machine, Dolphin 1018 Planetary Mixers, Inschem FRB-10 Viscometer, Brookfield DV-II+ Pro, Particle Size Analyser for nano-formulations, Stability Chambers for shelf-life study of herbal products, Homogenizer for herbal formulations, Sonicator for nano-formulations, Tablet machine.

Dr. D. Saikia Mk- Mh- lfd ;k

The antimicrobial activity of *Ravenia spectabilis*

The antibacterial and antifungal activity of the essential oil of *Ravenia spectabilis* was evaluated by disc diffusion and microdilution broth assays. The bacterial strains were *Staphylococcus aureus* (MTCC96), *Staphylococcus epidermidis* (MTCC435), *Escherichia coli* (MTCC723), *Klebsiella pneumoniae* (MTCC109), MRSA {methicillin-resistant *Staphylococcus aureus* (33591)}, MRSE {methicillin resistant *Staphylococcus epidermidis* (51625)}. The fungal strains were *Candida albicans* (ATCC14053) and *Candida kefyr* (ATCC204093). The activities were measured in terms of the net zone of inhibition (ZOI) and minimum inhibitory concentration (MIC), minimum bactericidal concentration / minimum fungicidal concentration (MBC/MFC). Norfloxacin and Amphotericin B were used as positive controls.

Table: Antimicrobial activity of the leaf essential oil of *Ravenia spectabilis*

Strains	Essential oil			Standard†		
	ZOI (mm)	MIC (mg/ml)	MBC/MFC (mg/ml)	ZOI (mm)	MIC (µg/ml)	MBC/MFC (µg/ml)
Staphylococcus aureus	28±0.58	2.08±0.0	4.16±0.0	35±0.58	1.56±0.0	1.56±0.0
Staphylococcus epidermidis	23±0.58	2.08±0.0	4.16±0.0	44±1.15	0.78±0.0	0.78±0.0
Escherichia coli	2±0.58	-	-	44±0.58	3.12±0.0	3.12±0.0
Klebsiella pneumoniae	2±0.58	-	-	44±1.15	3.12±0.0	3.12±0.0
Methicillin-resistant *Staphylococcus aureus*	27±0.58	2.08±0.0	4.16±0.0	38±0.58	3.12±0.0	3.12±0.0
Methicillin-resistant *Staphylococcus epidermidis*	24±0.58	2.08±0.0	4.16±0.0	44±0.58	0.78±0.0	0.78±0.0
Candida albicans	15±0.58	2.08±0.0	4.16±0.0	18±0.58	0.39±0.0	0.39±0.0
Candida kefyr	16±0.58	2.08±0.0	4.16±0.0	12±0.58	1.56±0.0	1.56±0.0

ZOI: Zone of inhibition (mean ± standard error of mean); MIC: minimum inhibitory concentration (mean ± standard error of mean); MBC: minimum bactericidal concentration (mean ± standard error of mean); MFC: minimum fungicidal concentration (mean ± standard error of mean); †norfloxacin used for bacterial strains; †Amphotericin-B used for fungal strains, - No inhibition observed.

Dr. D. Saikia & his team

Dr. Anirban Pal Mk- vfucu iky

Inhibition of heme detoxification pathway in malaria parasite by 3-hydroxy-11-keto-β-boswellic acid isolated from *Boswellia serrata*

Historical evidence proves that the plants possess a major resource for the development of novel anti-malarial drugs. In the present study, the bioactivity guided fractionation of the oleogum-resin of *Boswellia serrata* Roxb. yielded the optimum activity in the ethyl acetate fraction with an IC_{50} of 22±3.9µg/mL and 26.5±4.5µg/mL against chloroquine sensitive (NF54) and resistant (K1) strains of *Plasmodium falciparum* respectively. Further, upon fractionation, the ethyl acetate fraction yielded four major compounds, of which 3-Hydroxy-11-keto-β-boswellic acid (KBA) was found to be the most potent with IC_{50} values 4.5±0.60µg/mL and 6.25±1.02µg/mL against sensitive and resistant strains respectively. KBA was found to inhibit heme detoxification pathways, one of the most common therapeutic targets, which probably lead to an increase in reactive oxygen species (ROS) and nitric oxide (NO) detrimental to *P. falciparum*. Further, the induced intracellular oxidative stress affected the macromolecules in terms of DNA damage, increased lipid peroxidation, protein carbonylation as well as loss of mitochondrial membrane potential. However, it did not exhibit any cytotoxic effect in VERO cells. Under *in vivo* conditions, KBA exhibited a significant reduction in parasitemia, retarding the development of anaemia, resulting in an enhancement of the mean survival time in *Plasmodium yoelii nigeriensis* (chloroquine-resistant) infected mice. Further, KBA did not exhibit any abnormality in serum biochemistry of animals that underwent acute oral toxicity studies at 2000mg/kg body weight (***Biomedicine & Pharmacotherapy***, Vol. 144, 2021, 112302).

Dr. Anirban Pal & his team

Dr. Daya Nandan Mani Mk- n;k uUnu ef.k

Standardization of Chemical Induced Arthritis in small animal to screen MAPs for RA (*Amavata*)

Rheumatoid Arthritis is a chronic auto-immune disorder causing systemic inflammation and tends to affect multiple joints of the body. Disease primarily affects the joints of hands and feet symmetrically. Main symptoms of the disease include pain, stiffness and swelling in the affected joints. This pain & stiffness is more prominently felt in the morning or after long idle hours. Other pathological symptoms include – Synovial hyper plasticity, synovitis, damage of cartilage and erosion of bone (localized, peri-articular and also systemic). Currently, various drugs are being used to manage disease condition but no standard treatment regime is available. Treatment depends on the severity and disease duration. Treatments like NSAIDs (Dexamethasone), DMARDs (Methotrexate) and biological inhibitors (TNF-α inhibitors) like Infliximab, Eternacept and Abatacept are prescribed but have their own set of side effects.

According to Ayurvedic classical texts, *Amavata* disease first mentioned by *Madhavkar* in *Madhav nidan* is the most similar to modern Rheumatoid Arthritis. Inflammation of small and large joints is a prominent symptom of the disease and further pain, irritation and loss of function of the affected joint is also prevalent. It also causes consistent pain in the lower back region thus making it difficult for the patients to move. Formation of '*Ama*' in the body due to impaired digestion is the main cause behind *Amavata*. The probability of getting

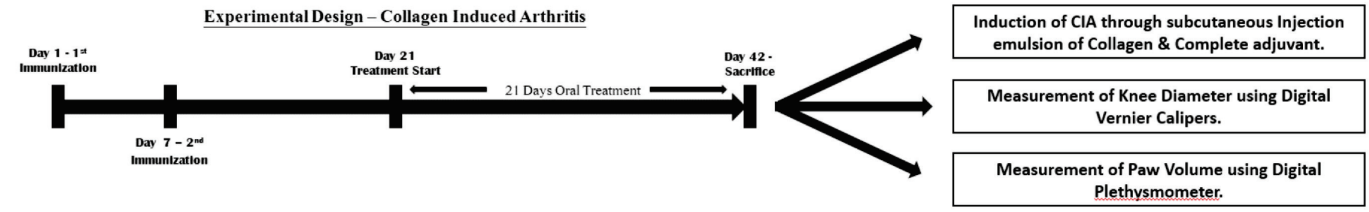
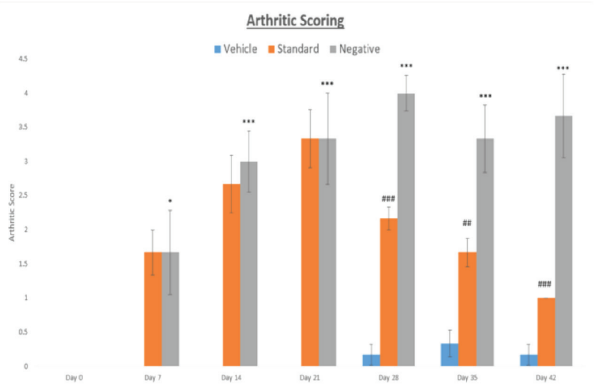


Figure 1 – Depicting paw conditions in different arthritic scoring conditions. Pictures depict arthritis scores 0 to 4 from a) to e) respectively. a) No redness or swelling, score 0. b) Severe redness in both hind paws, score 1. c) Mild swelling without redness, score 2. d) Moderate swelling with prominent redness and difficulty of movement, score 3. e) Severe swelling, redness and ankylosis with loss of movement.

Disease Scoring Criteria

Score 0 – No Redness or Swelling.
Score 1 – Moderate to severe redness in paws.
Score 2 – Mild swelling of one or more digits or paw with or without redness.
Score 3 – Moderate swelling of one or more digits or paw with or without redness.
Score 4 – Severe swelling of one or more digits or paw with or without redness OR Ankylosis and loss of function of limb.



Graph 1 - Measurement of Arthritic Score of Vehicle, Negative and Treatment group based on pre-defined criteria. Data is represented as mean ± SEM (n=6)
* Assessment of disease (CIA) Induction through comparison of Arthritic Score between Vehicle and Negative groups on particular days. *p ≤ 0.05, ** p ≤ 0.01, *** p ≤ 0.001. # Assessment of treatment(Dexamethasone) efficacy through comparison of Arthritic Score between Standard and Negative groups on particular days. # p ≤ 0.05, ## p ≤ 0.01, ### p ≤ 0.001.

affected by *Amavata* increases with age and is more in females compared to males. Cold environment, family history, mental stress, incompatible diet and disturbed sleeping cycle are some of the others causes behind *Amavata*. Spike of pain during cold nights, forces the patients to sleep during warm days when pain is reduced, causing disturbed sleeping cycle and self-perpetuating disease. According to *Ayurveda*, the main objectives of the treatment regime should be to normalize the impaired digestive fire - '*Agni*', eliminate toxins like '*Ama*' from the body and balance *Vata dosha* of the body.

Collagen Induced Arthritis (CIA) is an established model that corresponds with Human auto-immune Rheumatoid Arthritis. Disease is caused by immunizing animals with emulsion of Bovine collagen and Freund's Complete adjuvant through sub-cutaneous injection at the base of tail on Day 1 & Day 7. Symptoms of the disease start to develop from 10 to 14 days after immunization.

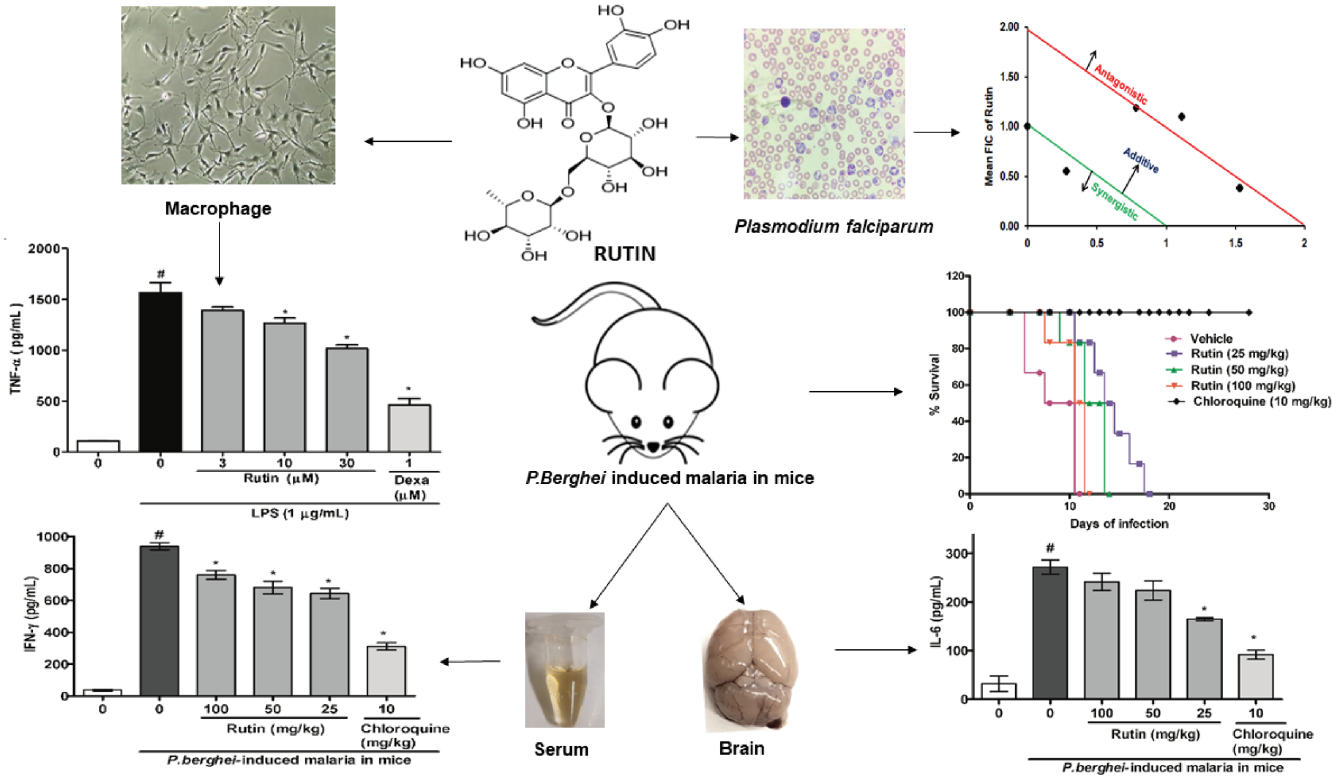
Disease Induction is primarily measured through scoring of arthritis based on the defined criterion mention in Fig. 1.

Dr. Daya Nandan Mani & his team

Dr. DU Bawankule Mk- Mh-;- ckoudy

Rutin ameliorates malaria pathogenesis by modulating inflammatory mechanism: An *in-vitro* and *in-vivo* study

Rutin (3, 3', 4' 5, and 7-pentahydroxyflavone-3-rhamnoglucoside) is a flavonoid glycoside, found in many edible plants such as buckwheat and berries. Severe malaria is an inflammatory response triggered by oxidative stress that results in multi-organ pathologies and a high mortality rate in children and pregnant women worldwide. Rutin is recommended as a food supplement for the treatment of various diseases due to its anti-oxidative and anti-inflammatory properties, which prompted us to investigate its ameliorative effects in severe malaria pathogenesis against oxidative stress and inflammatory response using in vitro and in vivo bioassays. Rutin was examined in this work for its anti-plasmodial activity against chloroquine-sensitive and resistant Plasmodium falciparum strains, as well as its anti-oxidative and anti-inflammatory activity against LPS-stimulated macrophage cells. The in vitro data were subsequently verified in mice fed orally with rutin alone or in combination with chloroquine in Plasmodium berghei-induced malaria pathogenesis. The anti-plasmodial and anti-inflammatory properties of rutin were demonstrated in in vitro results. Apart from its anti-inflammatory and anti-oxidant effects in malaria pathogenesis, in vivo efficacy studies indicated that oral treatment with rutin reduced parasitaemia, increased mean survival time, and restored haemoglobin and glucose levels in mice at lower dose. Interestingly, both rutin and chloroquine demonstrated synergy in in vitro and in vivo experiments.The findings of the present study thus highlighted the suitability of rutin for further study in the management of drug resistant malaria in combination with standard anti-malarial drugs (***Inflammopharmacology***, 30(1):159-171, 2022).



Dr. DU Bawankule & his team

Dr. NP Yadav Mk- ,u-ih- ;kno

Cliv-92-loaded nanoparticles for enhanced hepatoprotection

Cliv-92 is a mixture of three structurally similar coumarinolignoids and a proven hepatoprotective agent. Glycyrrhetinic acid linked chitosan nanoparticles loaded with Cliv-92 were prepared for active targeting to liver. The nanoparticles were prepared by ionic gelation method to avoid use of toxic solvents/ rigorous agitation. The method of preparation was optimized using central composite design with independent variables namely polymer: drug ratio (3:1; w/w), crosslinker concentration (0.5%) and stirring speed (750 rpm). The optimized nanoparticles had a mean particle size of 185.17 nm, a polydispersity index of 0.41, a zeta potential of 30.93 mV, and a drug loading of 16.30%. The prepared formulation showed sustained release of approximately 63% of loaded Cliv-92 over 72 h. *In vivo* imaging study showed that optimized nanoparticles were preferentially accumulated in the liver and successfully targeting the liver. The present study successfully demonstrated the improved pharmacokinetic properties (≈12% relative bioavailability) and efficacy profile (evidenced by *in vivo* and histopathological studies) of fabricated Cliv-92 nanoparticles (***AAPS PharmSciTech***. 2021, 22(8):259).

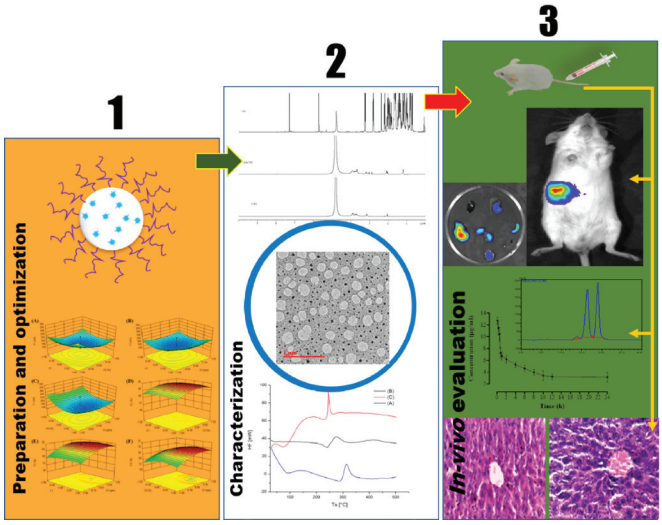


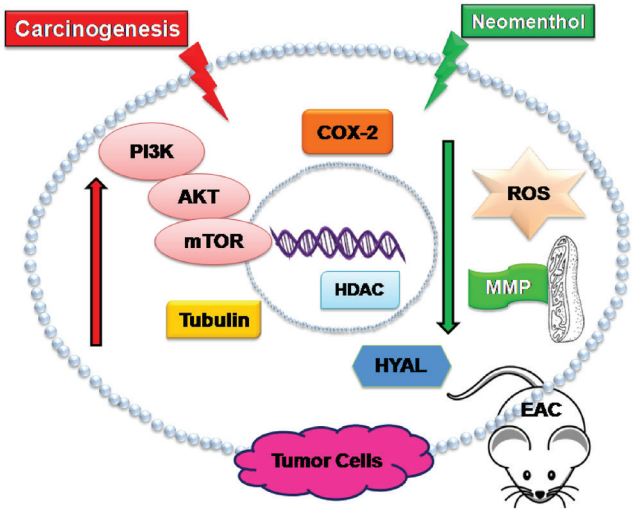
Fig. Cliv-92-loaded nanoparticles for enhanced hepatoprotection

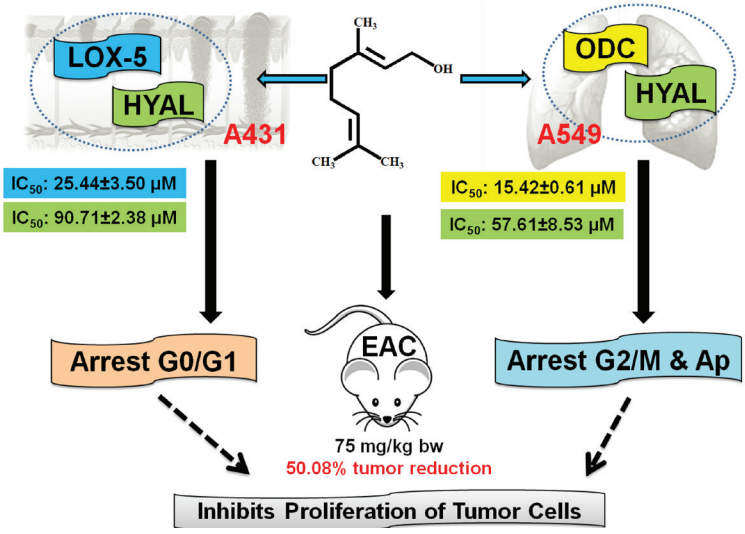
Dr. NP Yadav & his team

Dr. Suaib Luqman Mk- 'kk,c y;deku

Neomenthol averts the proliferation of skin cancer cells

Neomenthol delayed the growth of skin carcinoma cells by inhibiting the tubulin polymerization and hyaluronidase activity, which are responsible for tumor growth, metastasis, and angiogenesis (*Journal of Advanced Research 2021; 34: 93–107*).





Antiproliferative action of geraniol in lung and skin cancer cells

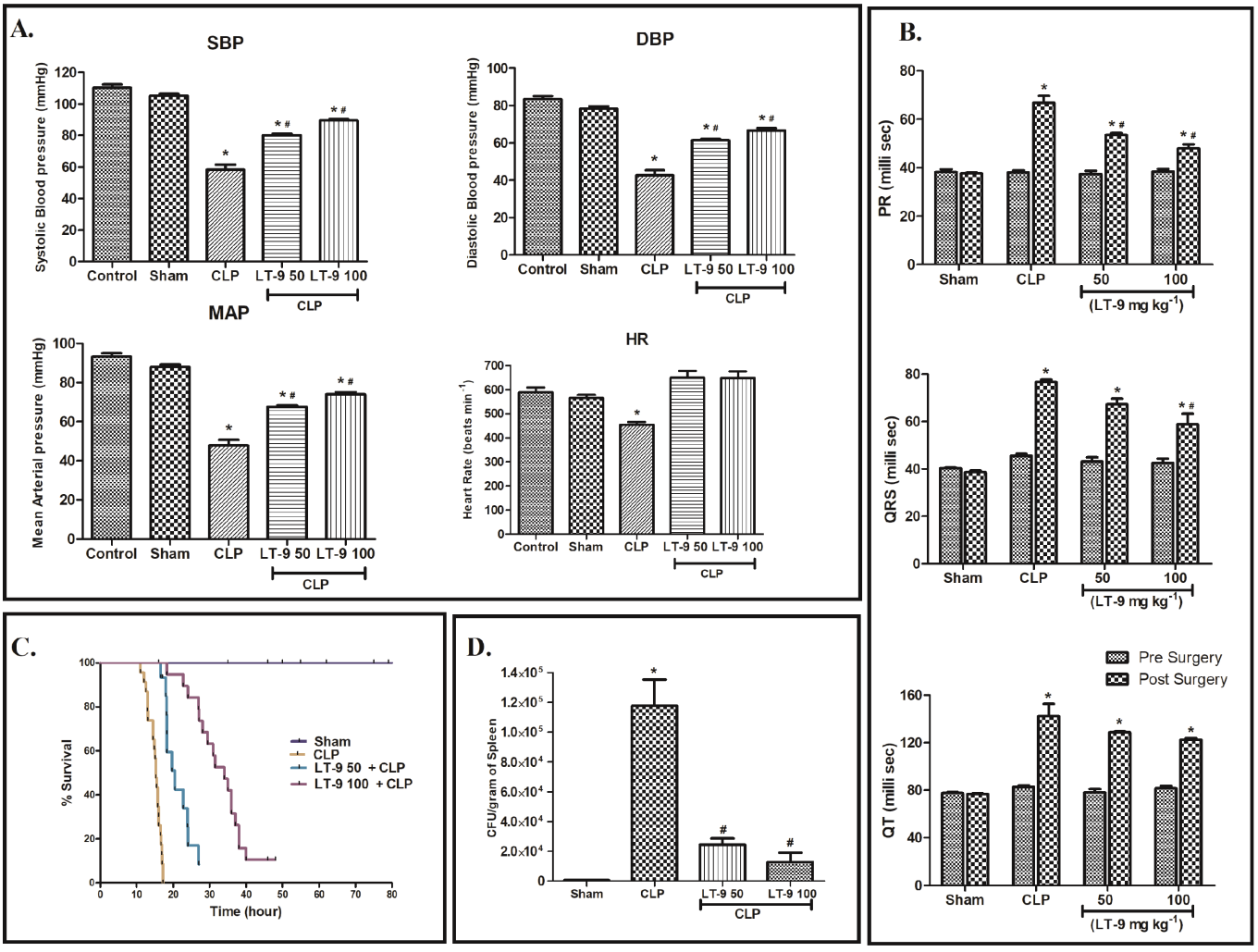
Geraniol is the acyclic monoterpene alcohol having two prenyl units' allied head-to-tail and functionalized with one hydroxyl group at its tail end could be responsible for the antiproliferative activity (*Phytotherapy Research* 2021; 37 (7): 3861-3874).

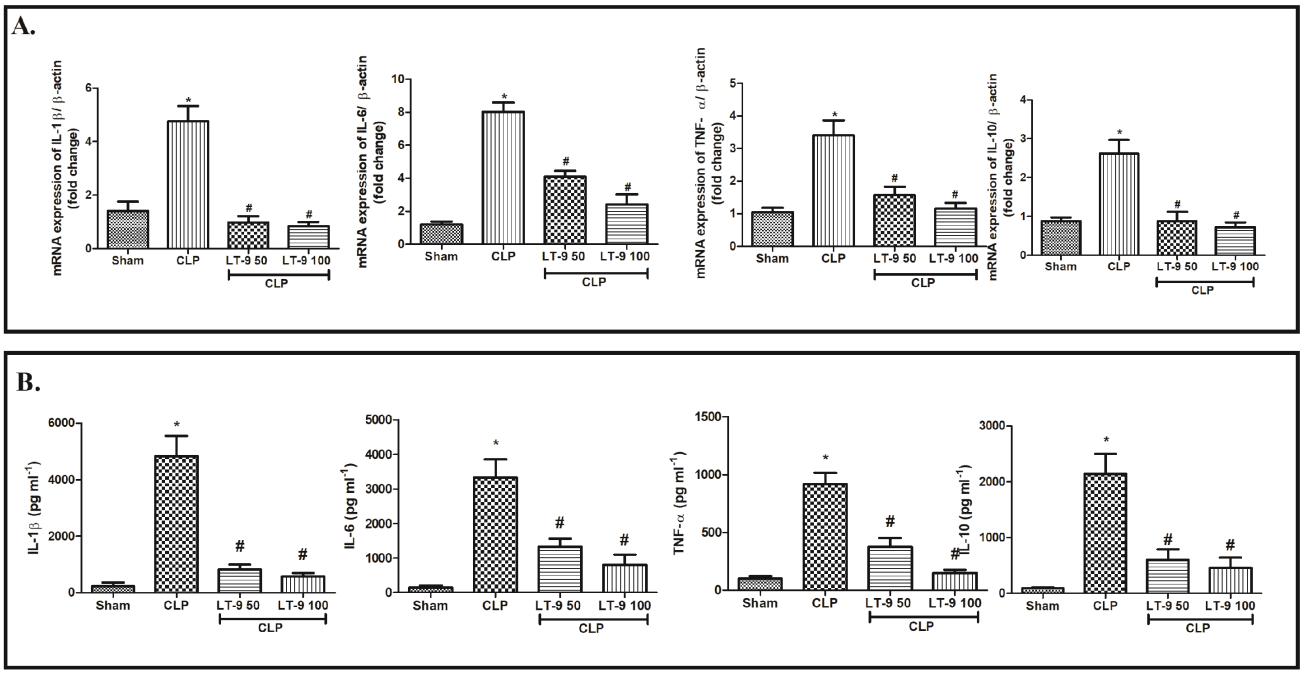
Dr. Suaib Luqman & his team

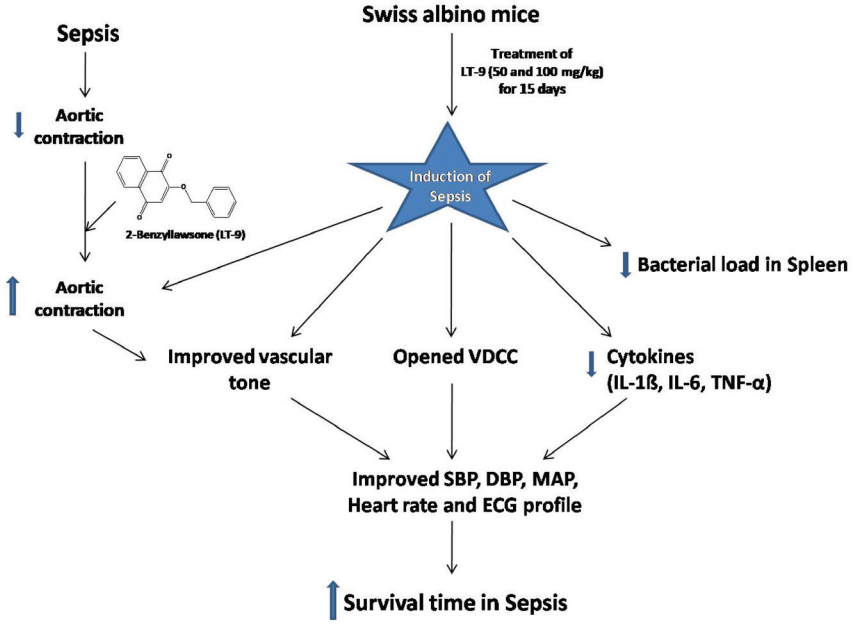
Dr. Debabrata Chanda Mk- nccr pnk

2-benzyllawsone protects against polymicrobial sepsis and vascular hyporeactivity in Swiss albino mice

Novel naphthoquinone, 2-benzyllawsone (LT-9) was evaluated against vascular hyporeactivity and sepsis in cecal ligation and puncture (CLP) model in mice in view of its preliminary antibacterial and anti-inflammatory properties and to explore whether pretreatment with the molecule could restore vascular tone and contractile response to norepinephrine. Evaluation of LT-9 against vascular hyporeactivity, hypotension, and sepsis-related inflammation and infection was carried out in the CLP model in Swiss albino mice and aortic smooth muscle cells *in vitro*. LT-9 showed potent reversal of the vascular hyporeactivity in CLP mice aorta. The increased contraction response to norepinephrine in CLP mouse aorta by LT-9 was mediated by opening of L-type voltage-dependent calcium channels (VDCC) verified by *ex vivo* experiment where LT-9 enhanced contraction response to $CaCl_2$ in the aorta while abolishing the contraction response of known VDCC opener Bay K8644. LT-9 in aortic smooth muscle cells showed Fluo-4 mediated increase in calcium fluorescence. Oral administration of LT-9 at 50 and 100 mg kg^{-1} day^{-1} for 15 days significantly enhanced the mean survival time, improved hemodynamic and Electrocardiogram (ECG) profile, and aortic tissue reactivity in CLP mice. Further, LT-9 significantly





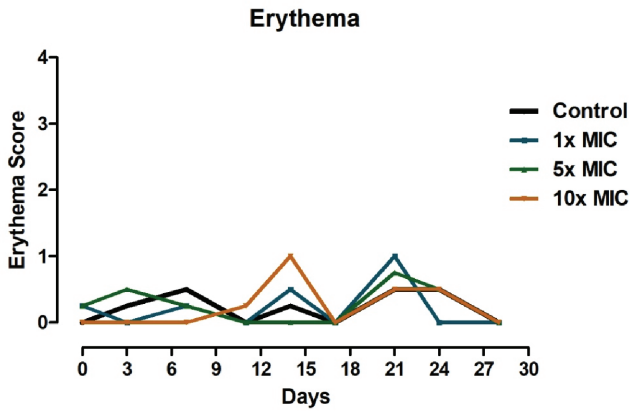


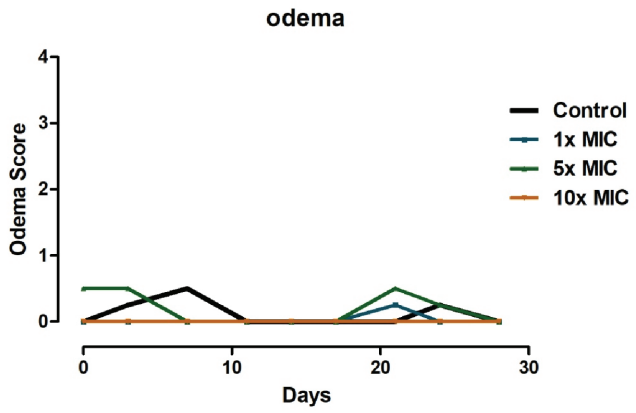
reversed the perturbation of the expression profile of inflammatory cytokines, reduced the splenic microbial load, and was well tolerated in oral toxicity. LT-9 showed potent biological activity against sepsis and was found to be well tolerated in the toxicity study in Swiss albino mice and showed promise for the benzyllawsone class of molecules against sepsis for the development of novel pharmacophore (***European Journal of Pharmacology*** 917 (2022) 174757).

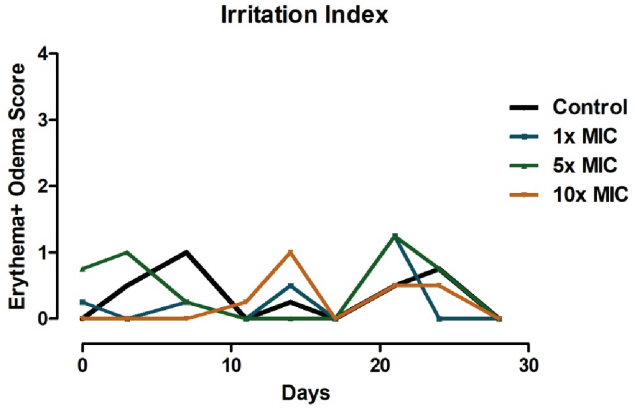
Preclinical dermal safety of economically important essential oils:

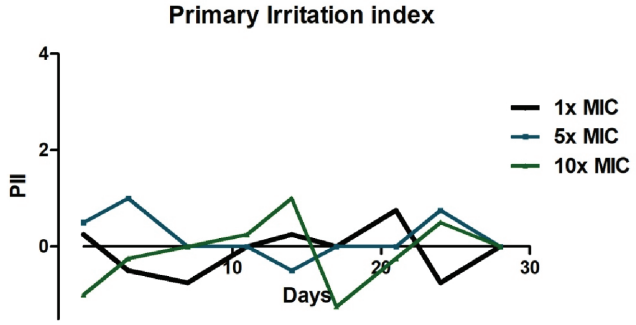
Acute and sub-acute dermal toxicity up to 10X concentration (1X is the reported MIC of the oil for antimicrobial activity) of essential oils from *Citronella-Bio13, Geranium, Ocimum basillicum* (Var. CIM-Saumya), *Mentha arvensis, Mentha spicata* found to be non-irritant to animal models studied.

PII score less than 2 is considered as non irritant







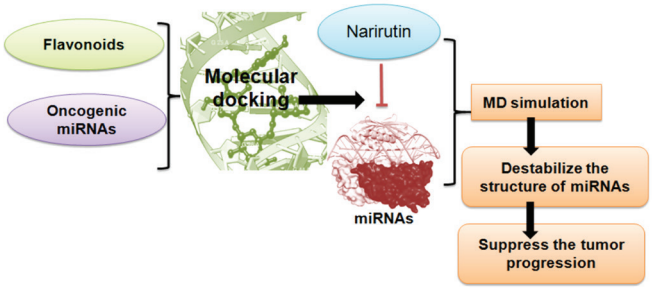


Dr. Debabrata Chanda & his team

Dr. Abha Meena Mk- vkHkk eh.kk

Dietary flavonoid narirutin as a prospective antagonist of oncogenic pri/pre-microRNAs

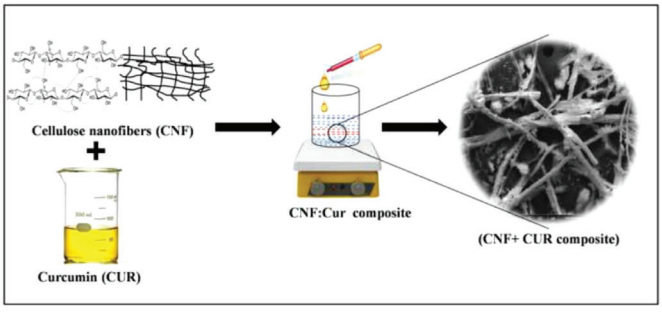
MicroRNAs (miRNAs) are involved in cancer progression via translational degradation in a sequence-specific manner of the 3′-untranslated region (3′UTR) of messenger RNA (mRNA). The involvement of miRNA in the biological progression of various cancer types is considered to be a potential target. Primary miRNA (pri-miRNA) and precursor-miRNA (pre-miRNA) synthesize the miRNA by dicer-catalyzed processes thus targeting pri/pre-miRNA by phytochemicals is amongst the appropriate approaches for anticancer therapies. Flavonoids category of phytochemicals is well-known for its chemotherapeutic and chemopreventive potential against multiple cancer types. However, the molecular interactions of flavonoids with miRNAs are not reported so far. Thus, this study aims to



identify the promising flavonoids as the antagonist of miRNAs (pre-miR21, pri-miR-208a, pri-miR-378a, pri-miR320b, pri-miR-300, pri-miR-19b, and pre-miR-20b) using molecular docking simulations studies. Among the tested flavonoids, narirutin showed highest binding energy (−11.7 kcal/mol) against pri-miR19b followed by pri-miR-378a (−11.4 kcal/mol) > pri-miR320b (−11.2 kcal/mol) = pri-miR-300 (−11.2 kcal/mol) > pri-miR-208a (−9.0 kcal/mol) > pre-miR-20b (− 8.3 kcal/mol). The molecular dynamic simulation experiment confirmed that narirutin destabilizes the tertiary structure of pri-miRNA in comparison to apo-RNA. The finding indicates that narirutin binding with pre-miRNA causes disruption of pri-RNA structure that creates a loss of DICER-pre-miRNA interactions by hindering the pre-miRNA synthesis, thereby affecting miRNA processing. Further pharmacokinetics and toxicity prediction revealed that it is non-carcinogenic, non-mutagenic, and does not inhibit the CYPs activity. Thus, narirutin could be a possible antagonist of oncogenic miRNAs, therefore could be useful for miRNA-targeted cancer prevention and treatment (***Phytotherapy Research***. 36, 963–983. 2022).

Lemongrass derived cellulose nanofibers for controlled release of curcumin and its mechanism of action

The enzyme-based cellulose nanofibers from lemongrass waste were used as a potential carrier for the sustained release of curcumin, a natural anticancer polyphenol against different cancers. However, its low bioavailability, solubility and suboptimal pharmacokinetic issues limit its use in cancer therapeutics. The curcumin was encapsulated into the cellulose nanofibers with the highest encapsulation efficiency of ~ 99% through homogeneous monolayer adsorption. Further, the binding of curcumin onto the cellulose nanofibers and its morphology were confirmed by FT-IR, molecular interaction study and SEM analysis. The controlled release profile of the encapsulated curcumin was determined at different simulated pH conditions, *i.e.*, 1.2, 5.3, 6.8 and 7.4. At all pH conditions, the highest correlation was observed in Korsmeyer-peppas equation, indicating release occurred through diffusion. Moreover, the

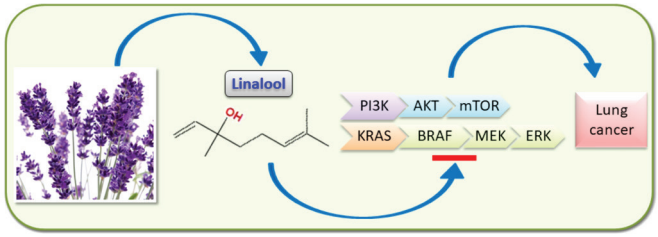


nanocomposite conserves the efficacy of curcumin in PC3 cell lines. Hence, the results suggest that the enzyme-based cellulose nanofibers are a good candidate for controlled release for curcumin without hindering its efficacy, which may be applied for pharmaceutical applications (***Industrial Crops and Products***. 173. 114099. 2021).

Exploration of Chemopreventive Potential of Linalool in Targeting Lung Cancer Biomarkers

Phytochemicals are used to treat lung cancer in contemporary and traditional medicine. The limitations of known chemotherapeutic drugs such as non-specificity, resistance, and toxicity restrict their use for lung cancer treatment. Therefore, the search for target-specific novel entities is required continuously.

Linalool, a monoterpene alcohol that possesses antiviral, anti-inflammatory, and antibacterial properties, is present in sweet basil, laurel, jasmine, rosewood, and lavender. Previous reports revealed its anticancer potential against colon, breast, and liver cancer. In this study, linalool's efficacy in targeting biomarkers associated with different lung cancer stages has been investigated



The in silico molecular docking analysis was used to explore drug-receptor interaction, and further, linalools cytotoxicity potential was evaluated on lung adenocarcinoma cell line (A549). The toxicity profiling of linalool was done by ADMET analysis. In the results, Linalool revealed an excellent binding affinity with the selected targets. It showed the highest interaction with BRAF with the binding energy of -5.6 kcal/mol. Furthermore, it successfully interacts within the binding pocket of BRAF, similar to its inhibitor (Sorafenib). In MTT analysis, linalool significantly reduces the percent viability IC30 474.94 ± 43.12, 379.33 ± 49.5, and 183.77 ± 66.7 µM in A549 cell lines for 24, 48, and 72 h, respectively.

These results concluded that linalool possesses chemopreventive potential against lung cancer by interacting or modulating selected biomarkers associated with a lung cancer diagnosis, progression, and proliferation (***Endocrine Metabolic & Immune Disorders - Drug Targets***, 2021).

Dr. Abha Meena & her team

Plant Biotechnology

HIGHLIGHTS

The Plant Biotechnology Division (DU) of CSIR-CIMAP, which includes 13 scientists, is working in the areas of genomics, molecular biology, biochemistry, synthetic biology, *in silico* biology and tissue culture with respect to Medicinal and Aromatic Plants (MAPs). Most of the divisional activities are basic research and aimed for the improvement of MAPs for improved quality and traits in terms of secondary metabolites. Active collaborations from faculty of other disciplines of CSIR-CIMAP are also integrated into the research programmes for generating high-quality data and output of international standards. The major focus plants during the year *Withania somnifera, Andrographis paniculata, Bacopa monnieri, Catharanthus roseus, Mucuna pruriens, Gymnema sylvestre, Ocimum species, Artemesia annua,* rose-scented Geranium, *Cannabis, Coleus* and few others. Most of the faculty of the division are actively involved in the R&D projects funded by CSIR or external Government agencies. Genome editing of five different MAPs and few other model crops is being done by scientists of the department for quality improvement in metabolite content and phenotypic characters under the CSIR Network Focussed Basic Research (FBR-Network) project, "Genome Editing for Crop Improvement (GE-Crop; MLP0007, in which CSIR-CIMAP is the Nodal laboratory with seven other participating laboratories. The scientists of this division are also involved in other FBR Network projects aimed to utilize endophytes (MLP0048) and Plant-based biostimants (MLP0049) from improvement of crop p[roductivity. In addition to these, four other CSIR FBR projects (MLP0002, MLP0003, MLP0005 and MLP0006) are being headed by scientist of this DU. Scientist from the DU have also actively participated under various vertical heads of CSIR-Aroma Mission (Phase-II implementation).

During this period (2021-22), scientist of the DU were involved in the identification, characterization and regulation of a number of enzymes involved in biosynthesis of important metabolites from various plants. Our work on microRNAs has uncovered the role of HY5 in regulating miR858, and miR775 has been found to integrate light, sucrose and auxin pathways in *Arabidopsis*. A BAHD acetyl transferase was identified to be involved in wound induced biosynthesis of oleo-gum resin triterpene in *Boswelia serrata*. A role of a novel UDP-glycosyltransferase in biosynthesis of labdane diterpenes in *Andrographis paniculata*. By subjecting *Catharanthus* plants to various treatment, a strong association between the expression of CrAOC gene and vindoline accumulation was inferred. A TPS gene from potato was established farnesyl synthase and was found to plant a role against bacterial infections. Towards understand the regulation of enzymes involved secondary metabolism, miRNA from *Bacopa monieri* was sequenced and analysed, and the group experimentally validate three Bm-miRNA targets, including Asparagine synthetase, Cycloartenol synthase, and Ferulate 5 hydroxylase (F5H). In another work, infection by velvet bean severe mosaic virus was found to cause an increase in L-dopa content in *Mucuna puriens* form which transcriptome data has been generated and is being analysed for identification of various transcripts associated with impotant metabolite synthesis. Effect of various condition of Mentha arvensis and Ocimum is also under progress. In *Withania somnifera*, important genes related to root phenotype are being analysed for improving the accumulation and extraction of withanolides from roots. In synthetic biology field for hetelogous production of commercially important molecules, strains of yeast (with altered lipid pathway) and Azospirillum have been developed which are showing increased production of beta-amyrin and valancene, respectively. The crystallography group has put insight into receptor-

binding of pyrazolopyrimidines which are not only used as a template in drug design but also as base molecule whose derivatives have medicinal and/or insecticidal activities.

During the course of these important studies, the scientist of the DU have published 15 publication (average impact factor >2.8) in SCI impact factored journal of high repute like, Plant Journal, Journal of Biological Sciences, Protoplasma, Plant Science, BBRC and Industrial Crop and Products etc as corresponding authors in addition to the contribution to many other publications including other research articles (as contributory authors/non-SCI), book chapter etc. In addition to the CSIR projects being run in the DU, during this session 2 new GAP projects were sanctioned in addition to 11 GAP projects being run already. Also, 5 GAP projects were successfully completed. 06 new Ph.D students joined the DU during the mentioned period. The scientists were involved in training of >41 Technical HR (PA/SPA/JRF/SRF/RA etc.) through various projects and >24 graduated trainees (ECF of 3.6 lakhs in excess to other sources like GAP projects). The DU was also involved in organization of many training programs and delivering invited lectures. Scientists of the DU have been selected in the editorial board of many prestigious jounals like Plant science, Frontiers in Plant science, etc. The persistent excellence to R&D has brought awards like JC Bose fellow (to Dr. Prabodh K Trivedi), and FNASc. (to Dr. Dinesh Nagegowda).

Scientists of Plant Biotechnology Divisional Unit

Upper Panel (L to R) : Dr. Dayanand C. Kalyani, Dr. Prema G. Vasudev, Dr. Sunita Singh Dhawan, Dr. Vikrant Gupta, Dr. Prabodh K. Trivedi, Dr. Laiq-ur Rahman, Dr. Pradipto Mukhopadhyay, Dr. Sumit Ghosh, Dr. Rakesh K. Shukla, Dr. Ashutosh K Shukla

Lower Panel (L to R) : Dr. Dinesh A Nagegowda, Dr. Venkata Rao, D.K and Dr. Mukti Nath Mishra

Dr. Prabodh K. Trivedi Mk- ick/k d- f=onh

Pathway Elucidation and Engineering of the Secondary Plant Products

Plants have developed very efficient approaches to magnetize pollinators or seed-dispersing animals and their defence against herbivores, micro-organisms and other plants. In natural growth conditions, one of the major strategies adopted by plants for these purpose is based on the production of secondary metabolites. Some of these secondary plant products are known to be beneficial for human health. Accumulation of these products in plants also fluctuates depending upon cellular, climatic and developmental conditions that limit their proper industrial utilization and drug development. There is an urgent need to scale up biosynthesis of these secondary plant products in homologous system or develops strategies for the synthesis of these molecules in heterologous systems through pathway engineering. My group has been working on plants synthesizing various bio-medically important phytoceuticals. We have characterized various regulatory factors from Arabidopsis, tobacco and tomato plants and using these to engineer plants for enhanced biosynthesis of secondary plant products.

Tobacco remains one of the most commercially important crops due to the parasympathomimetic alkaloid nicotine, used in cigarettes. Nicotine-reduced tobacco may contribute to reducing nicotine consumption and the risk of death from tobacco use. Most genes involved in nicotine biosynthesis are well characterized however; their light mediated regulation has not been studied till now. Based on homology search and phylogenetic analysis, we identified HY5 in tobacco (*Nicotiana tabacum*) as a regulatory component of nicotine as well as flavonoid biosynthesis and demonstrate that it binds to the light-responsive G-boxes in the NtPMT, NtQPT, NtODC and NtMYB12 promoters. NtHY5 was able to complement the *Arabidopsis thaliana hy5* mutant at molecular, morphological and biochemical levels. CRISPR/Cas9-based knockout mutant plants of tobacco showed down-regulation of the nicotine and phenylpropanoid pathway genes leading to a significant reduction in nicotine and flavonol content, whereas NtHY5 overexpression plants had the opposite effect. In addition, variance in plant height and seed size of NtHY5 mutant compared to overexpressed young plants suggested its role in the growth and development of tobacco. Modulated metabolites are found to provide salt stress tolerance by diminishing the ROS accumulation evident through DAB and NBT staining. This identification of NtHY5 provides insights into the regulation of nicotine biosynthesis and the development of tobacco plants containing less nicotine could help people to overcome their nicotine addiction.

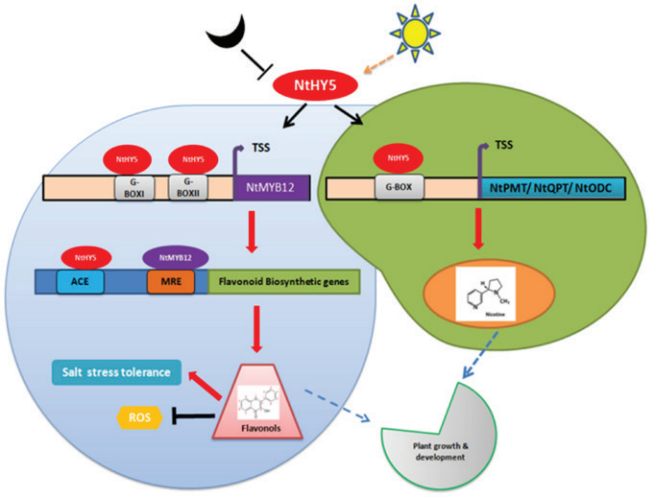


Fig. Proposed working model for the roles of NtHY5 in nicotine and flavonol accumulation in tobacco. It is proposed that NtHY5 positively regulates the expression of nicotine and flavonoid pathway genes in light which results increase in accumulation of nicotine and flavonoid. NtHY5 bind to the G-boxes in the promoters of nicotine/flavonol regulatory gene which lead to nicotine and flavonol production. Higher accumulation of secondary metabolites leads to salt stress tolerance. Arrowheads and tees indicate positive and negative regulation respectively.

miRNAs and Associated Factors

microRNA-encoded peptides (miPEPs) have been shown to have the potential to regulate corresponding miRNAs and associated functions. miPEP858a, encoded by the pri-miR858a, regulates the phenylpropanoid pathway and plant growth and development. In past, several studies have suggested that various environmental factors,

including light, regulate gene and their associated functions. However, detailed studies have not been carried out to understand the regulation of miPEPs. We report that light directly regulates miPEP858a expression and accumulation in *Arabidopsis thaliana*. Peptide assay in light and dark clearly showed the essential requirement of light. Along with this, group reported that HY5, a shoot-to-root mobile transcription factor, plays an important role in the light-dependent regulation and function of the miPEP858a. The transcript and endogenous protein accumulation of miPEP858a in *hy5-215*, OXHY5/*hy5*, and *cop1-4* suggested that HY5 is a positive regulator of miPEP858a. In addition, Analysis suggested that HY5 regulates light-dependent expression and accumulation of miPEP8588.

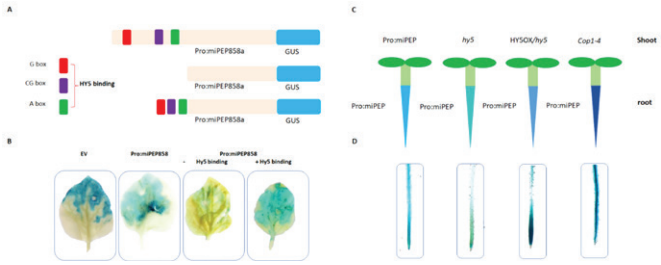


Fig. Shoot-to-root mobile transcription factor HY5 required for miPEP858a function. (A) Schematic representation of different promoter constructs used in the study. (B) Representative images of histochemical staining showing GUS activity in *Nicotiana benthamiana* leaves transiently expressing EV, PromiPEP858a:GUS, PromiPEP858a:GUS with and without HY5 binding sites (Scale bars 1 cm). (C) Schematic representation of different combination between root and shoot used for grafting. (D) Root of PromiPEP858a:GUS showing GUS activity after grafting it with shoot of PromiPEP858a:GUS, *hy5*, HY5OX/*hy5 cop1-4* (Scale bars 2 mm).

In another study, we also report the importance of cross-talk between miPEP858a/miR858a and Phytosulfokine (PSK4) in regulating plant growth and development in *Arabidopsis*. Genome-wide expression analysis suggested modulated expression of PSK4 in miR858 mutant and overexpression, miR858OX, plants. The silencing of PSK4 in miR858OX plants compromised the growth, whereas over-expression of PSK4 in miR858 mutant rescued the developmental defects. The exogenous application of synthetic PSK4 further complemented the plant development

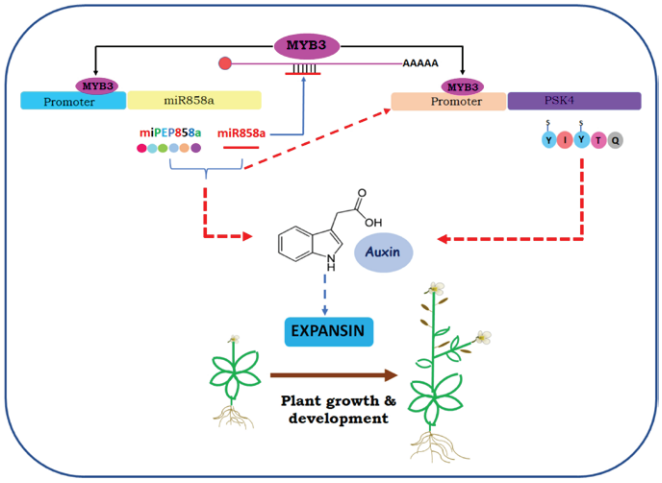


Fig. Proposed model for the regulation of plant growth via miPEP858a/miR858-MYB3-PSK4 module. PSK4 participates as an important signal molecule in miR858a/miPEP858a-dependent growth and development in *Arabidopsis*. MYB3 is regulated by miPEP858a/miR858a and is an essential component required for the expression of PSK4. Modulated levels of PSK4 also affect downstream auxin signalling and expansins, which together regulate plant growth and development.

in mutant plants. Exogenous treatment of synthetic miPEP858a in PSK4 mutant led to clathrin-mediated internalization of the peptide however did not enhance growth as in the case of wild-type plants. We also demonstrate that the MYB3 is an important molecular component participating in miPEP858a/miR858a-PSK4 module. Finally, our work highlights the signalling between miR858/miPEP858-MYB3-PSK4 in modulating the expression of key elements involved in auxin responses leading to the regulation of growth.

Dr. Prabodh K. Trivedi & his team

Dr. Laiq-ur Rahman Mk- ybd&mj&jgeku

Isolation and characterization of a novel xanthone from the hairy root culture of *Swertia chirayita* (Roxb.) H. Karst. and its biological activity

Swertia chirayita (Roxb.) H. Karst is a well-documented traditional plant used to cure liver diseases, malaria fever, jaundice, hepatitis and diabetes. Xanthones are produced by the plant and provide a variety of health benefits. The goal of this research is to develop an efficient and reliable approach for hairy root induction and to explore the biosynthesis of xanthones in hairy root lines. Infection of *S. chirayita* leaves with *Rhizobium rhizogenes* strain (LBA 9402) resulted in distinct hairy root lines. The *rolB* gene integration in the root was validated by polymerase chain reaction (PCR) in four hairy root lines. Hairy root line SA produced the maximum biomass of 13.32±0.50 g/flask FW (fresh weight) and 1.29±0.05 g/flask DW (dry weight) after 60 days. A novel 1,2,5,6-tetrahydroxyxanthone (**2**) was isolated and characterized from SA hairy root line using flash chromatography. Swerchirin (**1**) (0.382±0.089 mg/g DW) and 1,2,5,6-tetrahydroxyxanthone (**2**) (0.935 ± 0.02 mg/g DW) along with swertianin (0.0195±0.007 mg/g DW) were accumulated higher amount in SA line. 1,2,5,6-tetrahydroxyxanthone (**2**) exhibited strong antioxidant activity in DPPH (IC_{50}=1.600±0.004 µg/mL) and FRAP (4.83±0.02 Eq. to $FeSO_4$) assay. Further, swerchirin (**1**) exhibited anti-proliferative activity by suppressing the growth of MDA-MB-231 cells with IC_{50} of 18.82 µg/mL (65.83% at 50 µg/mL) and 1,2,5,6-tetrahydroxyxanthone (**2**) inhibited the growth of K562 cells with IC_{50} of 22.83 µg/mL (67.82% at 50 µg/mL). The characterized compounds with promising biological activity could be taken up its commercial production. The characterized compounds with promising biological activity could be taken up for commercial production.

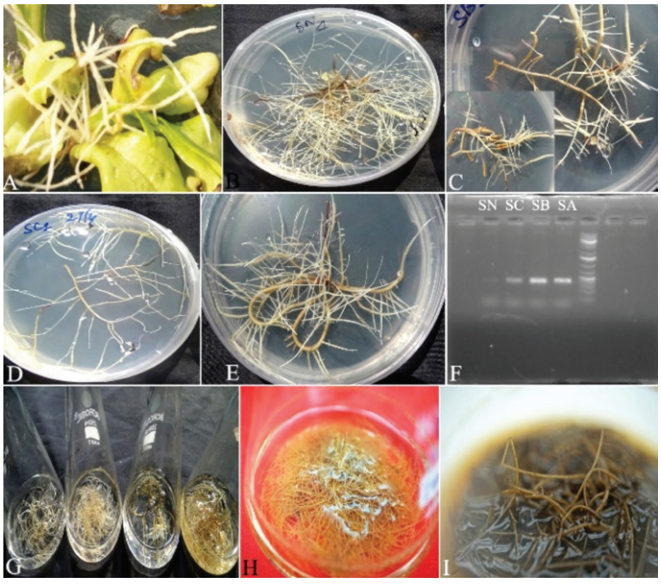


Fig. Hairy root induction in *Swertia chirayita*

Dr. LU Rahman & his team

Dr. Dinesh A Nagegowda Mk- fnu'k , ukxxkMk

An inducible potato farnesol synthase confers tolerance to bacterial stress

Plants have evolved various strategies to tackle biotic stresses including microbial infection. One such mechanism is the release of low-molecular weight specialized metabolites (volatile compounds) that play important roles in direct and indirect plant defense against the invading pathogen. Among different volatiles released by plants in response to biotic stress, majority belong to "terpenoids" class comprising of monoterpenes (C_{10}) and sesquiterpenes (C_{15}), which are synthesized by the action of a mid-size family of enzymes known as terpene synthases (TPSs). Though involvement of TPSs and their enzymatic products in herbivore defense have been well established in many plant species, their role in defense against microbes has been scarce and is emerging.

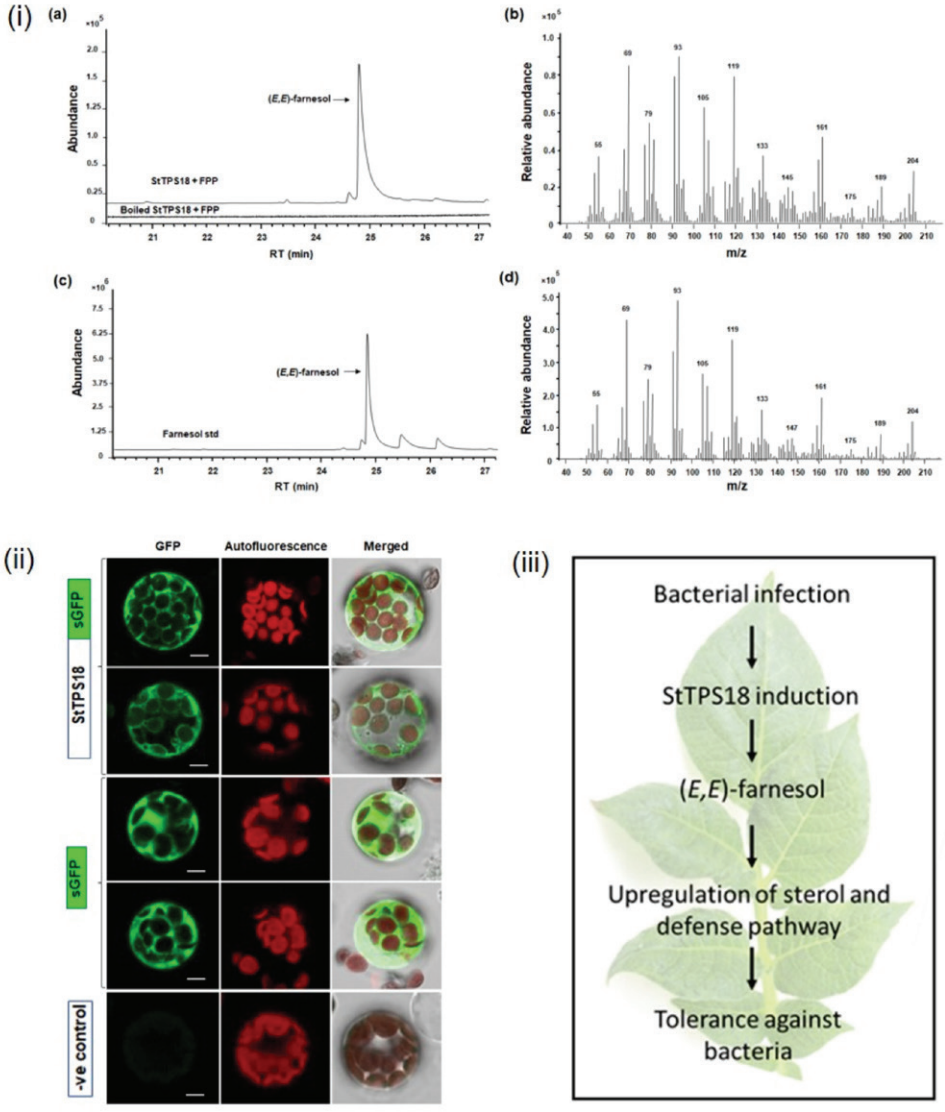


Fig. (i) Analysis of reaction products formed by recombinant StTPS18. Gas Chromatography- Mass Spectrometry (GC-MS) profile showing the products formed by StTPS18 enzyme from farnesyl diphosphate (FPP) (a) and authentic (E,E)-farnesol standard (c). (ii) Confocal laser scanning microscopy of transiently expressed StTPS18-GFP and GFP proteins in Arabidopsis protoplasts. (iii) Proposed mode of action of StTPS18 in potato-defense against bacteria

Through functional genomics, here we report the in planta role of potato (*Solanum tuberosum*) terpene synthase (StTPS18) in bacterial defense. Expression of StTPS18 was highest in leaves and was induced in response to *Pseudomonas syringae* and methyl jasmonate treatments. The recombinant StTPS18 exhibited bona fide (*E,E*)-farnesol synthase activity forming a sesquiterpenoid, (*E,E*)-farnesol as the sole product, utilising (*E,E*)-farnesyl diphosphate (FPP) (Fig. 1i). Subcellular localization of GFP fusion protein revealed that StTPS18 is localized to the cytosol (Fig. 1ii). Silencing and overexpression of StTPS18 in potato resulted in reduced and enhanced tolerance, respectively, to bacterial pathogens *P. syringae* and *Ralstonia solanacearum*. Bacterial growth assay using medium containing (*E,E*)-farnesol significantly inhibited *P. syringae* growth. Moreover, StTPS18 overexpressing transgenic potato and *Nicotiana tabacum* leaves, and (*E,E*)-farnesol and *P. syringae* infiltrated potato leaves exhibited elevated expression of sterol pathway and members of pathogenesis-related genes with enhanced phytosterol accumulation. Interestingly, enhanced phytosterols in $^{13}C_3$-(*E,E*)-farnesol infiltrated potato leaves were devoid of any noticeable ^{13}C labeling, indicating no direct utilization of (*E,E*)-farnesol in phytosterols formation. Furthermore, leaves of StTPS18 overexpressing transgenic lines had no detectable (*E,E*)-farnesol similar to the control plant, and emitted lower levels of sesquiterpenes than the control.

In conclusion, we have characterized a bona fide (*E,E*)-farnesol synthase StTPS18 from potato that is induced in response to bacterial inoculation. Although farnesol exhibited an in vitro antibacterial effect, our results indicate that StTPS18 and thus its product (*E,E*)-farnesol plays an indirect role in bacterial defense by functioning as an elicitor of phytosterol biosynthesis and defense genes (Fig. 1iii). The results provide insights into the role of (*E,E*)-farnesol synthase in bacterial defense, and further add to the understanding of the complex regulation of the terpenoid pathway and plant defense (Dwivedi *et al*., Plant Journal, doi.org/10.1111/tpj.15890).

Dr. Dinesh A Nagegowda & his team

Dr. Vikrant Gupta Mk- foØkr xIrk

Molecular studies on cold tolerance- and secondary metabolism-related gene homolog(s) in *Ocimum* sp.

Ocimum sanctum (*O. tenuiflorum*) is grown world-wide and kept at every home in India due to its medicinal and hallowed rituals values. It belongs to the family Lamiaceae and is one of the best known genera for its medicinal properties and economically important aromatic oils; some species are used in Ayurvedic medicines while few others are used in flavor. Being grown in a large scale in the country as economic crop, it faces environmental challenges due to sensitivity to cold and shows chilling injury which limits its total growth and dramatically reduces its oil yield, leading to economic losses to farmers during winters. Based on the information available in the model plant Arabidopsis, few genes such as *ICE1*, *CBF3*, *LTP3*, *MYB15*, and *CRT/DRE*, were used to perform homology-based search in the *Ocimum* transcriptome dataset(s), and putative candidate gene sequences (homologs) could be identified. Out of them *OsICE1*, *OsMYB15* and *CRT/DRE* were initially cloned in different vectors, and confirmed by restriction digestions and sequencing. Subsequently, primers having suitable restriction sites for directional cloning in pBI121 binary vector were designed and synthesized for *OsICE1* and *OsLTP3*. Successful cloning of these two gene homologs in pBI121 binary vector was done, and were mobilized into *Agrobacterium tumefaciens* (strain AGL1) individually for plant transformation. To investigate their role(s) in conferring cold tolerance, these binary constructs are being introduced into model plants such as tobacco by *Argobacterium*-mediated gene transfer methods. The diagrammatic representation of *OsLTP3* binary construct is shown in **Figure** below. Work is in progress to generate the tobacco transformants

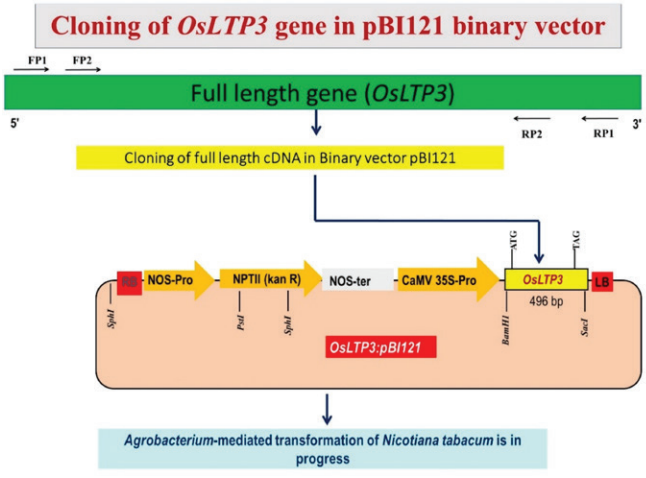


Fig. Schematic representation of *OsLTP3* binary construct

Studies on root-development related gene homolog(s) in *Withania somnifera*

Ashwagandha or Indian Ginseng (*Withania somnifera*) is an important member of Solanaceae family and widely used in Indian traditional systems of Medicine, Ayurveda and Unani to treat various human diseases and health disorders. The array of compounds that confer medicinal property lies in all parts of the plant body. Root of *W. somnifera* is rich in withanolide-A, while, withaferin-A is present in large amounts in the leaf and also in traces in its root. The quality of the plant to be used in the medicine system is assessed by root parameters. Therefore, in order to improve the root biomass and quality, attempts are being done to identify the genetic components that are expected to govern the root biosynthesis. Such candidates (like *BIG-BROTHER*, *DWARF4* and *SHORT-ROOT*) were previously identified in *W. somnifera* transcriptome dataset and successfully cloned in suitable vectors. *BIG-BROTHER*, *DWARF4* and *SHORT-ROOT* were made to full-length and found to be 1386 bp, 1922 bp, and 1818 bp, respectively. All the above cloned fragments were completely sequenced for confirmation. Subsequently for functional analyses, the ectopic expression of these genes are being carried out in tobacco as model plant. Primers having suitable restriction sites for directional cloning in pBI121 vector were designed followed by PCR amplification and further cloning in the binary vector for preparing plant transformation constructs. Binary constructs were confirmed by using restriction enzymes, and mobilized in *Agrobacterium tumefaciens* (strain AGL1).

Fig. T_0 generation of transformed tobacco plants with overexpression lines of *WsBIG BROTHER* gene

Agrobacterium-mediated genetic transformation of *Nicotiana tabacum* is being done individually by using these binary constructs for functional characterization. After co-cultivation of leaf explants and selection on MS media, T_0 plants have been achieved and are being grown in glass houses. All the transformed tobacco plants ectopically expressing *WsBB*, *WsSHR* and *WsDWF4* genes would be carefully analyzed for any phenotypic change. The effect of ectopic expression of these genes on secondary metabolic pathways will also be studied in details.

Dr. Vikrant Gupta & his team

Input: Sunita Singh Dhawan

Physiological responses and gene expression modulations in Ocimum linalool rich variety CIM- Shishir during low temperature

The effect of low temperature stress was analyzed on newly developed variety CIM-Shishir of Ocimum, which is an interspecific hybrid of Ocimum. Low

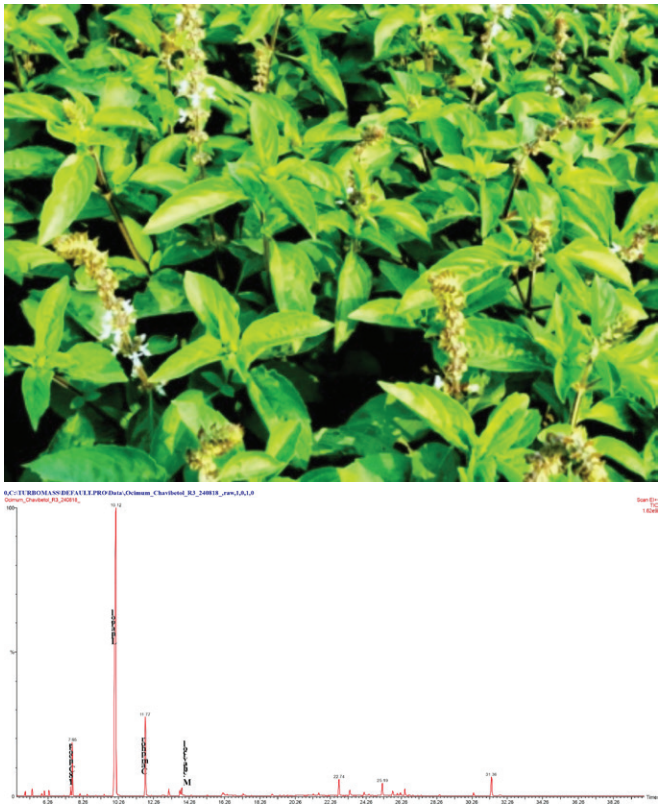


Fig. Linalool rich hybrid *Ocimum* variety CIM- Shishir

temperature causes several changes in physiological parameters, therefore study was performed to understand the physiological process during old tolerance. The trichome variations on abaxial and adaxial surface of leaf in Ocimum during cold stress treatment were assessed to determine the impact of low temperature on trichome density in these plant species. Expressions of key genes were analyzed in var. CIM Shishir showed high expression of WRKY53, ICE1, HOS1, COR47, LOS15, DREB5, CBF4, LTI6, KIN45 and ERD2 genes compared to control.

Exploration of global expression responses in *M. pruriens* var.CIM Sfurti

Mucuna pruriens L. (DC.) is an important source of traditional herbal medicinal compounds. *M. pruriens* is widely used to treat Parkinson disease in human. In this study, the transcriptome sequencing of leaf tissues of elite breeding line CIM-Sfurti of *M. pruriens* was performed. About 126289 million clean reads were generated and used for transcriptome

assembly. In this study, we have identified a large set of cDNA unigenes from *M. pruriens* leaf. This study will provide a platform to facilitate key gene discovery and advance functional genomic research in *M. pruriens.*

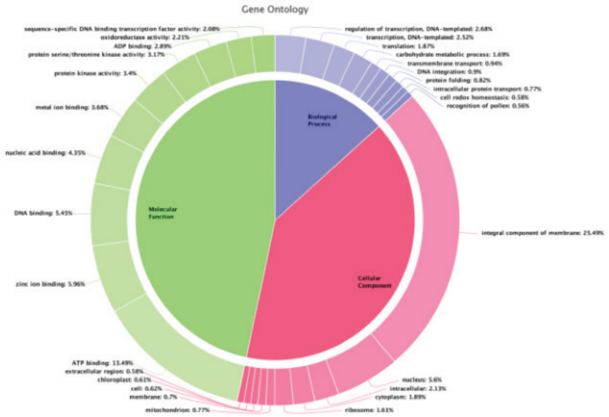


Fig. Representation of top 10 Gene Ontologies including molecular function, biological process and cellular components in *Mucuna pruriens*

Seed transmission of multiple viral infection *in Mucuna pruriens*: The anti- Parkinson medicinal crop

Mucuna pruriens an important medicinal crop, with richest natural source of L-DOPA. *M. pruriens* seed extract were used for the treatment of Parkinson's disease and several other diseases with reported bioactivities. Main bioactive component is L-DOPA. *Velvet bean Severe Mosaic Virus* (VbSMV) is known to infect the *M. pruriens* and whiteflies were known to transmit this virus. Here, it was observed that VbSMV was found to enhance the L-DOPA content significantly in *M. pruriens* and also enhances the expression of the L-DOPA biosynthetic pathway genes such as Arogenate dehydorenase and Polyphenol oxidase I. Further the results will be validated in successive generations.

Fig. Symptomatic leaves infected with the VbSMV on *M. pruriens* in field condition

Assessment of physiological and metabolic alteration in menthol biosynthesis pathway under diverse water deficit conditions in *Mentha arvensis*

Mentha arvensis produces many important commercially exploited monoterpene moieties, which are stored in trichomes. Therefore various accessions were analyzed in field conditions along with released varieties of *M. arvensis* for assessing yield potential for herbage, essential oil yield and constituent monoterpenes. During water deficit conditions physiological parameters shows alterations as in quantum yield, stomatal conductance and relative water content. However adaptive tolerance varied in diverse grnotypes and the varieties. Therefore *Mentha arvensis* accessions were selected based on initial observations in field conditions. Physiological and metabolite variations will be analyzed for further validations and correlations with biosynthetic yield potential.

Dr. Sunita Singh Dhawan & her team

Dr. Sumit Ghosh Mk- lfer ?kk"k

Identification and characterization of a novel BAHD acetyltransferase contributing to wound-induced biosynthesis of oleo-gum resin triterpenes in *Boswellia serrata* tree

Triterpenes (30-carbon isoprene compounds) represent a large and highly diverse class of natural products that play various physiological functions in plants. The triterpene biosynthetic enzymes, particularly those catalyzing the late-stage regio-selective modifications are not well characterized. The bark of select *Boswellia* trees, e.g., *B. serrata* exudes specialized oleo-gum resin in response to wounding, which is enriched with boswellic acids (BAs), a unique class of C3α-epimeric pentacyclic triterpenes with medicinal properties. The bark possesses a network of resin secretory structures comprised of vertical and horizontal resin canals, and amount of BAs in bark increases considerably in response to wounding. To investigate BA biosynthetic enzymes, we conducted tissue-specific transcriptome profiling and identified a wound-responsive BAHD acetyltransferase (BsAT1) of *B. serrata* catalyzing the late-stage C3α-O-acetylation reactions in the BA biosynthetic pathway. BsAT1 catalyzed C3α-O-acetylation of αBA, βBA, and 11-keto-βBA in vitro and in planta assays to produce all the major C3α-O-acetyl-BAs (3-acetyl-αBA, 3-acetyl-βBA, and 3-acetyl-11-keto-βBA) found in *B. serrata* bark and oleo-gum resin. BsAT1 showed strict specificity for BA scaffold, whereas it did not acetylate the more common C3β-epimeric pentacyclic triterpenes (Fig.). The analysis of steady-state kinetics using various BAs revealed distinct substrate affinity and catalytic efficiency. It was found that BsAT1 transcript expression coincides with increased levels of C3α-O-acetyl-BAs in bark in response to wounding, suggesting a role of BsAT1 in wound-induced biosynthesis of C3α-O-acetyl-BAs. Overall, the results provide new insights into the biosynthesis of principal chemical constituents of *Boswellia* oleo-gum resin. This work has been published in The Plant Journal **[Kumar et al., 2021, Plant J. 107(5):1403-1419]**.

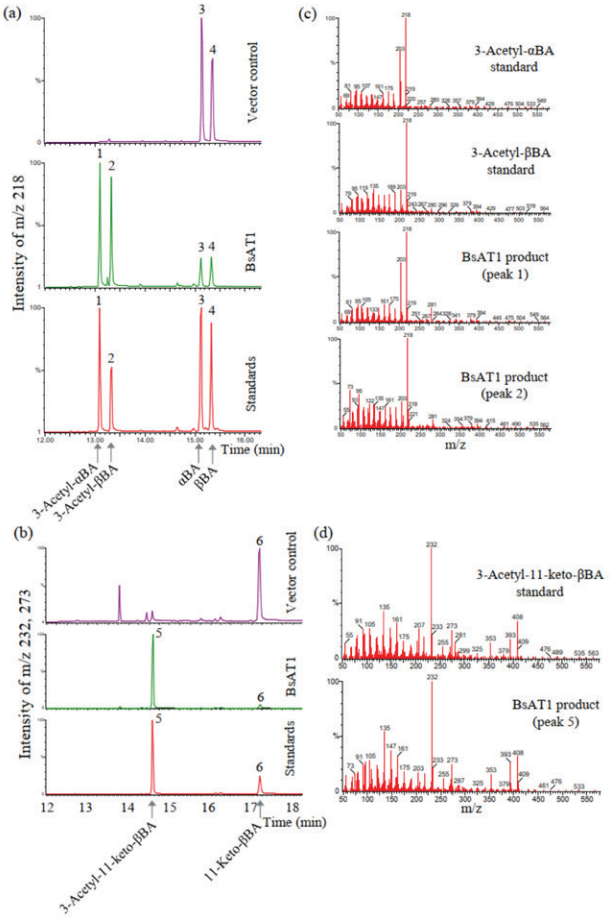


Fig. BsAT1 catalyzed in vitro C3α-O-acetylation of αBA, βBA and 11-keto-βBA. (a) *Escherichia coli* expressed recombinant BsAT1 converted αBA and βBA to 3-acetyl-αBA and 3-acetyl-βBA, respectively. Gas chromatography–mass spectrometry (GC-MS) extracted ion chromatograms (at m/z 218) detecting 3-acetyl-αBA (peak 1) and 3-acetyl-βBA (peak 2) in standards and BsAT1 assay. 3-Acetyl-αBA and 3-acetyl-βBA were not detected in assay conducted using total protein extract of *E. coli* transformed with empty vector (vector control). (b) Recombinant BsAT1 converted 11-keto-βBA to 3-acetyl-11-keto-βBA. GC-MS extracted ion chromatograms (m/z 232 and 273) detecting 3-acetyl-11-keto-βBA (peak 5) in standard and BsAT1 assay. 3-Acetyl-11-keto-βBA was not detected in assay conducted using total protein extract of *E. coli* transformed with empty vector (vector control). In vitro assay was carried out using acetyl acceptors (αBA, βBA and 11-keto-βBA) and acetyl donor (acetyl-CoA) in sodium phosphate buffer (pH7.5) at 35°C. (c-d) Electron impact-mass spectra of 3-acetyl-αBA, 3-acetyl-βBA and 3-acetyl-11-keto-βBA authentic standards and BsAT1 products (peaks 1, 2 and 5).

Identification and characterization of a novel plant UDP-glycosyltransferase involved in labdane diterpene biosynthesis in *Andrographis paniculata*

Glycosyltransferases constitute a large family of enzymes across all domains of life, but knowledge of their biochemical function remains largely incomplete, particularly in the context of plant specialized metabolism. The labdane diterpenes represent a large class of phytochemicals with many pharmacological benefits, such as anti-inflammatory, hepatoprotective, and anticarcinogenic. The medicinal plant kalmegh (*Andrographis paniculata*) produces bioactive labdane diterpenes; notably, the C19-hydroxyl diterpene (andrograpanin) is predominantly found as C19-O-glucoside (neoandrographolide), whereas diterpenes having additional hydroxylation(s) at C3 (14-deoxy-11,12-didehydroandrographolide) or C3 and C14 (andrographolide) are primarily detected as aglycones, signifying scaffold-selective C19-O-glucosylation of diterpenes *in planta*. Here, we analyzed UDP-glycosyltransferase (UGT) activity and diterpene levels across various developmental stages and tissues and found an apparent correlation of UGT activity with the spatiotemporal accumulation of neoandrographolide, the major diterpene C19-O-glucoside. The biochemical analysis of recombinant UGTs preferentially expressed in neoandrographolide-accumulating tissues identified a previously uncharacterized UGT86 member (ApUGT12/UGT86C11) that catalyzes C19-O-glucosylation of diterpenes with strict scaffold selectivity (Fig.). ApUGT12 localized to the cytoplasm and catalyzed diterpene C19-O-glucosylation *in planta*. The substrate selectivity demonstrated by the recombinant ApUGT12 expressed in plant and bacterium hosts was comparable to native UGT activity. Recombinant ApUGT12 showed significantly higher catalytic efficiency using andrograpanin compared with 14-deoxy-11,12-didehydroandrographolide and trivial activity using andrographolide. Moreover, ApUGT12 silencing in plants led to a drastic

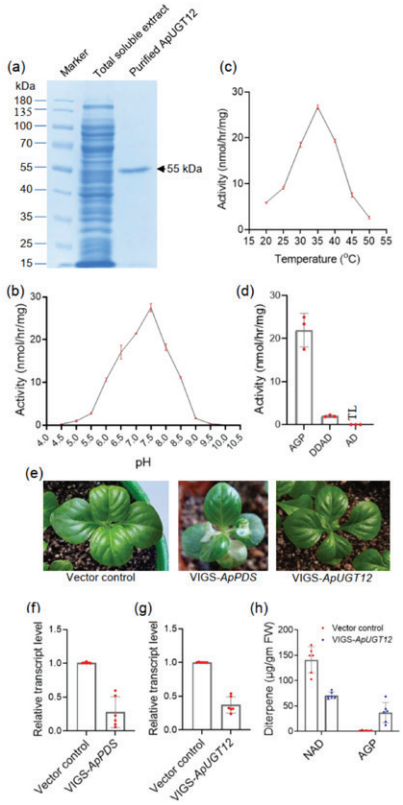


Fig. Biochemical analysis of ApUGT12 and virus-induced gene silencing in kalmegh. (a) *E. coli* expression and purification of N-terminally 6×His-tagged ApUGT12. ApUGT12 was resolved as ~55 kDa protein in 10% SDS-PAGE. (b) The optimum pH for ApUGT12 activity was determined in assays conducted at 35 °C in assay buffer of different pH. (c) The optimum temperature for ApUGT12 activity was determined in assays in 10 mM Tris–Cl and pH 7.5 at different temperatures. (d) A comparison of the rate of C19-O-glucosylation catalyzed by ApUGT12 using andrograpanin (AGP), andrographolide (AD), or 14-deoxy-11,12-didehydroandrographolide (DDAD). The assays were carried out in 10 mM Tris–Cl, pH 7.5 at 35 °C. (b), (c), and (d), the data are means ± SD, n = 3 independent reactions using total protein extract. TL, trace level. (e) Kalmegh seedlings at 35 days after vacuum infiltration with a mixture of Agrobacterium suspension containing pTRV1 and pTRV2-ApPDS/pTRV2-ApUGT12 in a 1:1 ratio. ApPDS silencing led to a typical leaf photobleaching effect. Vector control represents kalmegh seedlings infiltrated with Agrobacterium suspension containing pTRV1 and pTRV2 empty vectors. (f) The relative transcript level of ApPDS in vector control and VIGS-ApPDS seedlings was determined by quantitative RT-PCR. (g) The relative transcript level of ApUGT12 in vector control and VIGS-ApUGT12 seedlings was determined by qRT-PCR. (h) Neoandrographolide (NAD) and andrograpanin (AGP) content in vector control and VIGS-ApUGT12 seedlings was determined by HPLC analysis. (f)–(h), The data are means ± SD, n = 6 biological samples each comprising of six seedlings.

reduction in neoandrographolide content and increased levels of andrograpanin (Fig.). These data suggest the involvement of ApUGT12 in scaffold-selective C19-O-glucosylation of labdane diterpenes in plants. This knowledge of UGT86 function might help in developing plant chemotypes and synthesis of pharmacologically relevant diterpenes. This work has been published in the Journal of Biological Chemistry [Srivastava et al., 2021, J Biol Chem. 297(3):101045]

Dr. Sumit Ghosh & his team

Dr. Ashutosh K Shukla Mk- vk'kqrks"k dq- 'kDyk

Stress responsiveness of vindoline accumulation in *Catharanthus roseus* leaves is mediated through co-expression of allene oxide cyclase with pathway genes

Vindoline is an important alkaloid produced in *Catharanthus roseus* leaves. It is the more important monomer of the scarce and costly anticancer bisindole alkaloids, vincristine, and vinblastine, as unlike catharanthine (the other monomer), its biosynthesis is restricted to the leaves. Here, biotic (bacterial endophyte, phytoplasma, virus) and abiotic (temperature, salinity, SA, MeJa) factors were studied for their effect on vindoline accumulation in *C. roseus*. Variations in vindoline pathway-related gene expression were reflected in changes in vindoline content. Since allene oxide cyclase (*CrAOC*) is involved in jasmonate biosynthesis and MeJa modulates many vindoline pathway genes, the correlation between *CrAOC* expression and vindoline content was studied. It was taken up for full-length cloning, tissue-specific expression profiling, *in silico* analyses, and upstream genomic region analysis for *cis*-regulatory elements. Co-expression analysis of *CrAOC* with vindoline metabolism-related genes under the influence of aforementioned abiotic/biotic factors indicated its stronger direct correlation with the tabersonine-to-vindoline genes (*t16h*, *omt*, *t3o*, *t3r*, *nmt*, *d4h*, *dat*) as compared to the pre-tabersonine genes (*tdc*, *str*, *sgd*). Its expression was inversely related to that of downstream-acting peroxidase (*prx*) (except under temperature stress). Direct/positive relationship of *CrAOC* expression with vindoline content established it as a key gene modulating vindoline accumulation in *C. roseus*. (Mall et al., 2022, *Protoplasma* 259: 755-773).

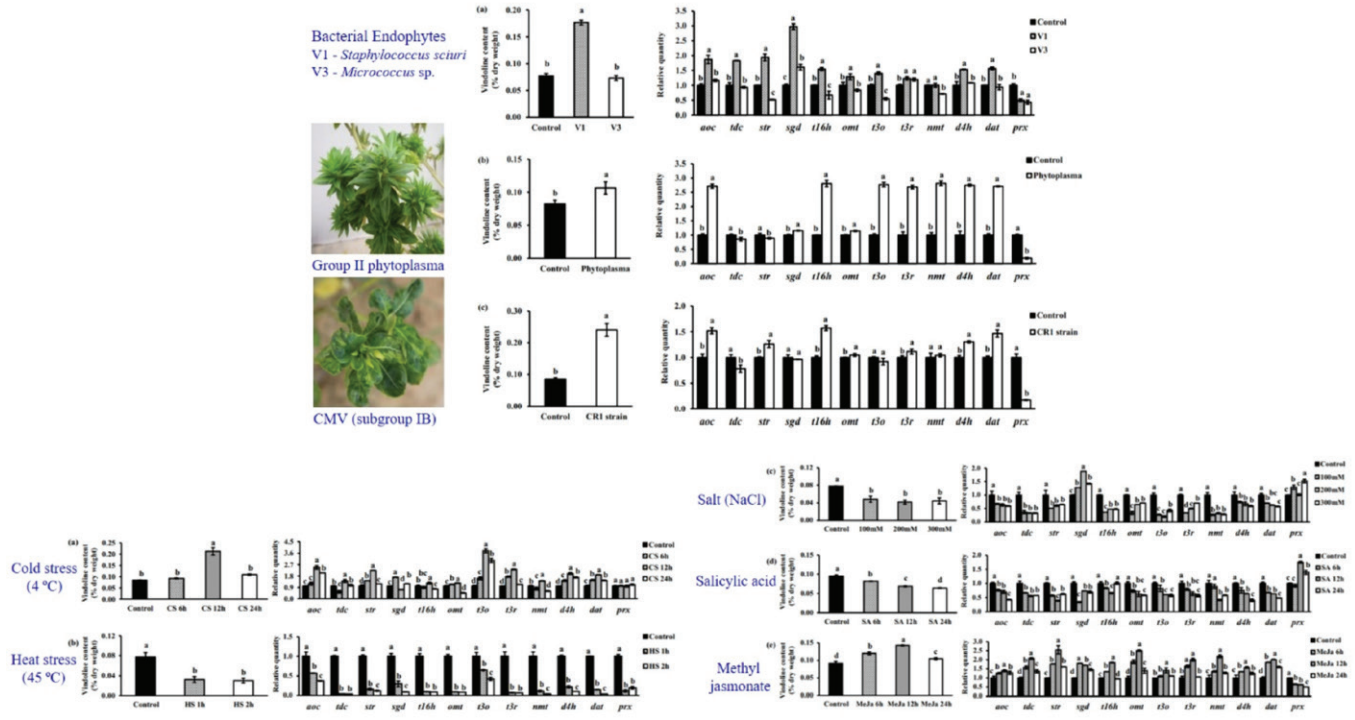


Fig. Stress responsiveness of vindoline accumulation in *C. roseus* leaves is mediated through co-expression of *CrAOC* with pathway genes.

Dr. Ashutosh K Shukla & his team

Dr. Prema G. Vasudev Mk- iek th- okl no

Molecular interaction patterns of pyrazolopyrimidines in protein complexes

Pyrazolopyrimidines (pyp) are fused-ring nitrogen heterocycles, which are often used as a template in drug design. Owing to their structural similarity to the nucleotide base adenine, their derivatives are considered as adenosine receptor antagonists. Derivatives of all the four isomers of pyrazolopyrimidine show medicinal and/or insecticidal activities, making them a hot target for pharmaceutical as well as biotechnological applications. *In-silico* structure-activity studies and molecular docking have a major share in the rich scientific literature on biological activities of pyrazolopyrimidines. In a typical *in-silico* binding study, the interactions originating from the core scaffold is often undervalued, as the receptor-binding is dominated by molecular interactions originating from the attached functional groups. However, if the core structures contain aromatic rings, specific stacking interactions of the core also become relevant in receptor recognition and binding. We conducted a detailed analysis of high-resolution crystal structures of protein-pyp complexes deposited in the Protein Data Bank (PDB) to identify the most prevalent intermolecular interactions of the pyrazolopyrimidine rings with proteins. The PDB has 471 crystal structures containing pyp derivatives, of which 151 structures have data resolution < 2.0Å. Almost 50% of the structures in the search result consist of 1H-pyrazolo[3,4-d]pyrimidine (pyp1) ligands (236/471), followed by pyrazolo[1,5-a] pyrimidines (pyp2) (182/471; 38.64%). 1H-pyrazolo[4,3-d] pyrimidines (pyp3) are present only about 12% of the total structures (53/471) and no structural data are available for pyrazolo[1,5-c]pyrimidine (pyp4) derivatives as ligands. Data with a resolution better than 2.0Å were chosen for the analysis of interaction geometries. The analysis showed that interactions between the pyp rings and protein are mainly of two types: (i) aromatic interactions to the side chains of

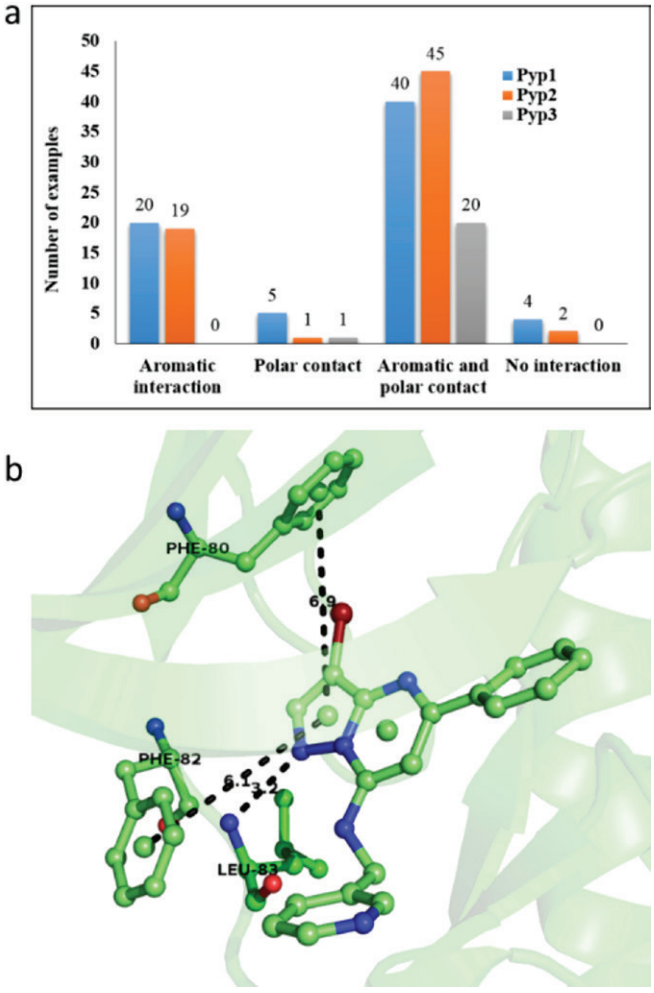


Fig. (a). Histogram showing the distribution of aromatic and polar interactions of the pyp rings with the receptor proteins in high resolution crystal structures. (b) Representative example of a pyrazolopyrimidine derivative bound to the receptor protein through aromatic ring interactions and polar contacts. Relevant distances are indicated by dashed lines.

aromatic amino acids in the receptor proteins and (ii) polar contacts (hydrogen bonding). Aromatic interactions are defined by the distance between the centroids (d_{cent}) of the interacting aromatic rings and the angle of orientations of the rings with respect to each other. In this study, we considered d_{cent}< 7.0Å as favourable aromatic interactions. The shortest average d_{cent} value observed was for pyp1 (1H-pyrazolo[3,4-d]pyrimidine) and pyp3 (1H-pyrazolo[4,3-d]pyrimidine) isomers. The distribution of both types of interactions for the three isomers of pyp is shown in Fig. a. The histogram shows that aromatic interactions from the pyp rings

are predominant than polar contacts. Interestingly, structures in which only aromatic interactions are present outnumber the examples in which only polar contacts are present. This indicates that aromatic π…π interactions between the pyp ring and the aromatic amino acid side chains in the receptor proteins are more relevant in their substrate recognition and binding than polar interactions.

Dr. Prema G Vasudev & her team

Dr. Venkata Rao, D.K Mk- oSdVk jko] Mh-d-

Unravelling lipid signalling in yeast: Alternative strategy for MEV/ERG pathway engineering

Plant-based secondary metabolites such as terpenes have ever-increasing importance due to their medicinal properties. *Saccharomyces cerevisiae* has been widely exploited as an alternate system for their production. Studies in our lab have reported a novel and critical link between phospholipid metabolism and the mevalonate (MEV)/ergosterol(ERG) pathway regulation, illustrated by the increase of MEV metabolite levels corresponding to PA accumulation by overexpression of phospholipid regulatory enzyme Diacylglycerol Kinase1 (DGK1). To investigate the link further we selected *spt10Δ* strain reported to have high phospholipid and neutral lipid accumulation, we discovered the expanded endoplasmic reticulum (ER) phenotype in *spt10Δ* strain. As the MEV/ERG pathway is bound to ER, we investigated possible changes of the pathway activity in *spt10Δ* strain. The qRT-PCR and metabolite analyses revealed that *spt10Δ* showed upregulation of MEV pathway genes and accumulation of squalene and ergosterol. We then further increased the endogenous phospholipid pool by overexpressing *DGK1* in *spt10Δ*. Interestingly, *DGK1* overexpression in *spt10Δ* displayed significant rise in MEV pathway activity and a reduction in lipid droplets (LD) and ER-phagy, stabilizing the expanded ER, as evidenced by our microscopic studies. Finally, we heterologously expressed β-amyrin synthase, an ER bound enzyme from *Artemisia annua* in *spt10Δ pGAL-DGK1* phenotype and observed a significant improvement in triterpene production. Overall, we determined that phospholipid overproduction affects ER size which translates to increased MEV/ERG pathway flux. From our result, we can infer that the expanded ER in spt10Δ is possibly due to the increased PA accumulation. But the PA accumulation also leads to an imbalance in cell, that prompts LD formation to

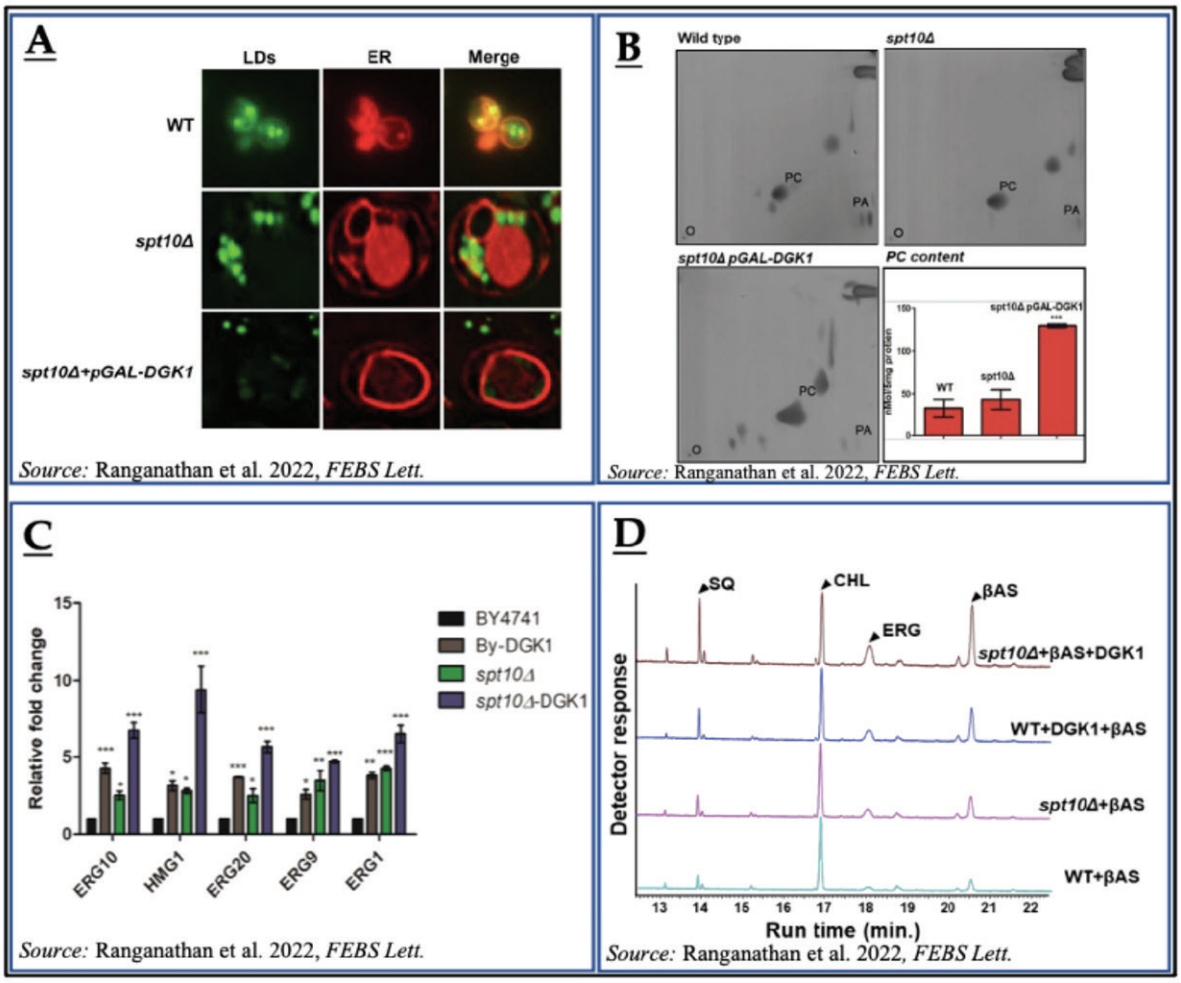


Fig. (A) Microscopy images of the wild type (top), spt10Δ (middle) and spt10Δ pGAL-DGK1 (bottom), the green is the lipid droplets (BODIPY493/503), and the red is the ER (SEC12-mRFP). spt10Δ pGAL- DGK1 strain possesses less lipid droplets with a massive expansion of ER. (B) The quantitative data of phospholipids. The high endogenous phospholipids were observed in spt10Δ pGAL-DGK1. (C) The quantitative gene expression data demonstrate elevated MEV/ERG pathway in spt10Δ pGAL-DGK1 strain. (D) The representative chromatogram of elevated MEV/ERG pathway metabolites and overproduction of β-Amyrin production in spt10Δ pGAL-DGK1 strain.

induce ER phagy. In case of spt10Δ pGAL-DGK1, the pathway for formation of LD is suppressed by DGK1 overexpression, which also increases the endogenous PA, resulting in ER expansion with minimal ER phagy. We theorized that, the ER expansion results in more embedded MEV/ERG pathway activity, thus increasing total MEV/ERG pathway metabolites. To determine the MEV flux in spt10Δ pGAL-DGK1, β-amyrin synthase (an ER embedded enzyme) was expressed, and β-amyrin overproduction was observed, possibly by ER expansion that directly plays a vital role in increasing the availability of MEV pathway intermediates.

Dr. Venkata Rao DK & his team

Dr. Rakesh K. Shukla Mk- jkds'k dqekj 'kqDyk

Deciphering the Small RNA mediated regulatory responses in *Bacopa monnieri*

B. monnieri (L.) Wettst, commonly known as 'Brahmi' is an important medicinal plant of extreme relevance. It has been used world-wide due to the presence of a wide range of pharmaceutically important compounds. B. monnieri has many effective compounds which mainly includes triterpenoidal saponins, alkaloids, flavonoids, betulic acid, stigmasterol, and beta-sitosterol. In the traditional system of Indian medicine, B. monnieri is well considered as a drug to improve memory functions and to overcome the effects of mental stress (Sivaramakrishna et al., 2005). B. monnieri extract acts as a potent nutritional antioxidant, with a distinct mechanism of action to protect the brain from oxidative damage and age-related cognitive disorders such as dementia and

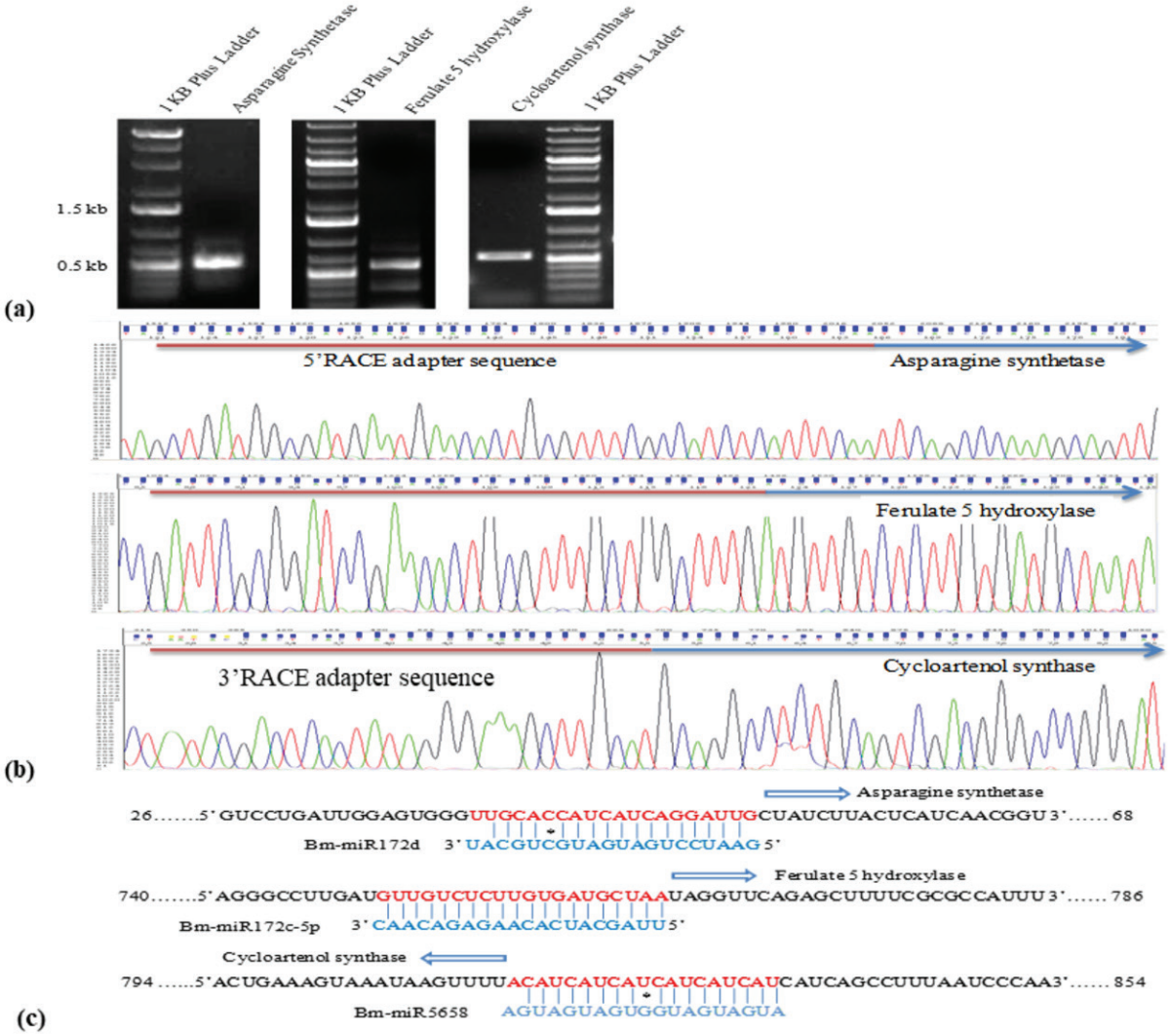


Fig. Identification of Bm-miRNA target cleavage site using modified RLM-RACE. Three Bm-miRNA targets, including Asparagine synthetase, Cycloartenol synthase, and Ferulate 5 hydroxylase are validated. (a) PCR amplification of target transcripts using adaptor specific and inner nested primers. (b) The sequencing results of cloned target transcripts in the PTZ57R/T vector confirm the presence of the Bm-miRNA cleavage site. Both 5' and 3' RACE adaptor sequence is shown by the red line in the sequencing chromatogram. (c) Complementary base pairing of miRNAs with their respective targets. A single mismatch is represented by an asterisk.

Alzheimer's disease (Saini et al., 2019). In spite of the immense pharmacological properties of this important medicinal plant, it is not much explored in terms of the regulatory aspects by endogenous small RNAs. In our study, we performed high-throughput Illumina-based small RNA sequencing to identify the conserved and novel miRNAs in *B. monnieri* and predict their putative targets. We in vitro validate the three Bm-miRNA targets, including Asparagine synthetase, Cycloartenol synthase, and Ferulate 5 hydroxylase. We have identified and functionally characterized the role of Bm-miR172c-5p in regulating lignin biosynthesis in *B. monnieri*. High-throughput Illumina sequencing was performed from a small RNA library to identify the potential miRNAs in B. monnieri. A total of 21363198 raw reads were generated after primary processing, out of which 20394274 reads remained after 3' adaptor removal. Low quality reads smaller than 16 nucleotides, and larger than 30 nucleotides were removed, which yields a total of 18932459 clean reads. The length distribution of small RNA showed maximum reads in the range of 21-24 nucleotides (Fig. S2). All the sequences were extracted and checked for non-coding RNA contamination. The unaligned reads to non-coding RNAs were used for the prediction of known miRNA. Thereafter, a homology search of these predicted miRNAs was performed against the mature miRNA sequences of Viridiplantae retrieved from the miRbase-v21.0 database. A total of 1429 known miRNAs sequences were identified in B. monnieri belonging to 95 conserved miRNA families. The maximum number of miRNAs belongs to the conserved MIR159, MIR156, and MIR166 families (Fig. 1a). The most abundant known miRNA families found in B. monnieri were aligned with the same miRNA families present in different species and found that they have a highly conserved consensus sequence. For in vitro validation of selected Bm-miRNA targets in B. monnieri, modified 5' and 3' RLM-RACE was performed. It is known that miRNAs mainly regulate their target genes by cleavage or inhibiting mRNA translation in plants (Wang et al., 2019). We experimentally validate three Bm-miRNA targets, including Asparagine synthetase, Cycloartenol synthase, and Ferulate 5 hydroxylase (F5H). We found that Bm-miR172d and Bm-miR5658 cleaved Asparagine synthetase and Cycloartenol synthase gene within the UTR region, whereas Bm-miR172c cleaves F5H within the coding region. Nested primers were designed for RLM-RACE, and the desired amplification was observed (Fig. 1a). The amplified fragment was purified and cloned in PTZ57R/T vector. Sequencing results further confirmed the cleavage site and their target genes (Fig. 1b). The Bm-miRNA binding sites show the perfect complementary with an only a single mismatch with their target genes (Fig. 1c). (GS Jeena, A Joshi, RK Shukla Plant and Cell Physiology 62 (5), 894-912).

Dr. Rakesh Shukla & his team

Dr. Pradipto Mukhopadhyay Mk- ih- e[kkik/;k;

Analysis of transcripts encoding LSH and BAG-domain for root improvement in *W. somnifera*

Previous analysis of transcriptome data for differentially expressed genes in Nagori and Poshita suggests two major group of genes being upregulated with developmental stage one comprising of heat shock transcription factors (HSFs), heat shock proteins (HSPs) and Bcl-2 associated anthogene (BAG) domain containing genes, other is ALOG (*Arabidopsis* LSH1 and *Oryza* G1) domain gene. HSFs are transcriptional activator of HSPs and bind specifically to heat shock sequence element. BAG proteins are characterized by a common conserved region located near the C-terminus, termed as BAG-domain (BD) that mediates direct interaction with ATPase domain of Hsp70/ Hsc70 molecular chaperones and regulate apopstosis. Analysis of RNA-seq data of *W. somifera* (nagori and poshita) for BAG-domain containing genes present in *W. somifera* reveals that homologues of all 7 *AtBAG* genes are present in *Withania*. Phylogentic tree of BAG domain containing transcripts from *W. somnifera* with *Arabidopsis thaliana, solanum lycopersicum, Solanum tuberosum, Oryzae sativa* and *Glycine max;* formed using MEGAX shows that BAG domain genes form two major groups, one group contain genes having UBQ (ubiquitination) motif (BAG1-4) and other containing IQ motif (BAG5-7). Domain analysis

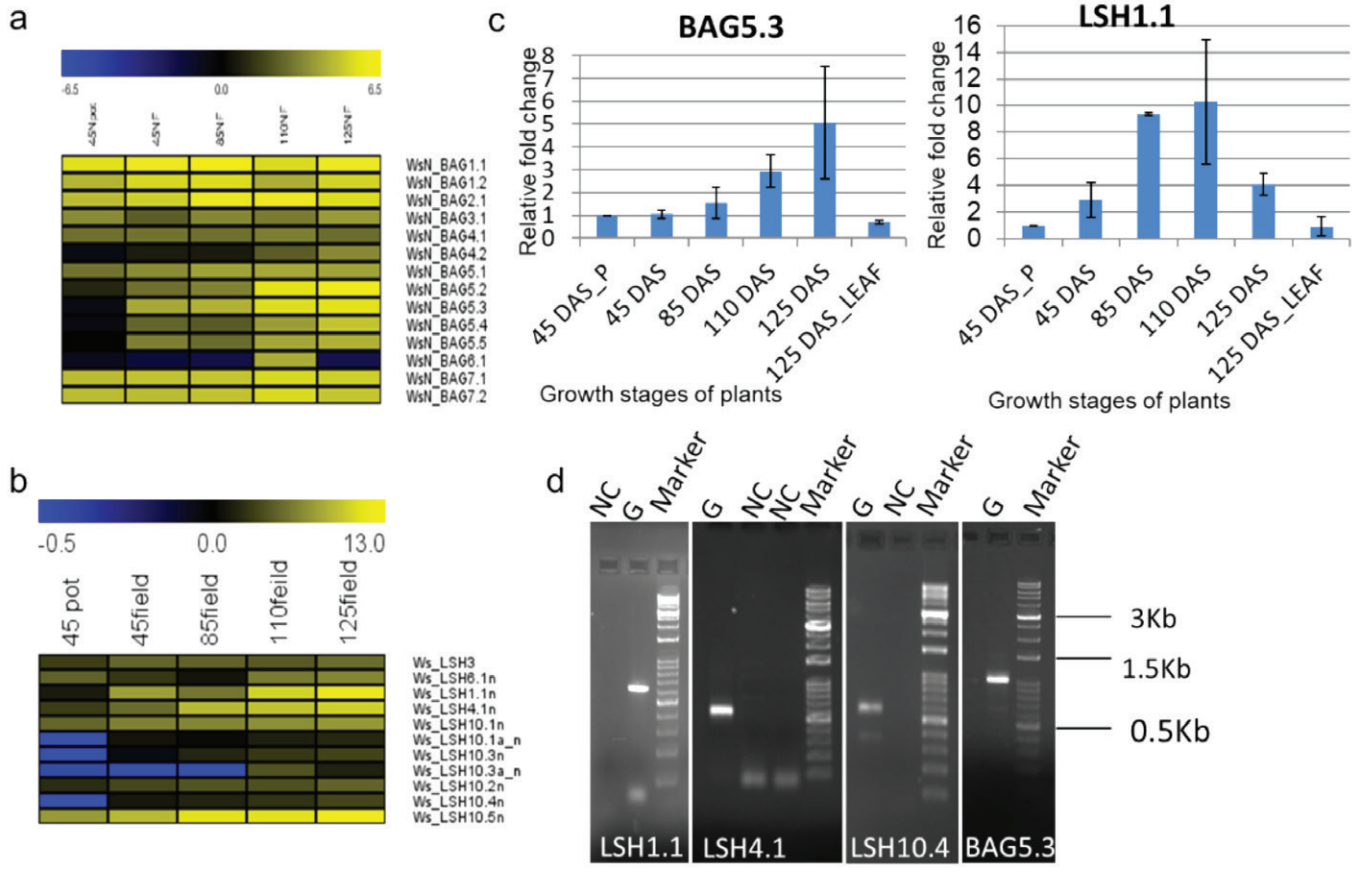


Fig. Expression analysis and cloning of LSH and BAG-domain protein. (a-b) Heat map showing developmental stage specific RNA-seq expression analysis of identified BAG-domain (a) and LSH transcripts (b) in roots of W. somnifera (cv Nagori). (c) qRT-PCR analysis of a representative BAG-domain and LSH gene during various root growth stages; DAS in Days after sowing in field and DAS_P indicates days after sowing in pots in glasshouse (d) Cloning few LSH and BAG-domain protein; NC, G and Marker indicates the negative control, amplified ORF and 1 kb DNA marker, respectively.

done using Expasy domain finder also reveals the same pattern. Cloning and sequence confirmation of HSP70, HSFB and BAG5 has been done. Their expression pattern was validated by real time PCR, which is in accordance with the TPM value of RNA seq data. For localization studies HSP70 has been cloned in localization vector (pSITE3CA) and was seen to localize in Nucleus and cytoplasm of leaf epidemarmal cell of *Nicotiana tabaccum* plant. Localization experiment for young leaf and root of *W. somifera* is under process. Other genes of group such as BAG domain genes and HSFs are under process of cloning in plant localization vector. ALOG (*Arabidopsis* LSH1 and *Oryza* G1)-domain gene family / DUF640 /Light- dependent Short Hypocotyl (LSH) are specific to land plants. Literature suggests ALOG-domain containing proteins may play role in regulation of hypocotyl elongation and organ boundary determination at shoot apical meristem Data analysis for total ALOG-domain genes present in Nagori morphotype suggests that most genes of this family have increasing trend of TPM (transcript per million). Phylogenetic tree of ALOG domain genes with *Arabidopsis thaliana, Solanum tuberosum ,Solanum lycopersicum and glycine max* shows that ALOG-domain genes from *Withania somnifera* roots falls in three major groups. Based on RNA-seq expression daya and the phylogenetic analysis, genes from different classes of ALOG-domain like LSH1, LSH10, LSH4 were chosen for further studies. Expression data was validated by real time PCR. Cloning and sequence confirmation of these genes was done. From literature it is known that ALOG domain genes are short and many of them do not contain introns. To check for the introns in ALOG domain genes of *W. somnifera* PCR amplification of genes has been done from genomic DNA. Further work for localization studies and functional characterization of these genes are in process. Over expression primers for LSH1 has been designed. Further work is under progress.

Dr. Pradipto Mukhopadhyay & his team

Dr. Mukti Nath Mishra Mk- efDrukFk feJk

Metabolic engineering to develop a bacterial platform for valencene production.

Valencene (a sesquiterpenoids) is economically important because it gives a juicy impression in citrus flavourings and fragrances. Currently, the market volume for valencene is about 10 000 kg per year. Another 5000 kg of valencene per year is used for the production of nootkatone, which is used to provide a grapefruit-like flavour to soft drinks. Since higher pool of farnesyl pyrophosphate (FPP) is a prerequisite for sesquiterpenoid producing platform strains, and since carotenoid overproducing microorganisms have endogenous high-flux isoprenoid pathway, we selected *Azospirillum brasilense*, a carotenoid over-producing bacterium, as a host to develop platform strains for production of high-value sesquiterpenes**.** By engineering to increase the endogenous isoprenoid flux (metabolic pushing) and expression of exogenous genes (metabolic pulling) in *Azospirillum brasilense*, we have developed a bacterial hosts for production of valencene. The developed system has been tested in shake-flask culture system and now attempts are being made to use bioreactor facility to evaluate the large-scale production efficiency.

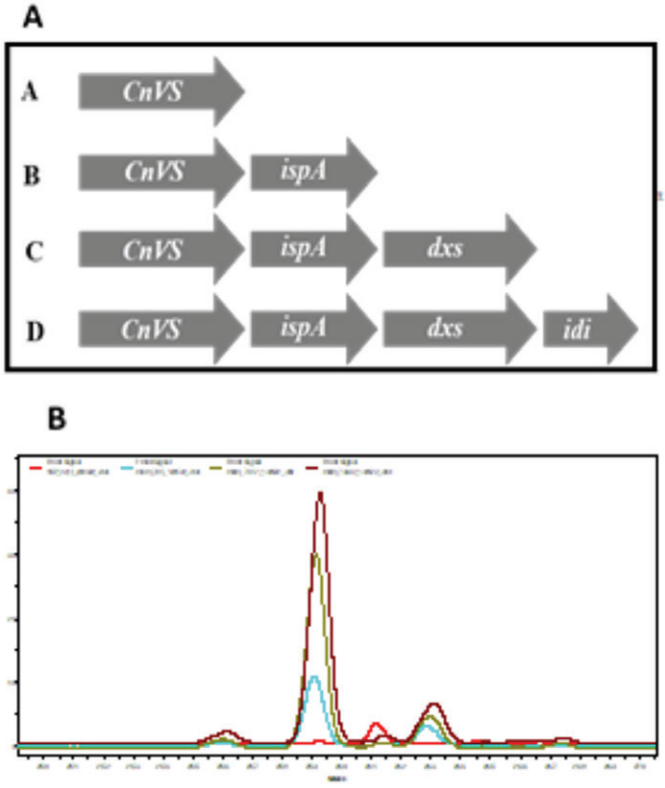


Fig. Different valencene biosynthetic operons constructed to engineer *A. brasilense* by using *CnVS* (valencene synthase), *ispA* (FPP synthase), *dxs* (1-deoxy-D-xylulose 5-phosphate synthase), and *idi* (IPP isomerase). **B.** GC chromatogram of the hexane extracts of different engineered strains.

Dr. Mukti Nath Mishra & his team

Crop Production and Protection

HIGHLIGHTS

Crop production and protection division has been actively engaged in the development of good agriculture practices for Medicinal and Aromatic Plants (MAPs) for various agro-climatic regions of the country, improvement of marginal/underutilized lands, assessing soil and water potential for enhancement of resource use efficiency maximizing the yields and profits of the medicinal and aromatic crops (MACs). The division is also engaged in development of cost effective and time & manpower saving various agricultural implements/equipments, post harvest losses and improving quality of important medicinal and aromatic produce, study on pests and diseases identification characterization and their measures.

The divisional faculty is also involved in academic activity such as guiding PhD scholars (CSIR-CIMAP: AcSIR academy & CSIR-CIMAP: JNU) training for skill development to farmers, industrialists, projects staff, post graduates students of different organization/university/institute in the area of medicinal and aromatic crops cultivation.

At present, the division has focused on optimization of post harvest technology for senna produce. Optimizing harvesting practices of Palmarosa for higher productivity & economics and water resource for higher biomass yield, essential oil constituents of Mentha arvensis. Promotion of Moringa cultivation and development of value added products, nutrient dynamics on rhizosphere of selected medicinal and aromatic plants. Application of bio-stimulants for enhancing the root yield and quality of *Withania Somnifera.*

During this period, an innovative circular model was developed and examined for the production of bio-char in an ash pit using easily available feedstock for the sustainable use of resources and recycling of biomass and animal waste. The residence time of 120 min is more suitable for production of bio-char and it has 39-60% of yield, alkaline pH 0.26-1.63 gm^{-3} bulk density, 11-78% water holding capacity and 15-124 meq/100g cation exchange capacity. Worked on phytostabilization of acid mine spoil through high value aromatic crop *P. graveolens* has been investigated in various combinations (T1: 100% soil; T2: 100% mine spoil, T3: 75 mine spoil: 25soil and T4: 50 mine spoil: 50 soil). By this improved the soil biological properties and immobilized the metals as well. The Poly-4 poly halide based product was developed by Sirius Minerals Plc. and recommended @ 142.86 kg/ha for commercial menthol-mint cultivation to achieve higher yields and profit as well.

Division has identified a disease in a *Artemisia annua* plants (26.820245°N, 80.9809763°E) at the early flowering stage with stem and root rot viz. brown stem nodes, sudden wilting, and vascular browning of the stems, withering of the whole plant, and black rotten roots. Based on the morphological and molecular evidences, the isolate ArSRK01 was reported as *Pseudofusicoccum adansoniae,* belongs to the family Botryosphaeriaceae. Further, the division has assessed the bacterial and fungal diversity associated with two contrasting verities of *O. Sanctum* and reported that varietal effect of plants in recruiting microbes which might be playing a key role in modulating the phytochemistry. Vetiver, ashwagandha and menthol mint based co-cultivation/intercropping agro-practices was optimized with pigeonpea, green gram, cowpea, soyabean, sugarcane and field bean. The study revealed that the intercropping of vetiver with field bean improve resource efficwency and could be getting more profitable than sole crop. Ridge plantation system of menthol mint through saplings with sugarcane was found maximum yields than sucker plantation. Liquid organic fertilizer applied @ 150 liters per acre recorded significantly higher leaf yield (1085.2 kg ha-1) and pod yield (318.7 kg ha-1).

In another study, it was reported that the application of Pusa PSB liquid biofertilizer + *Amaranthus viridis* WLE recorded the highest dry matter production of ashwagandha (157.3 g per plant), root fresh weight (65.0 g/plant) and root dry weight (23.0 g/plant). During this period, the division has also worked on study of physical properties of ashwagandha seeds to design and development of suitable sowing equipment and studied the kinetics of drying of shatavar roots for increasing shelf life and its quality for longer period. The scientists and technical staff of the DU contributed significantly to different skill development outreach programmes and institute building programme, survey & preparation of feasibility reports, technologies disseminations, agrotechnology demonstration etc.

During this tenure, crop production & protection division has published a total of 16 research articles in high impact factors journals such as Journal of cleaner production, Industrial crops & products, The plant journal, Environmental pollution, Journal of Environment management, Natural product research and applied soil ecology, 01 popular articles, 3 books & book chaters and one patent was filed.

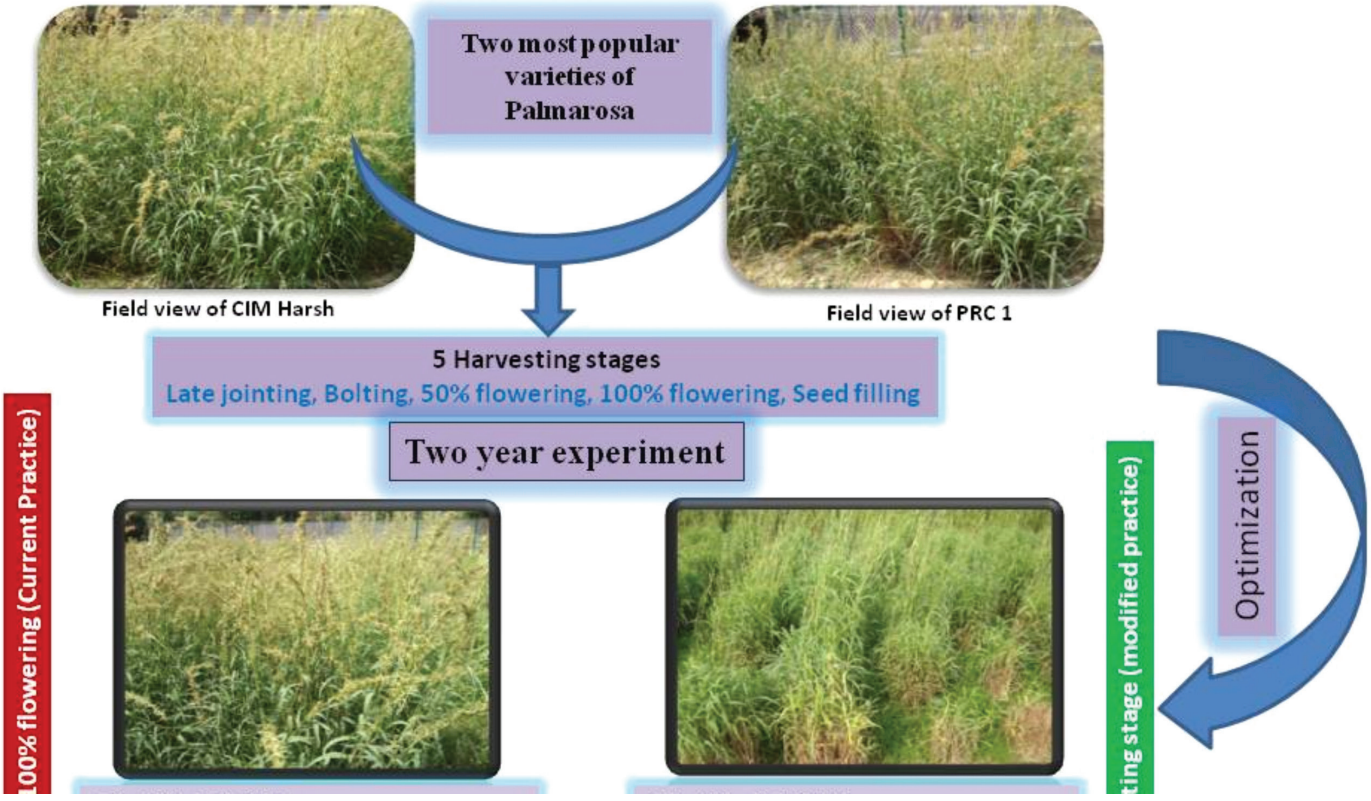
Scientists of Crop Production and Protection Divisional Unit

Dr. Saudan Singh, Dr. Rajesh Kumar Verma, Dr. Puja Khare, Dr. Rakesh Kumar Upadhyay, Dr. Kishore B. Bandamaravuri, Dr. Rakesh Kumar, Dr. Yogendra N. D., Dr. Jnanesha A C, Dr. Dipender Kumar, Dr. Priyanka Suryavanshi, Dr. Akansha Singh, Dr. Santoshkumar Chandappa Kedar, Dr. B. Shivanna and Dr. Anandakumar TM

Dr. Saudan Singh Mk- lkinku flg

Productivity, quality, and economics of *Cymbopogon martini* (Roxb.) Wats. as influenced by harvesting done at different phenological stages

Palmarosa [*Cymbopogon martini* (Roxb.) Wats.] is a perennial grass and commercialized for its high value and industrially important essential oil dominated by Geraniol and Geranyl acetate. The aim of this study is to optimize the harvesting stage for getting higher yields of essential oil, geraniol, geranyl acetate and maximum monitory returns. The experiment consisted harvesting of the crop at five stages of crop growth, i.e., (i) late jointing, (ii) bolting, (iii) 50% flowering, (iv) 100% flowering, and (v) seed filling stage, and two popular varieties, i.e., (i) CIM Harsh and (ii) PRC1 was selected. The research findings revealed that the survival percentage was 81.5% and 80.5% when harvesting was done at the late jointing and bolting stage, respectively, which was highest among different harvesting stages irrespective of varieties. Harvesting at bolting stage recorded highest herbage yield (74.23 t ha^{-1}), oil yield (420.07 l ha^{-1}), geraniol yield (314.33 l ha^{-1}), and geranyl acetate yield (96.09 l ha^{-1}) in 11 harvests taken during a period of two years. Net return and Benefit: Cost ratio were also computed maximum (7335.76 $ ha^{-1} and 5.75 respectively) when harvesting was done at bolting stage irrespective of both the varieties. The modified practice of harvesting resulted 12.12 % higher essential oil yield and 13.27 % higher net returns over present practice of harvest i.e., harvesting at 100% flowering stage (5 harvests taken in a period of two years). After taking an integrated view of the experimental results, it is recommended that palmarosa crop should be harvest at the bolting stage for obtaining better yields, maximum net returns, and higher benefit: cost ratio and present practice of harvesting i.e., at 100% flowering should be avoided.



Optimization of primary post-harvest processing techniques for safe storage and quality maintenance in leaves and pods of *Cassia angustifolia* Vahl.

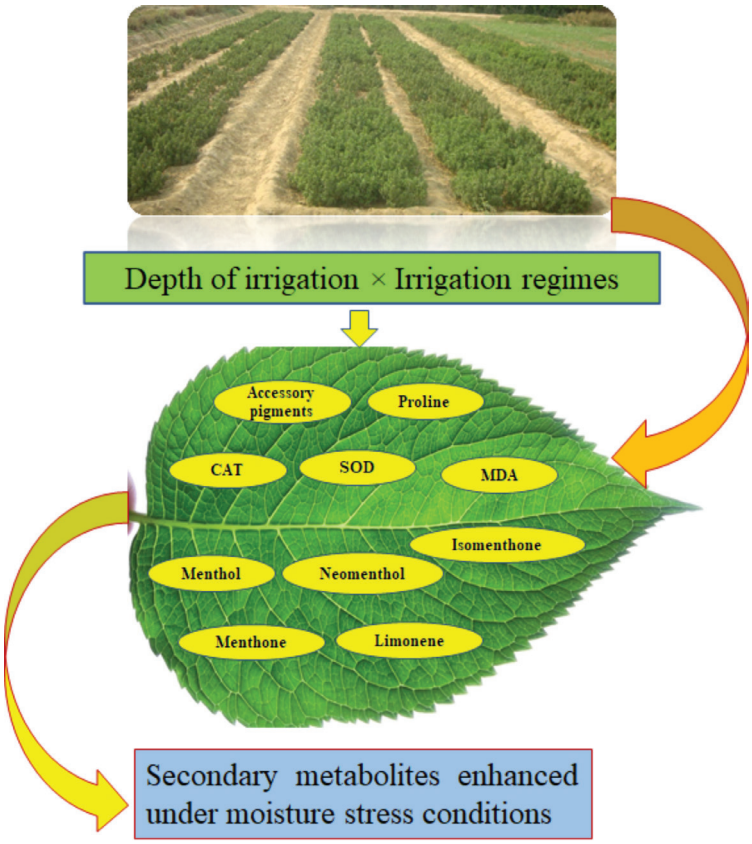
Cassia angustifolia Vahl. (Senna), a versatile medicinal plant that holds a considerable reputation in Ayurveda, Unani and Allopathic medicine system worldwide. It contains sennosides (2.5% in leaves and 3.6% in pods), which are utilized to treat habitual constipation and other related problems. India ranks first in the production of this valued medicinal crop. Leaves and pods and other processed materials are exported to Germany, France, the USA, the UK, Australia, and South East Asia. After the successful cultivation of any medicinal plant, it is essential that it must be dried effectively and packed safely to retain its quality for a longer period. Senna cultivation is done successfully in India; however, the primary post-harvest processing techniques are not optimized yet. Hence, experiments were planned on post-harvest primary processing for effective drying, safe packing for longer storage *Cassia angustifolia* Vahl.'s leaves, and pods. Results revealed that senna leaves are more prone to deterioration during storage irrespective of packing material used for storage. Drying in 100% shade condition retain the quality of pods (3.22%) and leaves (2.20%) in comparison with sun drying and 50% shade drying. However, pods' quality can be retained up to one year without any considerable deterioration if dried in 100% shade and packed in black poly bags (3.17%) whereas sennoside content of leaf was more rapidly deteriorated (0.27%) after one year of storage period. Calculation of economics revealed that cost of post-harvest processing was slightly high (662.04$) if drying was done in 100% shade in comparison with other two methods of drying. However, by drying under the 100% shade, it can retain the herb quality up to a longer time and make this crop more economically viable for farmers and medicinal plant-based industries.

Fresh leaves

Dried leaves

Impact of different depth of irrigations and moisture levels on yield, essential oil constituents and antioxidants response in two cultivars of menthol mint (*Mentha arvensis* L.)

The menthol mint (*Mentha arvensis* L.) can survive under water stress conditions because of the proper maintenance of metabolism. The present study has been carried out in order to optimize irrigation regimes for enhancing the yield of secondary metabolites and antioxidant activity in this crop with a considerable saving in water consumption. Two popular cultivars of *M. arvensis* L. were grown under three different depths of irrigation *viz.*, 30 (D_1), 60 (D_2), and 90 mm (D_3), and three levels of irrigation regimes, i.e., 60 (I_1), 40 (I_2), and 20±5% ASM (I_3), in a split-split plot design with three replicates under field conditions.



Dry matter yield, essential oil content, oil yield, relative water content, total chlorophyll, free proline, malondialdehyde level, reactive oxygen species scavenging enzymes *viz.*, superoxide dismutase, catalase, and aroma constituents were significantly affected under the various depths of irrigation and irrigation regime. A total of six major compounds consisted of monoterpenes *viz.*, menthol, neomenthol, menthyl acetate, isomenthol, menthone, and limonene extracted in the essential oil. The different antioxidants were increased under the depth of irrigation 30 mm (D_1) and applied irrigation maintain at 20±5% ASM (I_3). Similarly, the percentage of major essential constituents substantially increased under the lower depth of irrigation (D_1) and at higher moisture stress (I_3). Results indicated that 60 mm (D_2) depth of each irrigation applied at 40±5% ASM (I_2) was found the most beneficial combination in both cultivars of *M. arvensis* L. Furthermore, it provides an opportunity to save irrigation water during cultivation and improve the production of secondary metabolites.

Dr. Saudan Singh & his team

Dr. Rajesh Kumar Verma Mk- jkt'k dekj oek

Promotion of *Moringa* based farming system and development of value added products for livelihood security and employment in rural community

Reducing mall nutrition problems in people because of *Moringa* is known as the "Miracle Tree" it is exceptionally nutrient-dense. The most nutritious food on the planet, leaves are rich source of protein, fiber and contain 5 essential vitamins and minerals (calcium, iron, and vitamins A, E & K). By adopting good agriculture practices with integrated farming systems of *Moringa* cultivation growers can get remunerative profit and also they can used as vegetable (green pods) and nutrients rich food supplements for humans and animals as well. Under this project 50 farmers were selected and trained them for *Moringa* cultivation with aromatic and conventional crops. Quality planting /seed materials of *Moringa* (variety PKM-1, PKM-2 and ODC), vegetables and some selected MAPs to be given to project beneficiary farmers. The majority

of the selected farmers belong to small and marginal farmer's category. Developed *Moringa* "GAP" technical bulletin and released by DG CSIR on the occasion of CSIR-CIMAP Kisan mela-2022.CSIR-CIMAP trend for processing and facilitating to the project beneficiaries farmers for the marketing.

Microbial inoculants with inorganic fertilizers slacken the chlorosis impact on Kalmegh [*Andrographis paniculata* (Burm. F.) Wall ex., Nees] improve yields and quality traits

A common problem witnessed in Kalmegh [*Andrographis paniculata* (Burm. F.) Wall ex., Nees] plants are yellowing of leaves, when cultivated during rainy season which drastically affects the yield and quality of andrographolide. In the present study, four strains of bioinoculants (*Pseudomonas monteilii, Cedecea devisae, Cronobacter dublinensis, Advenella* species) were scrutinized along with combinations of inorganic fertilizers to identify the best bioinoculant-fertilizer combination which can curb the effect of yellowing in Kalmegh plants most efficiently as well as enhance its biomass and secondary metabolite content. Minimum percentage of yellowing of leaves was recorded in the plantlets inoculated with bioinoculants (*Cedecea devisae*) and N:P:K applied at the ratio of 80:60:40 kg ha^{-1}. Among all the treatments, *Cedecea devisae* (T_5) gave maximum fresh and dry herb yields. The results showed a significant variation in photosynthetic pigments along with the treatments. Maximum andrographolide yield was recorded in the plantlets inoculated with *Cedecea devisae* which was 63.07% more compared to control. Moreover, the concentration of andrographolide in different parts of Kalmegh plants followed the trend leaves>stem>inflorescence>flowers>seeds>seed husk>root. Except soil pH, other analysed soil parameters of the post harvest soil were significantly improved. Significant enhancement of the soil dehydrogenase, alkaline and acid phosphatase enzymes activity was 14.8% to 54.0%, 57.0% to 234%, and 51.6% to 276% greater, respectively over control. Principal component analysis revealed a strong positive interrelationship between vegetative attributes, soil enzyme activity, biomass yield and andrographolide content. From this study it can be suggested that bioinoculants especially free living nitrogen fixers (*Cedecea davisae*) along with recommended doses of NPK can effectively control the problem of yellowing (chlorosis) in Kalmegh plants during rainy season.

Dr. Rajesh Kumar Verma & his team

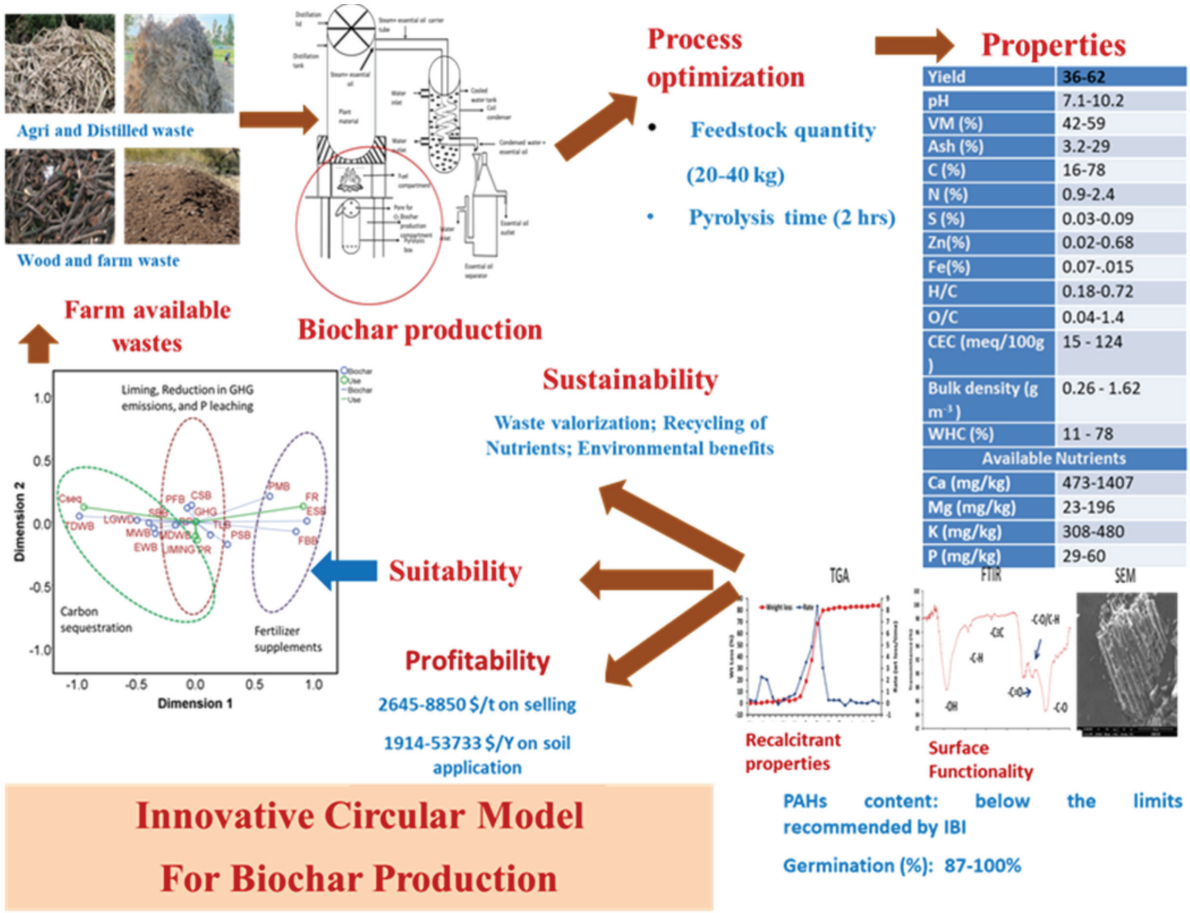
Dr. Puja Khare Mk- i tk [kj

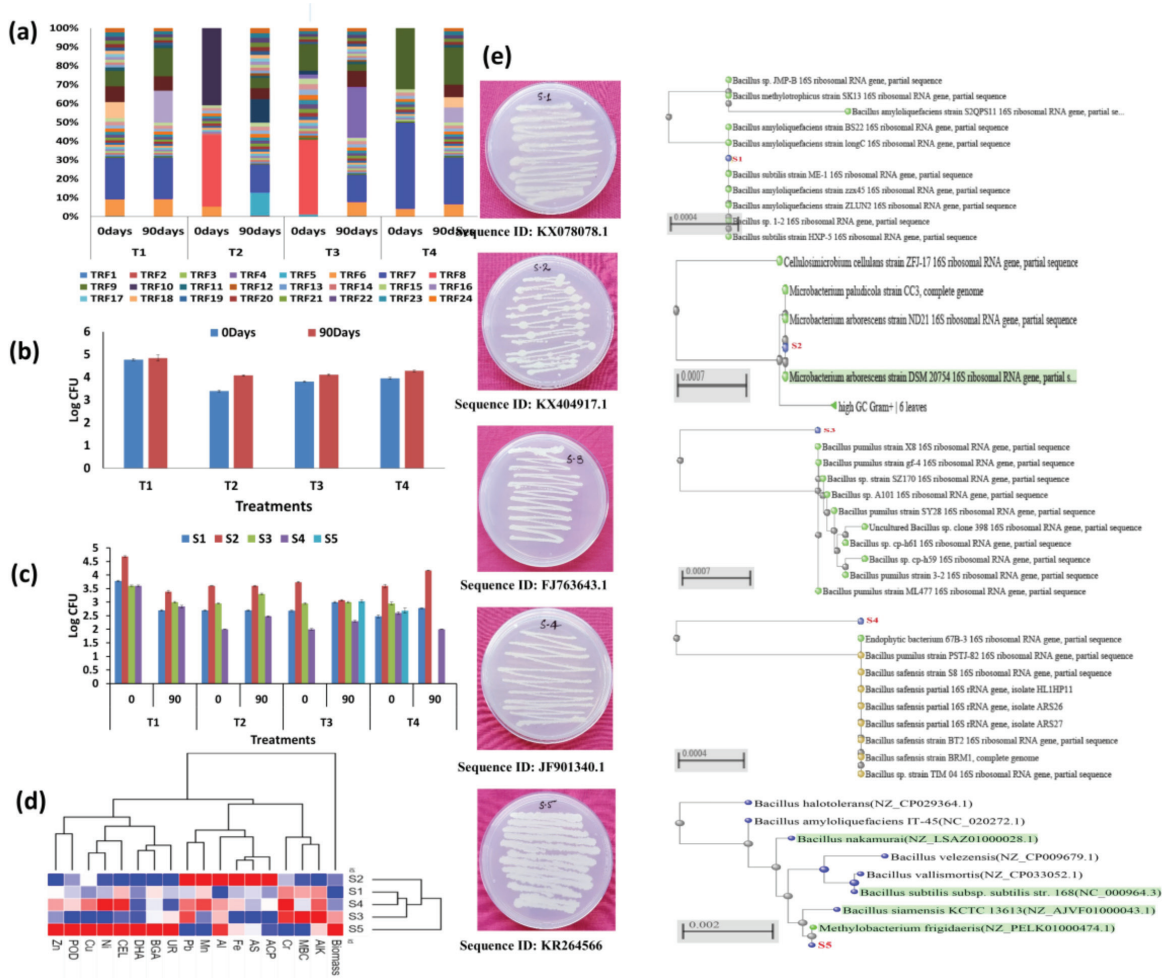
Recycling of farm wastes into biochar using distillation units: A way towards environmental sustainability and circular economy

An innovative circular model was examined for the production of biochar in an ash pit (with 432 L volume and 350°- 450° temperature) of essential oil distillation unit using different easily farm available feedstocks (13) for the sustainable use of resources and recycling of biomass and animal waste. The study demonstrated that residence time of 120 min was more suitable for biochar production as compared to 180 and 240 minutes. The biochar produced had 39-60% of yield, alkaline pH, 0.26-1.63 gm^{-3} bulk density, 11-78% water holding capacity, and 15-124 meq/100g cation exchange capacity. Biochars from animal waste have greater potential for fertilizer supplements while distilled waste-derived biochar and crop residue can be more effective for carbon sequestration and reduction in greenhouse emissions. The estimated benefits to cost ratio was $ 54 to 2174 for soil application and $32-982 for selling purposes, hence could be sustainable and profitable for the farmers and aroma industry (Journal of Cleaner Production 2022).

Sustainable phytoremediation of highly acidic mine spoil through economical valuable crop *Pelargonium graveolens* L

The phytostabilization of acid mine spoil by industrially important aromatic crops could be a sustainable solution with minimum input for the problem associated with acidic mine spoil-affected areas. In the present study, the suitability of *P. graveolens* for phytostabilization of acidic mine spoil has been investigated in three different combinations



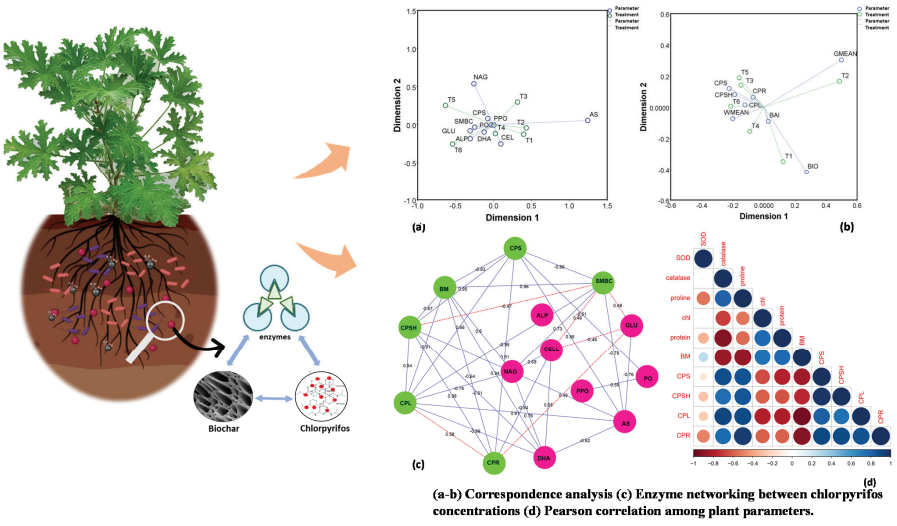


(T1: 100% soil; T2: 100% mine spoil, T3: 75 mine spoil: 25soil and T4: 50 mine spoil: 50 soil). The plant growth performance, metal accumulation, ecological indices, soil properties, enzymes, and microbial diversity along with the identification of dominant bacterial isolates were investigated in the study. The results indicated that mine spoil was highly acidic (pH 3.01) and rich in minerals and toxic metals. The values of the tolerance index and oil content of *P. graveolens* L under different treatments varied from 43 to 89% and from 0.10 to 0.13% without affecting oil quality, respectively. Bio-concentration (BCF) and translocation factor (TF) indicated that the *P. graveolens* can be used as a phyto-excluder for Al, Fe, Cr, Zn, and Pb and phytoextractor for Cu, Ni, and Mn. The plantation of *P. graveolens* enhanced the microbial biomass and enzymatic activities of soil and immobilized the metals. The increase in the Shannon index from 1.67-1.86 to 1.9-2.61 suggested enhanced bacterial diversity after plantation. The identify bacterial isolates were metal tolerant and plant growth promoters. The study suggested that P. *graveolens* is suitable for the phytostabilization purpose of acidic mine spoils along with the economic return. Environmental Progress and Sustainable Energy [IF:2.824]

Assessment of soil enzymatic resilience in chlorpyrifos contaminated soils by biochar aided *Pelargonium graveolens* L. plantation

Chlorpyrifos (CP), a broad-spectrum organophosphorus insecticide is known for deleterious effects on soil enzymatic activities. Hence, the present study aims to examine the resilience effect of biochar (BC) aided *Pelargonium graveolens* L. plantation on enzymatic activities of chlorpyrifos contaminated soil. The two chlorpyrifos

contaminated agriculture soils (with concentrations: S1: 46.1 and S2: 95.5 mg kg^{-1}) were taken for the pot experiment. The plant biomass, plant growth parameters, soil microbial biomass, and enzymatic activities such as alkaline phosphatase, N-acetyl glucosaminidase, aryl sulphatase, cellulase, β-glucosidase, dehydrogenase, phenoloxidase, and peroxidase enzymes were performed. Ecoenzymes activities and their stoichiometry were used to enumerate the different indices including geometric mean, weighted mean, biochemical activity indices, integrated biological response, treated-soil quality index, and vector analysis in all treatments. The results of the study demonstrated that the biochar incorporation enhanced the tolerance of *P. graveolens* (from 42-45% to 55-67%) in chlorpyrifos contaminated soil and reduced the CP accumulation in plants. A reduction in the inhibitory effect of chlorpyrifos on soil enzymatic activities and plant growth by BC incorporation was observed along with an increase in the activities of eco-enzymes (16.7-18.6%) in soil. The investigation indicated more microbial investments in C and P than that in N acquisition under CP stress. The BC amendment catalyzed the activities of lignin and cellulose-degrading enzymes and enhanced the nutrition acquisition. The CP contamination and BC amedement has no significant affect on the oil quality of *P. graveolens*. The study demostrated that BC aided *P. graveolens* plantation offers a sustainable phytotechnology for CP contaiminated soil with economic return.



(a-b) Correspondence analysis (c) Enzyme networking between chlorpyrifos concentrations (d) Pearson correlation among plant parameters.

Dr. Puja Khare & her team

Dr. R K Upadhyay Mk- vkj d mik/;k;

Introduction of mint as rainy season crop in traditional as well as in non-traditional areas:

- Efficient management of resource. Able to save approximately 40-60% irrigation water.
- Traditionally, menthol-mint is cultivated via stolons in spring season.
- A novel Agro-technology developed for off-season menthol-mint cultivation.
- Optimization of best part of stem of menthol-mint explored as a novel source of planting material for main & off-season crop both (as stolon are not formed in summer).

Among the three parts as source of planting materials, the maximum number of Mentha sapling was noted under S_3: Chopped 2/3 top areal plant, followed by S_2: Chopped 1/3 top areal plant followed by and lowest sapling was recorded in S_1. Among the planting methods of Mentha using mentha stem as source of planting material, the maximum number of Mentha sapling was noted under P_2: topdressing in furrow covered with soil, followed by topdressing and covered with Soil & Vermicompost (1:1) and lowest was recorded in P_4: topdressing. Therefore, It is recommended that, the mentha sapling/ seedling should be raised by planting of 2/3rd areal part (chopped) & topdressing in furrow and covered with soil provided quality planting material for Mentha.

Field view of optimization of best part of menthol mint stem for source of planting materials

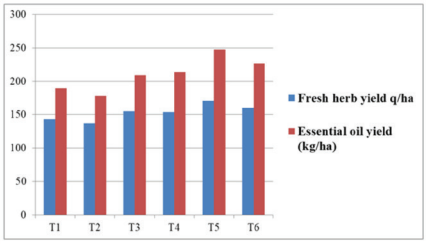
Study the impact of Poly4 on yield attributing characters, essential oil yield and quality of *Mentha arvensis* L.

POLY4 is the trademark name of all polyhalite products from Sirius Minerals Plc. Polyhalite is a naturally occurring, low chloride multi-nutrient fertilizer containing four of the six macro nutrients required for effective plant growth. POLY4 contains 14% K_2O, 19% S, 6% MgO, and 17% CaO.

Study the impact of POLY4 on yield attributing characters, essential oil yield and quality of *Mentha arvensis* L.

T_1- Recommended dose of fertilizer $N:P_2O_5:K_2O$ @ 120:60:40 Kg/ha through Urea/SSP/DAP/MOP & 20 Kg Sulphur/ha
T_2- $N:P_2O_5$ @ 120:60 Kg/ha through Urea/DAP
T_3- $N:P_2O_5:K_2O$ @ 120:60:40 Kg/ha through Urea/DAP/POLY4
T_4- $N:P_2O_5:K_2O$ @ 120:60:30 Kg/ha through Urea/DAP/POLY4
T_5- $N:P_2O_5:K_2O$ @ 120:60:20 Kg/ha through Urea/DAP/POLY4
T6- $N:P_2O_5:K_2O$ @ 120:60:40 Kg/ha through Urea/ DAP/ MOP/ POLY4 subject to supply 20 kg/ha sulphur through POLY4 and rest K_2O by MOP

POLY4 is low chloride multi-nutrient fertilizer containing four of the six macro nutrients 14% K_2O, 19% S, 6% MgO, and 17% CaO. The maximum fresh herb yield & essential oil yield recorded under T5 i.e. significantly at par with T6. The application of POLY4 helps in achieving higher yield and allso its able to supply K_2O, Ca, Mg,, S with single source POLY4.



On the basis of trial on study the impact of Poly4 on yield attributing characters, essential oil yield and quality of *Mentha arvensis* L., concluded that application of $N:P_2O_5:K_2O$ @ 120:60:20 Kg/ha through Urea/DAP/POLY4 provided highest essential oil yield 247.68 kg/ha & net income Rs. 178592/- per ha as compared T_1 (Recommended dose of fertilizer $N:P_2O_5:K_2O$ @ 120:60:40 kg/ha through Urea/SSP/ DAP/MOP & 20 kg sulphur/ha) essential oil yield 189.87 kg/ha & net income Rs. 121457/- per ha. There recommended that application of POLY4 at the rate of 142.86 kg/ha for commercial scale cultivation of menthol-mint to achieve higher essential oil yield & income both.

Dr. Kishore B. Bandamaravuri
Mk- fd 'kkj ch- cnkekjkofj

Stem and root rot disease of *Artemisia annua* caused by *Pseudofusicoccum adansoniae*

Artemisia annua, an annual short-day plant, has been cultivated in India on a commercial scale since 1980, owing to the production of the anti-malarial drug molecule artemisinin. *A. annua* plants (26.820245°N, 80.9809763°E) at the early flowering stage were observed with stem and root rot disease viz. brown stem nodes, sudden wilting, and vascular browning of the stems, withering of the whole plant, and black rotten roots. The disease causing agents isolate ArSRK01, was constantly isolated from the stems and roots of the symptomatic plants. The colony morphology of isolate ArSRK01 on malt extract agar showed aerial mycelia with white circular growth, becoming light brown to whitish-grey cottony growth at the center. The microscopic observations revealed an aseptate, straight or slightly bent smooth-walled, ellipsoid to rod-shaped conidia of size 10.16 × 7.8 µm, with fine granular content surrounded by a thin mucilaginous sheath. The molecular characterization

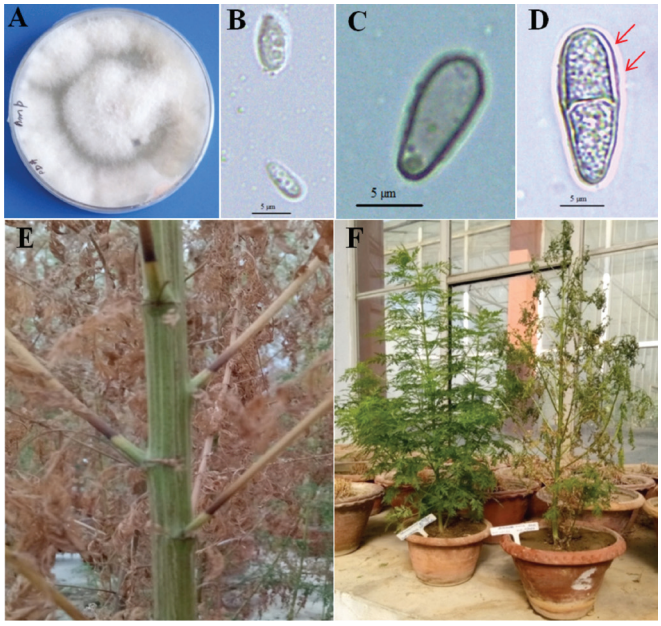


Fig. *Pseudofusicoccum adansoniae* ArSRK01 (A)Culture plate after 10-15 days (B-C)Conidia, (D)Conidia with mucilaginous sheath (arrows), E and F indicating the infected plants showing stem and root rot symptoms on artificially inoculated plants under glasshouse.

Fig. Field view of *Artemisia annua* plants showing stem and root rot disease symptoms.

was done using TEF1- alpha and ITS regions. Based on the morphological and molecular evidences, the isolate ArSRK01 was confirmed as *Pseudofusicoccum adansoniae,* belongs to the family Botryosphaeriaceae.

Observation of Fusarium wilt disease in *ocimum basilicum*

Fusarium wilt disease was observed on ***Ocimum basilicum*** crop during August, 2021 the infected plant samples were collected and fungal pathogen was isolated. The pathogenicity experiments and molecular identification of fungal pathogen is under progress.

Fig. Areal view and wilted plants of Ocimum basilicum

Root rot disease incidence on *Withania somnifera* var CIM Pushti:

W. somnifera plants were showed root rot disease symptoms, initially the plants were wilted and dried and the roots showed rotting during late winter season in Feb-March 2022. The root rot disease lead to death of the plant. The infected portion of the root was subjected to pathogen isolation. Morphological, pathogenicity and molecular characterization of the pathogen was performed.

Root rot disease of *Withania somnifera* caused by *Fusarium* spp. a. Infected plant, b. Colony morphology of pathogen and c. Microscopic images of mycelia and spores.

Dr. Kishore B. Bandamaravuri & his team

Dr. Yogendra ND Mk- ;kxUn ,uMh

Different competition indices and resource use efficiency under vetiver (*Vetiveria zizanioides* (L.) Nash) intercropping system

Vetiver (*Vetiveria zizanioides* (L.) Nash) is a perennial aromatic crop having enormous industrial demand and pharmaceutical applications. Since, vetiver crop is widely spaced with a lengthy initial lag phase, it provides better opportunity for co-cultivation/ intercropping to maximise resource use efficiency and to enhance the productivity. A field experiment was conducted at CSIR-CIMAP, Research Centre, Bengaluru. Seven treatments: sole crop of vetiver and co-cultivation of pigeon pea, green gram, ashwagandha, soybean, field bean and cowpea with vetiver was followed under randomized block design with three replications. Field bean intercropped with vetiver recorded higher root (3753.33 kg ha^{-1}) and oil yield (46.92 kg ha^{-1}) of vetiver compared to other treatments. Biological efficiency indices *viz.*, land equivalent ratio (LER) (1.47), area time equivalent ratio (ATER) (1.09), system productivity index (SPI) (6.17 t ha^{-1}) and land equivalent coefficient (LEC) (0.52) were also recorded higher in the same treatment, this indicates the greater biological efficiency of the field bean in intercropping with vetiver. Competitive indices *viz.*, competition ratio (CR) (1.78) and aggressivity (A) (-0.28) values indicate the dominance of pigeon pea over vetiver in the intercropping system, hence it is recommended to modify the spacing for pigeon pea in vetiver intercropping system. Monetary advantage index (MAI) (2144.29 US $), benefit-cost ratio (3.22) and net returns (6675.70 US $) were also recorded highest in field bean intercropping system, hence intercropping of field bean in vetiver can be a profitable option in generating more profit than sole cropping of vetiver and to enhance the resource use efficiency.

Table 1. Yield attributes and root yield of vetiver in sole and intercropping system.

Intercropping system	Vetiver growth and yield parameter						Intercrop yield		
	No. of tillers	Root Length (cm)	Root yield (g plant^{-1})	Oil recovery (%)	Root yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Sole crop yield (kg ha^{-1})	Yield in inter-cropping (kg ha^{-1})	Vetiver equiv-alent yield
Sole Vetiver	71^{a}	30^{a}	76.85^{a}	1.25^{a}	4189.44^{a}	52.37^{a}			54.37
Vetiver + Pigeon pea	38^{cd}	17de	48.75^{ef}	1.20^{ab}	2685.33^{ef}	32.22^{de}	1001*	359.7 (64.07)$^{\#}$	34.74
Vetiver + Green gram	63^{ab}	21^{cd}	60.50^{bcd}	1.15^{bc}	3411.11^{bcd}	39.23^{bcde}	1158*	299.4 (74.15) $^{\#}$	41.22
Vetiver + Cowpea	66^{ab}	26^{abc}	62.55^{bc}	1.20^{ab}	3490.00^{bc}	41.88^{bc}	1510*	400.5 (73.48) $^{\#}$	43.38
Vetiver + Soybean	65^{ab}	27^{ab}	58.50^{bcde}	1.20^{ab}	3350.00^{bcde}	40.20^{bcd}	2038*	670.8 (67.09) $^{\#}$	43.22
Vetiver + Ashwagandha	42^{c}	20^{d}	56.25^{bcde}	1.10^{cd}	2825.00^{cde}	31.07^{ef}	2000*	692.0 (65.40) $^{\#}$	42.60
Vetiver + Field bean	67^{ab}	27^{ab}	64.50^{b}	1.25^{a}	3753.33^{ab}	46.92^{ab}	3000*	1731.9 (42.27) $^{\#}$	59.91

Values followed by the same lowercase letters in a column are not significantly different at $p < 0.05$ by DMRT

* Economical yield was considered for calculating competition indices, whereas economical + biological yield was taken account for RNR and B:C ratio calculation.

$^{\#}$ Values in the parenthesis indicates the percent reduction in the yield of intercrop compared to sole crop yield.

Table 2. Different competition indices under intercropping systems.

Intercropping system	LER	ATER	SPI (t/ha)	LEC	Competition ratio		Aggressivity		RNR	MAI (US $)	IER veti-ver	IER inter-crop	IER
					CR vet-iver	CR in-tercrop	A veti-ver	A in-tercrop					
Vetiver + Pigeon pea	1.00	0.87	4.19	0.23	0.56	1.78	0.28	-0.28	0.58	0.68	0.62	0.36	0.98
Vetiver + Green gram	1.07	0.92	4.49	0.21	0.64	1.57	0.68	-0.68	0.70	219.77	0.75	0.26	1.01
Vetiver + Cowpea	1.10	0.96	4.60	0.22	0.64	1.57	0.70	-0.70	0.77	342.47	0.80	0.27	1.07
Vetiver + Soybean	1.13	0.94	4.73	0.26	0.82	1.21	0.64	-0.64	0.76	425.97	0.77	0.33	1.10
Vetiver + Ashwa-gandha	1.02	0.89	4.27	0.23	1.03	0.97	0.50	-0.50	0.72	67.00	0.59	0.35	0.94
Vetiver + Field bean	1.47	1.09	6.17	0.52	1.29	0.78	0.61	-0.61	1.11	2144.29	0.90	0.58	1.48

Dr. Jnanesha A C Mk- Kku'k , lh

Optimization of Jeevamrutha for enhanced growth, yield, and quality in Senna (*Cassia angustifolia* Vahl.)

Cassia angustifolia Vahl is considered as a leguminous and industrial crop for producing leaves and pods rich in high-quality glycosides (sennosides), which have significant therapeutic benefits for treating constipation all over the world. However, there is a lack of information on the use of Jeevamrutha in senna. So, the experiment was conducted for two consecutive years 2020-21and 2021-22 at CSIR-CIMAP, Hyderabad. The main aim is to identify the optimum dose of Jeevamrutha for higher growth, yield, and quality in senna (*C. angustifolia*). The experiment was laid out in a Randomized complete block design (RCBD) consisting of seven treatments replicated thrice. From the obtained result, it was observed that application of 150 liters of Jeevamrutha per acre recorded significantly higher leaf yield (1085.2 kg ha^{-1}) and pod yield (318.7 kg ha^{-1}) in comparison with other treatments and was comparable to T_2 *i.e.*, application of 125 liters of Jeevamrutha per acre (1022.5 kg ha^{-1}, 312.1 kg ha^{-1}) and was succeeded by T_3 *i.e.*, application of 100 liters of Jeevamrutha per acre (998.5 kg ha^{-1}, 288.5 kg ha^{-1}, respectively). Significantly, lower leaf (700.2 kg ha^{-1}) and pod yield (487 kg ha^{-1}) was noticed in control (T_7). Similarly, the application of 150 liters of Jeevamrutha per acre recorded significantly higher sennoside content in leaves (2.01 %) and pods (3.11%) in comparison to other treatments and was succeeded by T_2 (1.98 %, 3.09%) and T_3 (1.89%, 2.97 %). A similar trend was noticed in returns *i.e.*, the application of 150 liters of Jeevamrutha per acre recorded significantly higher gross return per ha ($ 1495 ha^{-1}) and net return ($ 1066.4 ha^{-1}).

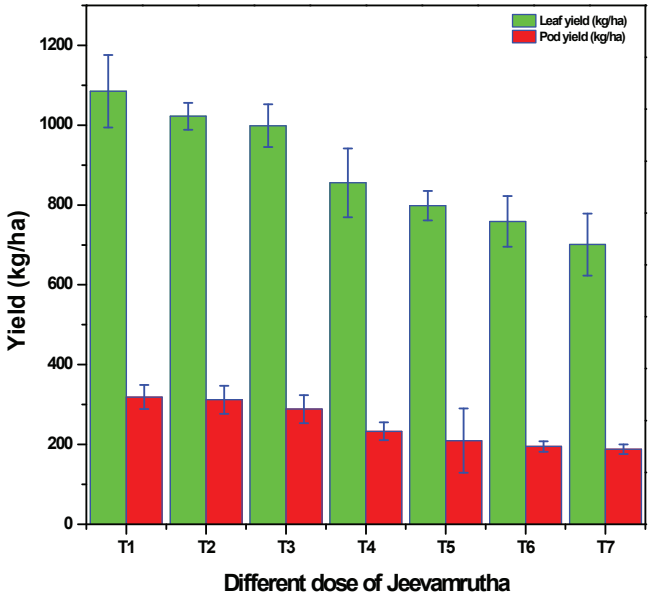


Fig. Influence of different doses of Jeevamrutha on Leaf yield (kg ha^{-1}) and pod yield (kg ha^{-1}) of Senna

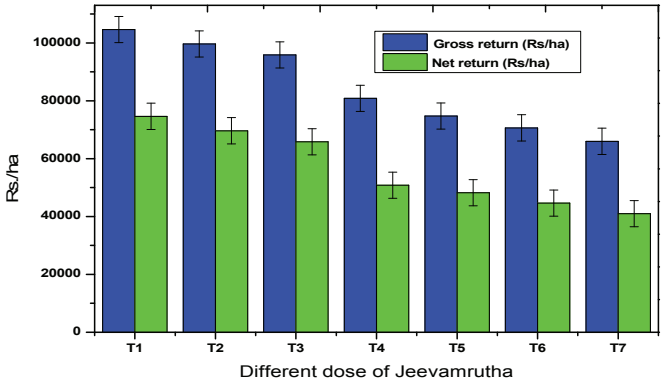


Fig. Influence of Jeevamrutha on gross and net return in Senna

Dr. Rakesh Kumar Mk- jkds'k dqekj

Performance of growth, herb yield and essential oil yield of mentha in sugarcane intercropping system

A field experiment was conducted to study the "Performance of growth, herb yield and essential oil yield of mentha in sugarcane intercropping system" at the experimental farm of CSIR- Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow during 2021-22. The four intercropping treatments were consisted viz., Sugarcane + Mint (Direct Suckers) on Ridge (T_1); Sugarcane + Mint (Nursery raised plants) on Ridge (T_2); Mint Sole (Direct Suckers) on Ridge (T_3) and Mint Sole (Nursery plants) on Ridge (T_4) in additive series in randomized block design with three replications. Recommended dose of fertilizer were applied only to sugarcane crop. The varieties were used 'Kosi' of Mentha and local variety of sugarcane. The crops were planted on 5th March, 2020 at the spacing of 90 cm apart, maintaining two rows of intercrop in between two rows of sugarcane. The actual suckers rate of 125 kg/ha and 300 kg/ha by seedlings and direct planting were used for planting of one hectare mint crop respectively. The crop was fertilized @120 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively. Half of N and full dose of phosphorus and potassium was applied as basal dose and these fertilizers were mixed homogenously in to the soil. The remaining amount of nitrogen was top-dressed in two equal splits, the first at 25-30 days and the second was at 55-60 days

Sugarcane + Mint (Direct suckers) Ridge

Sugarcane + Mint (Nursery Plant) Ridge

Sugarcane + Mint (Direct suckers) Flat

Sugarcane + Mint (Nursery Plant) Flat

Table 1: Analysis of growth, herb yield and essential oil yield of mentha with sugarcane intercropping system during 2021-22.

Treatments	Plant Height (cm)	No of Branch	Canopy width (cm)	Herbage yield /ha (q)	Oil Content (%)	Oil yield /ha (q)
Sugarcane + Mint (Direct Suckers) Ridge	80.67	23.33	54.94	96.58	1.40	120.28
Sugarcane + Mint (Nursery plants) Ridge	84.67	26.67	58.51	108.67	1.25	136.01
Mint Sole (Direct Suckers) Ridge	61.00	27.67	66.21	115.02	1.30	149.42
Mint Sole (Nursery plants) Ridge	66.00	39.00	58.56	116.12	1.33	154.74
Sem±	5.76	3.17	3.79	4.12	0.06	8.42
CD at 5%	12.50	6.87	8.22	8.94	0.13	18.27
CV (%)	9.69	14.96	8.31	5.30	5.58	8.35

after transplanting/sowing. Growth and yield attributes of mentha were compared. The maximum plant height (84.67 cm), number of branches/plant (39.00), canopy width (58.51cm), Herbage yield (108.67 q/ha), Oil yield (136.01 q/ha) of mentha were recorded under the treatment Sugarcane + Mint (nursery plants) on ridge, which was superior to the rest of other intercropping treatments except to the mint sole (nursery plants) on ridge. The maximum oil yield (154.74 kg ha^{-1}) was observed under (mint sole (nursery plants) ridge followed by T_4 (mint sole (direct suckers) on ridge 149.42 kg ha^{-1}) and T_2 (sugarcane + mint (nursery plants) ridge; 136.01 kg ha^{-1}) and sugarcane + mint (direct suckers) ridge 120.28 kg ha^{-1} and was significantly superior over rest of the treatments. The highest oil content (1.40%) was observed under sugarcane + mint (direct suckers) ridge, treatments during investigations.

Dr. Rakesh Kumar & his team

Dr. Akanksha Singh Mk- vkdk{kk flag

Assessment of bacterial and fungal diversity associated with two contrasting varieties of *Ocimum sanctum* using metagenomics approach

In the proposed work, two contrasting lines of *O. sanctum* namely CIM-Ayu (High eugenol content) and CIM-Angana (Low eugenol content) were selected for isolating the endophytes associated with different plant parts. Likewise, the same were used for identifying the unculturable bacterial and fungal diversity using metagenomics approach. A rich microbial diversity was found to be associated with CIM Ayu and CIM-Angana plants as through culturomics approach; 17 endophytes from CIM Ayu and 33 endophytes from CIM- Angana have been isolated and characterized. The culturable diversity revealed presence of *Bacillus*, *Lysinibacillus, Serratia, Pantoea, Pseudomonas, Rhodococcus, Staphylococcus, Enterobacter, Curvularia, Apispora, Alternaria etc.* in both the varieties amongst which *Bacillus* was the most abundant genera. Likewise, metagenomics study carried out using 16S and ITS rRNA genes revealed contrasting diversity associated with CIM-Ayu and CIM-Angana aerial and underground plant parts (Fig.). *Pseudomonas, Bacillus, Flavobacterium,* and *Stenotrophomonas* were most abundant genera in shoot of CIM-Angana plants while the root was dominated by *Pseudomonas, Stenotrophomonas, Bacillus*, and *Flavobacterium*. Likewise, *Bacillus, Lactobacillus, Methylobacterium*, and *Acenetobacter* were most abundant genera in shoot of CIM-Ayu plants while the root was dominated by *Pseudomonas, Stenotrophomonas, Rhizobium*, and *Flavobacterium.* However, the fungal diversity associated with CIM-Ayu and CIM-Angana was almost similar with major abundance of *Saitozyma* and *Kazachstania.* The study carried out clearly highlighted the varietal effect of plants in recruiting microbes which might be playing a key role in modulating the phytochemistry of contrasting varieties of *O. sanctum*.

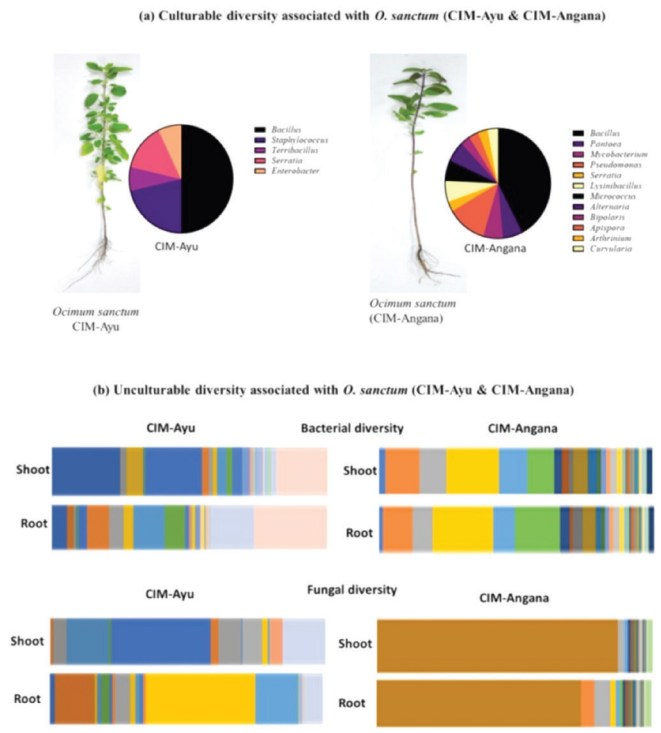


Fig. Schematic representation of culturable and unculturable diversity associated with two contrasting varieties of *Ocimum sanctum* (CIM-Ayu and CIM-Angana)

Dr. Akanksha Singh & her team

Dr. Dipender Kumar Mk- nhiUn d|ekj

Soil moisture stress induced changes in essential oil content and bioactive compounds in German chamomile (*Chamomilla recutita* L.)

Plants produce variety of secondary metabolites in response to stress. The aim of the present study is to evaluate the soil moisture stress on essential oil content and composition of German chamomile. The study was conducted during the cropping season 2021 at CSIR-Central Institute of Medicinal and Aromatic Plant, Research Centre, Pantnagar (Udham Singh Nagar) Uttarakhand, India. To see the influence of soil moisture stress, soil and flower samples were collected at pre and post-irrigation. The treatments were T_1 (just before irrigation), T_2 (24 h after irrigation), T_3 (72 h after irrigation), T_4 (120 h after irrigation), and T_5 (168 h after irrigation). Results showed that maximum oil content was found in the flowers obtained 24 h after irrigation, which was followed by 72 h after irrigation. It was observed that the oil content in both fresh and dry flowers decreased as the number of days to irrigation increased. The percentage of major secondary metabolites produced after 24 h of irrigation was lowest (74.02 %) while

Table 1.Effect of water stress on oil content (%) in fresh and dry chamomile flowers

Treatment	fresh flowers	dry flowers
T_1 (Before irrigation)	0.09±0.00	0.49±0.01
T_2 (24 h after irrigation)	0.26±0.01	0.57±0.03
T_3 (72 h after irrigation)	0.24±0.00	0.56±0.03
T_4 (120 h after irrigation)	0.19±0.01	0.52±0.02
T_5 (168 h after irrigation)	0.10±0.00	0.50±0.01
SEm (±)	0.01	0.02
CD(p=0.05)	0.02	0.06

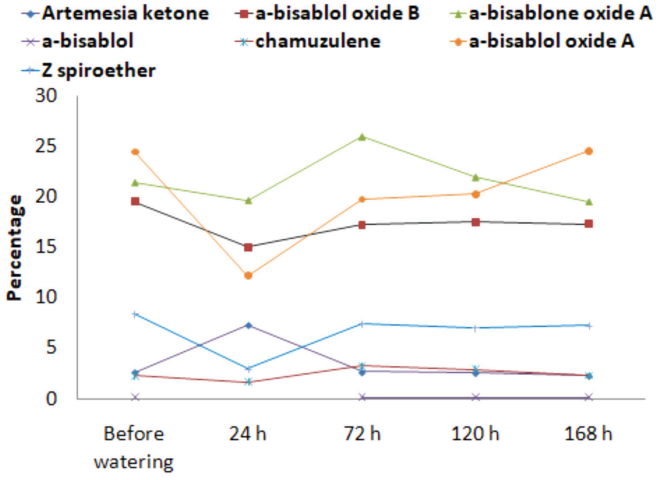


Fig. Major secondary metabolites of German chamomile essential oil at different hours after irrigations

maximum was recorded in acute drought conditions i.e. before irrigation (92.12 %). These results suggest that cultivation of plants like chamomile under soil moisture stress could enhance secondary metabolites production.

Response of spearmint, peppermint and menthol mint to salinity stress

Salinity stress is known to have a detrimental effect on growth and yield of plants. The aim of present work was to investigate the possible effects of salinity stress on three species of Mentha, namely *M. spicata*, *M. piperita* and *M. arvensis*. Plants were exposed to salinity stress by irrigating them with saline water using different concentrations of NaCl (0, 50, 100, 150 mM). Results indicated that salinity stress significantly decreased the growth, herb yield, oil content and oil yield of all mentha species as compared to control. However, *M. arvensis* experienced the maximum loss (%) in terms of oil yield as compared to the *M. spicata* and *M. piperita*. Chll. a,b, Total Chll., & carotenoids, relative water content (RWC) and electrolyte leakage (EL) were also significantly affected. Oil composition was also influenced by their exposure to salinity stress. In *M. spicata*, with increase in salinity stress, the content of piperitone oxide decreased from 78.40% in control to 38.07% in T_3, whereas the content of menthol significantly increased from 1.72 % to 37.18%. In *M. piperita*, menthone, isomenthone and limonene all increased in low stress conditions and then decreased in high stress. In *M. arvensis*, i.e menthol was not affected, while menthone increased.

Seedling emerging potential of palmarosa seeds at different time intervals

Palmarosa (*Cymbopogon martinii*) as a major essential oil bearing crop. It is utilized all over the world in the cosmetic and fragrance industries due to the presence of geraniol and geranyl acetate. However, its commercial cultivation is limited due to sometime seed having poor germination rate. Due to lack of knowledge about the sowing method nursery raising/ direct sowing, sowing depth and viability period under storage conditions are the major issues. The objective of this study was to determine the seedling emerging potential of two varieties of palmarosa, namely PRC-1 & CIM-Harsh in field conditions.

Table 1: Seedling emerging potential of PRC-1 and CIM-Harsh at different time intervals

Treatments	1st March	15th March	1st April	15th April	1st May	15th May	1st June
PRC-1							
T_1	538.67	603.67	653.00	740.33	855.33	900.67	923.00
T_2	655.33	894.00	968.67	1014.33	1084.67	1397.67	1448.00
T_3	615.33	279.33	240.33	146.33	139.00	107.00	80.67
T_4	389.33	656.33	790.33	878.67	930.33	1377.67	1452.67
SEm(±)	17.27	22.84	22.41	22.18	26.00	30.20	28.64
CD(p=0.05)	53.76	71.08	69.77	69.05	80.94	94.01	89.15
CIM-Harsh							
T_1	*	*	*	475.33	578.33	729.33	809.67
T_2	*	*	*	581.00	1008.00	1284.00	1427.00
T_3	*	*	*	217.33	173.67	121.33	85.00
T_4	*	*	*	570.00	876.00	1146.67	1293.67
SEm(±)	0	0	0	14.83	22.44	28.10	29.43
CD(p=0.05)	0	0	0	46.15	69.86	87.47	91.60

*: no germination

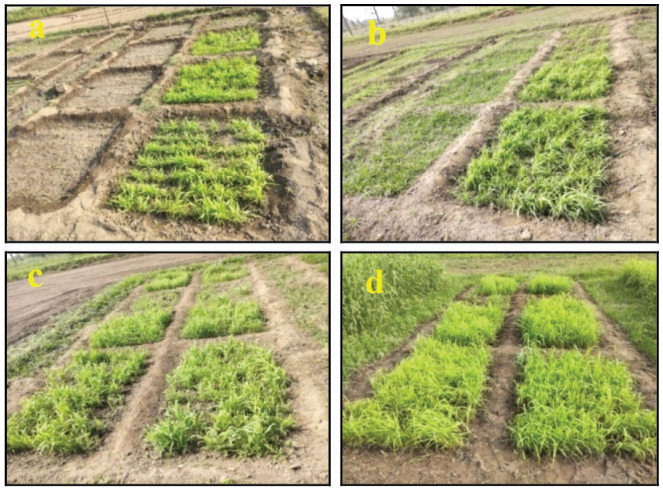


Fig. Seedling emerging potential of PRC-1 and CIM-Harsh at different time intervals **(a)** 1st March, 2022; **(b)** 15th March, 2022; **(c)** 15th April, 2022; **(d)** 1st June, 2022

The experiment was conducted in Randomized block design (RBD) with four treatments: T_1: direct sowing of seed in soil followed by light irrigation, T_2: seed sowing mixing with vermicompost followed with light irrigation, T_3: direct sowing of seed in soil, followed by light irrigation and straw mulch and T_4: seed sowing in moist soil (irrigated before sowing). The 20g seeds of each variety were sown at different time periods starting from March to June at an interval of 15 days. It was observed that the maximum seedling emerging potential in both the varieties recorded in T_2, followed by T_4 and the least number of seeds germinated in T_3. The rate of seedling emerging potential increased with the increase in temperature from March to June in all the treatments except T_3. It was also observed that though PRC-1 began to germinate since the month of March, CIM-Harsh began to germinate only once the temperatures rose a bit high i.e. from mid April.

Dr. Dipender Kumar & his team

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The enhancement of root yield and quality of ashwagandha (*Withania somnifera (L.) Dunal*) by weeds leaves extracts

Ashwagandha, having multiple therapeutic uses, is a highly valuable medicinal plant for pharmaceutical industry. Effect of weed leaves extracts (WLE) as biostimulants to improve yield and quality of ashwagandha roots were investigated in an experiment during 2020-21. The treatments consisted of combinations of four commercial preparations with microorganisms (Pusa Zinc solublizing biofertilizer, Pusa Azotobacter liquid biofertilizer, Pusa PSB liquid biofertilizer , Pusa Potash solublizing liquid biofertilizer) with four weeds leaves extracts (*Cyperus rotundus*, *Amaranthus viridis*, *Echinochloa colona*, *Digera arvensis*). The treated plants exhibited stimulatory responses in growth and physiology, leading to enhanced dry root yield over control. Among different combination of treatments, Pusa PSB liquid biofertilizer + *Amaranthus viridis* WLE recorded the highest whole ashwagandha plant dry matter production (157.3 g per plant), root fresh weight per plant (65.0 g) and root dry weight (23.0 g). Different bioactive compounds in ashwagandha roots (Withanoloides A, withanosides IV and withanone) were also enhanced with this treatment indicating the potentiality of weed leaves extracts as biostimulants, as a novel eco-friendly approach for

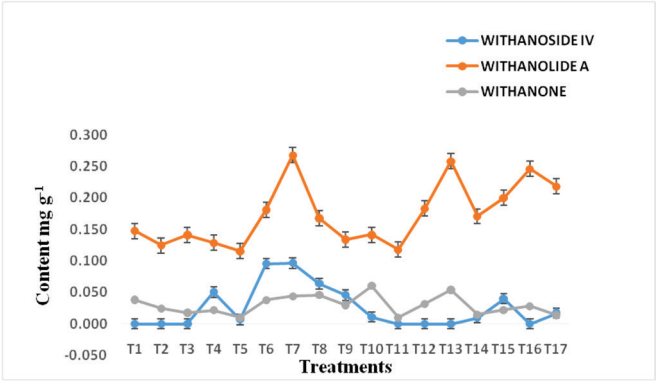
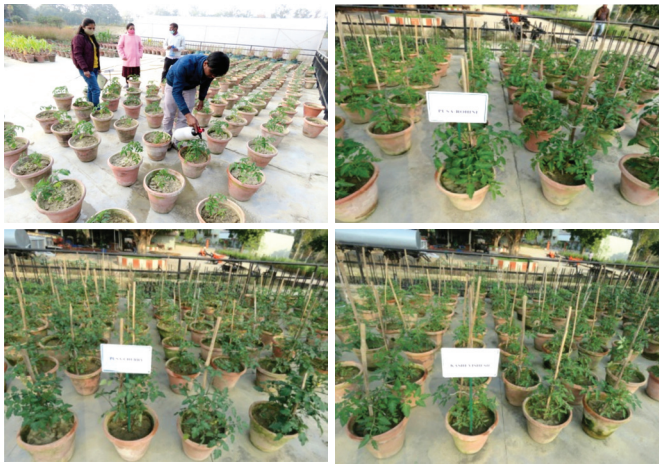


Fig. Effect of different treatments on the bioactive compounds of ashwagandha root.



enhancing root yield and quality of ashwagandha (*Indian Journal of Weed science,* 54 (1), 81-86).

During *rabi* season 2021-22, a pot experiment was being conducted (ongoing experiment) to determine the possible bio-stimulant effects of eight treatments i.e., essential oil/aqueous extract on three tomato varieties i.e. **Pusa Rohini, Pusa Cherry and Kashi Vishesh.** Two concentrations of each essential oil i.e., 0.1 and 0.2 (*v*/*v*) in case of *Mentha arvensis*, *Ocimum basilicum*, Palmarosa and Lemongrass, Geranium and *Tagetus minuta* and 3 and 5% in case of aqueous extract of *Andrographis paniculata and Withania Somnifera* were evaluated. Tomato seedlings were transplanted in soil in pots having 30 cm diameter. Three first spray was done at the time of branching, second at an thesis stage and third at early fruit setting stage. Results revealed that some of the treatments (T1, T3, T6) at specified concentrations enhanced yield and quality of tomato crop.

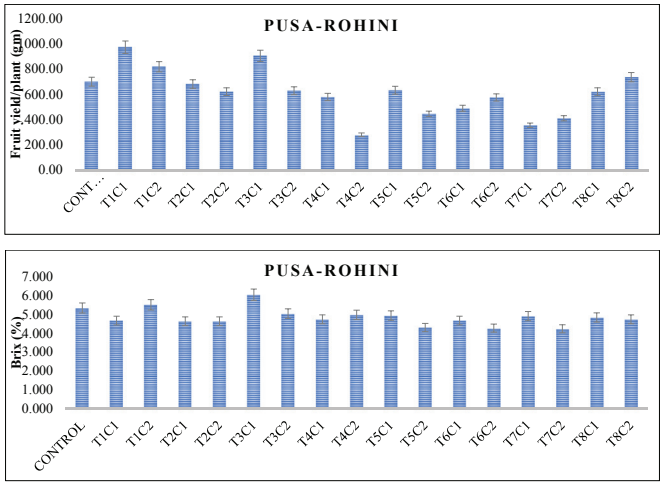


Fig. Effect of MAP based biostimulants on yield and quality parameters of tomato variety Pusa Rohini

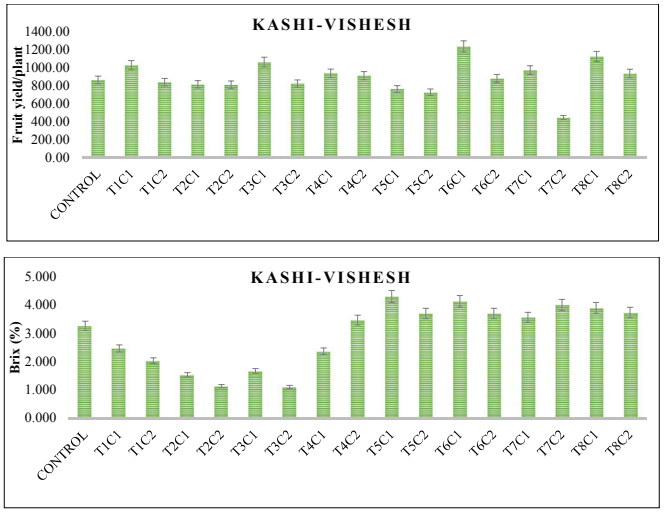


Fig. Effect of MAP based biostimulants on yield and quality parameters of tomato variety Kashi Vishesh

Dr. Priyanka Suryavanshi & her team

Dr. Santoshkumar C. Kedar
Mk- lrk"kdqekj lh- dsnkj

Arthropod pests and their natural enemies associated with Ashwagandha (*Withania somnifera*) cultivation: Progress towards integrated pest management development

Arthropod pests that influence crop growth must be understood for developing integrated pest management (IPM) strategies. Ashwagandha, *Withania somnifera* (L.) Dunal is an important Indian traditional Ayurvedic herb known for its therapeutic activities and potential to boost immunity. With the increasing global demand for herbal drugs, the cultivation of ashwagandha in India has escalated dramatically. Changing cropping patterns and climate change may lead to multiple insect pests attack on the ashwagandha crop during different growth stages. This study aimed to determine the diversity of arthropod pests and their natural enemies associated with *W. somnifera* in three growing seasons in subtropical climatic conditions of Northern India. The study revealed the presence of more than 50 phytophagous arthropod species and more than 25 natural enemies to be associated with ashwagandha. Numerous phytophagous pests appeared during vegetative to flowering stages of the crop, whereas, maximum phytophagous arthropod species occurred during flowering and berry formation stages. Several species of hemipterans notably bugs are regularly found during flowering and berry formation stages, but the damage potential remains unclear. The present study provides the basis for the identification of the pest problems of *W. somnifera* and their natural enemies. The information on the identification of pest problems will be an effective step for developing IPM programs for *W. somnifera.*

Withania somnifera berries damaged by mealybug, *Phenacoccus solenopsis*

Ceroplastes cirripediformis Comstock (Hemiptera: Coccomorpha: Coccidae) occurrence and spread in India

The notoriously destructive and invasive soft scale, *Ceroplastes cirripediformis* Comstock (Hemiptera:

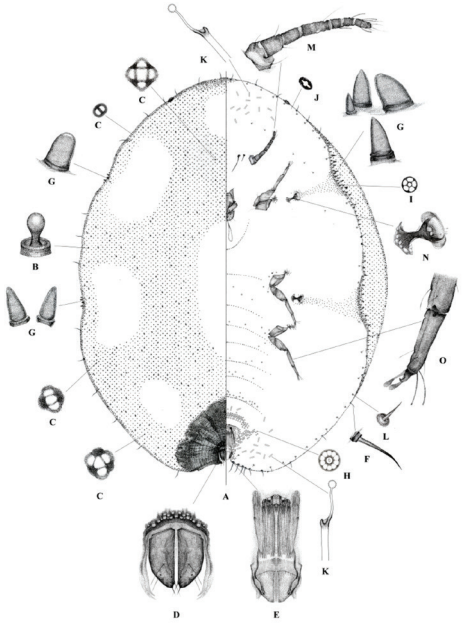


Fig. Taxonomic illustration of an adult female *Ceroplastes cirripediformis* Comstock. A. Body derm; B. Dorsal setae; C. Dorsal microducts; D. Anal plates; E. Anogenital fold; F. Marginal seta; G. Stigmatic setae; H. Pregenital disc–pores; I. Spiracular pore; J. Ventral microduct; K. Ventral tubular ducts; L. Submarginal setae; M. Antenna; N. Spiracle; O. Leg.

Coccomorpha: Coccidae), is recorded for the first time from India. The scale is redescribed to facilitate its identification and information on its host range, natural enemies and distribution is provided. An identification key to the Indian species in this genus is provided (Fig.). Management options in the event of an outbreak are discussed briefly. The establishment of this scale insect warrants special attention in India as it is a potentially damaging plant pest and has a broad host range across many plant families.

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Dr. B. Shivanna Mk- ch- f'koUuk

Plant nutrient dynamics in rhizospheres of selected aromatic plants

Rhizosphere is a interface between plant roots and soil where nutrient absorption is facilitated. The biogeochemical processes and nutrient dynamics are driven by microbiome of rhizosphere. The present study was taken up to investigate the nutrient dynamics in rhizospheres of selected aromatic plants. Soil samples were collected from the rhizospheres and analysed for nutrient content. The results indicated that the available phosphorus content was recorded significantly higher in rhizospheres of Lemon grass and Citronella followed by Palmarosa and Geranium. Similarly available potassium was recorded significantly higher in Citronella and Lemon grass followed by Palmarosa and Geranium. Cu is significantly higher in Geranium followed by lemon grass and Citronella where as boron was significantly higher in Lemon grass followed by Palmarosa and citronella.

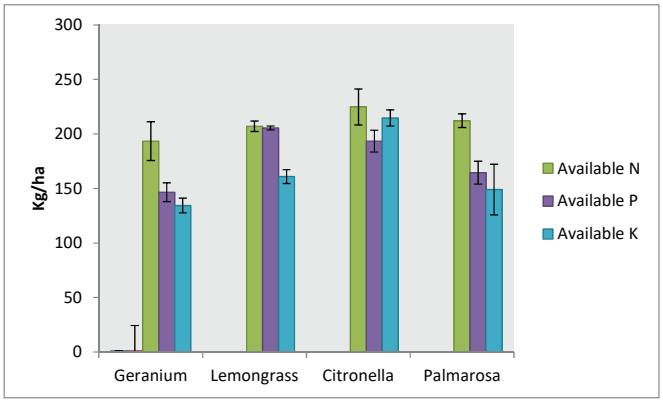


Fig. Plant available N, P, K in rhizospheres of selected aromatic plants

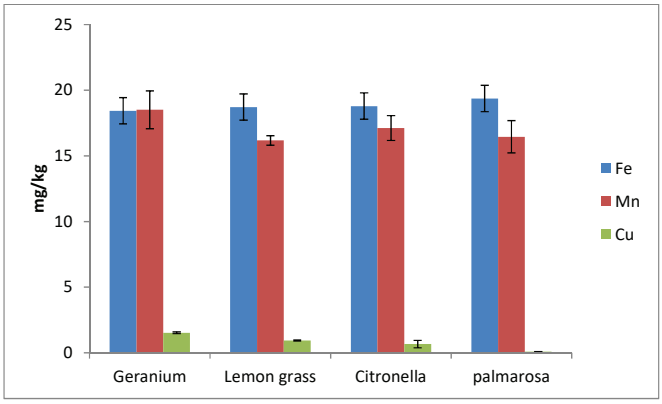


Fig. Plant available Fe, Mn, Cu in rhizospheres of selected aromatic plants

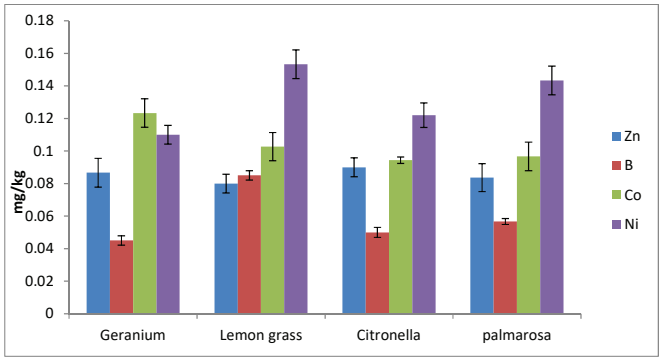
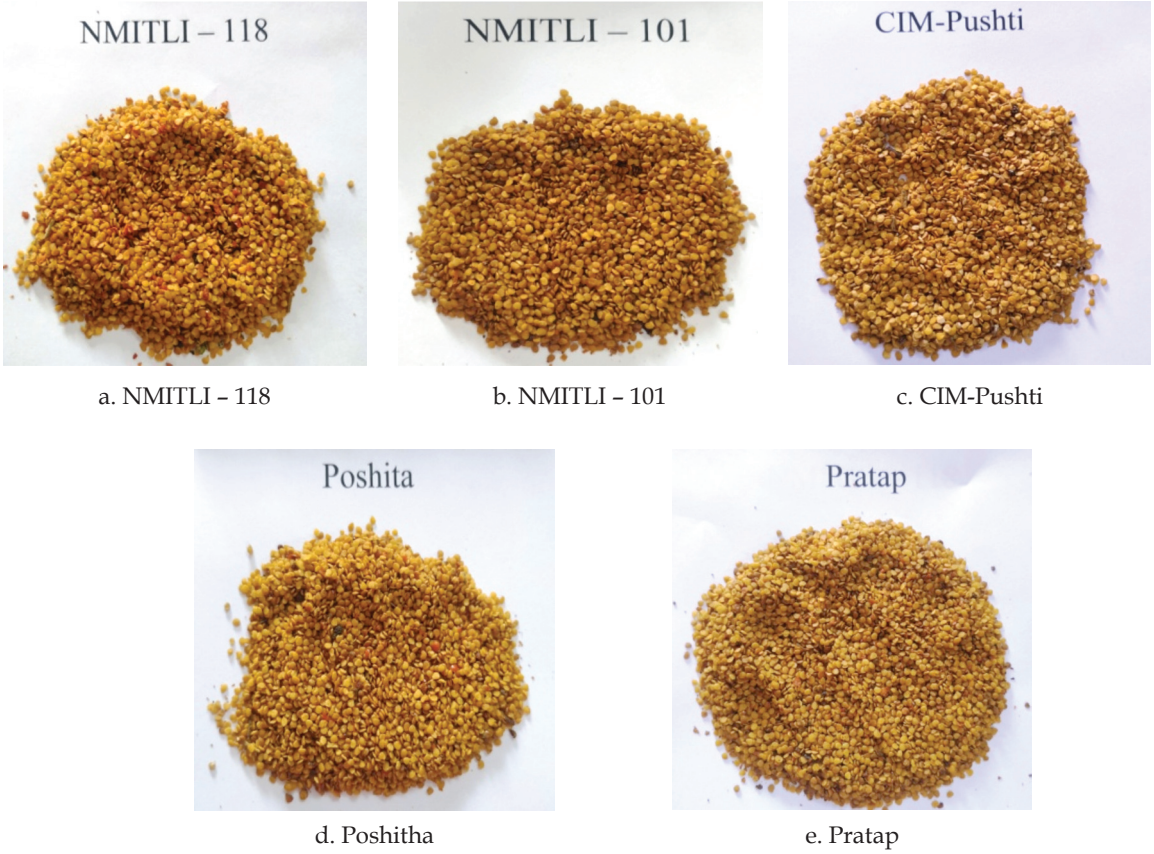


Fig. Plant available Zn, B, Co and Ni in rhizospheres of selected aromatic plants

Dr. Anandakumar T.M. Mk- vkunekj Vh-, e-

Physical properties of ashwaganda (*Withania somnifera* L.) seeds – a medicinal crop

Ashwagandha (*Withania somnifera* L.) is a potential medicinal plant belongs to the Solanaceae family, offers various health benefits, such as enhancement of memory, improved blood sugar, and inhibition of inflammation, stress and anxiety, and boosted in muscle strength and fertility. Sowing is one of the important unit operations, which effects the root yield and seed rate. Development of suitable sowing equipment for ashwagandha seed will be the better way to maximize the root yield and avoid the excess seed consumption. In this regard, the study has been conducted to determine the physical properties of ashwagandha seeds (Five cultivars, namely NMITLI-101, NMITLI-118, CIM-Pushti, Pratap and Poshitha) for designing and developing of seed sowing equipmentResults revealed that cv. CIM-Pushti seed has significantly higher values as compared with other cultivars in major, minor, intermediate diameter, arithmetic mean diameter, and geometric mean diameters. Similarly, in the case of physical properties like sphericity, surface area, sample volume, and elongation ratio, cv. CIM-Pushti showed significantly higher values as compared with other cultivars whereas in the case of aspect ratio and flakiness ratio, cv. Poshita showed significantly higher values. In the case of gravimetric properties, cv. Pratap and NMITLI-118 resulted in higher values of test weight (1000 seeds weight) as compared with other cultivars. Further, cv. Pratap and CIM-Pushti have significantly higher values of bulk density and true density over other cultivars, respectively. These results are likely to be very much helpful for agricultural engineers to design various seed



a. NMITLI – 118 b. NMITLI – 101 c. CIM-Pushti

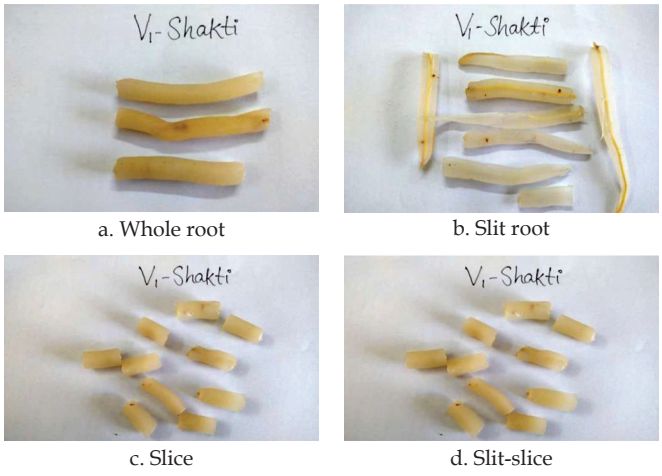
d. Poshitha e. Pratap

Fig. Ashwagandha cultivars

handling tools/machines like conveying machines, storage containers, processing machines and sowing equipment for Ashwagandha seeds (***Industrial crops & products*** 115233, 2022).

Studies on drying kinetics of shatavar roots (asparagus racemosus)

Drying process plays an important role in the preservation of food and medicinal herbs. Application of various suitable drying methods or dryers to remove the moisture content can reduce the post harvest losses and significantly contribute to the availability of the food and medicinal herbs for longer period. In this study, kinetics of drying of shatavar roots has been studied in hot air oven at four levels of drying air temperature i.e. 50, 60, 70 and 80°C, and comapared with shade and drying method. The roots were cut into four types of sample like, slit, slice, slit-slice and as whole. Results revealed that the samples dried at 80°C took only 390 mins as compared with the samples dried at 70, 60 and 50°C (510, 540, and 810 mins respectively). Further, the slit and slit-slice sample took less time as compared with whole and slice samples. The variations in drying time for different type of samples and temperature could be due to the variation in thichness and surface area of the sample. Ten thin layer drying models were used in this investigation to describe the drying behaviour of the root samples. Out of ten models, three models (Henderson and pabis model, Page model and weibull model) were found to be the best to define the drying characteristrics of root samples as SSE and RMSE values were least and R^2 values were highest as compared to the other drying models.



a. Whole root b. Slit root

c. Slice d. Slit-slice

Fig. Type of root samples

Dr. Anandakumar TM & his team

Plant Breeding and Genetic Resource Conservation

HIGHLIGHTS

This division focused its activities on development of improved varieties in all the major Medicinal and Aromatic plants to fulfill the core mandate and aspired objectives of the Institute. The major current scientific activities are centred on following lines: Application of recombination, Cloline, Mutation, polyploidy and Molecular Approaches for Qualitative and Quantitative Breeding of MAPs, Utilization of Biometrical, Population and Association Genetics to release Genetic Improvement of MAPs, General and Molecular Cytogenetics, DNA marker resources and Molecular phylogenetics.

During the 2021-2022, the plant breeding and GRC division has been actively involved in the development of new varieties and conservation of MAPs. During this period, various projects from external funding agencies such as NMPB, NMMP, and DST and AIIMS Raibareli (CNP) were also sanctioned and implemeted.

The "CIM Nandi" a *Eucalyptus citriodora* clone with high oil and citronellal content was released for commercial plantation. A lemongrass clone with high oil (about 2%) and high citral content has also been developed. Extensive breeding efforts in Menthol mint (*Mentha arvensis* L.) led to the isolation of superior OPSP progenies having 1.35% oil yield with 78% menthol content. Menthol rich peppermint (*M. piperita* L.) genotype MPS36-3-3 has been developed. Half sib progenies of spearmint (*Mentha spicata* L.) were screened for herb yield, essential oil yield, and carvone content. Superior lines with 1.05% oil having 65% carvone were isolated. Promising lines in a newly introduced aromatic herb, Catmint (*Nepeta cataria* L.) for high herb yield and high oil content were identified.

In *Papaver somniferum*, estimation of specific combining ability and heterosis for elite economic yield traits was evaluated. Superior accessions of Prishanparni (*Uraria picta* Desv.), a critically endangered annual shrub based on ten economic traits were identified, which can be used for commercial cultivation in northern Indian plains. Elucidation of natural variation and genetic kinship in core collections of *Tagetes minuta* L. and *Spilanthus* species (~50) was done, which can be used for commercial authentication and strategic metabolite targeted breeding. Radio-frequency (RF) room temperature plasma treatment of sweet basil seeds (*Ocimum basilicum* L.) for germination potential enhancement by immaculation was carried out and it was concluded that radio frequency cold plasma exposure of sweet basil could invigorate the germination potential for an optimum treatment condition.

Total 37 morphologically distinct plants with putative polyploidy were produced in *Stevia rebaudiana* variety CIM-Mithi through colchicine treatment. One triploid (2n=3x=33) and 14 tetraploid (2n=4x=44) lines were identified. Agro-geographical regions based kalmegh (*Andrographis paniculata*) germplasm lines have been characterized at agro-morphological, phytochemical, and molecular levels to explore the proportion of genetic diversity existing among them. Survey of 14 major cannabis growing states was done. Morpho-chemical and anatomical characterization of 85 accessions was completed under the project sponsored by Asheesh Concentrates International LLP.

Total 25 live germplasms of different MAPs were collected from different geographical regions of the country and were acclimatized in glasshouse and field conditions at CSIR-CIMAP, Lucknow. The specimen were deposited in the National Herbarium of Medicinal and Aromatic Plants (40 specimen) and Crude Drug Repository (>20 new samples) at CSIR-CIMAP, Lucknow. Pharmacognostic standards of two botanicals as per API / USP standards were

developed. Ashwagandha variety CIM Pushti was licensed to Xenon Biosciences, Hyderabad. Besides, 700Kg seed of this variety was also distributed to around 500 farmers.Manav Herbal Garden at AIIMS Raibareli was established.

During this period, 05 research article were published in reputed high impact journals such as industrial Crops and Products, American Journal of Plant Sciences, Environmental Geochemistry and Health, Journal of Applied Research on Medicinal and Aromatic Plants and one variety was released. Two students submitted Ph.D thesis in this period.

Scientists of Plant breeding and Genetic Resource Conservation Divisional Unit

L to R: Dr. V.R. Singh, Dr. A.K. Gupta, Dr. B. Kumar, Dr. V. Sunderasan, Dr. Tripta Jhang, Dr. Narendra Kumar, Dr. Channayya Hiremath, Dr. Venkatesha KT and Dr. Gunjan Tiwari

Dr. Ved Ram Singh Mk- on jke flg

Estimation of specific combining ability and heterosis for elite economic yield traits in opium poppy (*Papaver somniferum* L.)

The specific combining ability estimates revealed that out of 49 cross combinations, 8 each for days to 50% flowering, plant height, number of the capsule, capsule index, and codeine content, 9 each for capsule husk yield, morphine, and narcotine content, 12 each for pedicle length and thebaine content, 11 for seed yield, 7 for papaverine content and 6 for days to maturity were found significant in a desirable direction in the first generations. Since the non-fixable component was larger than the fixable component and over-dominance and partial dominance were prevalent for all the characters, a generalized breeding procedure could be suggested. The development of F1 hybrids to exploit over-dominance appropriately may be a rewarding proposition for many characters. Thus, in the presence of marked dominance, the selection of specific combinations is the most effective method of crop improvement. The heterosis over better parent for the seed yield was recorded maximum of 59.38% seed yield in the cross P1xP3, 43.94% for capsule husk yield in the cross P4xP7. Among other components, maximum heterosis was recorded for narcotine content in the cross P4xP6 and papaverine content in the cross between P2xP5.

Visit of Joint Secretary Revenue, Govt. of India evaluating the project progress (GAP-421) at CSIR-CIMAP, Lucknow

Development of new breeding line in opium poppy (fringed leaves alkaloid free advanced breeding line DR-44) for evaluation and selection

Selection of OPSPs and yield evaluation in menthol mint (*Mentha arvensis* L.)

Menthol mint (*Mentha arvensis* L.) is cultivated commercially for extraction of essential oil from upper ground herbage (leaves + stem) The essential oil of menthol mint is mainly used for the production of menthol and the by-product de mentholised oil (DMO) that find extensive applications in the pharmaceutical and cosmetic industry. A total of 102 half-sib progenies of *M. arvensis* cv. Kosi collected and raised for multiplication. The important morphological and

Fig. Superior genotype OPSP No.M.ar- 10

yield characters including quality character data were recorded in IET. The selected 31 genotypes (OPSPs) had 0.95-1.35% oil with 77.5 to 78% menthol. The most superior genotype OPSP No.M.ar- 10) has 1.35% oil yield with 78% menthol (standard essential oil quality).

Genetic improvement of *Mentha spicata*

In *M. spicata* 38 OPSPs progenies were selected in spearmint for assessment of morpho-metric traits and three economic traits: herbage yield, oil content, and oil yield/ plot. The best genotype OPSP line (M.Sp-31) has 25.0% higher herb yield and oil percent 1.05%, in M.sp -15 line having 65.21% Carvone against Neera (check) 53.0%.

Dr. Vedram Singh & his team

Dr. Anil Kumar Gupta Mk- vfuy dekj xIrk

Genetic variability and elite line selection for high essential oil and nepetalactone content in catmint (*Nepeta cataria* L.)

Nepeta cataria L., commonly known as catmint or catnip, belongs to the family 'Lamiaceae' and is indigenous to Europe and Asia. The essential oil of this species is known for the richness and diversity

Fig. Field-grown catmint (*N. cataria*) plants at CSIR-CIMAP. [A: *N. cataria:* Vegetative stage; B: Inflorescence of *N. cataria;* C: *N. cataria*: Flowering stage]

of nepetalactone (NPL) which is used as mosquito/ insect repellents in perfumery and cosmetic industries. With a view to explore the Indian catmint germplasm for its commercial potential as a natural, non-toxic source of insect repellents; commercial open-pollinated seeds of catmint collected from its native, temperate habitat in the Himalayas were introduced in the tropical plains. Subsequent to adaptation to a new zone we were able to isolate nineteen individual plants based on plant growth. Hydro-distillation of the fresh herb yielded essential oil in the range of 0.01% to 0.2%. Gas Chromatography (GC) and GC-Mass Spectrometry (GC-MS) analyses of the oil revealed the dominance of monoterpene hydrocarbon, namely, 4aα,7α,7aα NPL (1) isomer (84%). The other two isomers of nepetalactone, 4aα,7α,7aβ NPL (2) and 4aα,7β,7aα NPL (3) were also present, although in very fewer amounts (1.0%

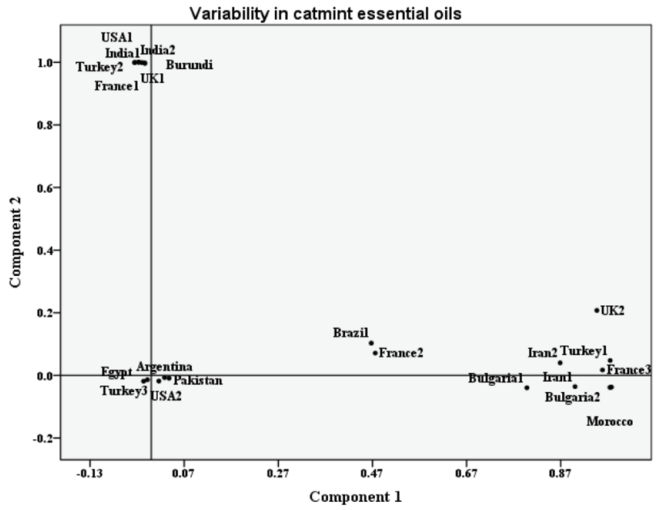


Fig. Variability in catmint essential oil by Principal Component Analysis.

and 1.6%, respectively). Sesquiterpenes identified were α-humulene (traces), (E)-caryophyllene (0.6%) and caryophyllene oxide (1.7%). The identified Indian catmint chemotype oil with the other oils from temperate, sub-tropical, and tropical locations was compared based on a literature search. The Indian chemotype was found to be similar to the oils from Burundi, France, Turkey, UK and USA, mainly due to more accumulation of 4aα,7α,7aα NPL (1) isomer. These oils grouped together in Principal Component Analysis. The development of improved breeding lines in this plant is required for successful commercial catmint cultivation.

Fig. Geographical distribution of catmint natural population

Dr. Anil Kumar Gupta & his team

Dr. Birendra Kumar Mk- chjUnr d[ekj

Radio-frequency (RF) room temperature plasma treatment of sweet basil seeds (*Ocimum basilicum* L.) for germination potential enhancement by immaculation

Stimulative effect of non-thermal plasma (NTP) treatment of sweet basil seeds (*Ocimum basilicum* L.) for a combined effect of process parameters, such as RF power (W0=0; W1=60 watt, W2=150 watt; W3=240 watt), Process pressure (P0=0; P1=0.2 mbar; P2=0.4 mbar; P3=0.6 mbar) and Treatment time (T0=0; T1=5 minutes; T2=10 minutes and T3=15 minutes) using gas mixture of Ar & O_2 is reported here. Radio-frequency plasma treatment improves vital quality parameters such as seedling vigor index-I (SVI I), seedling vigor index II (SVI II), carbohydrate content, and protein content. It is also observed that lipid peroxidation (LPO), enzymatic anti-oxidant (Catalase) and non-enzymatic anti-oxidant (Proline) get significantly enhanced after treatment. Overall effect enhances the germination percentage up to 30%. Combined effect of process parameters such as pressure (P), wattage (W), time (T), and their interactions [(P × W), (P × T), (W × T) and (P × W × T)] was also found statistically significant. It is also observed that plasma treatment at P3W3T3 shows inhibitory effect which might be because of seed deterioration at high wattage for a longer exposure time. The results are further analyzed and corroborated by SEM and water imbibitions study. It may be concluded that radio frequency cold plasma exposure of medicinal crop, sweet basil (*Ocimum basilicum* L.), could invigorate the germination potential for an optimum treatment condition. [Journal of Applied Research on Medicinal and Aromatic Plants. 2022].

Development of menthol-rich peppermint (*Mentha piperita* L.) genotype

Peppermint genotype MPS36-3-3 has been developed having following morpho-chemical traits: Erect growth habit, flowering, sucker producing ability, menthol (70.3-77.5%), menthofuran (0.25-0.89%), menthone (9.5-11.1%), iso-menthone (1.5-1.7%), neo-menthol (2.1-3.3%), menthyl acetate (0.2-0.3%), limonene (0.6-1.8%) and about 20% oil yield improvement over Kukrail. Final data and oil quality analysis are in progress. This genotype would be proposed for variety release very soon.

Quantification of genetic variability and stable genotype selection over the years in the germplasm of critically endangered Prishanparni (*Uraria picta* Desv.)

Prishanparni (*Uraria picta* Desv.), is a critically endangered annual shrub belonging to the family 'Papillionaceae'. The consistent performances of *U. picta* accessions based on ten economic traits studied, six (P-12, P-16, P-21, P-22, P-31, P-47, and P-48) accessions were identified better. These accessions could be used for commercial cultivation in northern Indian plains. Among the twenty-three studied accessions P-50, P-21, P-48, and P-47 were found superior for rhoifolin content in their aerial as well as root part, which have various therapeutic potentials used in traditional and modern systems of medicines. These accessions could be exploited for commercial cultivation or in a hybridization program for further crop improvement. Wide range cultivation of the selected accessions in the Indo-Gangetic plains will fits in the existing cropping systems of this region, resulting in comparatively better supplementation of herbs to the pharmaceutical and herbal drug industries and will reduce the pressure on the wild populations. [Environmental Geochemistry and Health. 2022].

Fig. UP-50: High rhoifolin content in aerial part

Fig. UP-21: High rhoifolin content in root part

Identification and selection of THC, CBD, cannabinoid terpene, and THCa rich strain/line/genotype of *Cannabis* spp

Surveyed 14 major cannabis growing states and collection of about 175 germplasm/accession was made and evaluated at CSIR-CIMAP. Among collected accessions/collections, about 85 Cannabis accessions have been morpho-chemically, yield attributing traits, and anatomically characterized. Among 85 accessions, 37 accessions are Fibre type and 48 Drug type. During the initial screening, only two Indian accessions have 0.17% & 0.25% total THC and 2.85% & 1.36% total CBD content were recorded in CIM-CS-64 and CIM-CS75B/JCM-3, respectively. The confirmation of cannabinoid content (THC & CBD) consistency in said accessions needs more cropping cycles. During the initial screening, few accessions also showed low total CBD with high total THC and high total CBD with high total THC (more than 0.3%) contents were also recorded, and such accessions were destroyed in the presence of deputed excise officers by Excise Commissioner. Nipping had a positive effect on the number of branches, stem diameter, fresh and dry plant weight (t ha^{-1}), fresh and dry biomass yield (t ha^{-1}), seed yield

(t ha^{-1}), and oil yield (kg ha^{-1}). Among different nitrogen levels (No N, N75/kg/ha, N150kg/ha, N225kg/ha) and crop geometry (1mx1m, 1mx0.8m, 1mx0.6m): N@150kg/ha and 1mx0.8m were recorded best for maximum no. of inflorescence/plant. Nipping at 35 DAT with 120:60:40kg/ha NPK level was found suitable for the maximum flower yield/plant and yield attribute traits. Oral administration of cannabis extract coded as IVT/CB-1 and IVT/CB-2 has shown significant analgesic (pain relieving) potential@100 and 300mg/kg body weight in mice against the chemical and thermal-induced pain model in mice.

Dr. Birendra Kumar & his team

Dr. V. Sunderasan Mk- oh- lnjlu

Genetic diversity and population structure assessment of *Hellenia speciosa* from Indian agro-ecological regions using inter-simple sequence repeat markers

Hellenia speciosa (J. Koenig) S. R. Dutta (Syn: *Costus speciosus* (J. Koenig) Sm.) is well known for its anti-diabetic properties and is in high demand for its steroidal sapogenin, diosgenin, which is used in the pharmaceutical industry for manufacturing steroidal drugs. The increasing demand for this plant has led to the depletion of its wild population. This study was conducted to reveal the genetic diversity of *H. speciosa* collected from various agro-ecological regions of India for use in devising conservational strategies, and cultivation and breeding programs. Twenty inter-simple sequence repeat markers yielded 304 products with 100% polymorphism demonstrating high genetic diversity. Nei's gene diversity and Shannon information indexes were estimated among the populations as 0.19 ± 0.23 and 0.28 ± 0.25, respectively. High genetic differentiation (G_{ST}= 0.40) and low gene flow (N_m = 0.74) were observed, which corroborated with the analysis of molecular variance revealing maximum (86.75%) variance within populations. The unweighted pair group method with arithmetic mean analysis grouped all accessions into three major clusters. Principal component analysis showed that the first three components accounted for 30.66%, 4.54%, and 3.98% variation, respectively, and Bayesian clustering through STRUCTURE showed the presence of two genetic population (K = 2). This study revealed high genetic diversity among the populations collected from high altitude compared to those from the plain. A positive but low correlation among genetic and geographic distances was obtained (r = 0.282, p<0.0001). Identification of genetic diversity and intra population variation of a species are prime factors to take defined conservation strategies.

Population restoration of tissue culture raised plants of *Decalepis salicifolia*, a Critically Endangered, medicinal and aromatic plant in the wild:

Decalepis salicifolia (Bedd. ex Hook.f.) Bruyns is a suffrutescent, medicinal and aromatic plant growing in crevices of open rocky slopes in southern Western Ghats of Tamil Nadu and Kerala. The aromatic root tubers are used in liver afflictions, debility due to tuberculosis, ulcers and ulcer related

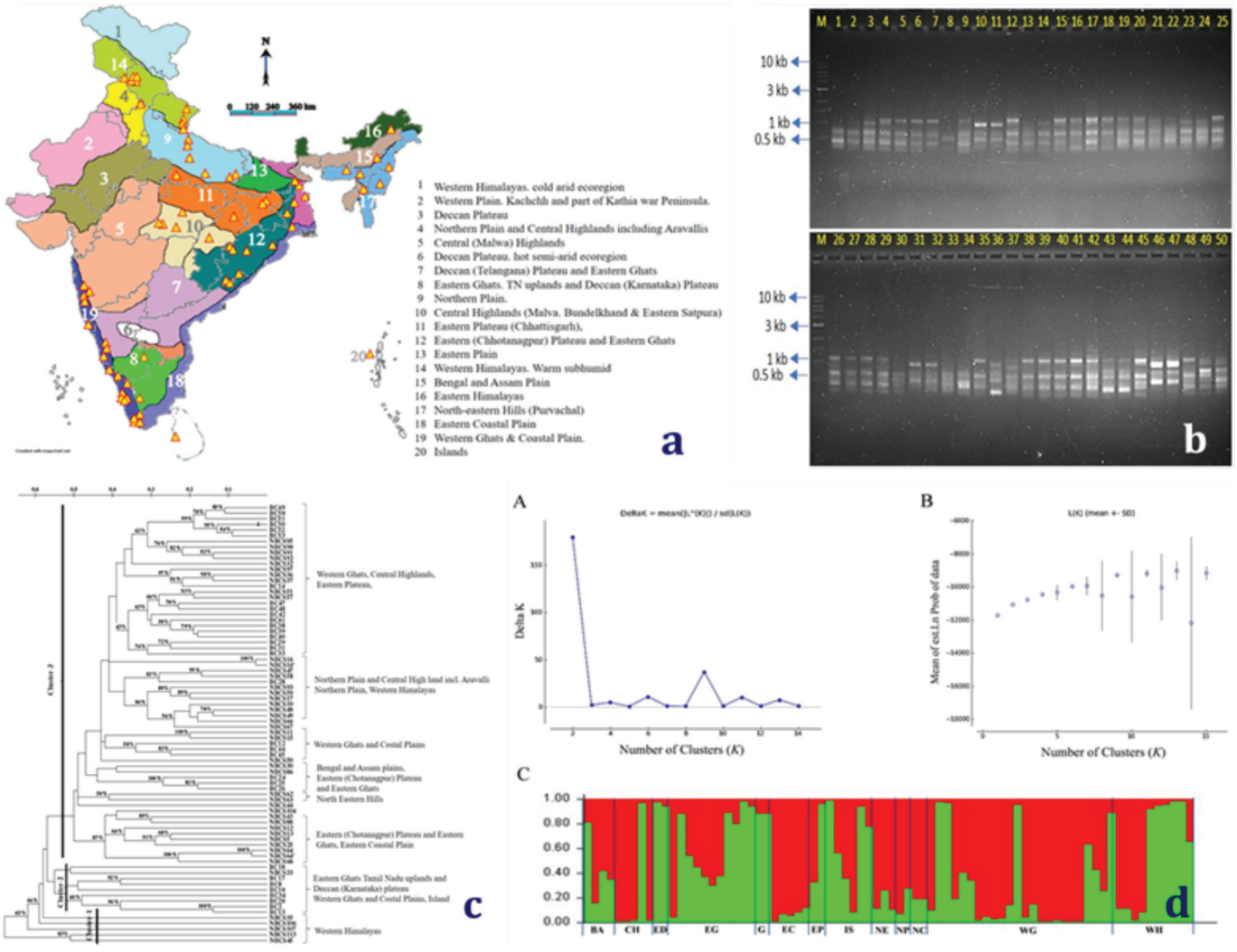


Fig. a. Agro-ecological map of India showing the collection sites of *Hellenia speciosa;* b. A representative ISSR profile of *Hellenia speciosa* generated by primer UBC 848; c. UPGMA dendrogram of *Hellenia speciosa* based on genetic distance; d. Population structure in *Hellenia speciosa* as determined by Bayesian analysis

internal bleeding, indigestion, asthma, skin diseases etc. Pharmacological studies have revealed the tuber extract possesses antiulcer, anti-cancer, and hepatoprotective properties. Endemism, prevailing threat include indiscriminate harvesting for ethnomedicinal use from the wild, forest fires and habitat degradation categorised under Critically Endangered by IUCN. Considering the critically endangered status and poor regeneration, an efficient multiplication technique for propagation and mass multiplication was undertaken.

Shoot segments of actively growing in vitro germinated seedlings were inoculated onto semi solid MS medium supplemented with 6-benzylaminopurine (BAP) alone or in combination with Indole-3-acetic acid (TAA), Naphthalene acetic acid (NAA) and Kinetin (Kin). Shoot tip proliferation was achieved in media supplemented with BAP and IAA. Multiple shoots (3.5 ± 0.11) were obtained in BAP containing media. MS media viz full strength, half strength, and quarter strength basal media and supplemented with IBA, IAA and NAA individually were used for root induction. Efficient rooting (12.4 ± 1.2) was achieved in modified media containing reduced nitrates. Rooted plants were successfully hardened and potted in field. Hardened plants were

Fig. a. In vitro shoot & root initiation from nodal explants; b. Hardening in soil rite; c. Reintroduction in Varayattumottai of Megamalai Tiger Reserve; d. Reintroduction in Vistharamalai of Kalakad Mundanthurai Tiger Reserve

after checking their genetic fidelity reintroduced in similar habitats. A total of 20 saplings were reintroduced in SMR estate, Megamalai and Vistharamottai of Kalakad Mundanthurai Tiger reserve, Tirunelveli, Western Ghats.

Dr. V. Sundaresan & his team

Dr. Tripta Jhang Mk- rIrk >x

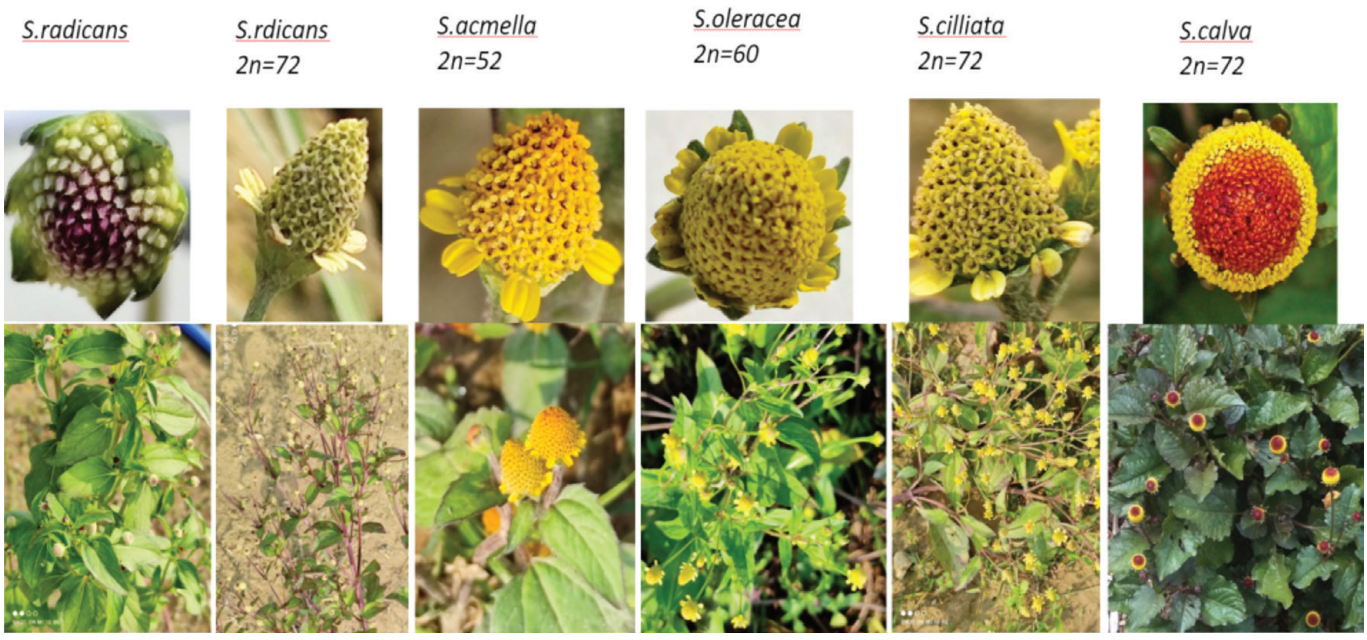
Development of Neral and Geranial rich high essential oil yielding breeding line of *Ocimum basilicum*

Amidst the blooming essential oil market, 41.5% share is captured by citrus oil which is to a larger extent catered by *C. flexuosus* that essentially demands at least 6-8 months to grow with an average 65-80%citral content and 0.6-0.8% essential oil yield. An advanced

Neral and Geranial rich high essential oil yielding breeding line of *Ocimum basilicum* has completed the advanced variety trials with an average citral content of 71-80%, an essential oil content 0.6-0.76, and an average potential fresh herb yield of 450q/hand and essential oil yield of 150-175Kg/ha in three to four months fetching a net income of more than Rs 1,50,000Lakhs per ha.

Pre breeding for Spilanthol in *Spilanthus* spps

Cataloguing and elucidation of natural variation for genetic kinship in core collections of *Spilanthus species* (~50) which can be used for commercial authentication and strategic metabolite targeted breeding in Indian yellow Akarkara (*Spilanhtus acmella*) by exploring *Spilanthus radicans, S. oleracea, S.cilliata, S. acmella, S.paniculata* for Spilanthul content.



Dr. Tripta Jhang & her team

Dr. Channayya Hiremath Mk- pUu, ;k fgjeFk

CIM – NANDI High-oil and high-citronellal *Eucalyptus citriodora* clone

CIM-Nandi is a high oil-yielding and high citronellal-containing variety, the variety gives herb yields of 5-6 t/acre/harvest and oil yields of 80-100kg/acre/harvest. This variety shows more trichomes or hairs on the leaves during the seedling stage and these trichomes will disappear as the plant became older. This variety is giving significantly higher oil content (1.4-1.6 %) and citronellal content (80.-82.00%). The variety can be cultivated in poor soil and problematic soils.

CIM-Nandi

Local

Evaluation of lemongrass clones for high oil and citral content

Superior clones selected last year were evaluated in Advanced Varietal Trial and Bench Scale trial. The superior clones maintained their superiority over check varieties. The oil content ranges from 2.20-2.8% compared to the check variety of 1.2-1.4%.

Fig. General Field View of newly Developed clone

Comparative Performance of newly selected clones of lemongrass

Lines	Herb yield (Kg/plot)		Oil yield (ml)		Oil content (%)	
Harvests	I	II	I	II	I	II
C1	16.07+2.44	14.13+1.290	208.21+31.63	240.03+34.77	1.30+0.0012	1.67+0.030
C2	19.49+0.86	14.90+0.195	324.80+14.32	258.18+02.71	1.67+0.0003	1.72+0.017
C3	18.57+0.57	14.25+0.032	422.20+13.03	244.64+03.15	2.27+0.0048	1.68+0.044
C4	**22.34+2.04**	**18.57+0.718**	**336.86+30.67**	**340.68+21.25**	**1.51+0.0012**	**1.80+0.029**
C5	18.73+2.12	15.74+0.918	309.50+34.93	252.40+24.08	1.65+0.0013	1.60+0.025
C6	22.19+2.55	18.35+0.571	308.66+35.42	318.65+41.00	1.39+0.0001	1.73+0.017
Krishna	17.55+3.42	27.65+0.867	187.00+36.37	230.24+08.37	1.07+0.0015	0.84+0.008
Shikhar	16.90+0.87	14.611+0.635	137.73+07.09	140.53+20.45	0.82+0.0014	1.00+0.029

General Field View of newly Developed clone

Dr. Venkatesha K.T. Mk- o;dVs'k d;-Vh-

Improvement of herb yield, essential oil yield, and carvone content in spearmint (*Mentha spicata* L.)

Presently all cultivated varieties of spearmint have less oil-yielding ability with low carvone content. The essential oil industry require spearmint variety with high oil yield and high carvone content. By considering this, 252 half-sib seed progenies were developed from genetically different spearmint varieties like MSS-5, Arka, Neera, and Neerkalka during 2017-2019. These half-sib seed progenies were propagated vegetatively and evaluated/characterized for herb yield, oil yield, and chemical composition of essential oil for two seasons (November- April) 2020-2021 and 2021-2022. Among 252 half-sib seed progenies, plant height varied from 14.5 cm to 96. cm, leaf length ranged from 1.8 cm to 6.5 cm, leaf width 0.61 cm to 3.21 cm, herb yield ranged between 0.5 to 2.8 kg/ 4 m^2 area, oil content rangeing from 0.2% to 0.9%, and carvone content was varied from 32.6% to 74.32 %.

Fig. General field view of morphologically distinct half-sib seed progenies at CIMAP, Research Centre, Pantnatnagar.

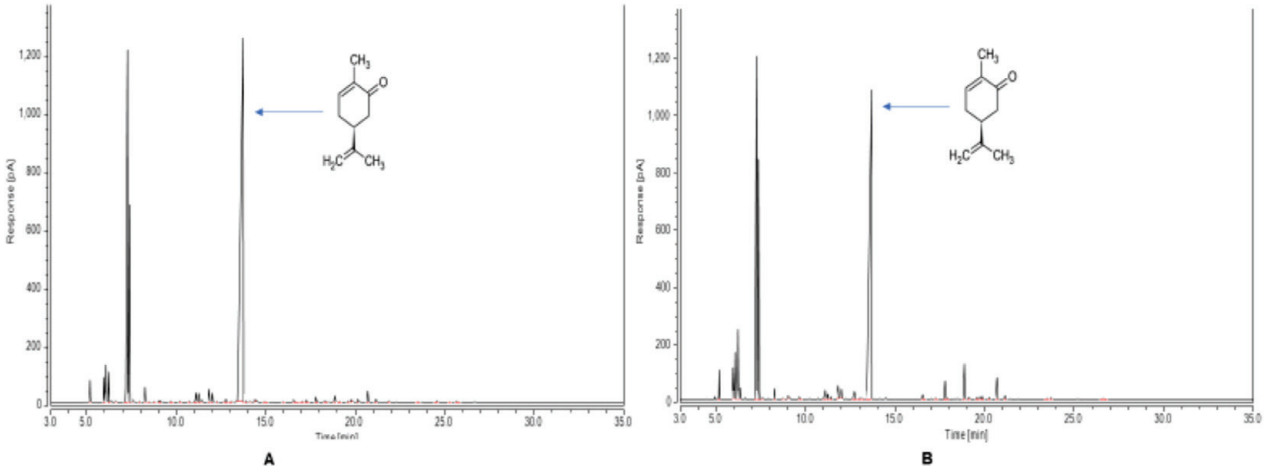


Fig. Chromatography profile of essential oil of half-sib seed progeny (A) MS-50,(B) MS-55

Colchicine induced polyploidy in stevia (*Stevia rebaudiana*) to enhance herb yield, Stevioside, and Rebaudioside–A content.

Stevia rebaudiana (Bertoni) also known as sweet leaf or sugar leaf is a perennial herb (2n=22) of the *Asteraceae* family. Leaves of stevia produce diterpene glycosides (Stevioside and Rebaudioside), which are high-potency sweeteners and substitutes for sugar. The demand for stevia-based products is increasing in national and international markets. The stevia varieties available for commercial cultivation at present have lower herb yield (2-4 t/ha of dry herb yield) and lower Rebaudioside-A content (4-7.34%). So, there is a need to develop a high herb yield with Rebaudioside-A rich stevia variety. Totally 37 morphologically distinct plants with putative polyploidy were produced in *Stevia rebaudiana* (variety CIM-Mithi) through colchicine treatment. These putative polyploid lines were subjected to ploidy determination through flow cytometric analysis. Out of 37 putative polyploidy plants, one line was triploid (2n=3x=33) and 14 lines were tetraploid (2n=4x=44). Thereafter, during the pre-flowering stage, leaves were collected from all fourteen polyploid plants separately and were shade dried for estimation of Rebaudioside-A and Stevioside content through HPLC analysis.

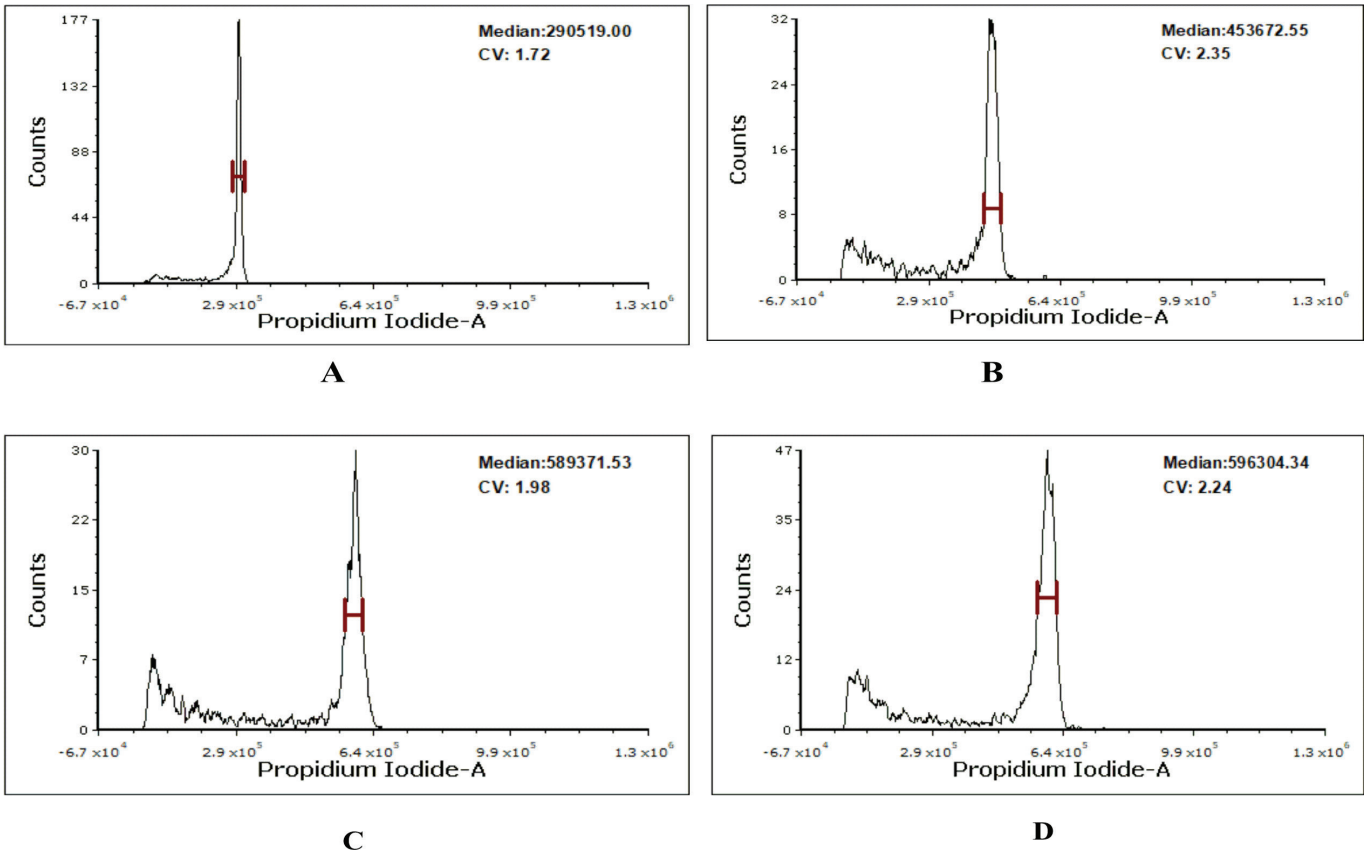


Fig. Polyploidy identification by flow cytometric analysis. A. Control (2n=2x=22), B. Triploid(2n=3x=33), C.Tetraploid (2n=4x=44), D. Tetraploid (2n=4x=44).

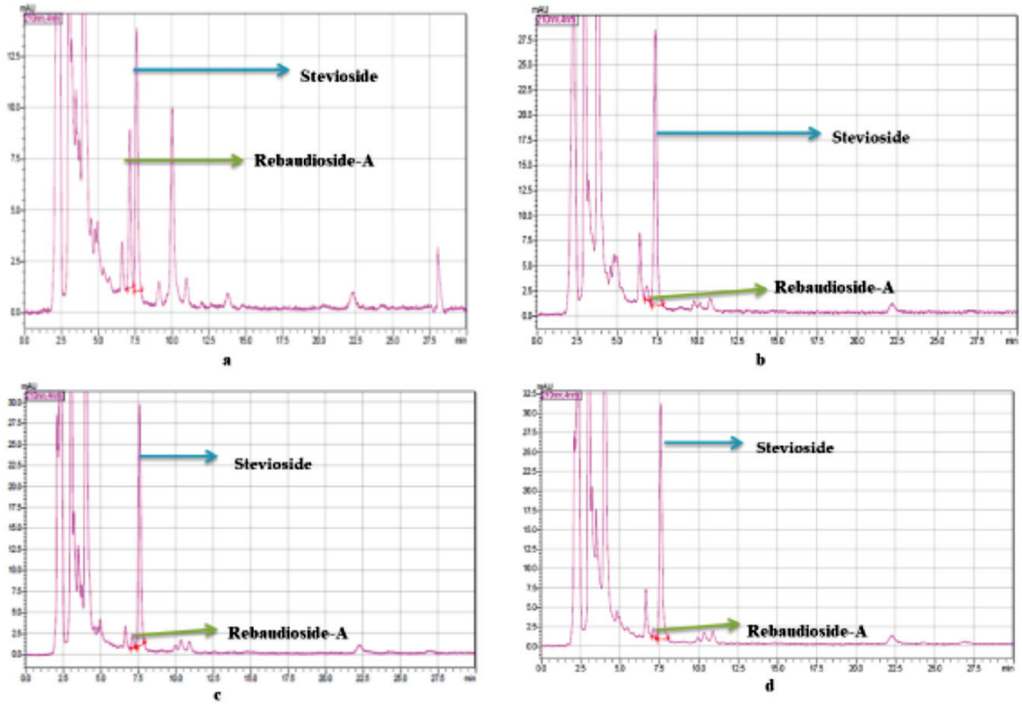


Fig. HPLC chromatogram of Rebaudioside-A and Stevioside content a) in check variety, b) in triploid line, c) in tetraploid line, d) in tetraploid line.

Dr Narendra Kumar Mk- ujUn d[ekj

Survey, inventorization, and collection of medicinal and aromatic plants

The plant survey was conducted in the sub-tropical region of Uttar Pradesh, processed and accessioned in the Herbarium and crude drug repository. Commercial market samples of crude drugs were authenticated as per the guidelines and deposited in the repository.

Pharmacognostic study of commercially important raw drugs and data generation for IND filing

The pharmacognostic analysis is used for crude drug authentication and the data is required for

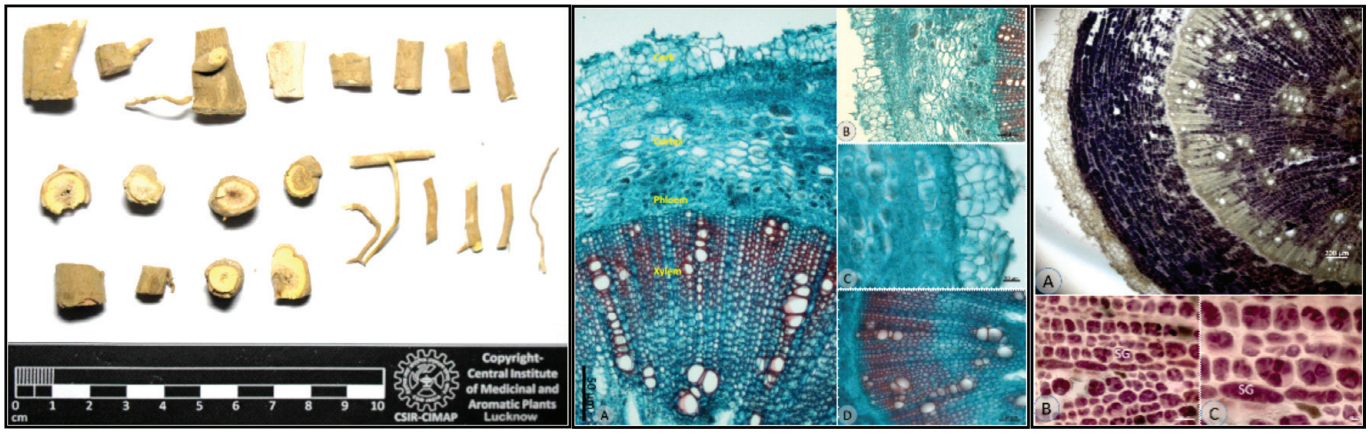


Fig. Pharmacognostic standardization of *Withania somnifera* root

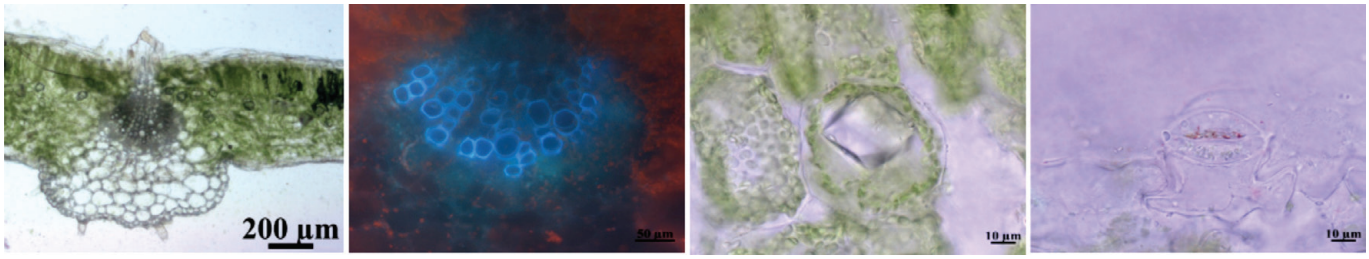


Fig. Pharmacognostic standardization of *Withania somnifera* Leaf

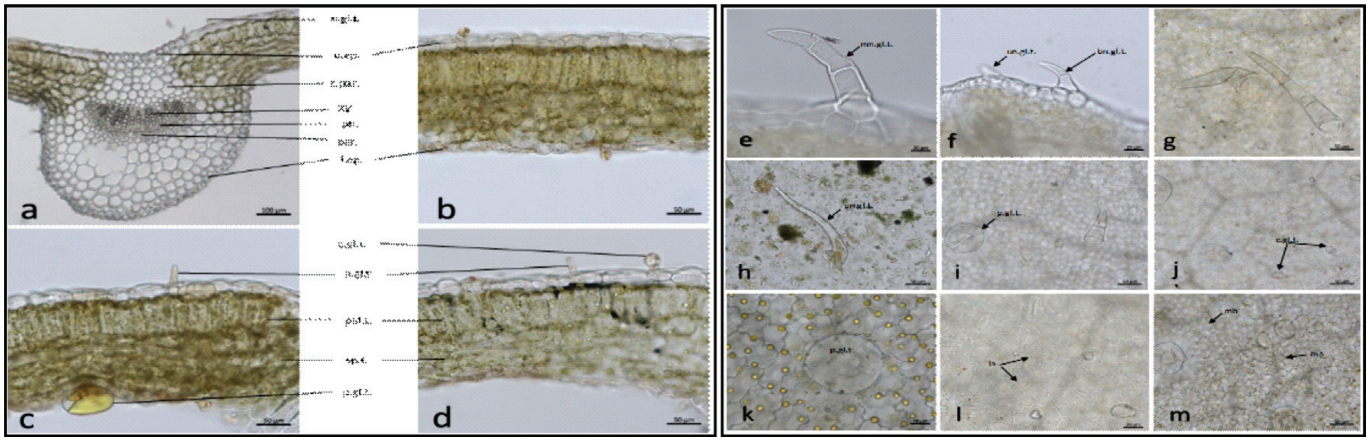


Fig. Pharmacognostic standardization of *Mentha piperita* leaf

quality assurance and quality control. Here we have generated the quality data as per the ISO 17025:2017, API, and EP guidelines.

Premature-senescence modulates the biochemical, essential oil profile at different senescence stages in *Pelargonium graveolens* L'Hér.

Pelargonium graveolens L'Hér is a commercially important aromatic plant. The essential oil is used in fragrances, flavor and cosmeceutical industries. The essential oil is secreted in the glandular trichomes distributed mainly on the leaves. In India, *P. graveolens* is growing only in specific climatic conditions due to the susceptibility of plants to rainfall, high humidity and waterlogging stress. We analyzed the rainfall-induced premature senescence in *P. graveolens* at six phenotypic leaf senescence stages. The physiological and biochemical parameters, cell viability, trichomes density, essential oil yield, and variation in chemical constituents were evaluated. Results showed a significant increase in chlorophyll-a and b and a decrease in anthocyanin content. Also, the protein content, MDA, SOD, H_2O_2, catalase, electrolyte leakage were significantly higher, and cell viability decreased with the progression of senescence. The gland density on leaves was reduced during the

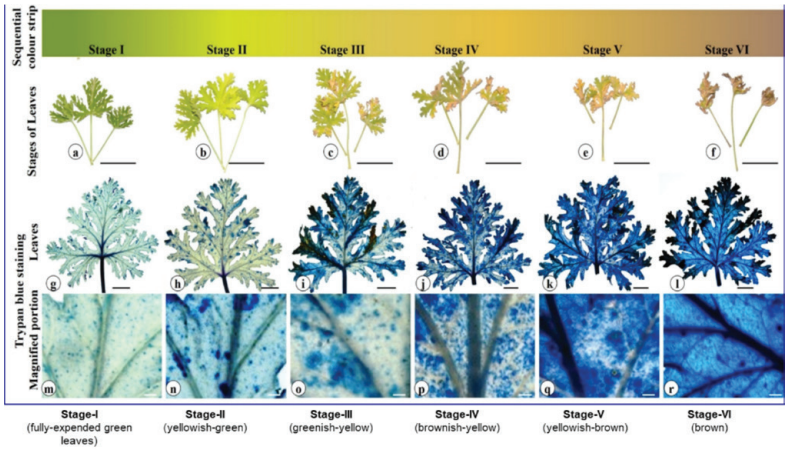


Fig (a-f) The leaf senescence phenotypes of *P. graveolens*; **(g-r)** Trypan blue stained leaves showing the degree of increasing cell death at different stages of senescence.

advancement of senescence. The GC and GC-MS analysis showed that the senescence significantly modulates oil constituents and oils yield (0.048 to 0.123 %) at different senescence stages. Overall, this study confirms that rainfall induces premature senescence in *P. graveolens*, significantly affecting essential oil yield and constituents. *[Industrial Crops and Products 178 (2022): 114630]*

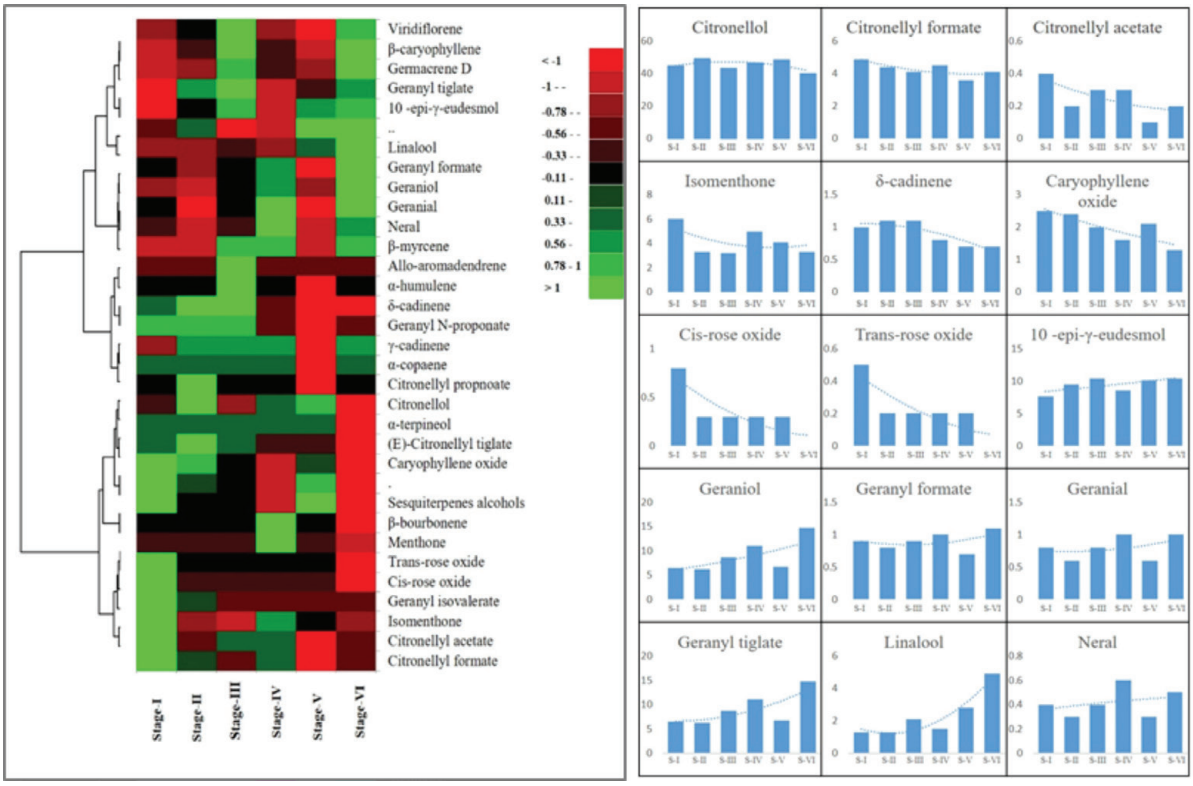


Fig. (a) Heatmap and dendrogram cluster analysis representing the changes of the essential oil constituents at different senescence stages of *P. graveolens* (S-I to S-VI). The coloured scale indicates the relative concentration of various essential oil constituents. **(b)** The patterns of the major essential oil compounds (concentration %) as influenced by different senescence stages of *P. graveolens* (S-I to S-VI).

Dr Narendra Kumar & his team

Dr Gunjan Tiwari Mk- xqtu frokjh

Assessment of genetic diversity among thirteen half-sib populations of Catmint (*Nepeta cataria* L.)

The mosquito repellent Nepetalactone of *Nepeta cataria* L. has a variety of therapeutic and industrially potential. Reports on the genetic diversity of *N. cataria* germplasm are minimal globally and need attention for adding a new variety into commercial cultivation. The present study, therefore assessed the genetic diversity among thirteen half-sib populations of *N. cataria* using agro-economic and phytochemical traits. Among the eleven phytochemical constituents which were detected in different concentrations in the essential oil of experimental sets, 4aα,7α,7aα-Nepetalactone (67.9-87.5%) constituted the significant proportion of essential oil. The cluster analysis revealed the least interactions between various agro-economic and phytochemical variables. However, the chief potential phyto-compound of the plant, i.e.,4aα,7α,7aα-Nepetalactone, showed a negative correlation with oil content but a positive correlation with herb yield, indicating an indirect path for its improvement.

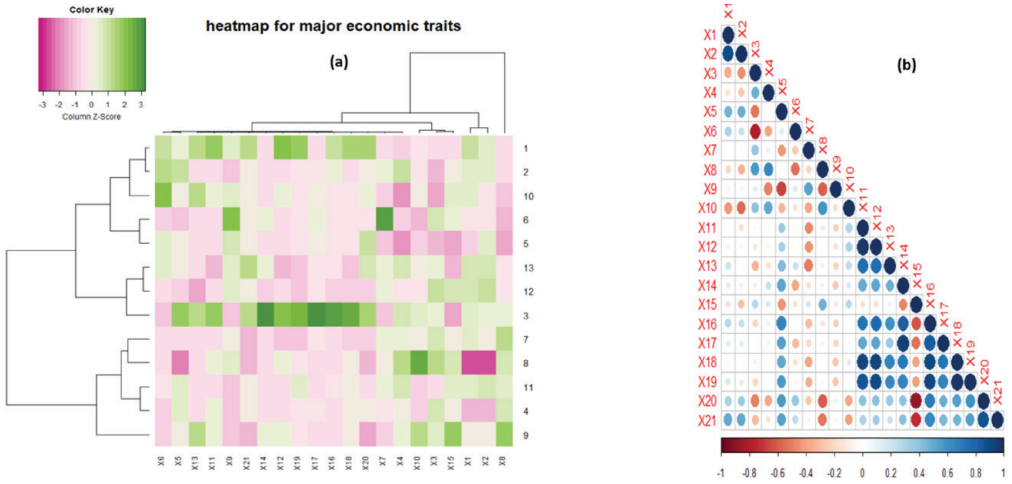


Fig. Heat map(a) and correlation matrix (b) between agronomic and phytochemical traits in catmint experimental populations (where, X1= days to 50%flowering, X2= days to maturity, X3=plant height, X4= number of primary branches, X5= number of nodes per plant, X6= Internode length, X7=inflorescence length, X8=herb yield, X9= Oil Content, X10= Oil yield, X11=(Z)-β-Ocimene, X12=(E)-β-Ocimene, X13=Lavandulol, X14= Methyl Salicylate, X15= 4aα,7α,7aα-Nepetalactone, X16= 4aα,7α,7aβ-Nepetalactone, X17=4aα,7β,7aα-Nepetalactone, X18=β-Caryophyllene, X19=α-Humulene, X20= Caryophyllene oxide, X21=Humulene epoxide II)

Dr Gunjan Tiwari & her team

Technology Dissemination & Computational Biology

HIGHLIGHTS

Technology Dissemination: During the year 2021-22, 06 technologies related to different herbal formulations have been transferred to four industries and 3 NGOs. An amount of Rs 30.56 lakh has been received as premia and Rs 20.16 lakh was received as royalty. During the same period 02 projects from Chief Conservator of Forest Bundelkhand Zone, Jhansi UP, and Directorate of Horticulture and Food Processing, Uttar Pradesh worth Rs. 55.49 lakh were also received from different Government Departments.

06 online 03 days training and 04 offline training programs has been organized in which 798 farmers and entrepreneurs were participated from various parts of the country. 46 one-day awareness programs were organized in different states, especially in remote and tribal areas in which about 2688 farmers were made aware and trained on various aspects of medicinal and aromatic plants according to the regional agro-climatic conditions. A step towards making self-sustainable for the unemployed and poor women for making incense sticks by using offered or used flowers for self-employment activity, CSIR-CIMAP organized 03 training programs attended by 240 women during the period.

This year 10 days Kisan Mela have been organized by the institute from January 21 to January 31, 2022 (excluding 26 Jan 2022). Considering the COVID-19 pandemic situation daily 100 to 200 farmers participated in the program by following Covid- 19 protocol. The main function of Kisan Mela




Scientists of Technology Dissemination & Computational Biology Divisional Units

Upper Panel (L to R) : Dr. Sanjay Kumar, Dr. R.K. Srivastava, Dr. R.S. Sharma and Dr. Rushikesh
Lower Panel (L to R) : Dr. Manoj Semwal, Dr. Feroz Khan and Dr. Bhaskar Shukla

was organized on 29th January 2022, in which Dr. Shekhar C. Mande, Director General, CSIR, New Delhi was the chief guest and addressed the farmers who participated in Kisan Mela. On this occasion, Dr. Shekhar C. Mande, Director General, CSIR also discussed with aroma mission beneficiary farmers and industries. The major objective of this discussion is to know how CIMAP aromatic crop varieties help farmers to change their lives. About 3500 farmers, entrepreneurs, representatives of industries, and buyers of essential oil hailing from the different states participated.

During the period 2307 visitors including farmers, students, school/ college teachers, government officials, and other common people from society visited CSIR-CIMAP and were apprised about the different activities of the institute. CSIR-CIMAP technologies were also displayed in different exhibitions at various locations in the country.

Four extension literature and five research articles were also published during the period.

Human Resource Development: A total of 24 students of CSIR-CIMAP were awarded their doctorate degrees under the Academy of Scientific and Innovative Research (AcSIR) and CIMAP-JNU Ph.D. Programs during 2021-22. During this period 21 and 16 students were enrolled under the AcSIR and CIMAP-JNU Ph.D. programs, respectively. Currently, CSIR-CIMAP has 111 students in AcSIR and 76 students in the CIMAP-JNU Ph.D. Programs. CSIR-CIMAP offered graduate training for about 65 M.Sc. students from various colleges and universities during 2021-22.

Patent Cell: CIMAP Patent Cell works in cooperation with CSIR-Innovation Protection Unit, New Delhi to protect and manage intellectual property generated through research in the area of medicinal and aromatic plant varieties, agro-technology, bioactivities, chemical processes, and product formulations. During 2021-22 CSIR–CIMAP successfully granted 3 patents of which were two Indian-granted and one US-granted patent. Simultaneously 3 patents were filed during 2021-22.

Project Monitoring and Evaluation (PME): PME Cell of CSIR-CIMAP coordinates the planning for research and development activities and manages the ongoing projects funded by CSIR and various external funding agencies. PME cell also plays a vital role in coordination between CSIR-CIMAP and CSIR-HQ, New Delhi. The unit organized several meetings of scientists to review the progress of ongoing projects and scrutinized projects before submission to different funding agencies. During 2021-2022, 30 projects (including 14 GAPs, 11 CNPs, 01 SSP, 02 MLPs, 01 HCP and 01 NMITLI) from various agencies like DBT, SERB-DST, State Governments, CSIR, etc. were received and executed in CSIR-CIMAP.

Computational Biology: The scientists involved in the bioinformatics related studies in the Computational Biology Unit research focus is bioinformatics tools & techniques, Next Generation Sequencing data analysis of Medicinal and Aromatic Plants Genome & Transcriptome, Molecular Modelling & Simulation studies especially in lead identification/ optimization, virtual screening, biological activity/ toxicity prediction through Quantitative Structure-Activity/Toxicity Relationship (QSAR/QSTR), Pharmacophore Modeling, Structural Bioinformatics, Cheminformatics studies, In-silico studies in Bioprospection domains such as exploration of drug targets and their Mechanism of action through Molecular Docking & Molecular Dynamics, Predictive Pharmacokinetics, Predictive Toxicity Risk Assessment, Oral Bioavailability and Systems Pharmacology.

The scientists working on the precision agriculture research studies work on the satellite and UAV data to develop machine learning models for major aroma crops yield estimation and crop monitoring. The unit is equipped with high end drones, hyperspectral camera, multispectral cameras (Micasense Altum and Parrot Sequioa), Optical Camera and IoT sensors to use the advanced remote sensing tools and techniques for development of spectral libraries and medicinal and aromatic crop monitoring. The focus is to develop precise resource use efficiency of major aroma crops using remote sensing tools and techniques. During this period, several externally funded projects from the National Medicinal Plant

Board, New Delhi, Industry Sponsored Project (SSP), Forest Department, UP and Department of Biotechnology, New Delhi were also executed.

During the year 2021-2022, various studies on discrimination of crop management in menthol mint and citronella crops using portable hyperspectral remote sensing. Research work of Unmanned Aerial Vehicle (UAV) based high resolution remote sensing for modernized and efficient cultivation practices of commercially important medicinal and aromatic crops were also undertaken with focus on usage of machine learning and Artificial Intelligence tools and techniques for medicinal and aromatic crops. Under the project Indian Bioresource Information Network (IBIN) Geoportal for enhancing bio resource services, institutional linkages and outreach about 700 records of medicinal and aromatic plants were also digitized.

In the research work on the development of bioinformatics pipeline, lncRNA Detector: a bioinformatics pipeline for long non-coding RNA identification and MAPslnc: a repository of medicinal and aromatic plant lncRNAs were developed. The lncRNADetector has been further utilized to analyse and identify more than 915 lncRNAs from 8 species of MAPs. Seven days' online skill development training program entitled "Genetic algorithm & receptor-ligand binding mode detection through molecular docking ", December 1-7, 2021 under NWP-100 project was also organised by the division. During this period, the Computational Biology Unit published 05 publications and 1 Book Chapter in high impact journals such as Industrial Crops and Products, Current Topics in Medicinal Chemistry and Journal of the Indian Society of Remote Sensing.

ICT Services: Information & Communication Technology Department has the prime objective of providing networking, mailing and computer services at the institute. The major activities of the department are maintenance and up gradation of the mail, web, intranet, DHCP, DNS, router, bridge, anti-virus, backup and database servers.

A campus LAN (Local Area Network) has been set which connects together approximately 350 computers spread over the CIMAP campus. The network utilises a mixture of optical fibre, UTP cables and switches. The internet access is also provided through a gateway to the external world via a 20 Mbps fibre optical link. Email and Internet services are thus brought to the user's desktops. ICT has started the initiative to establish a new Data Centre facility. Migration to improved infrastructure, with new servers to improve of the quality of service has been already completed. Multilayered firewall and antivirus solution have been implemented to enhance the overall network security.

The department is also involved in development of the various in-house databases, applications (standalone & web), ICT enabled agro advisories and virtual lab for students under JIGYASAA.

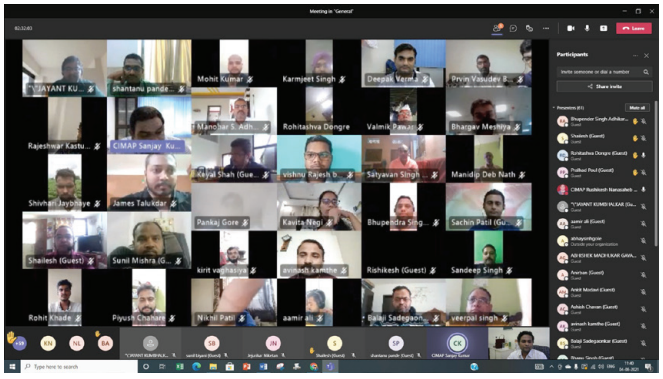
Dissemination of medicinal and aromatic plants-related technologies for socio-economic gains

Sanjay Kumar, Ramesh Kumar Srivastava, Ram Suresh Sharma, Rushikesh N. Bhise, Ram Pravesh, Deepak Kumar Verma and Manoj K. Yadav

Skill Development Programmes

1. Training Programmes on Medicinal and Aromatic Plants Production Technology

Sr. No.	Date	Place	No. of participant	Sponsored by
1	12-14 April, 2021	CIMAP Lucknow (Online)	42	SIDBI
2	28-30 June, 2021	CIMAP Lucknow (Online)	61	SIDBI
3	04-06 August, 2021	CIMAP Lucknow (Online)	56	SIDBI
4	29-30 Sep to 01 Oct, 2021	CIMAP Lucknow (Online)	95	SIDBI
5	16-18 November 2021	CIMAP Lucknow (Online)	39	SIDBI
6	24.11.2021 to 25.11.2021	CIMAP दो दिवसीय ऑन लाइन हिन्दी कार्यशाला	105	HCP-0007
7	11-12 March 2022	IGNTU, Amarkantak (MP)	300	HCP-0007+IGNTU
8	15-16 March 2022	CIMAP Lucknow	18	HCP-0007+DHO Palwal, Haryana



9	23-25 March 2022	CIMAP Lucknow	58	HCP-0007
10	27-30 March 2022	CIMAP Lucknow	24	HCP + BAMETI, Bihar
Total			798	

2) Awareness Programmes conducted under different projects

Sr. No.	Date	Place	No. of Participants	Sponsored by
1	31.05.2021	CIMAP, Lucknow (Online)	20	SIDBI
2	23.06.2021	Chandauli, Rasulpur Gunda, Raebareli (UP)	65	HCP-0007
3	05.07.2021	CIMAP, Lucknow (Online), for Maharashtra farmers	193	HCP-0007
4	09.07.2021	Semrai, Ramnagar, Barabanki (UP)	54	HCP-0007
5	19.07.2021	CIMAP, Lucknow (Online), Rajasthan	45	HCP-0007
6	29.07.2021	Hasanpur, Hodal, Haryana	60	HCP-0007
7	10.08.2021	Webnair,Dimapur, Nagaland	64	HCP-0007
8	08.08.2021	Vill-Chichikala, Hazaribag, Jharkhand	32	HCP-0007
9	09.08.2021	Vill- Kapariya, Khunti, Jharkhand	20	HCP-0007
10	13.08.2021	Narwana, Jind, Haryana	63	HCP-0007
11	14.08.2021	Semrai, Ramnagar, Barabanki (UP)	18	HCP-0007
12	18.08.2021	Kolihari, Jhadol, Rajasthan	61	HCP-0007
13	19.08.2021	Khatamla, Rajsamandra, Rajasthan	30	HCP-0007
14	19.08.2021	Sewa Mandir Udaipur, Raj.	10	HCP-0007
15	20.08.2021	Bhachedi, Pratapgragh, Rajasthan	37	HCP-0007
16	26.08.2021	Muktsar, Punjab	95	HCP-0007
17	27.08.2021	Amritsar, Punjab	202	HCP-0007
18	27.08.2021	Sudma, Bhairamgarh, Bijapur, Bastar ,Chhattisgarh	35	HCP-0007
19	24.09.2021	Rampur Rauli, Dhakerwa, Lakhimpur Kheri	80	HCP-0007
20	24.09.2021	Malikpur, Sikar, Rajasthan	45	HCP-0007
21	24.09.2021	Khetri, Jhunjunu, Rajasthan	25	HCP-0007
22	24.09.2021	Kalapuchi,Sonitpur, Assam	30	HCP-0007
23	21.10.2021	Zila Collectorate office Kondagaon, Bastar, Chhattisgarh	46	HCP-0007
24	22.10.2021	KVK, Bijapur, Bastar, Chhattisgarh	50	HCP-0007
25	10.11.2021	Khatamla, Rajsamandra, Rajasthan	25	HCP-0007
26	11.11.2021	Koliyari, Jhadol, Udaipur, Rajasthan	58	HCP-0007
27	17.11.2021	Runne Pasighat East Siang, Arunachal Pradesh	82	HCP-0007
28	18.11.2021	MEBO HQ, East Siang, Arunachal Pradesh	37	HCP-0007
29	24.11.2021	Anighara, Khunti, Jharkhand	33	HCP-0007
30	25.11.2021	Peto, Daru, Hajaribagh, Jharkhand	11	HCP-0007
31	15.11.2021	Ajara, Dist-Kolhapur, Maharashtra	24	HCP-0007
32	16.11.2021	Shenoli, Karad Dist.-Satara, Maharashtra	30	HCP-0007
33	16.11.2021	Chikurde, Walva, Sangali, Maharashtra	42	HCP-0007
34	19.11.2021	Varvand, Daund, Pune, Maharashtra	10	HCP-0007

35	01.11.2021	Datia, Madhya Pradesh	150	HCP-0007
36	13.12.2021	Scientist-Industry meet,Lucknow(Online and offline)	65	HCP-0007
37	16.12.2021	Kakarva, Bhachau, Kutch, Gujarat	150	HCP-0007
38	18.12.2021	Panchasiya, Wankaner, Morbi, Gujarat	170	HCP-0007
39	23.12.2021	N.B. Institute Agartala, Tripura	70	HCP-0007
40	24.12.2021	Environment bhawan Agartala, Tripura	45	HCP-0007
41	27.12.2021	Vill- Sariya Baduraha, East Champaran, Bihar	57	HCP-0007
42	05.01.2022	Bhamni, Kondagaon, Chhattisgarh	45	HCP-0007
43	17.02.2022	Gopalgarh(Aurangabad), Palwal, Haryana	50	HCP-0007
44	04.03.2022	Golpara, Assam	72	HCP-0007
45	11.03.2022	Hangpung, Ukharul, Manipur	50	HCP-0007
46	14.03.2022	Dumarhatha, Plamu, Jharkhand	32	HCP-0007
Total			**2688**	

Views of different awareness training programs

Exchange of MoU with Department of Horticulture, Govt of Assam, for expansion of area under Aroma Mission and World Bank assisted project in Assam

3) Entrepreneurial training to women on making of incense sticks using floral Bio-resource

A step towards making self-sustainable to the unemployed and poor women for making incense sticks using discarded or used flowers for self-employment activity, CSIR-CIMAP organised 3 training programmes attended by 240 women. The dates of such trainings along with number of participants are given in the Table.

View of Agarbatti Making Training Programs

Agarbatti Making Training Programs

S. No.	Date	Place	No. of Partici-pants	Sponsored by
1	27-30-07.21	Online Training Programmes on Making Stock, Cones and Havansamagri in FFDC Kannauj	40	DBT Spon-sored
2	27-28-08-21	Lucknow Univer-sity MSc Chemis-try Student partic-ipated in Making Agarbatti and cones, CIMAP, Lucknow	118	SSP-370
3	22-23 March 2022	Tainting Pro-grammes on Making Incense Sticks at INTAC Panchmukhi Hanuman Mandir Guptarghat at Ayodhya	82	HCP-0007
		Total	**240**	

4) CSIR-CIMAP, Kisan Mela- 2022

CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow has been organizing CSIR-CIMAP Kisan Mela every year on 31st January. Kisan Mela is being organized for the last 19 years. The increasing number of farmers attending this Kisan Mela every year shows that the popularity of CSIR-CIMAP Kisan Mela is increasing in society. Due to Covid -19 situation last two years Kisan Mela has been organised for longer period, in 2021 it was organised for 20 days. This year Kisan Mela was organized for 10 days from January 21st to January 31st, 2022 (excluding 26 Jan 2022).

The following points were the main attraction of this Kisan Mela-2022:

- Market of medicinal and aromatic plants - from eyes of industry
- Sale of improved planting material and publications

Dr. Shekhar C Mande, Director General, CSIR, Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, Dr. Barik, Director, CSIR-NBRI, and scientist releasing Aus Gyanya on the occasion of Kisan Mela-2022.

- Display of improved varieties and CIMAP products
- Live demonstration of distillation units/ processing
- Training in making incense sticks and rose water
- Demonstration of early farming techniques of Geranium cultivation
- Incorporation of medicinal and aromatic crops into the traditional cropping system

By following all Covid -19 precautionary guidelines this year about 3500 farmers from different states like Uttar Pradesh, Madhya Pradesh, Bihar, Uttarakhand, Chhattisgarh, Gujarat, Rajasthan, West Bengal, Orissa, Haryana, Punjab, Delhi, Karnataka, Maharashtra etc, participated in Kisan Mela. Scientists, officers and, students under the leadership of Dr. Prabodh Kumar Trivedi, Director of CIMAP, contributed to this farmers' fair of 2022 and set an example of farmer's connect of CSIR-CIMAP among the society. Farmers from all over the country participated in this Kisan Mela through the daily pre-registration process. Industries associated with the aroma business such as Norex Flavour Pvt. Ltd., Amroha, Expo Essential Oil, Kanpur, Ingredients Pvt. Ltd., Mumbai, The East Corridor Consultant Ltd., Mumbai, Aromatic & Allied, Bareli, Ajmal Biotech, Mumbai, Nishant Aromas, Mumbai, Ashri Menthol, Barabanki & HCL Foundation, Sandila, etc. also participated in the Kisan Mela with farmers. Participation of these industry were really appreciable from market point of view. Industry representatives shared information related to national and international market demand and focused given on quality of essential oils production for international market.

Views of the participating farmers on the occasion of Kisan Mela-2022

Glimpses of registration desk during Kisan Mela-2022

CSIR- CIMAP has been continuously developing agricultural technologies to increase the income of farmers and improve their economic status. By the

team of CIMAP scientists, detailed information about improved cultivation techniques, improved varieties, processing and marketing were made available to the farmers daily in the Kisan Goshti.

CSIR-CIMAP scientists addressing the farmers on the occasion of Kisan Mela-2022.

Planting material of improved varieties of medicinal and aromatic plants like Mentha, Geranium, lemongrass, Citronella, Khus, Tulsi, Satwar, Ashwagandha, Sarpgandha, Kalmegh etc. were distributed to the farmers in Kisan Mela. In this Kisan Mela newly developed variety of menthol mint CIM-Unnati was major attraction for farmers and highly demanded by farmers.

On January 29, 2022, Chief Guest Dr. Shekhar C. Mande, Director General, CSIR, New Delhi participated in Kisan Mela. In his address, he said that CSIR-CIMAP has been working for more than

Dr. Shekhar C. Mande, Director General, CSIR, New Delhi addressing the farmers in Kisan Mela

60 years in the service of farmers by developing improved agro-techniques, plant varieties, and processing technologies of medicinal and aromatic plants and made available to farmers. CSIR-CIMAP maintains positive trust among the farmers and entrepreneurs through continuous research and extension work.

Glimpses of Kisan Goshti on the occasion of Kisan Mela-2022

On this occasion, CSIR-CIMAP, Bangaluru research centre developed the Eucalyptus variety 'CIM-Nandi' released. Two booklets - A successful project on Demonstration of Cultivation, Processing, and Value Addition of Aromatic Crops in Bundelkhand Region, and another 'Aromatic Crops Suitable for Hardoi Region' were also released.

On this occasion Chief Guest Dr. Shekhar C. Mande, Director General, CSIR also discussed with aroma mission beneficiary farmers and industries. The major objectives of this discussion to know that how CIMAP aromatic crop varieties helps farmers to changing their lives.

Valedictory Function of Kisan Mela-2022

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP on the occasion of closing ceremony of Kisan Mela, welcomed all the participants and said that this Kisan mela have been organized from the last 18 years shows the continued use success of CSIR-CIMAP and shows the popularity of mela among the farmers, industry, and society. Kisan Mela always carried good opportunities for farmers to interact with scientists, industries and to get valuable updated information in the field of medicinal and aromatic plants.

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, addressing the farmers on the occasion of closing ceremony of Kisan Mela-2022

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP in his speech also encourages youth and women to come forwards and start the cultivation of aromatic and medicinal plants for the upliftment of their farm income that will help to get additional income for the family. He also highlights the future opportunities in the field of entrepreneurship through aroma oils.

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP felicitating farmers

Dr. Saudan Singh, Chief Scientist, CSIR-CIMAP proposed a vote of thanks. Dr. Sanjay Kumar, Convener, Kisan Mela conducted various programs of Kisan Mela for 10 days. For the successful organization of the 10-day Kisan Mela, scientists, students and staff of CSIR-CIMAP make a remarkable job.

Farmers carrying new variety of Mentha during Kisan Mela: 2022

5. Visitors

2307 visitors including farmers, students, school/ college teachers, government officials, and other common people from society visited CSIR-CIMAP and were apprised about the different activities of the institute.

Visitors @ CIMAP

6. Participation at National and State Level Exhibition

During 2021-22 Technology Dissemination Division scientists and technical team have been demonstrated CSIR-CIMAP technologies in various exhibitions at different state and national levels. Actively participated at Gorakhpur, Delhi, Varanasi, and Nagpur exhibitions. With these efforts and initiation, a large number of youth, women, and farmers were motivated toward the CIMAP mission program and technologies.

7. Export Performance of Palmarosa oil in India

The study attempts to examine the annual and compound growth rate in the export of Palmarosa

oil. The time-series data for years from 2000 to 2020 was analysed by using a growth model. Quantitative analysis was used to perform descriptive statistics, linear and exponential, and quantum change estimation using exclusively on secondary data. The results revealed that the compound growth rate (CGR's) of export of Palmarosa oil was statistically significant at 1 percent probability level. The quantity export compound growth rate was 22.33 percent per annum, and exported value was 39.17 percent per annum. The maximum and positive to negative annual growth rate of the export of Palmarosa oil during the entire study period and instability have been directly related to each other. The top three countries USA, France, and Spain recorded significant imports (quantity and value) of Palmarosa oil from India. The result also reveals that the most significant change in quantity export increase was more prominent in Spain, and value export increased in Australia during 2019-20 over the previous year.

8. Potential of Indian Menthol Mint Oil in Production and Export

The present study is an attempt to examine the growth potential and instability in the area, production, productivity, and export of menthol mint oil. The time-series data for the period of 2000-01 to 2017-18 has been analysed by using growth and instability models. The study revealed that compound growth rates (CGRs) of area, production, productivity, quantity, and exported value have shown a positive growth trend and are statistically highly significant. The instability indices have been measured in terms of adjusted co-efficient of variation and accounted to be 28.74, 28.96, 2.14, 32.03, and 63.39 percent respectively. From the results, growth rates and instability have been simultaneously associated with each other. Although, the productivity of menthol mint marginally accelerated in spite to realize more stability followed by area, production, and export quantity and value. The export of menthol mint oil witnessed a remarkable positive growth trend with low future trading risk.

9. Publication of Extension Literature/ Publicity folders/ Brochures

1. Aus Gyanya was published and released on the occasion of Kisan Mela-2022.
2. A successful project on Demonstration of Cultivation, Processing, and Value Addition of Aromatic Crops in Bundelkhand Region published on the occasion of Kisan Mela-2022.
3. Aromatic Crops Suitable for Hardoi Region published on the occasion of Kisan Mela-2022.
4. CSIR-CIMAP brochure.

Dr. Manoj Semwal Mk- eukt leoky

Hyperspectral Vegetation Indices offer insights for determining economically optimal time of harvest in *Mentha arvensis*

Continual crop monitoring and harvesting at optimum time to ensure maximum economic returns is a huge challenge for farmers having small landholdings in Indo-Gangetic plains where *Mentha arvensis* is a popular cash crop. The present study evaluates different hyperspectral indices for phenotyping the canopy of *M. arvensis* winter crop (cv. CIM-Kranti) for detection of optimum harvest time using ground-based plant traits. Field experiments were conducted during mid-crop growth stage to late crop growth period for two consecutive years using hyperspectral camera (400 - 940 nm) to acquire images representing the spectral reflectance of crop canopies. Numerous hyperspectral vegetation indices (HVIs) derived from these images were further evaluated with an aim to identify those hyperspectral indices showing a strong correlation to measured crop parameters. Out of the 18 HVIs, 4 HVI's i.e. carotenoids reflectance index (CRIr), hyperspectral normalized difference vegetation index (HNDVI), photochemical reflectance index (PRI), and plant senescence reflectance index (PSRI) were found to have potential as predictors for sucker biomass as well as sucker girth and thereby indicators of optimum harvesting time for *M. arvensis* winter crop (cv. CIM-Kranti) cultivated primarily to produce suckers for crop propagation. Our results show promise for the development of non-destructive methods for the detection of optimum harvest time using crop reflectance. This study holds importance for the menthol mint farmers, who cultivate the crop for suckers during winter months for additional income generation.

Non-invasive Estimation of Foliar Nitrogen Concentration Using Spectral Characteristics of Menthol Mint (*Mentha arvensis* L.)

Menthol mint (*Mentha arvensis* L.), popularly known as corn mint or Japanese mint, is an important industrial crop that is widely grown for its valued essential oil. Nitrogen (N) is an important macro-

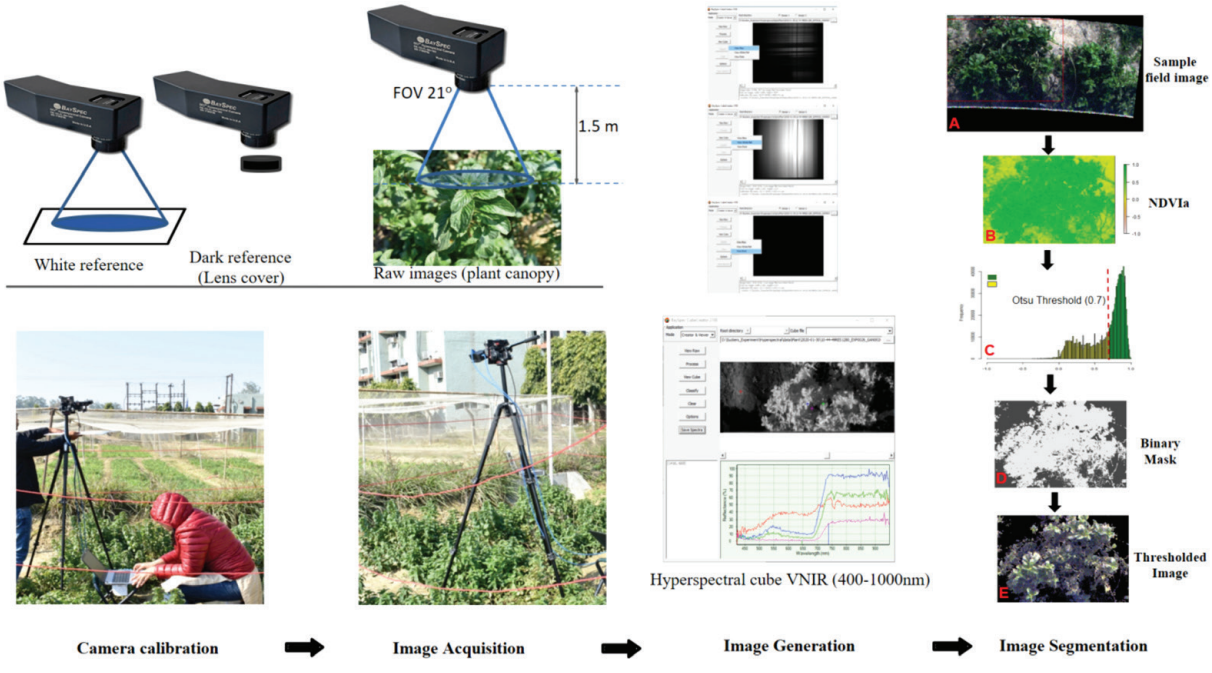


Fig. Schematic representation of hyperspectral data acquisition for optimal time of harvest for *Mentha arvensis*

nutrient and an essential factor for optimizing the yield and quality of crops. Hence, rapid and accurate estimation of the N content is crucial for nutrient diagnosis in plants and to make precise N fertilizer recommendations. Generally, N concentration is estimated by destructive sampling methods; however, an indirect assessment may be possible based on spectral characteristics. Research studies were conducted to compare the foliar N concentration based on non-destructive (reflectance) and destructive (laboratory analyses) methods in menthol mint. Foliar N concentration was measured through the Kjeldahl method and reflectance by Miniature Leaf Spectrometer C-710 (CID Bio-Science). Using reflectance data, several vegetation indices (VIs), that is, normalized difference red edge (NDRE), red edge normalized difference vegetation index (reNDVI), simple ratio (SR), green–red vegetation index (GRVI), canopy chlorophyll content index (CCCI), photochemical reflectance index (PRI), green chlorophyll index (CIGreen), red edge chlorophyll index (CIRed Edge), canopy chlorophyll index (CCI), normalized pigment chlorophyll ratio index (NPCI), and structure insensitive pigment index (SIPI), were developed to determine the foliar N concentration.

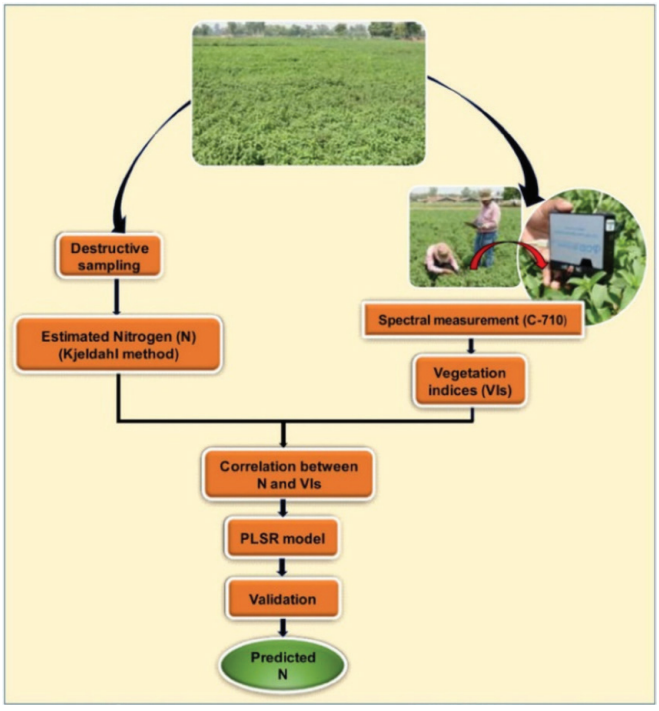
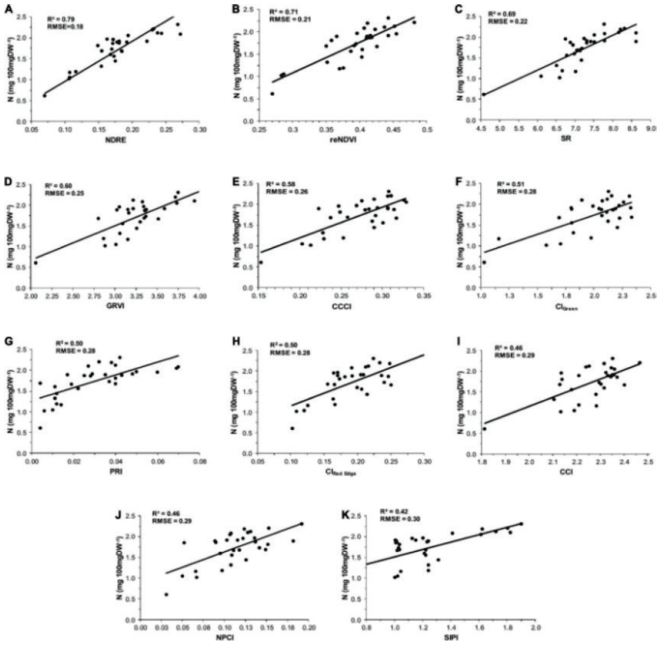


Fig. Research methodology



Relationship between foliar nitrogen concentrations and vegetation indexes

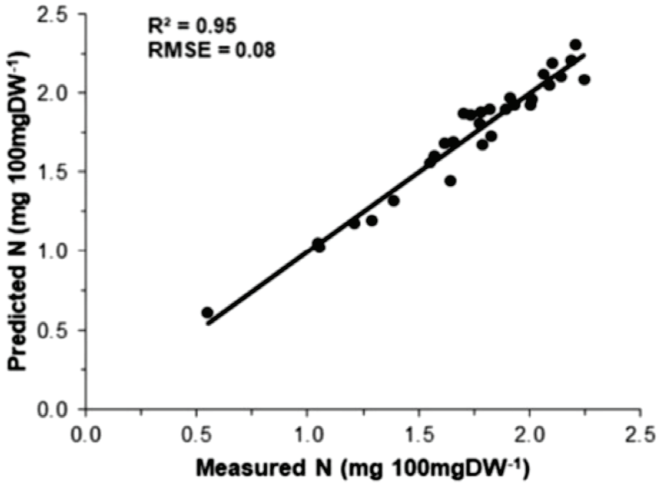
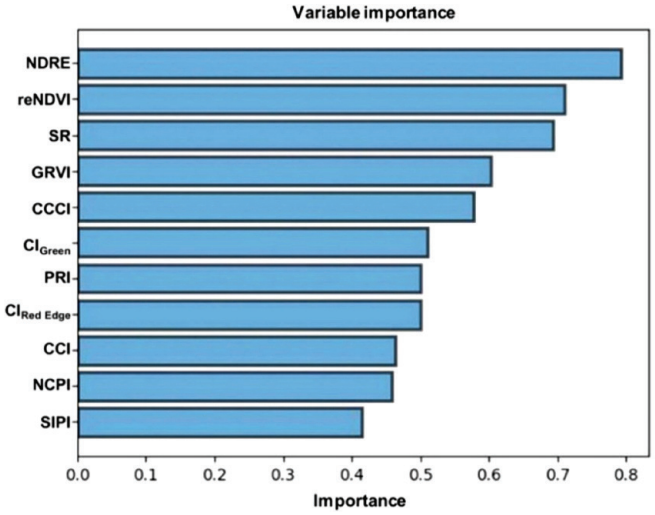


Fig. Relationship between measured and predicted nitrogen concentrations

The highest correlation (r) between VIs and foliar N concentrations was achieved by NDRE (0.89), followed by reNDVI (0.84), SR (0.83), GRVI (0.78), and CCCI (0.76). Among the VIs, the NDRE index has been found to be the most accurate index that can precisely predict the foliar N concentration (R2 = 0.79, RMSE = 0.18). Our results showed that the N deficiencies faced by the crop during its growth period can be detected effectively by calculating NDRE and reNDVI, which can be used as indicators



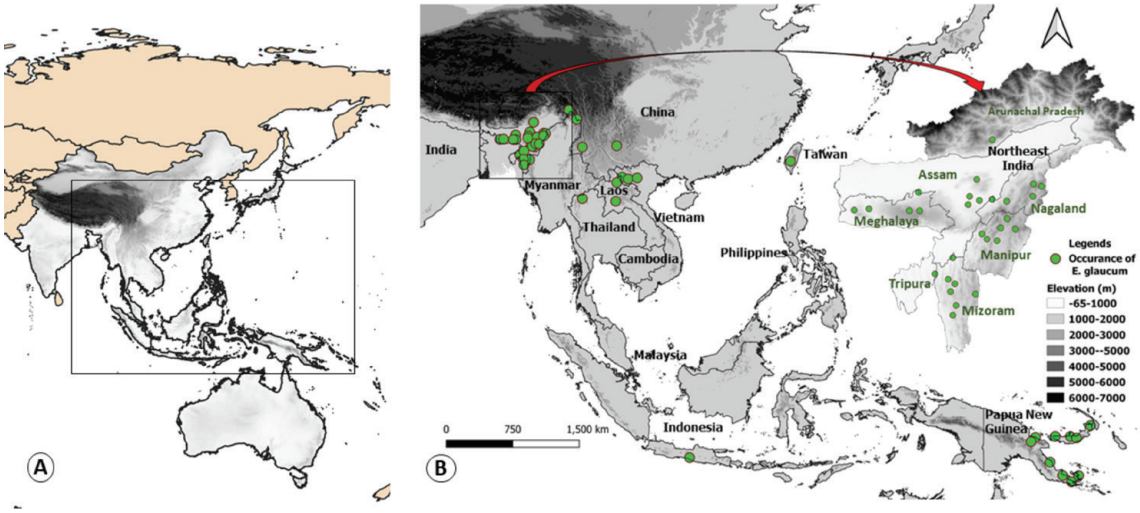
Independent variables with their respective importance values.

for recommending precise management strategies for the application of nitrogenous fertilizers.

Predicting potential suitable habitat for *Ensete glaucum* (Roxb.) Cheesman using MaxEnt modelling

Ecological niche models (ENMs) and species distribution models (SDMs) are widely used to predict suitable habitat for plants and animals. In the present study, we used MaxEnt ecological niche modelling to identify the potential suitable habitat for *Ensete glaucum*—a pseudo banana species found in Northeast India, Yunnan region of China, Southeast Asia, and Papua New Guinea. Fifty-one occurrence records along with 19 bioclimatic and three topographic variables were used for the modelling. The model accuracy was tested using the area under the receiver operating curve (AUC) metric, and each variable's contribution was estimated using a Jackknife test. Highly suitable regions were observed in the Indo-Burma region with an area of 58,371 km^2, while less suitable regions were observed in most of the countries of Southeast Asia. The potential habitat suitability of *E. glaucum* was mainly influenced by three bioclimatic variables (precipitation of warmest quarter, temperature annual range, and mean diurnal range) and one topographic variable (slope). The predicted suitable habitat regions (high, medium, and low) can be used for future explorations to study the morphological and genetic diversity in *E. glaucum* and to conserve the genetically diverse and vulnerable populations of this banana crop relative.

Dr. Manoj Semwal & his team



Study area used for distribution modelling of *Ensete glaucum*

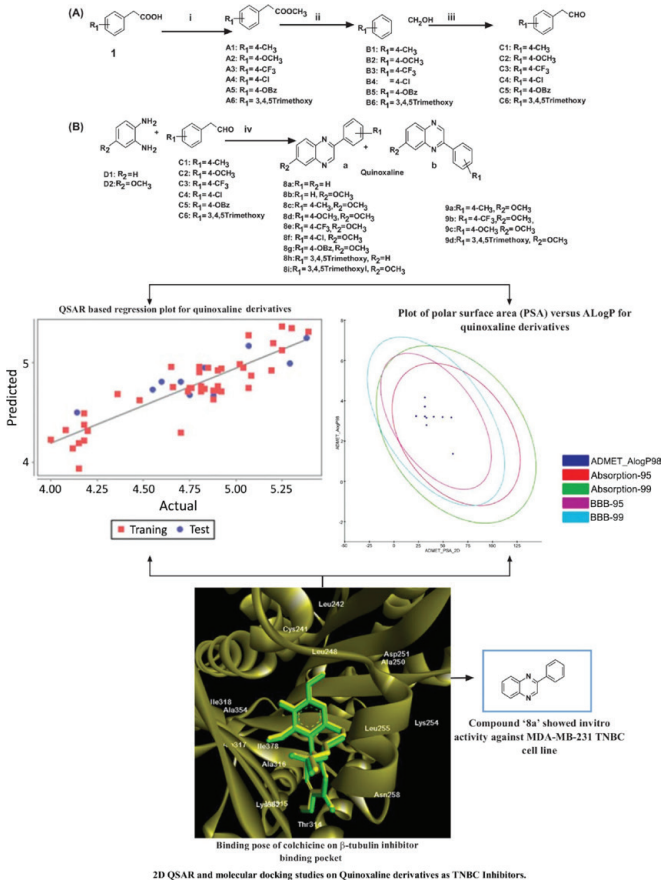
Dr Feroz Khan Mk- fQjkt [kku

Synthesis, molecular docking and 2D-QSAR modeling of quinoxaline derivatives as potent anticancer agents against triple-negative breast cancer.

Breast carcinomas aka triple-negative breast cancers (TNBC) are one of the most complex and aggressive forms of cancers in females. Recently, studies have shown that these carcinomas are resistant to hormone-targeted therapies, which makes it a priority to search for effective and potential anticancer drugs. The present study aimed to synthesize and develop the 2Dquantitative structural activity relationship model (QSAR) of quinoxaline derivatives as a potential anticancer agent.

Quinoxaline derivatives were designed and synthesized (8a-8i and 9a-9d) and the 2DQSAR model against TNBC was developed using VLife MDS v4.4. The anticancer activity was investigated against the TNBC MDA-MB-231 cell line using an MTT cytotoxicity assay. Molecular docking studies along with the estimation of ADMET parameters were done using Discovery Studio. The most potent compound was docked against the β-tubulin protein target (PDB: 4O2B), using the Autodock Vina v0.8 program.

Eleven derivatives of quinoxaline were designed and synthesized (8a-8i and 9a-9d) and a 2D-QSAR model was developed against the TNBC MDA-MB231 cell line. The regression coefficient values for the training set were (r2) 0.78 and (q2) 0.71. Further, external test set regression (pred_r2) was 0.68. Five molecular descriptors viz., energy dispersive (Epsilon3), protein-coding gene (T_T_C_6), molecular force field (MMFF_6), most hydrophobic hydrophilic distance (XA), and Zcomp Dipole were identified. After ADMET, the best analog 8a showed the best activity against the TNBC cell line. The best-predicted hit '8a' was found to bind within the active site of the β-tubulin protein target.



2D QSAR and molecular docking studies on Quinoxaline derivatives as TNBC Inhibitors.

The newly synthesized quinoxaline compounds could serve as potent leads for the development of novel anti-cancer agents against TNBC.

Other Research Involvements

- Developed a machine learning supervised regression model for quantitative structure-activity relationship of Triterpene derivatives based on cytotoxic activity of triple-negative breast cancer cell line (TNBC) MDA-MB231 and explored the binding mode of action through molecular docking simulation targeting beta-tubulin.
- Reviewed the phenolic compounds and studied the structure-activity relationship.
- Explored the binding mode of action of pure compounds and its derivatives of *Tetrastigma sulcatum* leaf extract through molecular docking and validated *in-vitro* and *in-vivo* for anti-inflammatory activity.
- Performed the bioinformatics sequence analysis of Triterpenoid Biosynthetic Pathway Gene

HMGS in Centella Asiatica (Linn.) and later validated through Molecular Cloning and Characterization.

- Performed *in-silico* Antihyperglycemic Activity of some Semi-synthetic Phytol Derivatives later validated through in-vitro & in-vivo studies.
- Performed molecular docking studies on eugenol hybrids obtained by Mannich and 1, 3 dipolar cycloaddition reactions and later synthesized and evaluated for biological bioactivity.
- Performed the molecular docking studies on substituted amide derivatives of C4-ageratochromene dimer analog and later synthesized and evaluated for biological evaluation.
- Performed molecular modelling studies on indolyl chalcone derivatives and later synthesized and evaluated for antimalarial activity.
- Performed molecular docking studies on synthesized novel hybrids of Thiazolidinedione-Triazoles as Potential Lipase and a-glucosidase Inhibiting Agents.
- Performed molecular docking studies, guided design, synthesis of diarylindoles for broad spectrum antibreast cancer activity through induction of apoptosis in aggressive breast cancer cells.
- Performed molecular docking studies to explore binding mode of action of Diarylnaphthofurans for antiproliferative activity through microtubule destabilization.
- Performed molecular docking studies and guided synthesis of indanocine and antiproliferative activity of 2-benzylindanocine via microtubule destabilization.
- Performed in-silico studies and in-vitro validation of Camptothecin derivatives for anticancer activity against human liver HepG2 and lung A549 cancer cell lines.
- *In-silico* explored the mechanism of action of antihypertensive effect of a novel angiotensin II receptor blocker Fluorophenyl Benzimidazole and validated predictive results with in-vitro/in-vivo experiments. Results revealed contribution of cGMP, voltage-dependent calcium channels, and BKCa channels to vasorelaxant mechanism.
- *In-silico* molecular docking based explored the mechanism of action of Swertiamarin from *Enicostemma littorale*, counteracts PD associated neurotoxicity via enhancement α-synuclein suppressive genes and SKN-1/NRF-2 activation through MAPK pathway.
- Studied *in-silico* structure-activity relationship of Brevifoliol and its analogs: a new class of Antitubercular agents.
- Developed the R-package tool namely '**QSARTNBC**' for predicting cytotoxic/ anticancer activity of Triterpene & Quinoxaline class of compounds based on MLR QSAR model using in-vitro inhibitory activity data of small molecules against Triple Negative Breast Cancer (TNBC) cell line MDA-MB231.

Dr Feroz Khan & his team

Dr Bhaskar Shukla Mk- HkkLdj 'kDyk

Identification of long non-coding RNAs in MAPs

The non-coding RNA has gotten a lot of interest in the scientific community over a few decades because of its involvement in gene regulation. Experimentally validated plant lncRNAs have been shown to regulate important agronomic traits such as phosphate starvation response, flowering time and interaction with symbiotic organisms, making them of great interest in plant biology and in breeding. The application of new generation sequencing has allow for a more thorough analysis of non-coding RNAs.

The LncRNAs still remain uninvestigated in most of sequenced plant species. Therefore, we detected and analyze the lncRNAs of eight plant species (*Solanum nigrum, Menthaaquatic, Salvia sclarea, Phyllanthus emblica, Hyoscyamus niger, Chlorophytum borivilianum, Azadirachta indica, and Ocimum tuniflorum*) using lncRNADetector webserver (https://lncrnapipe.cimap.res.in). The lncRNADetector has been utilized to analyse and identify more than 836 lncRNAs from 5661 transcripts from 21 species of MAPs. For validation, we also compared result with other three lncRNA State-of-the-art that use sequencing data and annotate non-coding RNA. They include the LGC, CPC2, and CNIT web server. The summary of identified lncRNAs and comparative validation with other tools is shown in table.

Summary of identified lncRNAs in various medicinal and aromatic plant species.

Medicinal and aromatic plant species	Total number of nucleotide sequences in the dataset	Number of identified lncRNAs (All filters including blastx against pataa only)	Number of identified lncRNAs (All filters including blastx against pataa and nr both)	lncRNA-Detector - identified lncRNAs validated through CPC2	lncRNA-Detector-identified lncRNAs validated through CNIT	lncRNA Detector-identified lncRNAs validated through LGC
Ocimum tuniflorum	316	127	124	149	149	115
Solanum nigrum	508	50	38	38	38	38
Mentha aquatica	127	63	62	62	62	62
Salvia sclera	249	13	9	9	9	9
Phyllanthus emblica	152	49	48	48	48	48
Chlorophytum borilianum	780	193	187	185	183	187
Hyoscyomus niger	2328	265	219	219	211	217
Azadirachta indica	1201	155	149	149	149	149

Dr Bhaskar Shukla & his team

Dr. Alok Krishna Mk- vykd d".kk

Influence of lemongrass (Cymbopogon flexuosus (Nees ex Steud.) essential oil yield under inter - cropping with pomegranate (Punica granatum L.) with special reference to the plant - soil relationship

A comparison between pomegranate trees was intercropped with lemongrass crop and regular orchards with full sun conditions have been investigated in terms of yield of lemongrass essential oil and pomegranate fruit quality. The intercropped microclimate was more favourable for the production of lemongrass essential oil and pomegranate arils with attractive red colour and high total anthocyanin content. Pomegranates under these conditions contained total volatile content that was about two times higher than that in separate fruits. Particularly, hexanal and limonene were the most abundant compounds characterizing the aroma profile of fruits cultivated under intercropped, and their arils were the most appreciated in terms of colour, odour, and taste by Indian consumers. The correlations between intercropped varieties of pomegranate and lemongrass, irrigated water, soil, and manure factors, elevated moisture in the soil in the intercropping impaired the expression of high yield of fresh herb and lemongrass oil of the good quality and pomegranate fruits production.

Organic source on productivity of pomegranate– lemongrass-based agroforestry system in central India

Abstract The present study was conducted to assess the response of organic sources of nutrition on productivity of pomegranate (Punica granatum L.) and lemongrass (Cymbopogon flexuosus Stapf.) under agroforestry system in central India. The experiment was designed in Factorial Randomized Block Design with two cultivars of pomegranate (V1—Ganesh and V2—Bhagwa) and four levels of nutrient management [T1—vermicompost (30 kg/plant), T2—farm yard manure or FYM (30 kg/plant), T3—vermicompost (30 kg/plant) ? FYM (30 kg/plant) and T4—recommended doses of chemical fertilizers (RDF)]. A control of pure lemongrass was also maintained separately. Findings revealed that vermicompost either alone or in combination with FYM was more effective than the chemical fertilizer in influencing almost all the studied plant characters. The minimum fresh biomass and oil recovery were observed in T2. Pure lemongrass (control) plot yielded highest fresh biomass as well as oil recovery in all the 3 years of the study period. In nutshell, it is concluded that organic sources of nutrition in general and vermicompost in particular proved to be more effective than the chemical sources of nutrition for sustainable productivity from the pomegranate–lemongrass-based agroforestry system in rainfed conditions.

Skill Development Training Programme

During the period, three Skill Development training programme on "Cultivation, Processing and Processing of Economically Important Medicinal & Aromatic Plants (MAPs)" have been organized at CIMAP, Lucknow.

National & International Programs

CSIR-Aroma Mission Phase-II

PROGRESS AT A GLANCE

Total Area Covered (ha)	4500
Total Distillation Units Installed	05
Total Varieties Developed	01
Total Awareness/ Training Programs	73
Total Manpower Trained	7965

The second phase of CSIR Aroma Mission started in the year 2020. Under this phase, the target of CSIR-CIMAP is to bring about 13,000 ha area under cultivation of high-value aromatic crops in addition to the development of 08 high-yielding and resource-use efficient varieties of selected aromatic crops. Further, the development of eleven region-specific and problem solving agro-technologies of different crops along with installation of 102 improved and fuel-efficient distillation units at farmers' fields for helping them in the processing is to be achieved. In addition, about 250 awareness/ training/ skill development programmes have to be conducted by March 2023.

CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), in the second year of the Phase-II, continued to endeavour towards expansion of area and about 4500 hectares of additional land was successfully covered under aromatic crops. About 05 distillation units were installed in farmers' fields. CIM-Nandi, a high-yielding clone of *Eucalyptus citriodora* with high content of citronellol

Lemongrass plantation at Wanaparthy, Telangana

Geranium cluster in Meghalaya

Palmarosa cultivation in Jharkhand tribal region

Tulsi cluster in Madhya Pradesh

Distribution of Lemongrass quality planting material to farmers in Telangana

Distribution of Geranium quality planting material to farmers in Uttarakhand

Distribution of Geranium quality planting material in Maharashtra

Planting of Citronella in Gajapati, Odisha

was released for commercial cultivation Also, more than 70 awareness/ training/ skill development programmes have been organized in which more than 7900 human resources have been trained including 1500 women. CSIR-CIMAP has signed 12 MoUs with various organizations/ NGOs/ Universities/ State Government/ Corporate sector, FPOs, etc. in the year 2021-22.

CSIR-CIMAP has achieved considerable success in its efforts to achieve the targets set under the second phase of the mission, and will meet the targets within the defined time period. Emphasis has already been given to include aspirational districts and other regions or districts which are frequently affected by the vagaries of weather like floods, cyclones and droughts. Furthermore, the unutilized fields are also being brought under cultivation by introducing some stress-tolerant crops. Even in areas where traditional crops are commonly affected by animal attacks, several aromatic crops have been introduced that are not damaged by wild or domestic animals. The mission provided crop alternatives to the farmers, especially tribals, economically weaker sections having small landholdings, to achieve higher incomes even from a small piece of farmland.

A separate vertical for value-addition is part of the Aroma Mission programme, where technology related to value-addition is being developed so that the farmers' income could be increased. Efforts are also being made to connect the user industry

with the farmers so that they may earn a fair price for their produce without having to go through a middleman. In addition, frequent meetings involving all the stakeholders including farmers, industry and scientists, are being arranged to examine and address the industry's needs as well as the difficulties faced by farmers. The institute has been conducting frequent awareness or training programmes for the skilling of the farmers and to make them aware about the appropriate crop varieties and agro-technologies for maximizing their yields. CSIR-CIMAP has also popularized waste utilization especially distillation waste and flower offering in various places of worship by conducting training-cum-demonstration programmes for women on making incense sticks and fragrant cones.

One-Day Awareness Programme Conducted at Kondagaon, Chhattisgarh

Awareness programme organized at Forestry College, Ponnampet (University of Agricultural and Horticultural Sciences, Shivamogga), Kodagu, Karnataka by CRC, Bengaluru

Awareness Programmes Conducted at Praharajapalem, Srikakulum, Andhra Pradesh and Marikal, Narayanpet, Telangana by CRC, Hyderabad

Kisan Goshthi, CRC, Pantnagar

Kisan Mela-2022, CSIR-CIMAP, Lucknow

Training cum Workshop organized at Indira Gandhi National Tribal University (IGNTU), Amarkantak, MP

MoU Signed with Dr Balasaheb Sawant Konkan Krishi Vidyapeeth (BSKKV), Dapoli, Maharashtra

In clusters where a large number of farmers are cultivating aroma crops, infrastructural support in the form of improved processing facilities has been provided to reduce post-harvest processing losses. Several Aroma Mission beneficiaries cultivating these crops have gone on to become successful entrepreneurs, making essential oil-based formulations or products and employing many others in rural areas.

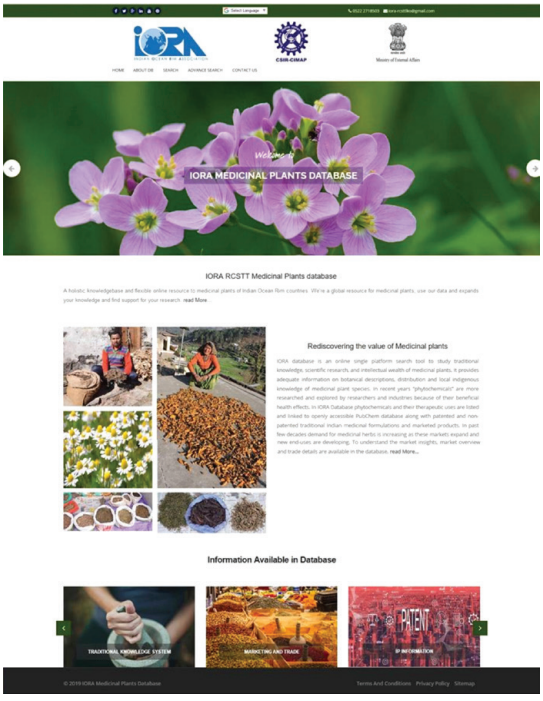
Distillation Unit Installed in Meghalaya

Training cum Demonstration of Essential Oil Distillation at Banda, Uttar Pradesh

IORA-RCSTT Coordination Centre on Medicinal Plants (ICCMP)

IORA-RCSTT Coordination Centre on Medicinal Plants (ICCMP), CSIR-CIMAP, Lucknow, India is engaged in strengthening regional cooperation and sustainable development among 23 Member States and 10 Dialogue Partners in the field of highly traded Medicinal and Aromatic Plants. The centre is striving to establish close link between Scientists, Researchers, Institutes, Farmers, Industry, and other stakeholders for knowledge dissemination and equitable benefit sharing.

The high demand of medicinal plant material has increased trading at domestic and international levels. Monetary value of medicinal plants is growing with new research findings, but the information on medicinal plants is still limited and scattered throughout the world. Fuller acquaintances of local people about their native medicinal flora and their local uses can give leads towards discovery of new chemical compounds in future. In addition, protection and sharing of ethno-botanical knowledge helps in awareness about their sustainable utilization, legal mechanisms of intellectual property, access and benefit sharing. Medicinal Plants based databases are helpful for researchers, traders, industrialists, policy makers, stakeholders and other end users for knowledge sharing and scientific advancement.



ICCMP is engaged in developing an online comprehensive IORA medicinal plants database. The developing database is going to be helpful for researchers, traders, industrialists, policy makers, stakeholders and other end users for knowledge sharing and scientific advancement. ICCMP is digitalizing the medicinal plant information i.e., botanical, chemical, ethno- pharmacological, patents, market research and agriculture data of highly trade medicinal plants. The Centre is collecting and compiling information of medicinal and aromatic plant species from 23 IORA countries i.e., Commonwealth of Australia, People's Republic of Bangladesh, Union of Comoros, French Republic, Republic of India, Republic of Indonesia, Islamic Republic of Iran, Republic of Kenya, Republic of Madagascar, Malaysia, Republic of Maldives, Republic of Mauritius, Republic of Mozambique, Sultanate of Oman, Republic of Seychelles, Republic of Singapore, Federal Republic of Somalia , Republic of South Africa, Democratic Socialist Republic of Sri Lanka, United Republic of Tanzania, Kingdom of Thailand, United Arab Emirates and Republic of Yemen.

ICCMP Team Members


Dr. Anirban Pal


Dr. Jitendra Kumar


Dr. Deepa Bisht

International Science and Technology Affairs Group (ISTAG)

The International S&T Affairs Group (ISTAG), looks into the visits of the International visits of personnel primarily aimed at international collaborations. The team at CSIR-CIMAP comprises of Dr. Anirban Pal, Dr. Vikrant Gupta, Dr. Suaib Luqman, Dr. V.Sundaresan, Dr. Ramesh K Srivastav, Dr. Narendra Kumar, Dr. Akanksha Singh and Dr. Ratnasekhar C.H. The following International Affairs were taken care of during the year 2021-22.

Meetings:

CSIR-CIMAP had held an online meeting with National Institute of Medicinal Materials (NIMM), Hanoi and Vietnam's Office of Science and Technology (VOST) on 11th November, 2021. The primary agenda was to discuss the possibilities of mutual cooperation and collaboration between CSIR, India, CSIR-CIMAP, and NIMM,VOST in the field of Agrotechnology, Phytochemistry, Bio-prospection and Biotechnology. Following up the meeting, The Institute of Medicinal Plant Research and Development, Vietnam National University of Agriculture (VNUA), organized an International conference on "Asian herbal medicines: Potentials, Challenges and Opportunities for Development" in Hanoi in December 2021. Dr. V. Sundaresan, Dr. D. Chanda and Dr. R.K.Srivastava delivered their talks in their relevant fields.

Another meeting on the possibility of collaboration in the field of herbs and Medicinal Plants was held on 28th March, 2022 between the National Agency for Technology Entrepreneurship and Commercialization Development, Vietnam & CSIR-Central Institute of Medicinal and Aromatic Plants, India. The meeting was attended by nine persons of eminence from Vietnam and eight from CSIR-CIMAP. The primary discussion was on the technologies that Vietnam is interested in taking up directly for commercialization by their enterprises.

Besides the two above meetings, active communications have been taking place between CSIR-CIMAP and countries like Uzbekistan, Uganda and Mozambique.

Visits:

Prof. Mohamed Fahad AL Ajmi from King Saud University and a Vice Minister Consultant for Aromatic and Medicinal Plants of the Kingdom of Saudi Arabia visited CSIR-CIMAP to introspect the possibilities of collaboration between the two countries in the area of Medicinal and Aromatic Plants. He visited the Institute on 25th November, 2021 and was briefed about all the facilities at CSIR-CIMAP.

Dr. Jabborova Dilfuza from the Institute of Genetics and Plant Experimental biology, Uzbekistan. She has recently been given the responsibility of establishing Medicinal Plant Research and that is where she narrowed on our Institute. She visited CSIR-CIMAP on 19th August, 2021.

International Science and Technology Affairs Group (ISTAG) Group at CSIR-CIMAP

Dr. Anirban Pal | Dr. Vikrant Gupta | Dr. Suaib Luqman | Dr. V.Sundaresan | Dr. R.K Srivastava | Dr. Narendra Kumar | Dr. Akanksha Singh | Dr. Ratnasekhar CH

Science & Technology

Variety Released

CIM–NANDI ¼f l e&unh½: High-oil and high-citronellal *Eucalyptus citriodora* clone

Eucalyptus citriodora (EC) is an important aromatic tree species endemic to north-eastern Australia and commonly known as lemon-scented gum or spotted gum. The essential oil of the EC mainly consists of monoterpene aldehyde citronellal. Oil from the *Eucalyptus* tree is used in perfumery, insect repellents (especially against mosquitoes), and in antiseptic and fumigation agents. In India, the crop is under commercial cultivation mainly in Karnataka, Andhra Pradesh, Tamil Nadu, Assam, and Maharashtra. One of the important aspects of this crop is, it can be successfully grown in poor soils and ravine areas and crop is tolerant to clay, drought, gravel, laterites, light frosts, podzols, poor soil, and slopes, but is not

Fig. Field view of CIM-Nandi

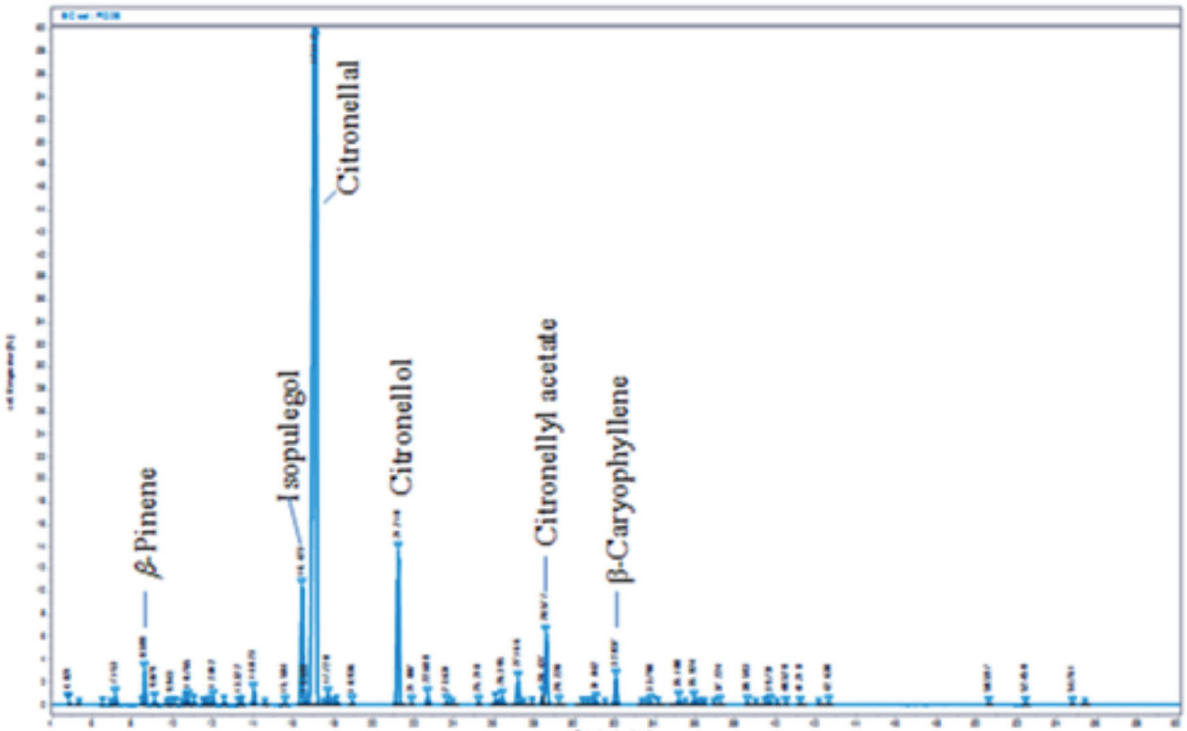


Fig. : GC-FID Chromatogram of CIM-Nandi

very tolerant to waterlogging. The world essential oil production of EC is 250 tons/year, however estimated requirement is >1000 tons/year. So, it is very much essential to increase the oil production to meet out the demands of the industries. Looking into these aspects, we have developed a EC clone with high-oil yielding and high-citronellal content. The new clone gives herb yield of 5-6 t/acre/harvest and oil yield of 80-100kg/acre/harvest.

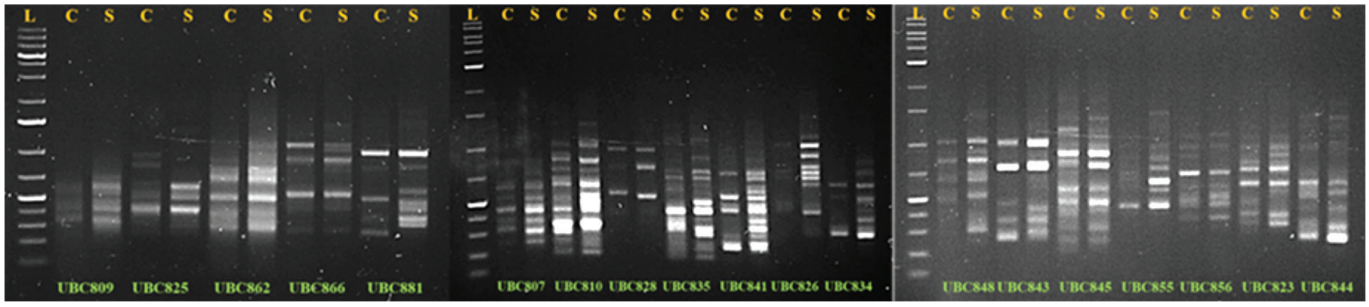


Fig. ISSR Markers Molecular profile of CIM-Nandi

Description of the new clone CIM-NANDI	
Attributes	**Contents**
100 Seeds weight	0.725 ± 0.005
Leaf Length (cm)	21.78 ± 0.66
Leaf Width (cm)	3.65 ± 0.45
Petiole length (cm)	2.50 ± 0.50
Herb yield (t/Acre/h) (Estimated)	5.375 ± 0.131
Oil content (%) (Clevenger)	2.99 ± 0.015
Oil content (%) (30 kg capacity unit)	1.80-2.20
Oil yield (kg/Acre/h) (Estimated)	14.50-16.00
Citronellal (Clevenger)	88.00 ± 1.31
Citronellal (%) (30 kg capacity unit)	80.17 ± 3.38

Recommended agronomical Practices	
Planting	Round the year, ideal time of planting during monsoon season
Seed material	100-150 g/acre
Spacing	Plant to Plant Spacing - 1 meter Row to Row spacing - 1 meter
Suitable planting condition conditions	Suitable for irrigated, rain fed conditions, degraded waste land high suitable
Practice of nipping	Planting after 9 months nipping is recommended to reduced plant height and more branching.
Harvesting	I harvest: 14 Months II and subsequent: 110-120 days
Herb Yield (t/acre/harvest)	5 to 7
Oil yield (kg/acre/harvest)	80 - 100

On the occasion of CSIR-CIMAP Kisan Mela on 29th January 2022, a new citronellal-rich and high-oil yielding variety CIM-NANDI of *Eucalyptus* was released for commercial cultivation by Dr. Shekhar C. Mande, Secretary, DSIR and DG, CSIR.

Team: Channayya Hiremath, K. Baskaran, V. Sundaresan, Dinesh A. Nagegwoda, Ram Swaroop Verma, K.V.N. Satya Srinivas, Niranjan Kumar, V.S. Pragadheesh, Swati Singh and Alok Kalra

Exhibition

Regional Fruit-Vegetable and Flower Exhibition at Raj Bhavan, Lucknow

CSIR-CIMAP, Lucknow participated in the "Regional Fruit-Vegetable and Flower Exhibition" held on 4-6, March 2022 at Raj Bhavan, Lucknow, Uttar Pradesh. CSIR-CIMAP was awarded the best score in cut flowers of roses for participating in various classes in this exhibition. CIMAP received 51 awards (1st prize-16, second-14, third-21) in different categories. CIMAP received three awards for the best score in the cut flowers of roses and one for the best rose of the show for participating in different classes.

1. Late Shri Shivghan Yadav Chal Vaijayanti Award
2. Late Shri Abdullah Chal Vyjayanthi Award
3. Shri Rajypal Vyjayanthi Award
4. Late Smt. Kripa Sinha Memorial Trophy (Best Rose of the show)

Award Presented by Hon'ble Governor Madam Smt. Anandiben Patel, Uttar Pradesh

The awards placed on the desk of CIMAP were viewed by the Director, CSIR-CIMAP

CIMAP Publications

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संस्थान द्वारा गृह राजभाषा पत्रिका 'औस विज्ञान' वर्ष 2021, अंक–1 और 2 का प्रकाशन हो चुका है। इस पत्रिका में संस्थान के विभिन्न वैज्ञानिकों, शोधार्थियों, प्रशासनिक, तकनीकी अधिकारियों, कर्मचारियों द्वारा सीमैप प्रयोगशाला में हो रहे शोध एवं विकास कार्यो को हिन्दी के माध्यम को प्रोत्साहित करने हेतु प्रस्तुत किया गया है। यह पत्रिका हमारे भावों की वाहिनी होने के साथ–साथ हमारी प्रगति को जन–जन तक पहुँचाने का सबल माध्यम है।

औषधीय एवं सगंध पौधों के अनुसंधान से होने वाले लाभ जनसाधारण तक पहुँचाने के लिये 'औस विज्ञान' तत्पर है। एक ओर जहां अनुसंधान व ज्ञान का लाभ सभी तक पहुँचाने में 'औस विज्ञान' जुटी है, वही हमारी मातृ भाषा का उपयोग वैज्ञानिक उपलब्धियों को यथार्थ में परिवर्तित कर पाना संभव हो पा रहा है। औस विज्ञान पिछले वर्ष से अधिक योगदान 'विज्ञान से सशक्त समाज' की परिकलपना के लिये देने में सफल हो सकी है।

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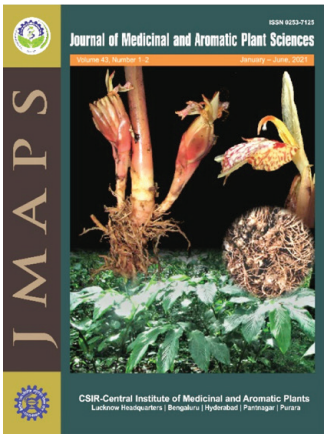
औषधीय एवं सगन्ध पौधों की उन्नत कृषि तथा प्रसंस्करण प्रौद्योगिकियों की वैज्ञानिक स्मारिका है। सीएसआईआर–सीमैप प्रति वर्ष किसान मेला कार्यक्रम मे औषधीय एवं सगंध कृषि तकनीकियों एवं उनके प्रसंस्करण आधारित उद्योग तथा व्यापार संबंधी महत्वपूर्ण जानकारी को किसानों मे प्रचार–प्रसार करने हेतु "औस–ज्ञान्या" पुस्तिका का प्रकाशन करता है। "औस–ज्ञान्या" पुस्तिका की उपयोगिता के कारण प्रतिवर्ष यह किसानों के बीच लोकप्रिय होती जा रही है। इस स्मारिका मे औस फसलों के कृषि तकनीकियों की जानकारी दी गयी है तथा बाजार भाव संबंधी महत्वपूर्ण जानकारी देने का प्रयास किया गया है। इसका मुख्य उद्देश्य किसानों द्वारा उत्पादित उत्पाद के क्रय–विक्रय मे महत्वपूर्ण भूमिका निभाना है। यह पुस्तिका हरस्सल लगभग 10000 से 15000 किसानों तक विभिन्न कार्यक्रमों के अंतर्गत पहुँचाई जाती है।

Journal of Medicinal and Aromatic Plant Sciences



Journal of Medicinal and Aromatic Plant Sciences (ISSN 0253-7125; NLM ID: 9801900), popularly known as *JMAPS*, is a peer reviewed quarterly journal published from CSIR-CIMAP. The Journal was incepted in 1979 under the popular name of *Current Research on Medicinal and Aromatic Plants* (CROMAP) and renamed as *Journal of Medicinal and Aromatic Plant Sciences (JMAPs)* in 1996. It is dedicated to publish the *Original Research Articles*, *Review Articles*, *Short Communications*, and *expert opinion* on different aspects of R&D related to Medicinal and Aromatic Plants (MAPs) following a double-blind peer review process. Besides, it also provides data on the production, utilization, foreign trade, as well as market trend analysis of MAPs and related products. An additional attraction of *JMAPS* is the registration reports on new varieties of MAPs.

The journal is covered by abstracting services of Medicinal and Aromatic Plants Abstracts (NISCAIR, India), Chemical Abstracts (USA), Plant Breeding abstracts, Review of Aromatic and Medicinal Plants (CAB International, Wallingford, UK) and Biosis Preview, USA.

During 2021-22, the journal published volume 43 covering its four issues *namely* Vol. 43(1-2), 2021 and Vol. 43(3-4), 2021. Vol. 43(1-2), 2021 featured seven Original Research papers, two Review Articles, and two Short Communications whereas Vol. 43(3-4), 2021 had seven Original Research papers, one Review Articles and two Short Communications.

Science and Technology

Inputs: Dr CS Chanotiya

MoU signed between CSIR-CIMAP & M/s PerkinElmer India Pvt Ltd, Mumbai

Under AROMA Mission Phase II programme, CSIR-CIMAP & M/s PerkinElmer India Pvt Ltd, Mumbai (PKI) has entered into a cooperative agreement to create Facility for "Detection of Adulteration in High Value Essential Oils" in order to meet the objectives effectively and time bound manner. As per the agreement, M/s PKI will install their high end instruments in CSIR-CIMAP and also provide the required service and application support.

Inputs: Er. G.D. Kiran Babu

Awareness programs conducted by CSIR-CIMAP Research Center, Hyderabad

CSIR-CIMAP Research Centre, Hyderabad has conducted several training cum awareness program on cultivation, value addition and post-harvest processing of aromatic crops. The details of trainings, field visits and demonstration programs are listed below:

S. No.	Program Date	Name of the Farmers' group/ College/ Institute/ Organization	Village Name/ Location	No. of Participants	Women Participants
1	30/7/2021	Farmers from Pamireddy Palli, ChekuruChettu Tanda, Chinukutanpally, Chilukatoni, Veltoor	ChikaruChettu Tanda, Wanaparthy, TS	24	18
2	12/10/2021	Farmers from Pamireddy Palli, ChekuruChettu Tanda, Chinukutanpally, Chilukatoni, Veltoor	ChikaruChettu Tanda, Wanaparthy, TS	80	50
3	21/10/2021	B. Pharma, 4th Year Students from Bharat Institutions, Ibrahimpatnam, Rangareddy District, Telangana	CRC-Hyderabad	70	42
4	02/11/2021	National Institute of Indian Medical Heritage, National Research Institute of Unani Medicine for Skin Diseases (Ministry of Ayush, Govt. of India)	Gaddiannaram Rd, Revenue Board Colony, Gaddiannaram, Hyderabad, TS	60	49

5	03/11/2021	Agricultural Extension Services for Input Dealers (DAESI) under the National Institute of Agricultural Extension Management (MANAGE), Govt. of India from Yadari-Bhuvangiri District	CRC-Hyderabad	40	0
6	10/11/2021	Six clusters from Dhanwad, Narayanpet, Damarigidda, Maddur, Makthal and MarrikalMandals, along with Sarpanches, MPO, DMP, APM, Cluster Coordinators, and Govt. officials from DRDA, District Agriculture Office, Narayanpet District, Telangana	CRC-Hyderabad	68	20
7	16/11/2021	Final year B. Pharmacy from NNR Education Society's Group of Institutions, Chowdariguda, Medchal District (TS)	CRC-Hyderabad	37	27
8	17/11/2021	B Pharmacy (3rd Year) from Nalla Narasimha Reddy Education Society's Group of Institutions, Korremula X Cross Road, Medchal District (TS)	CRC-Hyderabad	47	30
9	26/11/2021	Essential oils Buyer-Seller Meet-2021	CRC-Hyderabad	24	2
10	21/12/2021	Vision Pharmaceutical Sciences and Research, Hyderabad	CRC-Hyderabad	41	28
11	23/12/2021	Geetanjali College of Pharmacy, Cheeryal Village, Kesaraju Mandal, Ranga Reddy District, Telangana	CRC-Hyderabad	15	10
12	23/12/2021	Samskruti College of Pharmacy, Kondapur Village, Ghatkesar Mandal, Medchal District, Telangana	CRC-Hyderabad	54	23
13	28/01/2022	Farmers from Nizamabad District, Telangana State	CRC-Hyderabad (Online)	35	7
14	04/02/2022	Farmers from Nizamabad District, Telangana State	CRC-Hyderabad	6	-
15	18/02/2022	Farmers and DRDA, Agriculture Extension Officers from Marikal Mandal, Narayanpet District	Mamdipalli village, Narayanpet District, TS	150	43
16	19th to 22nd August 2021	Farmers of Raiwada, Sarvakota Mandal, Srikakulam District, Andhra Pradesh (Lt: 18.606341; Lo: 84.023929)	Vill. Raiwada, Srikakulam, AP	16	0

17	19/02/2022	Farmers from Village Laidam (Latitude: 18.37396783, Longitude: 83.78083364),	Vill. Laidam, Srikakulam, AP	23	-
18	19/02/2022	Farmers from in and around Praharajapalem village (Latitude: 18.60808751, Longitude: 84.02363569)	Praharajapalem village, Srikakulam, AP	42	3
19	3rd& 4th March 2022	CSIR-CIMAP,	RC, Hyderabad	104	

Inputs: Dr. RC Padalia

Organized KISAN GOSTHI at CSIR-CIMAP Research Center, Pantnagar

CSIR-CIMAP Research Center, Pantnagar organized KISAN GOSTHI-2022 on 8th Feb., 2022. About 150 farmers and industry representatives participated in the program. Demonstration of agro-technologies of medicinal and aromatic crops, distillations processes, rose-water technology, and early mint technology, training for Agarbatti/Incense sticks production were carried out during the Kisan Gosthi. Various stalls displayed different activities pertaining to MAPs technologies, herbal products, agro-advisory, and CIMAP publications. Farmers also purchased the quality plantings material of menthol-mint and other MAPs

Participation in Kisan Kumbh: 109th All India Farmer's Fair and Agro-Industrial Exhibitions at G.B. Pant University of Agriculture &Technology, Pantnagar

CSIR-CIMAP, Research Center, Pantnagar participated in 111th All India Farmer's Fair and Agro-Industrial Exhibition (March 24-27, 2022) at GBPUA&T, Pantnagar, Uttarakhand. In this four day long fair farmers of Uttarakhand and adjoining regions like Uttar Pradesh, Punjab, Himachal Pradesh were prevalent visitors at CIMAP stall, among others, students, KVKs, R&D scholars etc. The CIMAP staff interacted with them and enlightened them about

MAPs technologies and how the cultivation of MAPs can enhance their income apart from traditional agricultural crops. The newly installed distillation unit and CIMAPs products, publication were also a major highlight during the fair. CIMAP, RC, Pantnagar also won a special prize in MAPs category at the farmer fair.

Skill Development program conducted at CSIR-CIMAP Research Center, Purara, Uttarakhand

A two days training cum awareness program on cultivation, value addition and post-harvest processing of aromatic crops was organized by CSIR CIMAP at Research Centre, Purara, Bageshwar, Uttarakhand on March 21-22, 2022. On the first day of the program interactive lectures and demonstration given by CIMAP Scientists and technical staff on CSIR-Aroma mission activities; Rose scented geranium; chamomile; Rose; mints; Rosemary. On the second day of the program interactive lecture and demonstration given by CIMAP Scientists and technical staff on ocimum, lemongrass, geranium planting material saving agrotechnlogy, Post-harvest processing; distillation and quality of extracted essential oils from aromatic crops. Nursery preparations, rose water preparation, and cultivation practices on aromatic crops suitable for hilly areas were demonstrated. Total 70 nos. of farmers (60 nos. women) actively participated. Rosemary var. CIM-Hariyali distributed to interested farmers who showed keen interest for its cultivation during training program.

Inputs: Dr Sudeep Tandon

Installation of Distillation Unit at different Aroma Clusters throughout India

In the second phase of AROMA MISSION project in 2022, twenty three different types of directly fired type, cohobation, boiler operated improved distillation units of varying capacities & designs have been successfully designed, fabricated, installed and commissioned at different aroma clusters throughout India at following locations

S. No	Type of Unit	District / State (Cluster Location)
1.	MS 500 kg capacity Directly fired type field distillation unit	Tiruchirapalli District, Tamil Nadu
2.	SS-304 500 kg capacity Directly fired type field distillation unit	Coimbatore District, Tamil Nadu
3.	SS-304 500 kg capacity Directly fired type cohobation distillation	Hoskote Taluk, Bangalore Rural, Karnataka
4.	SS-304 500 kg capacity Directly fired type field distillation unit	Idduki, Kerala
5.	SS-304 200 kg capacity Directly fired type cohobation distillation	Udham Singh Nagar, Uttarakhand
6.	SS-304 50 kg capacity Directly fired type cohobation distillation	District Almora Uttarakhand
7.	MS 500 kg capacity Directly fired type field distillation unit	Jalna, Maharashtra
8.	MS 500 kg capacity Directly fired type field distillation unit	Hingna Nagpur, Maharashtra
9.	SS 50 kg capacity boiler operated steam distillation units	CIMAP Lucknow
10.	MS 500 kg capacity Directly fired type field distillation unit	Tehsil Manjohli, District, Jabalpur M.P.
11.	MS 250 kg capacity Directly fired type field distillation unit	Alwar, Rajasthan
12.	MS 1000 kg capacity Directly fired type field distillation unit	Hamirpur, Bundelkhand (UP)
13.	MS 500 kg capacity Directly fired type field distillation unit	Sikar / Jaipur, Rajasthan
14.	MS 500 kg capacity Directly fired type field distillation unit	Hisar / Fatehabad, Haryana
15.	MS 500 kg capacity Directly fired type field distillation unit	Muktsar / Bhatinda Punjab
16.	MS 500 kg capacity Directly fired type field distillation unit	Bijapur, Chhattisgarh
17.	MS 500 kg capacity Directly fired type field distillation unit	Cooch Behar, Bankura, Hoogly West Bengal
18.	MS 500 kg capacity Directly fired type field distillation unit	Nadia district, West Bengal
19.	MS 500 kg capacity Directly fired type field distillation unit	Lidaguna, Kuchinda, Sambalpur Orissa
20.	SS 500 kg capacity Directly fired type field distillation unit	Bilipda, Votaka, Rasulpur, Jajpur, Orissa
21.	MS 500 kg capacity Directly fired type field distillation unit	Majuli, Assam
22.	MS 500 kg capacity Directly fired type field distillation unit	Telamara, Tezpur, Assam
23.	MS 500 kg capacity Directly fired type field distillation unit	Sekerkote near bishalgarh, West Tripura

Consultancy services:

Provided consultancy for designing, fabrication and setting up of Rose oil and Rose water distillation Units for Horticulture Department, Govt of Rajasthan: The units have been successfully fabricated installed and commissioned at Sawai Madhopur, Rajasthan. The units are now being used by the farmers cultivating rose in the district for producing high quality Rose water and Rose oil thereby enhancing their incomes

Provided consultancy for designing, fabrication and setting up of MS directly fired type field distillation unit of 500 kg capacity for essential oils based on CSIR-CIMAP knowhow & design at Krishi Vigyan Kendra Kawardha, Chhattisgarh: The unit has been designed, fabricated, installed and successfully commissioned. The unit has been installed to promote the cultivation of Lemongrass in the region by supporting the farmers through the improved distillation unit

Provided consultancy for designing, fabrication and setting up of SS portable distillation unit of 50 kg capacity for essential oils based on CSIR-CIMAP knowhow & design at IGKV, Raipur: The unit has been designed, fabricated, installed and successfully commissioned at site. The unit is being used for carrying out R&D trials for enhancing oil yield and quality of the aromatic crops being cultivated in Chhattisgarh.

Provided consultancy for designing, fabrication and setting up of MS directly fired type field distillation unit of 500 kg capacity for essential oils based on CSIR-CIMAP knowhow & design for KVK, Koriya, Chhattisgarh: The unit has been designed, fabricated, installed and successfully commissioned at site. Large scale cultivation of Lemongrass has been taken up by the farmers of District Koriya, Chhattisgarh. An improved Stainless Steel distillation unit has been installed by CSIR-CIMAP under a consultancy project through the Krishi Vigyan Kendra for helping the famers in distilling their crops.

Provided consultancy for designing, fabrication and setting up of SS 250 kg capacity cohobation distillation unit for essential oils based on CSIR-CIMAP knowhow & design at Horticulture Research Center, Tamil Nadu Agriculture University, Yercaud Tamil Nadu: The unit has been designed, fabricated, installed and successfully commissioned at site. High value aromatic crops like Geranium, Rosemary and Rose are now being promoted for cultivation in the hills of Ooty for enhancing the incomes of the farmers. CIMAP under a consultancy project taken up along with Tamil Nadu Agriculture University, Ooty has successfully installed and commissioning a Cohobation type Distillation unit which has been specially designed for rose and geranium.

Inputs: Dr. Sunita Singh Dhawan

Delivered invited lecture for the STEM Programme (Science, Technology, Engineering and Mathematics) at City International School, Manas City, Lucknow on International Women's day 7.3.2022 and interacted with the students.

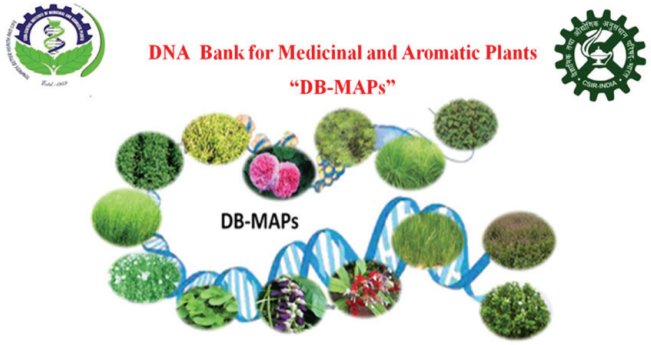
CSIR-CIMAP organised Jigyasa programme on 23rd December 2021, at MD Shukla Inter College Nadan Mahal Road, Lucknow for promoting scientific temperament among the students and established Arogyavatika in college campus.

- CSIR-CIMAP Conducted visit of 145 students and 2 faculty members of City International School, Manas City, Lucknow at CSIR-CIMAP, STEM learning and to undertake lab visit to acquire practical knowledge of 'Medicinal and Aromatic Plants'. Organized under Jigyasa programme on 16th March 2022, for promoting scientific temperament among the students

DNA Bank of Medicinal and Aromatic Plants "DB-MAPs"

CIMAP Gene Bank, established in 1993 as a follow up action taken in the summit of G-15 countries held at Caracas, is one of the three National Gene Banks of the country that focuses on the conservation of Medicinal and Aromatic Plants of India in the form of Field, Seed, Tissue and DNA Banks. However, National Biodiversity Authority of India has recognized CIMAP as a Designated National Repository (DNR) under the Biological Diversity Act, 2002, to keep in safe custody, specimens of different categories of biological material. Molecular techniques are becoming increasingly important in the study and management of genetic resources therefore DNA has been extracted and stored from Medicinal and Aromatic Plant Varieties / accessions. In this context, on the auspicious occasion of CSIR Foundation Day on 26th September, 2021, the reestablished, strengthened and modernized DNA Bank of Medicinal and Aromatic Plants "DB-MAPs" was inaugurated by Chief Guest Dr. Ram Vishwakarma, Advisor to DG, CSIR and Former Director, CSIR- IIIM, Jammu and Dr. Prabodh Kumar Trivedi, Director , CSIR-CIMAP, Lucknow, India.

Family : 16	**Species: 45**	**Accessions done : 130**
Aromatic plants: 98	**Medicinal plants: 28**	**In Processing: 06**



DNA Bank of Medicinal and Aromatic Plants "DB-MAPs" inaugurated on CSIR Foundation Day by Chief Guest Dr. Ram Vishwakarma, Advisor to DG CSIR and Former Director, CSIR-IIIM and Dr. Prabodh Kumar Trivedi, Director , CSIR-CIMAP

Inputs: Dr. Kishore B. Bandamaravuri

A field observations were carried out during 2021-2022 for the occurrence of fungal diseases on medicinal and aromatic crops. Farmer training-cum-demonstration programs on "Pesticide free cultivation of Menthol mint crop and early mint technology" at Bareilly and NCR regions during March 2022 were conducted under Aroma Mission-II.

Organized training-cum-demonstration programme on "Cultivation practices using Early Mint Technology (EMT)" on March, 2022 at two places Murgupur and Shahpur, Dhanaura, Amroha.

Others

Technology Transfer for Commercialization

Sl. No	Title	Period during which developed	Date of transfer	Organization/ Industry
1.	Hand Sanitizer gel/liquid	2020-2021	02.06.2021	M/s. Prahava India Private Limited , Ghaziabad, Uttar Pradesh
2.	Technical know-how for utilization of flowers offered at Temples of Dehradun for making incense sticks under CSIR Aroma Mission Phase-II	2011-2017	22.07.2021	Jagrati Foundation, 50/55 Jhanda Bazaar, Dehradun
3.	Technical know-how for utilization of flowers offered at Temples of Nashik, Maharashtra for making incense sticks under CSIR Aroma Mission Phase-II	2011-2017	06.08.2021	Shri Sai Institute of Rural Development, Varanasi (Uttar Pradesh)
4.	Technical know-how for utilization of flowers offered at Temples of Nashik, Maharashtra for making incense sticks under CSIR Aroma Mission Phase-II	2011-2017	17.08.2021	Anand Foundation, Nashik Maharashtra
5.	Agreement for Technology package for cultivation of Milk thistle (CIM-Sil)	2005-2013	23.10.2021	M/s. Umalaxmi Organics Pvt. F-245-249, Agro food Park Boranada Jodhpur-342001 Rajasthan
6.	Sanitary Pad	2010-2012	02.02.2022	M/s. AN Health Care, East Godavari, Andhra Pradesh
7.	Know-how for making of Painchoo (Pain Balm)	2001-2005	22.02.2022	M/s Aayukart Pvt. Ltd., Jaipur
8.	Know-how for making of CIM-Kesh (Hair Oil)	2018-2020	22.02.2022	M/s Aayukart Pvt. Ltd., Jaipur

Technology transfer for commercialisation of herbal technologies to industry

Technology licensing to a Start-up for commercialisation of formulation developed by CSIR-CIMAP

Start-ups/MSMEs utilized the Pilot Plant Facility (TBIC) in the FY 2021-2022

S. No.	Period	Name of the MSME/Start-ups	Name of Products
1.	May-2021	M/s Vyom India Organics Pvt. Ltd. Bareilly, UP	Hankool
2.	June-2021	M/s Nains Herbals and Organics Private Limited, Sonipath, Haryana	Relaxomap
3.	June-2021	M/s Prahava Pvt.Ltd, Ghaziabad, UP	Hankool
4.	October-2021	M/S Bansod Agri Ayurved Laboratory, Nagpur, Maharashtra	Clean germ
5.	November -2021	M/s A&A Traders, Balrampur, UP	Herbichew
6.	February-2022	M/s Sai International, Lucknow, UP	Hankool Plus
7.	February-2022	M/s Sai International, Lucknow, UP	Hankool Plus
8.	February-2022	C/o The Deputy Conservator of Forests, Tripura	Mospray, Flomop, Toothpaste, CIM-Paushak, CIM-Phalse, Cleangerm, Painchhoo

TBIC facility at CSIR-CIMAP, Lucknow

Awards and Recognitions (2021-22)

1. Dr. Prabodh K. Trivedi awarded prestigious J.C. Bose National Fellowship by Science & Engineering Research Board, Government of India.

2. Dr. Prabodh K. Trivedi was felicitated with Professor K.K. Nanda Memorial Lecture Award-2021 by the Indian Society for Plant Physiology.

3. Dr. Dinesh A. Nagegowda has been elected Fellow of The National Academy of Sciences, India (NASI) in the year 2021 for his pioneering work involving Plant Molecular Biology / Functional Genomics /Metabolic Engineering.

4. Dr. Dinesh A. Nagegowda Elected as Sir CV Raman Young Scientist, State Award in Agricultural Science (2019) by Karnataka Government.

5. Dr. Dinesh A. Nagegowda featured in the List of World's Top 2% Scientists database 2021 released by Elsevier BV based on a study conducted by Stanford University, USA

6. Dr. Akanksha Singh has been awarded INSA Young Scientist Medal.

7. Dr. Suaib Luqman featured in the List of World's Top 2% Scientists database 2021 released by Elsevier BV based on a study conducted by Stanford University, USA

8. Dr. Ram Swaroop Verma featured in the List of World's Top 2% Scientists database 2021 released by Elsevier BV based on a study conducted by Stanford University, USA.

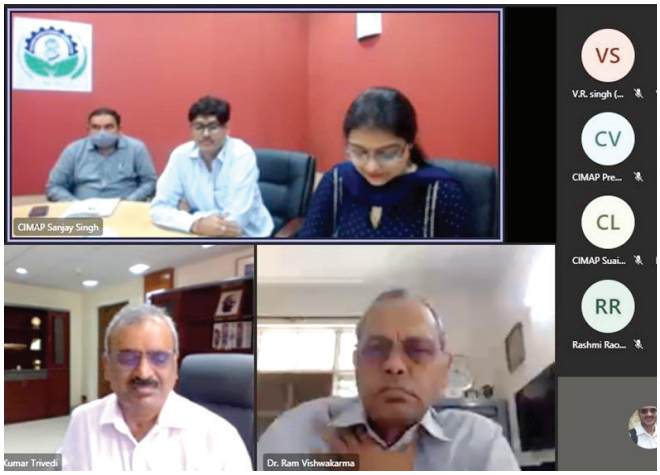
9. Dr. Karuna Shanker was elected as a Fellow of Royal Society of Chemistry (FRSC) and also won second prize for prestigious PD Sethi Award.

Glimpses of Events

Inaguration of 3 days training program by Prof. S Ayyappan, Chairman of KSTA, former DG ICAR and Dr. Prabodh K. Trivedi, Director CSIR-CIMAP on 2nd December 2021 at Research Centre, Bengaluru

Celebration of 75th Independence day in CSIR-CIMAP on 15th August 2021

Kisan Mela at CIMAP Research Centre Pantnagar on 9th February 2022



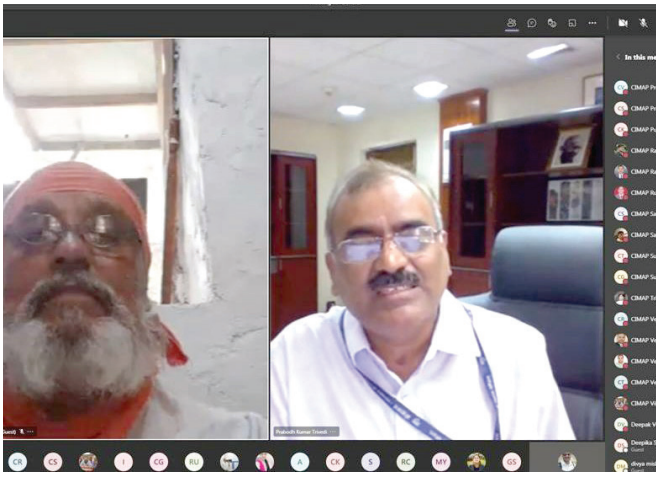
CSIR Foundation day lecture delivered by Dr. Ram Vishwakarma

CSIR - CIMAP celebrated International Yoga Day on 21st June 2021

CSIR - CIMAP organised Kisan Mela from 21-31 January 2022

Covid - 19 vaccination camp for all staff of CSIR-CIMAP was organised by BRD Hospital Mahanagar on 20 July 2021

73rd Republic Day celebration at CSIR-CIMAP, Lucknow



Annual Day celebration and lecture by Dr. Anil P. Joshi, 11th August 2021

CSIR-CIMAP celebrated World Environment Day on 5th June 2021

CSIR-CIMAP signed MoU with Sai Institute of Rural Development, Varanasi on 6th August 2021

Technology Transfer of making incense sticks from flower to Anand Foundation Nashik on 17th August 2021

Visit of Hon'ble Minister Shri Giriraj Singh at CSIR-CIMAP, Lucknow

Visit of Forest Officials of Uttarakhand, Forest Training academy to CSIR-CIMAP Research Centre, Pantnagar

Visit and interaction of Prof. Tapas Kundu Director CSIR-CDRI with Scientists and staff of CIMAP Research Centre, Bengaluru

Team CSIR-CIMAP Research centre bengaluru has initiated vetiver cluster under CSIR Arom Mission (Phase - II) in Tamil Nadu on 26 July 2021

Inaguration of Walkathon under Fit India Programme on 1st October 2021 by Dr. Prabodh Trivedi

Media Coverage

किसानों को दी गयी उन्नत कृषि तकनीकों प्रसंस्करण व बाजार की जानकारी

लखनऊ। केन्द्रीय औषधीय एवं सगंध पौधा संस्थान (सीमैप) में चल रहे दस दिवसीय किसान में शनिवार को दूसरे दिन किसान गोष्ठी का आयोजन किया गया, इसमें वैज्ञानिकों व उद्यमियों ने किसानों को उन्नत कृषि तकनीकियों, प्रसंस्करण तथा वाजार संवंधी जानकारी दी। तकनीकी सत्र में मेला संयोजक डा. संजय कुमार ने क्षार प्रभावित भूमि में औषधीय एवं सगंध पौधों की खेती करने से संवंधित जानकारी दी तथा संस्थान के वैज्ञानिक डा. सौदान सिंह, डा. वी. आर. सिंह, डा. राजेश वर्मा तथा डा. राम सुरेश शर्मा ने मेंथा, जिरेनियम, खस, नींवूघास की खेती से संवंधी जानकारी किसानों से साझा की। प्रश्न-उत्तर सत्र में उपस्थित वैज्ञानिकों ने किसानों के जिज्ञासाओं का समाधान किया गया। इस दौरान संस्थान के वैज्ञानिक डा. संतोष केदार ने सुगंधित पौधों की खेती में हानिकारक कीटों से वचाव की जानकारी दी। मेला में मेंथा तथा अन्य औषधीय एवं सगंधीय पौधों की पौध सामग्री की खरीदी भी किसानों ने की।

किसानों ने जाना औषधीय और सगंध पौधों की खेती का तरीका

जासं, लखनऊ : सीएसआइआर-सीमैप में आयोजित 10 दिवसीय किसान मेले में शनिवार को लखनऊ के अलावा गाजियाबाद, उन्नाव और नोएडा के किसान पहुंचे। इस अवसर पर गोष्ठी के माध्यम से किसान, उद्यमियों और विज्ञानियों के बीच खेती की उन्नत कृषि तकनीक, प्रसंस्करण और बाजार भाव संबंधी विचारों पर मंथन किया गया।

किसान गोष्ठी के तकनीकी सत्र में डा. संजय कुमार ने औषधीय एवं सगंध पौधों की खेती किस प्रकार की जाए, उसे समझाया। इसके अलावा डा. सौदान सिंह, डा. वीआर सिंह, डा. राजेश वर्मा और डा. राम सुरेश शर्मा ने मेंथा, जिरेनियम, खस, नींवूघास की खेती संबंधी विचार स्पष्ट किए। सवाल-जवाब सत्र में उपस्थित विज्ञानियों ने किसानों के प्रश्नों के उत्तर दिए। वहीं, डा. संतोष केदार ने सुगंधित पौधों की खेती में हानिकारक कीटों से बचाव के बारे में बताया। कार्यक्रम का संचालन डा. ऋषिकेश एन. भिसे ने किया। इससे पहले मेला में किसानों ने मेंथा व अन्य औषधीय एवं सगंधीय पौधों की पौध सामग्री खरीदी।

सीमैप में लगे किसान मेला में किसानों को औषधीय और सगंध पौधों की फसली के बारे में जानकारी देते विज्ञानी डा. संजय कुमार • जागरण

किसानों से बातचीत

मेंथा और नींबूघास की खेती करने जा रहा हूं। खेती कैसे करनी है, इस बारे में काफी कुछ सीखने को मिला है। अब जल्द ही अपनी 15 एकड़ की जमीन पर इनकी खेती शुरू करूंगा। इसके पहले भी मैं मेले में शामिल हो चुका हूं।
-मनोज सिंह, गाजियाबाद

किसानों को पैदावार कैसे बढ़ानी है, इसके बारे में जानकारी हासिल हुई है। हालांकि, बारिश की वजह से थोड़ी परेशानी हुई। इसके बावजूद मेंथा, जिरेनियम, खस, नींबूघास की पैदावार को लेकर अच्छे सुझाव दिए गए।
-विनीत गुप्ता, उन्नाव

आय दोगुनी करने की दिशा में मील का पत्थर बनेगा किसान मेला

स्वदेश संवाद, लखनऊ।

केंद्रीय औषधीय एवं सुगंध पौधा संस्थान (सीमैप) में दस दिन तक चलने वाले किसान मेले की शुक्रवार को शुरुआत हो गई। कोविड के कारण, इस वर्ष 21 से 31 जनवरी तक किसान मेले का आयोजन किया जा रहा है। मेले में प्रतिदिन 200 किसान, उद्यमी और उद्योग जगत के प्रतिनिधि एवं सीमैप के वैज्ञानिक भाग ले रहे हैं। किसान मेले का उद्घाटन सीमैप के निदेशक डॉ. प्रबोध कुमार त्रिवेदी ने किया। कोविड के कारण पहले से पंजीकृत और डबल टीकाकरण वाले व्यक्तियों को ही मेले में प्रवेश की अनुमति होगी।

सीमैप के निदेशक डॉ. प्रबोध कुमार त्रिवेदी ने देश के विभिन्न हिस्सों में सीमैप की किसान केंद्रित गतिविधियों के बारे में बताया। उन्होंने कहा कि कोविड के बावजूद, संस्थान के वैज्ञानिक और कर्मचारी, किसानों को ऑनलाइन प्रशिक्षण, रोपण सामग्री एवं सेवाएं प्रदान करते रहे हैं, जिससे उनको आय बढ़ाने में मदद मिली है। संस्थान द्वारा औषधीय एवं सगंध पौधों की किस्मों और प्रौद्योगिकियों में

उच्च गुणवत्ता वाले अनुसंधान को इन मेलों को आम जनता तक पहुंचाया जा रहा है। संस्थागत अनुसंधान के फल किसानों को उनकी आय में वृद्धि में मदद कर रहे हैं। डॉ. त्रिवेदी ने इस किसान मेले में भाग लेने वाले देश के विभिन्न राज्यों के किसानों एवं उद्यमियों का स्वागत किया। मेले के माध्यम से किसानों को सीमैप में विकसित औषधीय एव सगंध पौधों की उन्नत प्रजातियों एवं कृषि तकनीकियों तथा उनसे बने हर्बल उत्पादों के बारे में जानकारी मिलती है।

इस अवसर पर किसान मेले कि स्मारिका 'औस ज्ञान्या' का विमोचन किया गया।

मेले में मोरिंगा आधारित उत्पादों जैसे चाय, साबुन, तेल, पाउडर, कैप्सूल और टैबलेट को प्रदर्शित करने वाली मोबाइल वैन को भी सीमैप निदेशक डॉ. प्रबोध कुमार त्रिवेदी ने झंडी दिखाकर रवाना किया। उत्पादों को सीमैप के तकनीकी मार्गदर्शन में 'जेवीकेएस कंपनी' विकसित कर रही है। इस अवसर पर निदेशक ने देश के विभिन्न आईसीएआर एवं शैक्षणिक संस्थानों से एकत्रित गुलाब की 80 से अधिक किस्मों की नवविकसित रोजरी का भी उद्घाटन किया गया। सीमैप किसान मेले में डॉ. सौदान सिंह ने विशेष गोष्ठी का संचालन किया। इसमें अगेती मिंट तकनीकी व जिरेनियम की खेती के बारे में किसानों से जानकारी साझा की। डॉ. वी आर सिंह ने औषधीय एवं सगंध पौधों की पौध सामग्री संवर्धन के बारे में प्रतिभागियों को बताया। किसान गोष्ठी ने डॉ. सौदान सिंह, डॉ. राजेश वर्मा, डॉ. सुदीप टंडन, डॉ. राम सुरेश शर्मा, डॉ. राकेश पाण्डेय, डॉ. ऋषिकेश, डॉ. संजय कुमार आदि ने अपने विचार व्यक्त किए। मेले में औषधीय एवं सगंध पौधों पर उत्पादन से बाजार तक परिचर्चा गोष्ठी, उन्नत पौध सामग्री व प्रकाशनों का विक्रय, सीमैप प्रोडक्टस का प्रदर्शन, आसवन/प्रसंस्करण का सजीव प्रदर्शन, अगरबत्ती व गुलाब जल बनाने का प्रशिक्षण, मेंथा की अगेती कृषि तकनीकी का प्रदर्शन, औष फसलों का परंपरागत फसल प्रणाली में समावेश का विशेष प्रशिक्षण कार्यक्रम आयोजित किया गया। कार्यक्रम को वर्चुअल माध्यम से प्रसारण किया गया।

मेले से आमजन तक पहुंचेंगे अनुसंधान

सीमैप में 10 दिवसीय किसान मेला शुरू मिली मेंथा की नई प्रजाति की जानकारी

जासं, लखनऊ: केंद्रीय औषधीय एवं सगंध पौधा संस्थान (सीमैप) के निदेशक प्रमोद कुमार त्रिवेदी ने कहा कि प्रयोगशाला में किसानों की बेहतरी और उनकी आय में वृद्धि करने के लिए लगातार विज्ञानी प्रयासरत हैं। इसके अंतर्गत संस्थान में शुक्रवार से 10 दिवसीय किसान मेला शुरू किया गया है, जिसमें देशभर से किसान प्रतिभाग कर रहे हैं। उन्होंने कहा कि संस्थान द्वारा औषधीय एवं सगंध पौधों की किस्मों और प्रौद्योगिकी में उच्च गुणवत्ता वाले अनुसंधान को मेले द्वारा आम जनता तक पहुंचाया जा रहा है।

किसान मेले के उद्घाटन सत्र में ही रोजरी का उद्घाटन भी किया गया है। इसके बारे में प्रधान विज्ञानी डा. राजेश वर्मा ने बताया कि देशभर के अलग-अलग संस्थानों से गुलाब की 80 प्रजातियों को मंगाकर एक रोजरी यानी रोज गार्डन तैयार किया गया है। वहां पर इंडियन एग्रीकल्चरल रिसर्च इंस्टीट्यूट दिल्ली, आइसीएआर इंस्टीट्यूट पुणे, इंडियन इंस्टीट्यूट आफ हार्टिकल्चर रिसर्च बेंगलुरु और बोस इंस्टीट्यूट कोलकाता से गुलाब की बेहतरीन प्रजातियों को मंगाकर एक कंजरवेटरी तैयार की गई है। इससे भविष्य में नई प्रजातियां विकसित की जा सकती हैं। रोज गार्डन का नाम सीमैप के पहले निदेशक के नाम पर 'अख्तर हुसैन रोजरी' रखा गया है।

किसान मेले में सहजन के उत्पादों की बिक्री के लिए तैयार वैन के बारे में जानकारी देतीं परियोजना विज्ञानी कामिनी सिंह • जागरण

मैं तुलसी, सतावर जैसे औषधीय पौधों की खेती पिछले छह वर्षों से परिवार के साथ मिलकर कर रही हूं। मेरे घर में आयुर्वेदिक चिकित्सक हैं। मेरे खेत से कई औषधियां तैयार होती हैं, जिनकी काफी मांग रहती है। आज के मेले में कुछ नई फसलों के बारे में जानकारी जुटा रही हूं।
-वंदना मिश्रा, खलासा

पिछले कई वर्षों से मेंथा की खेती कर रहा हूं। सीमैप द्वारा विकसित की गई नई प्रजाति सिम उन्नति से मुझे डेढ़ लाख रुपये तक का फायदा हुआ। किसान मेले से नई जानकारियां लेकर जाएंगे ताकि अपने आसपास के लोगों को भी इसके फायदे बता सकें।
-उदय राज चौहान, सीतापुर

आठ वर्ष पहले तक मैं एक निजी कंपनी में प्रोडक्शन मैनेजर के पद पर कार्यरत था। फिर लगा कि कुछ ऐसा करना चाहिए, जिससे कई अन्य लोगों को फायदा हो सके। सीमैप की मदद से पारंपरिक खेती के साथ-साथ औषधीय पौधों के गुण की जानकारी लेकर उनके उत्पाद तैयार किया।
-विजय सिंह चौहान, लखनऊ

मोबाइल वैन में मिलेंगे सहजन से बने उत्पाद: किसान मेले में सीमैप की सहायता से मोरिंगा या सहजन से बनाए गए उत्पादों को विकसित करने वाले एक किसान द्वारा शुरू की गई जीवीकेएस कंपनी की मोबाइल वैन को भी हरी झंडी दिखाई गई। इस मोबाइल वैन में सहजन और कुछ अन्य औषधीय पौधों के उत्पादों को मलिहाबाद में खेती कर रहे विजय सिंह चौहान ने अन्य किसानों के साथ मिलकर तैयार किया है। इनमें 25 रुपये हर्बल पैकेट से लेकर चाय, साबुन, तेल, पाउडर, कैप्सूल, टैबलेट, जैम समेत 1,500 रुपये तक के उत्पाद शामिल हैं। नौकरी छोड़कर किसानी करने वाले विजय सिंह चौहान कहते हैं कि सीमैप की सहायता से हमने कुछ ऐसे उत्पाद तैयार किए हैं जो लोगों की स्वास्थ्य क्षमता को बेहतर कर सकते हैं। किसी भी उत्पाद में कोई रसायनिक तत्व नहीं मिलाया है। इससे लोगों को सहजन के गुणों का पता चलेगा और हमारे समूह के किसानों को आय में वृद्धि हो सकेगी। सीमैप में परियोजना विज्ञानी कामिनी सिंह ने बताया कि सहजन को सुपरफूड कहा जाता है। इसमें कई ऐसे महत्वपूर्ण तत्व होते हैं जो स्वास्थ्यवर्धक हैं।

किसानों को मिली पौध सामग्री: किसान मेला के पहले दिन 150 किसानों को मेंथा की सीमैप में विकसित की गई प्रजाति 'सिम उन्नति' के साथ 'कोसी' और 'सिम-संकृति' की पौध सामग्री बांटी गई। निदेशक डा. प्रमोद कुमार त्रिवेदी ने बताया कि कोविड-19 के नियमों को ध्यान में रखते हुए इस वर्ष पंजीकरण के आधार पर मेले में प्रतिदिन 150 किसानों के आने की व्यवस्था है। उन सभी को यह पौध सामग्री वितरित की जाएगी।

फूलों से अगरबत्ती बनाने का हुनर सीखा

पंचमुखी हनुमान मंदिर दो दिवसीय कार्यशाला का आयोजन

ऊंजाबाद (अयोध्या)।

पंचमुखी हनुमान मंदिर परिसर गुप्तार घाट में इंटैक अयोध्या, सीएसआईआर केंद्रीय औषधीय व सगंध पौधा संस्थान सीमैप लखनऊ) की ओर से दो दिवसीय कार्यशाला का आयोजन किया गया। इसमें इंटैक दिल्ली के परवीन और रमीता ने भी सहयोग किया। प्रशिक्षण की विशेषता महिलाओं को मंदिरों में चढ़ाये फूलों को सुखाकर अगरबत्ती बनाने का हुनर सिखाना था।

पहले ही दिन 50 महिलाओं ने इसमें भाग लिया जिसमें से 31 महिलाओं ने अगरबत्ती बनाई। इनमें कई बालिकाएं भी थीं। कार्यशाला में इंटैक सदस्यों ने बताया कि इससे मंदिर में चढ़ाये फूलों का अनादर नहीं होगा। ये जल में नहीं बहाए जाएंगे तो नदियां भी स्वच्छ रहेंगी। अगरबत्तियों में बांस का प्रयोग नहीं होगा और यह रसायन मुक्त होंगी जो पर्यावरण संरक्षण का काम करेगा। ये महिलाओं को उनके खाली समय का प्रयोग कर उन्हें रोजगार प्रदान करेगा। इस अवसर पर इंटैक अयोध्या चैप्टर की मंजुला झुनझुनवाला, जया स्वरूप, अलका रोहतगी, ज्योति मूद, पीयूष रोहतगी और पूनम मूद मौजूद रहीं।

अयोध्या–आसपास

हिन्दी दैनिक शुक्रवार, 25 मार्च, 2

फूलों को सूखा कर अगरबत्ती बनाने का सीखा हुनर

संदीप पाण्डेय। अयोध्या।

पंचमुखी हनुमान मंदिर परिसर, गुप्तार घाट में इन्टैक अयोध्या एवं सी. एस. आई. आर केंद्रीय औषधीय एवं सगंध पौधा संस्थान - सीमैप, लखनऊ के सौजन्य से दो दिवसीय कार्यशाला का आयोजन किया गया।इसमें इन्टैक दिल्ली कार्यालय से आए परवीन और रमीता ने भी सहयोग किया।

दो दिवसीय कार्यशाला की शुरुआत प्रार्थना से की गई। इस प्रशिक्षण की विशेषता ये रही कि इसमें मंदिरों में चढ़ाये गये फूलों को सूखा कर अगरबत्ती बनाने का हुनर वहीं आसपास रहने वाली घरेलू महिलाओं को सिखाया गया। पहले ही दिन 50 महिलाओ ने इसमें भाग लिया जिसमें 31 महिलाओं ने अगरबत्ती बनाई। इनमें कई बालिकाएं भी थी।

कार्यशाला में उपस्थित इन्टैक अयोध्या की सदस्यों ने बताया कि इस कार्यशाला के विभिन्न उद्देश्य है।इससे मंदिर में चढ़ाये हुए फूलों का अनादर नहीं होगा। वे जल में नहीं बहाए जाएंगे तो नदियां भी स्वच्छ रहेंगी। इन अगरबत्ती में बांस का प्रयोग नहीं होगा और यह रसायन मुक्त होगी जो पर्यावरण संरक्षण का काम करेगा। ये घरेलू एवं जरूरतमंद महिलाओं को उनके खाली समय का प्रयोग कर उन्हें रोजगार प्रदान करेगा। कई क्षेत्रों मे स्थानीय महिलाएं अपने खाली समय का सदुपयोग कर इस प्रशिक्षण से लाभान्वित हो 500 रुपये से लेकर 2,000 - 3,000 तक प्रति माह की अतिरिक्त आय कर लेती हैं। इस अवसर पर इन्टैक अयोध्या चैप्टर की मंजुला झुनझुनवाला, जया स्वरूप, अल्का शेखर, ज्योति सूद, पीयूष रहेजा और पूनम सूद मौजूद रहीं।

सीमैप ने हस्तांतरित की रिलेक्सोमैप व सिम केश हेयर ऑयल की तकनीक

लखनऊ (एसएनबी)। केन्द्रीय औषधीय एवं सगंध पौधा संस्थान ने मंगलवार को रिलेक्सोमैप व सिम-केश हेयर ऑइल की तकनीक को मेसर्स आयुकार्ट प्राइवेट लिमिटेड, जयपुर को हस्तांतरित किया।

कंपनी ने लगभग एक महीने पहले सीएसआईआर-सीमैप से रिलेक्सोमैप व सिम-केश हेयर ऑइल की तकनीक लेने के लिए पत्राचार शुरू किया था। कंपनी सीएसआईआर-सीमैप से रिलेक्सोमैप व सिम-केश हेयर ऑइल की तकनीकी को प्राप्त कर अपने नाम दिव्य श्री आदिवासी हेयर ऑइल एवं रिलीफ़ 24 के साथ इस उत्पाद को बाजार में उतारेगी। इस रिलेक्सोमैप व सिम-केश हेयर ऑइल की विशेषता यह है कि दोनों उत्पाद सुगंधित तेलों के मिश्रण से बनाए गए है जिनके उपयोग से यूजर पर कोई बुरा प्रभाव नही पड़ता है। रिलेक्सोमैप जोड़ों के दर्द व मसेल्स के खिचाव के दर्द में अत्यंत कारगर है। सिम-केश हेयर ऑइल सुगंधित तेलों के मिश्रण से बने होने के नाते बालों को चमकदार व गिरने से रोकने के साथ रूखी से भी सुरक्षा प्रदान करता है।

इस समझौते पत्र पर मेसर्स आयुकार्ट प्राइवेट लिमिटेड, जयपुर के प्रतिनिधि रमेश कुमार एवं सीएसआईआर-सीमैप के प्रशासनिक अधिकारी नरेश कुमार द्वारा हस्ताक्षर किए गये। कंपनी के प्रतिनिधि रमेश कुमार, डॉ. संजय कुमार, धरेन्द्र राठौर ने बताया कि रिलेक्सोमैप व सिम-केश हेयर ऑइल का उत्पादन मेसर्स आयुकार्ट प्राइवेट लिमिटेड, जयपुर में किया जाएगा, जिससे यह महत्वपूर्ण उत्पाद जन समूह को जल्दी से जल्दी बाजार में उपलब्ध हो सके।

सीएसआईआर-सीमैप के डॉ. रमेश कुमार श्रीवास्तव, प्रमुख व्यापार विकास ने बताया कि यह उत्पाद ज्यादातर सगंध एवं औषधीय पौधों से बने होते है और इस कंपनी द्वारा उनके उत्पादन से देश में औषधीय एवं सगंध पौधों की खेती करने वाले किसानों को भी आर्थिक लाभ होगा। इस अवसर पर डॉ. संजय कुमार एवं नरेश कुमार, प्रशानिक अधिकारी आदि उपस्थित थे।

सैनिटरी नैपकिन की तकनीक सौंपी

■ एनबीटी, लखनऊः सीमैप ने बुधवार को सैनिटरी नैपकिन की तकनीक आंध्र प्रदेश की मेसर्स एएन हेल्थ केयर काकीनारा को हस्तांतरित की। कंपनी के निदेशक वाई सतीश और सीमैप के प्रशासनिक अधिकारी ने समझौते पर हस्ताक्षर किए। वाई सतीश ने बताया कि सेनिटरी नैपकिन का उत्पादन आंध्र प्रदेश में किया जाएगा और जल्द बाजार में उपलब्ध होगा। इस मौके पर डॉ. रमेश कुमार, डॉ. अनिरबान पाल, डॉ. संजय कुमार, डॉ. राजेश कुमार वर्मा और डॉ. राम सुरेश शर्मा मौजूद रहे।

कई हुए आकर्षित, इसी साल जुड़ेंगे 100 किसान

लेमन ग्रास की खेती कर निकाला तेल और चार ने खरीदी बाइक

हरिभूमि न्यूज ▶▶ कोण्डागांव

जिला कोण्डागांव की गा्रम पंचायत मालगांव में पिछले लगभग डेढ़ साल से कुछ किसान लेमन ग्रास की खेती कर रहे हैं। उन्हें यह खेती करने के लिये सीएसआईआर सीमैप केन्द्रीय औषधीय एवं सुगंध पौध संसधान व सीएसआईआर ऐरामा मिशन के तहत माता अमृतानंदमयी से संयुक्त रूप से सतत मार्गदर्शन व प्रशिक्षण मिल रहा है।

लखनऊ मालगांव से पहुंचे डा. संजय कुमार इसी योजना के तहत आज 27 मई को सीमैप लखनऊ के वैज्ञानिक संजय कुमार अपनी टीम के साथ माल गांव पहुचे और ग्रामीणों को सरल सहज तरीके से लेमन ग्रास की खेती करने व उससे तेल निकालने की आसवन विधि को समझाया। दिनभर चले इस आयोजन में मालगांव देउरवाल व आसपास के पांच गांवों के लगभग 100 से अधिक किसानों ने शिकरत की। बता दें कि मालगांव में सीमैप व अमृतमई सर्व के सहयोग से लेमनग्रास से तेल निकालने के लिये एक आसवन ईकाई स्थापित की गयी है जिसमें स्थानीय लेमन ग्रास उत्पादक किसान खुद लेमन ग्रास का तेल निकाल कर मुनाफा कमा रहे है। मांल गांव के किसानों ने महज डेढ साल में अब तक 200 लीटर लेमन ग्रास तेल आसवित कर लिया है जो कि एक बडी सफलता है। चार किसानों ने खरीदी बाइक अब तक स्थानीय स्तर व बस्तर में लेमन गा्रस प्रोजेक्ट पर कई बार किये गये प्रयास यथोचित लाभ नहीं कमा सके है और तकरीवन ऐसे ही हालातों में सिमट गये है। यह पहला स्थल है जहां लेमन गा्रम किसान लगातार सफल हो रहे है। इसी से प्रभावित हो कर लेमन गा्रम उत्पादक किसानों की संख्या में सतत वृद्धि हो रही है। मालगांव में आरम्भ मे महज 10 किसानों ने लेमन गा्रस की खेती करने की ओर कदम बढाया था जो इस साल जुलाई माह में 100 किसान इस खेती में प्रवेश करेगे। डॉ संजय कुमार के अनुसार इन 100 किसानों को लेमन ग्रास की बेहद उन्नत किस्म कृष्णा के पोधे उपलब्ध कराये जायेगे। अभी युवा किसान चन्दर बघेल , नगेन्द्र नेताम, लखीराम , सुखदेव व सुकल राम के साथ 30 किसान ये खेती कर रहे है।

उच्च गुणवत्ता वाले पौधे दिए जाएंगे

घनश्याम उपाध्याय कार्यक्रम समन्वयक ने बताया कि इस साल बारिस के मौसम में 100 किसान लेमन ग्रास की खेती के लिये उत्साहित है। उन्हें उच्च गुणवत्तावाली कृष्णा किस्म की पौधे उपलब्ध कराया जाएगा। इन किसानों को सम्पूर्ण प्रशिक्षण दिया जायेगा। इस अवसर पर सीमैप के डॉ संजय कुमार, मनोज यादव, एसपी सिंह, माल गांव की सरपंच सुकुलवाई नेताम, महेन्द्र नेताम, मोहन नेताम, जमुना देवी सहित बडी संख्या में ग्रामीण मौजूद रहे।

नवभारत टाइम्स। कानपुर (कानपुर व लखनऊ में एक साथ प्रसारित)। सोमवार, 7 मार्च 2022 | लखनऊ | www.lucknow.nbt.in

प्रदर्शनी में छाए सीमैप के गुलाब और एलडीए के गमले

राजभवन में तीन दिन चली प्रादेशिक फल-शाकभाजी एवं पुष्प प्रदर्शनी का समापन

अधीक्षक राजभवन उद्यान को मिले सबसे ज्यादा अंक, सबसे बड़ा इनाम भोला नर्सरी को

■ एनबीटी, लखनऊ

राजभवन में तीन दिवसीय शाक-भाजी और पुष्प प्रदर्शनी के आखिरी दिन रविवार को 50 हजार से ज्यादा लोग पहुंचे। लोगों ने यहां प्रदेशभर के संस्थानों और नर्सरियों के स्टॉल पर सब्जियों और फूलों की जानकारी ली। इसके साथ मुंबई की मशहूर भेली पूरी, कटहल के पकवान, अमेरिकन भुट्टा, फलूदा कुल्फी और पूड़ी सब्जी समेत कई व्यंजनों का लुत्फ उठाया। दिनभर चली प्रदर्शनी के बाद शाम को विजेताओं को पुरस्कार दिए गए। इनमें सबसे ज्यादा 139 अंकों के साथ अधीक्षक राजभवन उद्यान अव्वल रहे, हालांकि नियमों के कारण 51 हजार रुपये का सबसे बड़ा पुरस्कार 73 अंक पाने वाले हरदोई रोड स्थित भोला नर्सरी के ओमप्रकाश को दिया गया। इसके साथ गुलाब के कटे फूल की श्रेणी में सीमैप और गमले में लगे पौधों की श्रेणी में मलिक नर्सरी व एलडीए अव्वल रहे।

प्रदर्शनी के समापन पर राज्यपाल आनंदी बेन पटेल ने कहा कि पर्यावरण को बचाना है तो सभी को पौधरोपण के लिए जागरूक होना पड़ेगा। हर बच्चे को एक पौधा लगाने के लिए प्रेरित करना होगा। तभी प्रदूषण कम होगा और हमें बेहतर ऑक्सिजन मिलेगी। इस दौरान मुख्य सचिव दुर्गा शंकर मिश्रा ने कहा कि खाद्य एवं प्रसंस्करण विभाग ने विजेताओं को दी जाने वाली धनराशि दो गुना कर दी है। इस तरह से और लोग भी खेती और बागवानी के लिए प्रेरित होंगे। उन्होंने बताया कि इस बार प्रदर्शनी ने सारे रेकॉर्ड तोड़ दिए हैं। इन तीन दिनों में एक लाख से अधिक लोग राजभवन आए और 1889 प्रतिभागियों ने हिस्सा लिया।

उद्यान निदेशक डॉ. आरके तोमर ने बताया कि प्रदर्शनी में प्रदेश के फल, शाकभाजी, पुष्प और औषधीय फसलों की खेती करने वाले उत्पादकों ने हिस्सा लिया। प्रदर्शनी को 49 श्रेणियों और 629 वर्गों में विभाजित किया गया। इसमें प्रदेश के उत्पादकों एवं बागवानी से जुड़े हुए प्रतिभागियों ने 6817 उत्पाद प्रदर्शित किए।

राज्यपाल ने प्रतियोगिता के विजेताओं संग खिंचवाई फोटो

दर्शकों ने प्रदर्शनी के दौरान सेल्फी लेकर सहेजी यादें।

न्यूट्री जैम-पौष्टिकता से समृद्ध हर्बल जैम

जैम के पोषक गुणों में वृद्धि के लिए एनबीआरआई ने पोषक तत्वों से भरपूर हर्बल जैम विकसित किया है। इसे न्यूट्री जैम नाम दिया गया है। प्रदर्शनी में एनबीआरआई के स्टॉल पर यह जैम भी दिखाया गया।

इन्हें मिले पुरस्कार

अतिविशिष्ट चल बैजयंती पुरस्कार अधीक्षक राजभवन उद्यान (139 अंक), 11 हजार नकद

चल कप

- ■ ओम प्रकाश, भोला नर्सरी, हरदोई रोड (73 अंक), 51 हजार नकद
- ■ प्रिंसिपल, लामार्टीनियर कॉलेज (66 अंक), 31 हजार नकद
- ■ कैलाश नाथ मौर्या, (59 अंक), 11 हजार नकद

करेले का मगरमच्छ

प्रदर्शनी में हर तरफ लोग सेल्फी लेते दिखे। यहां सबसे ज्यादा आकर्षक करेले से बने मगरमच्छ रहा। इसके अलावा फूलों से बने हंस के साथ भी लोगों ने खूब फोटो खिंचवाए।

बाल वर्ग कलात्मक सज्जा

संस्कृति टंडन, यश दीक्षित, श्लोक त्रिवेदी, रिद्धिमा त्रिपाठी, मो. वाहिद, नभेंद्र सिंह ...

एकल प्रतियोगिता

शाकभाजी: हरीश चंद्र सक्सेना, अधीक्षक, जिला कारागार सीतापुर
यूरोपियन सब्जियां: जय प्रकाश निषाद, लखनऊ
गमले में पौधे: मलिक नर्सरी और एलडीए
गमलों में कलात्मक समूह: यूपी मेट्रो कॉरपोरेशन
गुलाब के कटे फूल: सीमैप व्यक्तिगत प्रतिस्पर्धा
फोटोग्राफी: प्रशांत कुमार सिंह
हाइब्रिड शाकभाजी: विश्व नरायन श्रीवास्तव
पॉलीहाउस उत्पादित सब्जियां: पोद्दार नेस्ट जेन फर्म बुलंदशहर
मौनपालक: ओम प्रकाश हरदोई और राजकीय मौन पालक उपकेंद्र आलमबाग
कलात्मक पुष्प सज्जा (महिला): स्वाती सिंह और शक्ति निगम
फूलों से बनी आकृति: यूपी मेट्रो कॉरपोरेशन और प्रशांत कुमार सिंह
पॉली हाउस में पुष्प खेती: कैलाश नाथ मौर्य और दिनेश कुमार
हाइड्रोपोनिक्स विधि से ...

'हर व्यक्ति एक पौधा लगाए तो हवा शुद्ध हो जाए'

राजभवन में 53वीं शाकभाजी व पुष्प प्रदर्शनी में उत्कृष्ट प्रदर्शन करने वाले राज्यपाल से पुरस्कृत

माई सिटी रिपोर्टर

लखनऊ। राजभवन में चल रही 53वीं प्रादेशिक शाकभाजी एवं पुष्प प्रदर्शनी के अंतिम दिन रविवार को उत्कृष्ट प्रदर्शन करने वाले प्रतिभागियों को सम्मानित किया गया। वहीं, पुष्प प्रदर्शनी देखने वालों की भी भीड़ रही।

इस अवसर पर राज्यपाल आनंदीबेन पटेल ने कहाकि प्रदेश स्तरीय इस प्रदर्शनी के आयोजन का मुख्य उद्देश्य बागवानी के क्षेत्र में हो रहे विकास, नवीन किस्मों, उनकी उत्पादन तकनीक से लोगों को रूबरू कराना है। प्रदेश में एक व्यक्ति एक पौधा लगाए और उसकी देखभाल करें तो देश में शुद्ध वायु एवं जल की समस्या दूर हो जाएगी। प्रदेश के मुख्य सचिव दुर्गा शंकर मिश्र ने बताया कि प्रदर्शनी में अब तक एक लाख से अधिक उद्यान प्रेमियों ने भ्रमण किया है। प्रतिभागियों ने बड़ी संख्या में विविधता के साथ प्रतिभाग किया गया, जिन्हें कुल 889 पुरस्कारों से सम्मानित कर हौसला बढ़ाया गया। अपर मुख्य सचिव राज्यपाल महेश कुमार गुप्त, मंडलायुक्त रंजन कुमार, निदेशक उद्यान डॉ. आरके तोमर उपस्थित रहे।

राजभवन में फल, शाकभाजी व पुष्प प्रदर्शनी में उत्कृष्ट प्रदर्शन से सम्मान पाने वाले प्रतिभागी। -संवाद

इन्हें मिले पुरस्कार

सर्वाधिक अंक लाने वाले विजेताओं में 139 अंक प्राप्त करने के लिये अधीक्षक राजभवन उद्यान को अतिविशिष्ट चल बैजयन्ती पुरस्कार व ग्यारह हजार रुपये प्रदान किए गए। 73 अंकों के साथ व्यक्तिगत वर्ग में लामार्टीनियर कॉलेज को कप व 51 हजार रुपये दिए गए। ऐसे ही 4 से 9 वर्ष आयु वर्ग में कलात्मक पुष्प सज्जा के लिए प्रथम पुरस्कार पाने वालों में संस्कृति टंडन, यश दीक्षित, मॉडल मांटेसरी, प्रतिष्ठा धुसिया शामिल रहीं। एकल प्रतियोगिताओं में शाकभाजी के लिए हरीश चंद्र सक्सेना को पुरस्कार मिला। वहीं, जय प्रकाश निषाद सहित एलडीए, यूपी मेट्रो और इरटिम को भी सम्मानित किया गया।

■ **लविवि के छात्रों ने पुष्प प्रदर्शनी का किया भ्रमण**

लखनऊ। राजभवन में चल रही पुष्प प्रदर्शनी का लविवि के विभिन्न विभागों के 50 से ज्यादा छात्रों ने अवलोकन किया। छात्रों ने पुष्प के विभिन्न प्रजातियों का अवलोकन कर उनके बारे में जानकारी हासिल की। इस दौरान छात्र कल्याण अधिष्ठाता प्रो. पूनम टंडन, कुलपति की पत्नी संगीता राय, डॉ. मीरा सिंह, डॉ. अल्का मिश्रा समेत कई मौजूद रहे। (माई सिटी रिपोर्टर)

{ AROMA MISSION PROJECT LED BY CSIR-CIMAP }

India becomes one of the 'largest exporters' of lemongrass

Aakash Ghosh

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LUCKNOW : From being one of the largest importers of lemongrass a few years back, India has now become one of the largest exporters in the world, courtesy, the 'Aroma Mission' project led by CSIR-CIMAP, Lucknow.

According to Dr Prabodh Kumar Trivedi, director of CSIR-CIMAP, "About 1000 tonnes of lemongrass are produced every year, and out of it, 300 – 400 tonnes are exported. Thanks to the 'Aroma Mission' project led by CSIR-CIMAP, Lucknow. The mission also syncs with the PM's mission to make India 'Atmanirbhar Bharat,' as the Council of Scientific and Industrial Research (CSIR) has made important contributions to the establishment, fostering, and positioning of the country's essential oil-based aroma industry. It benefited the industry, farmers, and next-generation businesses, besides, also boosting the export of lemongrass over the time."

Lemongrass SOURCED

"During the Covid-19 pandemic, the demand for disinfectants skyrocketed which has significantly increased the demand for lemongrass across the world. As per the CSIR-CIMAP, Lucknow, the global market of lemongrass was USD 38.02 million in 2020 which is expected to grow from USD 41.98 million in 2021 to 81.43 million by 2028," said Dr Trivedi.

"In India, lemongrass cultivation became widely popular due to its fewer challenges in farming. It can be easily grown in drylands and even in areas frequently affected by drought or insufficient rainfall. Inherently tolerant to moisture stress, it grows very well under moisture deficient conditions including in areas such as Vidarbha, Bundelkhand and Marathwada regions. Mostly, it is grown in Western Ghats including Kerala, Maharashtra, UP, Andhra Pradesh, Karnataka, Odisha and in several North-Eastern states. Interestingly, there is no risk of damage from animals because the essential oil present in the leaves makes it unpalatable to the wild or domestic animals," he said.

"This crop under Aroma Mission has been highly successful in areas close to forests, tribal lands and places like Bundelkhand where Annapratha (leaving domestic animals in fields) is a common practice," he said.

मेले में किसानों ने जाने औषधीय खेती के फायदे

■ **एनबीटी लखनऊ :** सीएसआईआर-सीमैप की ओर से आयोजित किसान मेले के दूसरे दिन भी किसानों में उत्साह नजर आया। शनिवार को मेले के दौरान जारी बारिश के बीच भी करीब 60-70 किसान मेले में पहुंचे। बारिश की वजह से मेले का स्थान परिवर्तित कर उसे पार्किंग में आयोजित करवाया गया। कार्यक्रम में एक गोष्ठी का आयोजन भी किया गया। इसमें किसानों को कृषि की उन्नत तकनीकों एवं बाजार भाव संबंधित मुद्दों के बारे में समझाया गया। इसके साथ किसानों को औषधीय एवं सगंध पौधों की खेती के गुण और फायदे भी बताए गए। मेले के संयोजक संजय कुमार ने किसानों को क्षार प्रभावित जमीन में औषधीय पौधों की खेती कैसे की जाए इसके बारे में जानकारी दी। इसके साथ ही मेले में उपस्थित डॉ. सौदान सिंह, डॉ. बी आर सिंह, डॉ. राजेश वर्मा और डॉ. राम सुरेश शर्मा ने मेंथा, जिरेनियम, खास, नींबू घास की खेती के संबंध में किसानों को बताया।

सीमैप में लगे किसान मेले में वैज्ञानिकों ने दी जानकारी।

Sponsored Projects

Externally Funded Projects

SN	Funding Agency	Project No.	Project title	PI	Start date	Total cost (Rs. in Lakh)	End date
1	Horticulture Research Station Tamil Nadu Agriculture University, Tamil Nadu	CNP-464	Providing consultancy for designing, fabrication and setting up of S.S. directly fired type field Cohobation Distillation unit of 250 kg capacity for essential oils based on CSIR-CIMAP knowhow & design	Dr. Sudeep Tandon	21.04.2021	7.000	20.04.2022
2	DST-SERB	GAP-465	Dual acting side directed 3-aryl-benzopyran based platinum complexes for treatment of estrogen dependent and independent Breast carcinoma	Dr. Atul Gupta	03.04.2021	36.5524	02.04.2024
3	CoE MAPs NTFP, IGKV, Raipur	CNP-466	Providing consultancy for designing, fabrication, supply and setting up of Stainless Steel (SS) portable Distillation unit of 12 kg capacity for rose flower based on CSIR-CIMAP knowhow & design	Dr. Sudeep Tandon	01.04.2021	1.1338	31.03.2022
4	Indo-German Technical Collaboration, GIZ, India	CNP-467	Road map/action plan for strengthening Medicinal and Aromatic Plants (MAPs) value chain efficiency as a climate adaptation strategy in Bundelkhand region of Uttar Pradesh	Dr. Alok Kumar Krishna	08.07.2021	16.4374	07.12.2021
5	Sirius Minerals India Pvt Limited, New Delhi	CNP-468	Study the impact of Poly4 on yield attributing characters, essential oil yield and quality of Mentha arvensis L.	Dr. Rakesh Kumar Upadhyay	13.05.2021	21.240	12.05.2023

6	Department of Science & Technology, North East Centre for Technology Application and Research (NECTAR)	GAP-469	Design, development and demonstration of pilot scale environment friendly decentralized solar aroma distillation unit (20 kg capacity) for north east region farmers cultivating aromatic crops	Er. Ashween D. Nannaware	20.08.2021	16.990	19.08.2022
7	Chief Conservator of Forest Bundelkhand Zone, Jhansi, UP	CNP-470	Providing consultancy for survey and analysis for setting up of processing plant facilities and training on improved cultivation and processing of aromatic crops under NAFCC project at Banda	Dr. Ramesh Kumar Srivastava	25.08.2021	35.812	24.08.2022
8	DBT	GAP-471	Identification and isolation of the high value aroma related genes from the fragrant flower Nyctanthes arbortristis and production in vitro	Dr. Chandan Singh Chanotiya	21.08.2021	24.3416	20.08.2023
9	Indira Gandhi Agriculture University, KVK, Korea (CG)	CNP-472	Providing consultancy for designing, fabrication and setting up of Stainless Steel (SS) directly fired type field Distillation unit of 500 kg capacity for essential oils based on CSIR-CIMAP knowhow & design	Dr. Sudeep Tandon	06.10.2021	11.9944	05.10.2022
10	M/s Norex Flavours Private Limited, Amroha	CNP-473	Popularization of menthol mint cultivar CIM-Unnati through training, demonstration and cost effective package of practices in multiple villages of Dhanaura block, District Amroha UP	Dr. Rakesh Kumar	13.10.2021	10.0005	12.10.2023
11	Tamil Nadu Agriculture University, Tamil Nadu	CNP-474	Providing consultancy for designing, fabrication and setting up of Stainless Steel (SS) directly fired type Cohobation Distillation Unit of 500 kg capacity for essential oils based on CSIR-CIMAP knowhow & design.	Dr. Sudeep Tandon	06.10.2021	7.9684	05.10.2022

12	Krishi Vigyan Kendra, Kawardha (CG) Indira Gandhi Agriculture University, Raipur	CNP-475	Providing consultancy for designing, fabrication and setting up of MS directly fired type field Distillation unit of 500 kg capacity per batch for essential oils based on CSIR-CIMAP knowhow & design.	Dr. Sudeep Tandon	08.12.2021	7.6904	07.12.2022
13	DST-SERB	GAP-476	Enantiospecific catalytic transformation and immobilization of low cost essential oils for enhancing the bioactivity through economically green processes.	Dr. Prasanta Kumar Rout	10.12.2021	29.2706	09.12.2024
14	DBT	GAP-477	"Functional characterization of light-associated factor(s) regulating flavonoid biosynthesis in tomato" under TATA Innovation Fellowship Award.	Dr. Prabodh Kumar Trivedi	01.04.2020	27.00	31.03.2023
15	DST-SERB	GAP-478	Phytochemical exploration, extraction optimization and biological activity evaluation of Garcinia pushpangadaniana, a recently described plant from western ghats, India.	Dr. VS Pragadheesh	20.12.2021	33.4286	19.12.2024
16	DST-SERB	GAP-479	Design, development and comparative performance evaluation of tractor operated digging equipment for vetiver roots	Dr. Anandakumar TM	28.12.2021	25.8243	27.12.2023
17	Kancor ingredients Limited, Bareilly, UP.	CNP-480	Organization of training and demonstration on cost effective and eco-friendly package of practices for the Menthol mint growers of district Bareilly U. P.	Dr. Saudan Singh	14.01.2022	8.4075	13.01.2025

18	DST-SERB	GAP-481	Characterization of MaRAP2.13 and MaMYB49 proteins to understand their role in waterlogging induced adventitious root development in Mentha arvensis	Dr. Rakesh Shukla	28.12.2021	45.0533	27.12.2024
19	DST-SERB	GAP-482	Investigating system-wide coordination and communication of tissue-specific metabolism of plant responses to Abiotic stress using metabolomics and metabolic flux approaches	Dr. Ratnasekhar CH	27.01.2022	32.1084	26.01.2024
20	DBT	GAP-483	Pathway-flux redirection by CRISPR-Cas9/Cpf1-medicated gene editing for enhancement of medicinal traits in Rosamarinus officinalis	Dr. Dinesh Nagegowda	10.02.2022	59.2512	09.02.2025
21	DBT	GAP-484	Enhancement of Tribal Framers income through cultivation and prcessing of aromatic crops suitable for aspirational district of Nandurbar region in Maharashtra	Mr. Ashween Deepak Nannaware	01.03.2022	58.120	29.02.2024
22	AIIMS, Rae-bareli	CNP-485	Establishment of Herbal Garden (Manav) at AIIMS, Raebareli	Dr. Narendra Kumar	22.02.2022	5.2982	21.02.2023
23	DST-SERB	GAP-486	Modulation of TRPC channel-medicated angiogenesis in carcinoma cells using selected monoterpenes	Dr. Abha Mee-na	09.03.2022	36.8772	08.03.2025
24	DST-SERB	GAP-487	The Award of J C Bose Fellowship	Dr. Prabodh Kumar Trivedi	28.03.2022	74.420	13.02.2026 and further extension upto 5 years

25	INSA, New Delhi	GAP-488	Unravelling the mysteries and ethnomedicinal healing Art of Paliyars: a tribe from Western Ghats, India.	Dr. V Sundaresan	03.11.2021	2.280	02.11.2022
26	Directorate of Horticulture and Food Processing, UP, Lucknow	SSP-489	Organization of training programmes on cultivation, primary processing and marketing of medicinal and aromatic plants suitable for Uttar Pradesh.	Dr. Sanjay Kumar	31.03.2022	19.6875	30.03.2023
27	CSIR, New Delhi	FC2020-23/ NMIT-LI/ TLP0002	Industrially scalable Ashwagandha (Withania somnifera) charged formulation for better bone healh	Dr. Prabodh Kumar Trivedi	09.06.2021	124.372	31.03.2024
28	CSIR, New Delhi	MLP-18	Pan CSIR clean air devices	Dr. Anirban Pal	18.06.2021	7.300	31.03.2022
29	CSIR, New Delhi	HCP-035	Immuno Modulatory Function of Nutritionals and Nutraceuticals for Health and Wellness	Dr. Anirban Pal	06.10.2021	108.700	31.03.2023
30	CSIR, New Delhi	MLP-019	Yeast-based synthetic biology platform for high-value rare phytochemicals	Dr. Sumit Ghosh	30.12.2021	98.000	31.03.2023

DBT-Department of Biotechnology, DST-Department of Science and Technology, UPCST-Council of Science and Technology, UP, NMPB-National Medicinal Plants Board

DHR-Department of Health Research, SERB-Science and Engineering Research Board, IORA-Indian Ocean Rim Association

Superannuated Scientist

Shri P.V. Ajayakumar

Poovappallivadakethil Viswanathan Nair Ajayakumar (P. V. Ajayakumar), an eminent multi-disciplinary scientist, Electron Microscopist as well as non-invasive analyst, superannuated as Chief Scientist on 31 May 2021. He has served as a Professor (Chemical Sciences) of the Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, and Adjunct Professor of the Jawaharlal Nehru University (JNU), New Delhi (for the ClMAP-JNU Ph.D. program). During his illustrious career he served the institute in various position, at the time of retirement he was leading DU1 (Phyto Chemistry Division) of CSIR-CIMAP and was managing CSIR-CIMAP activities during the absence of its director during the "Corona period".

Born on 30th May 1961, in Cheriyanad Village, Alapuzha district, Kerala. His primary and high school education was in two schools in the village. His higher education was in Christian College, Chengannur, S. B College, Chanaganacherry which is one of the prestigious colleges in Kerala and in another prestigious college called University College, Thiruvananthapuram. After his post-graduation with specialization in Solid State Electronics at that time 'hot subject", he immediately got a job in an Instrument manufacturing Company in Bangalore as an Engineer.

There he got opportunity to understand and work on different instruments and in institutions like Central Power Research institute (from where he learned basics of Electron Microscopy), Physics and Instrumentation labs of IISC, Bangalore, Indian Horticulture Institute, Bangalore and Indira Gandhi Centre for Atomic Research, Kalpakkam (from here he learned basis of Particle size measurements using light diffraction). From IISc he completed a short-term course on "Microprocessors". In 1987, he joined in CIMAP Lucknow as Scientist B, in Electron Microscopy. At that time CIMAP had a TEM and he operated and maintained the TEM without any AMC from any external agencies. He also installed a SEM in that TEM and converted the TEM to (S)TEM. Our instrument got a fame of "longest working TEM" in India. He did all the works, single headedly, in a biological EM lab from sample preparation and fixation, block making, thin section preparations, observation under TEM/SEM and interpretation of the images, dark room activities and all types of maintenance and repairs of the TEM and its accessory machines. He played a key role in the identification and characterization of viruses associated with medicinal and aromatic plants (MAPs) as well as creating diagnostics for plant pathogenic viruses and phytoplasmas using Electron microscopy and spectroscopical approaches. His works helped to identify the pathogens and its host-parasite interactions. Atleast in Lucknow, he is the first person who "saw" and identified silver and gold nanoparticles inside the cells. In CIMAP. Two of his papers published in 2001 from this work got a total of 2249 citations including 86 citations in this year 2021.

Recently with his efforts, our institute acquired an Atomic Force Microscope (AFM) fitted with Raman Spectrometer and got installed.

In addition to his normal jobs, he was associated with various committees, like technical committees (including other institutes), purchase committees, medical committee, Test Facility Manager (TFM) of AnalytiCSIR, First Appellate authority of RTI, etc. For a short period, when institute was feeling acute financial crunches, he was deputed to head ICT. During that time, he implemented "One CSIR" ERP system in CIMAP. He also played significant role in getting NABL certificates (two times), and ISO certificate for the institute.

In CIMAP, he introduced a green analytical technique, non-invasive analysis for rapid and highly economical analysis of Phyto-molecules and other bio-molecules using FT- IR, FT-NIR, Raman and AFM. One of his papers based on non-invasive analysis of a drug molecule was cited in an IEEE journal (ieeexplore.ieee.org) which is an engineering related journal in the same week of publication.

He had more than 85 papers, 3 U.S patents and 1 book chapter. Also, he is the only non-chemist of this institute with a paper in Angewandte Chemie international edition. He got several best paper awards from different symposia and seminars and the most notable one is best paper awards from NCL Pune in 2002 in physical sciences.

Obituaries

Smt. Beepeta Mallikamba, an Administrative Officer of CSIR-CIMAP Research Center, Hyderabad passed away in the embrace of the CIMAP family on dated 27/04/2021 due to COVID-19.

Smt. Beepeta Mallikamba, born on 20/06/1962 in Secunderabad, Telangana, and married to Mr. Gouri Shanker having two kids, Dheeraj Muthyampeta and Divya Muthyampeta. She did her diploma in commercial practice in Hyderabad in the year 1981 and completed her graduation Bachelor of commerce in the year 1986. After completing her graduation from Osmania University, she joined CSIR-IICT, Hyderabad as a Junior Stenographer in the year of 1982 to 30th January 2017 and after that, she joined CSIR-CIMAP Research Center, Hyderabad as an administrative officer on 31st January 2017 to till her demise.

Her sudden demise was a shock to all the staff, students, colleagues, and friends. She was outstanding in administrative related works.

CSIR-CIMAP family expresses deep and heartfelt condolences to the sorrowing family and joins in their prayers for the deceased. May Lord Almighty take the departed soul to her heavenly adobe and give the entire family strength and courage to bear this irreparable loss.

Mrs. Nargis Sufia Ansari

Mrs Nargis Sufia Ansari w/o Mohd Ilyas Ansari joined on 22/04/2009 in CSIR-CIMAP Lucknow and worked in dispensary and devoted herself to CIMAP patients and employees. She was cool and helping to all the patients and work oriented.

Mrs. Sudha Agarwal
(24th January 1975 - 13th May 2021)

Late Mrs. Sudha Agrawal was born on 24th January, 1975 at Pakaur Distt. Dumka, presently a district headquarter in the state of Jharkhand. Her schooling was from Pakaur and she completed B.Tech. in Cosmetic Technology from Nagpur in 1996. After completion of graduation she joined cosmetic industry at Mumbai.

She was married to Mr. Mudit Agarwal, a Lucknow based gentleman and after marriage she settled down at Lucknow (UP). In the year 2003, she joined CSIR-CIMAP as a consultant with Dr. Anirban Pal and assisted in translating traditional knowledge and scientific evidences into products such as shampoo, face wash and floor disinfectant etc. For a short period she discontinued the project work at CSIR-CIMAP and again joined with Dr. Dinesh Kumar, PTO as a consultant. Mrs. Sudha Agarwal further contributed in the development of many herbal formulations related to skin care, pain relievers and disinfectants. In the year 2013, October she joined as Senior Technical Officer at CSIR-CIMAP after which she developed herbal formulations for oral care, skin care, hair care, hand and surface disinfectants besides pain relieving formulations. She also helped in establishing the pilot plant facility (TBIC) in the institute and actively involved in manufacturing the research based herbal products for the startups/ entrepreneurs. Her immense contributions would be remembered while jotting down the growth of the Institute. Her popularity in Expo's and Exhibitions can only he heard from the public figures who had thronged the stalls during the last decade. She worked tirelessly till her unfortunate demise due to COVID-19 on 13th May, 2021. Her contributions to CSIR would be indelible. Her unexpected death is a big loss for the Institute and would be difficult to replenish in the years to come.

Staff Members (As on 31 March 2022)

Dr. Prabodh Kumar Trivedi
Director

Chief Scientist

Dr. A.K. Shasany(On Deputation)
Dr. Saudan Singh
Dr. Alok Kumar Krishna
Dr. Ved Ram Singh
Dr. Arvind Singh Negi
Dr. A.K. Gupta
Dr. Sudeep Tandon
Dr. Birendra Kumar

Senior Principal Scientist

Er. G.D. Kiranbabu
Dr. Laiq-Ur-Rahman
Dr. Dharmendra Saikia
Dr. Dinesh A. Nagegowda
Dr. Vikrant Gupta
Dr. Anirban Pal
Dr. J. Kotesh Kumar
Dr. Karuna Shanker
Dr. (Mrs) Sunita Singh Dhawan
Dr. Dayanandan Mani
Dr. Sumit Ghosh
Dr. Rajesh Kumar Verma
Dr. Sanjay Kumar
Dr. Manoj Semwal
Dr. Dnyaneshwar Umrao Bawankule
Dr. Feroz Khan

Principal Scientist

Dr. Ashutosh Kumar Shukla
Dr. Narayan Prasad Yadav
Dr. Suaib Luqman
Dr. Rajendra Chandra Padalia
Dr. V. Sunderesan
Dr. Ram Swaroop Verma
Dr. KVN. Satya Srinivas
Dr. Chandan Singh Chanotiya
Dr. Debabrata Chanda
Dr. Prasanta Kumar Rout
Dr. (Mrs) Prema G. Vasudev
Dr. Rakesh K. Shukla
Dr. Venkata Rao D.K
Dr. (Mrs) Puja Khare
Dr. Ramesh Kumar Srivastava
Dr. (Mrs) Abha Meena
Dr. Atul Gupta
Dr. Pradipto Mukhopadhyay
Dr. Ram Suresh Sharma
Dr. Rakesh Kumar Upadhyay
Dr. (Ms.) Tripta Jhang
Er. Ashween D. Nannaware
Dr. Bhaskar Shukla

Sr. Scientist

Dr. Kishore Babu Bandamaravuri
Dr. Mukti Nath Mishra
Dr. Hari Om Gupta
Dr. Narendra Kumar
Dr. Channayya Hiremath
Dr. Venkatesha K.T.
Dr. Dayanand Chandrahas Kalyani
Dr. Yogendra N.D.
Dr. Jnanesha A.C

Scientist

Dr. Rakesh Kumar
Dr. Akanksha Singh
Dr. Dependra Kumar
Dr. (Mrs) Gunjan Tiwari
Dr. Kapil Dev
Dr. (Ms) Priyanka Suryavanshi
Dr. Bhise Rushikesh Nanasaheb
Dr. Santosh Kumar Chandappa Kedar
Dr. B Shivanna
Dr. V S Pragadheesh
Dr. Ananda Kumar T.M.
Dr. Ratnashekhar C.H.

Group-III

Principal Technical Officer

Er. A.M. Khan
Dr. Sukhmal Chand
Shri K. Bhaskaran

Sr. Technical Officer (2)

Dr. Neerja Tiwari
Smt. Anju Kumari Yadav
Shri Shiv Prakash
Dr. (Mrs) Manju Singh
Dr. Anil Kumar Singh
Dr. Rajendra Prasad Patel
Dr. Rakshpal Singh

Sr. Technical Officer (1)

Shri Ram Pravesh
Shri A.K. Tiwari
Dr. Amit Chauhan
Dr. Anil Kumar Maurya
Shri Amit Mohan
Smt Namita Gupta

Technical Officer (Gr. III (3))

Shri Sanjay Singh
Shri A. Niranjan Kumar
Mrs. Anju Kesarwani
Shri Balakishan Bhukya
Shri Amit Kumar Tiwari
Shri Manoj Kumar Yadav
Shri Ashish Kumar
Shri Prawal Pratap Singh Verma
Shri Ashish Kumar Shukla

Technical Assistant

Shri Manish Arya
Shri Sanjeet Kumar Verma
Shri Deepak Kumar Verma
Miss Pooja Singh
Shri Sonveer Singh
Shri Abhishek Kushwaha
Shri Ranjith Kumar Sunkari
Shri Abhishek Singh
Dr (Mrs) Sujata Singh Yadav
Shri Mohd Danish Hussain
Miss. Rajni Gautam
Mrs. Parul Sharma
Mr. Parmanand Kumar

Group-II

Sr. Technician (3)

Dr. Abdul Khaliq
Shri Raghubind Kumar
Smt S. Sharda
Shri Salim Uddin Beg

Sr. Technician (2)

Shri SK Pandey
Shri Gopal Ram
Shri Joseph M Massey
Shri Ram Lakhan
Shri PK Tiwari
Shri Vinod Kumar

Sr. Technician (1)

Shri Dharam Pal Singh
Shri Pankaj Kumar Shukla
Shri Kundan Narayan Wasnik
Shri Basant Kumar Dubey

Technician (2)

Shri Yalla VVS Swamy
Shri Vijay Kumar Verma
Shri Harendra Nath Pathak
Shri Hemraj Sharma
Shri Jitendra Kumar Verma
Shri Pramod Kumar

Technician (1)

Shri Santosh Prasad Saroj
Shri Junaid
Shri Sonu Kumar
Shri Manish Kumar Maurya
Shri Sujit Singh Chauhan
Shri Sateesh Kumar

Group-I

Lab Assistant
Shri Ram Ujagir
Shri Subhash Kumar
Shri Bharat Singh Bisht
Shri Munawwar Ali
Shri Hari Pal
Shri Nurul Huda
Shri Surendra Nath
Shri Lal Chand Prasad

Lab Attendant (2)

Shri T.P. Suresh

Administrative Staff

Group-A
Administrative Officer
Shri Naresh Kumar

Finance & Account Officer
Shri H. Changloi

Store & Purchase Officer
Shri Sanjay Kale

Group-B (Gazetted)

Sec. Officer (Gen)
Shri J.S. Menon
Shri Vikas Verma
Shri Rahul Singh
Ms Sanyogita Sainger

Sec. Officer (F&A)
Shri Anil Kumar Sharma
Shri Ayush Singhal

Sec. Officer (S&P)
Shri Shamiullah Khan
Shri Mohd. Rijwan

Private Secretary
Smt Kanchan Lata Thomas
Miss Gaitry Sharda

Group-B (Non-Gazetted)

Asstt. Section Officer (Gen)
Smt Sufia Kirmani
Shri Sant Lal
Shri P Srinivas
Shri Kaushal Kishore
Shri Siddharth Shukla
Shri Ravi Prakash
Shri P.K. Chaturvedi
Shri Manoj Swaroop Shukla
Smt. Sheela Yadav

Asstt. Section Officer (F&A)

Shri Shiv Kumar
Shri A.L. Sahoo
Smt K.C. Nagarathnamma

Asstt. Section Officer (S&P)

Shri Ajeet Verma

Senior Stenographer

Smt P. Sabitha
Shri Srikar Ji Sinha
Ms. Suchita Gupta

Group-B (Isolated Posts)

Shri Rohit Khanna

Group-C Posts

Sr. Secretariat Asstt (Gen)
Sri Ravi Prakash Mishra
Ms Pratibha Maurya

Jr. Secretariat Asstt (Gen)
Shri Abdul Nadir Khan

Jr. Secretariat Asstt (S&P)
Shri Tula Singh

Jr. Secretariat Asstt (F&A)
Ms. Sonali Kumari Yadav
Shri. Mohd. Shameem

Group C (Non –Tech)

Drivers

Shri Ajay Kumar Verma
Shri Sanjay Kr. Singh
Shri Sarwesh Yadav
Shri Chandrapal Verma
Shri Rajesh Kumar

Canteen Staff

Shri Victor Mukherjee

Multi-Tasking Staff

Shri Ashok Kr. Pathak
Smt Nirmala Verma
Smt Tara Devi
Smt Sunita Devi
Shri Sant Ram

PB-1

Shri Sudhir Kumar Bhattacharya
Shri Harihar
Shri Praveen Kumar
Shri Kishan Ram
Smt. Zarina Bano
Shri Dharam Pal Balmiki
Shri Arvind Kumar
Smt. Raj Mati
Shri Mohd. Mohseen
Smt. Pushpa

New Staff Members

S.No	Name	Designation	Date of Joining	Posting
1.	Mrs. Parul Sharma	Technical Assistant	01.07.2021	CSIR-CIMAP, Lucknow
2.	Miss. Rajni Gautam	Technical Assistant	01.07.2021	CSIR-CIMAP, Lucknow
3.	Shri Sanjay Kale	Store & Purchase Officer	19.08.2021	CSIR-CIMAP, Lucknow
4.	Shri Anil Kumar Sharma	Section Officer (F&A)	19.08.2021	CSIR-CIMAP, Lucknow
5.	Shri J.S. Menon	Section Officer (Gen)	31.08.2021	CSIR-CIMAP, Lucknow
6.	Mr. Parmanand Kumar	Technical Assistant	17.11.2021	CSIR-CIMAP, Lucknow
7.	Shri Mohd. Rijwan	Section Officer (S&P)	30.12.2021	CSIR-CIMAP, Lucknow
8.	Shri Vikas Verma	Section Officer (Gen)	31.12.2021	CSIR-CIMAP, Lucknow
9.	Shri Rahul Singh	Section Officer (Gen)	31.12.2021	CSIR-CIMAP, Lucknow
10.	Shri Naresh Kumar	Administrative Officer	31.12.2021	CSIR-CIMAP, Lucknow

Staff Superannuated

S. No.	Name	Designation	Date of Retirement
1.	Shri P N Gautam	Senior Technician(2)	30.04.2021
2.	Shri Pratap Singh Chauhan	SO(S&P)	30.04.2021
3.	Shri P V Ajayakumar	Chief Scientist	31.05.2022
4.	Shri Yograj Singh	Security Officer	31.05.2021
5.	Shri Pradeep Kumar	Assistant(F&A)II	31.05.2021
6.	Shri P Bhikshapathi	Lab Attendent	30.06.2021
7.	Shri Vinod Kumar Shukla	Senior Technician(2)	30.06.2021
8.	Shri Prem Singh	PTO	31.08.2021
9.	Shri E Bhaskar	Senior Technician(2)	30.09.2021
10.	Shri Ram Chandra	Senior Technician(2)	30.11.2021
11.	Shri Shyam Behari	Senior Technician(2)	30.11.2021
12.	Shri K G Thomas	ASO(G)	31.12.2021
13.	Dr Vinay K Agarwal	Sr Medical Officer	28.02.2022

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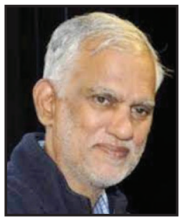

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Summary of the cases during 1st April 2021- 31st March 2022					
Application Received	**Rejected**	**Information provided**	**1st Appeal**	**Decision where 1st appeal replied**	**Referred to CIC, New Delhi**
93 including Transfer cases	NIL	93	04	04	NIL

Budget at a Glance (As on 31 March 2022)

	Allocation (₹ in lakhs)	Expenditure (₹ in lakhs)
Pay and Allowance	3032.225	3030.444
Contingency	363.4	362.625
HRD	–	–
Lab Maintenance	284.492	284.492
Staff Qtr. Maintenance	53.398	53.398
Chemicals / Consumables	575.724	575.687
Works and Services	133.45	133.448
Apparatus and Equipment	847.82	847.82
Office Equipment	–	–
Furniture and Fitting	–	–
Library (Books& Journal) P50	55.49	55.29
Staff Qtrs. (Construction)	16.55	12.297
CSIR Network Projects	1432.687	1340.016
Total	**6795.236**	**6695.517**
Pension	2844	2842.037
External Budgetary Resources		
Lab Reserve Fund (LRF)	–	29.344
External Cash Flow (ECF)	–	701.621

Ph.D. Awarded

1st April 2021 to 31st March 2022							
S. No.	**Student**	**Supervisor**	**Batch**	**Enrolment No.**	**Thesis Title**	**Date of viva Voce**	**University**
1.	Ankita Srivastava	Dr. Abdul Samad	2016 Aug	10CC16A10009	Development of Podophyllotoxin congeners as cancer chemotherapeutics through fragment based drug discovery approach"	02-05-2021	AcSIR
2.	Hina Iqbal	Dr. D. Chanda	2015 Aug	CIMAP/14/012	Study of antihypertensive potential of natural and derived plant phenolics in rodents using in-vitro in-vivo and studies	08-06-2021	JNU
3.	Kaneez Fatima	Dr. Suaib Luqman	2015 Aug	10BB15A10006	Molecular and cell target based study of selected terpenoids as anticancer agents	18-06-2021	AcSIR
4.	Sandeep	Dr. Sumit Ghosh	2015 Jan	CIMAP/14/017	Molecular and Biochemical Basis of Pentacyclic Triterpene Biosynthesis in Banaba [*Lagerstroemia speciosa* (L.) Pers]	25-06-2021	JNU
5.	Ranjana Maurya	Dr. Chandan Singh Chanotiya	2017 Jan	10CC17J10003	Unravelling the aroma of *Chrysopogon zizanioides* and *Ocimum* species: Identification and Characterization of Odor-impact Compounds	30-06-2021	AcSIR
6.	Nandan Singh	Dr. D. Saikia	2014 Jan	CIMAP/13/016	Study Of Mechanism Action Of Some Selected Phytomolecules Against And Their Combination And Toxicity Profile *Candida Spp*	09-07-2021	JNU
7.	Pragya Trivedi	Dr. Rajesh Kumar Verma	2015 Jan	CIMAP/14/014	Structural and functional dynamics of microbial communities in various *Mentha arvensis* cultivars and soil moisture regimes	26-08-2021	JNU
8.	Priyanka Kumari	Dr. Abha Meena	2015 Aug	10BB15A10012	Green synthesis and characterization of nanomaterial from plant sources and its pharmaceutical applications	01-09-2021	AcSIR

9.	Saumya Sinha	Dr. Abdul Samad	2016 Aug	10BB16A10005	Genomic characterization of cucumber mosaic virus(es) infecting selected medicinal and Aromatic plants:- Pathogenic effects and management strategies.	23-09-2021	AcSIR
10.	Zulfa Nooreen	Dr. N.P. Yadav	2017 Aug	CIMAP/17/005	Chemical investigation and bio-evaluation of *Zanthoxylum armatum* DC. and *Cuscuta reflexa* Roxb	24-09-2021	JNU
11.	Saurabh Kumar	Dr. M.P. Darokar	2016 Jan	CIMAP/ 2016/003	Studies on phytochemical(s) for their potential as drug-resistant reversal agents in malaria parasite	28-09-2021	JNU
12.	Indrajeet	Dr. Abdul Samad	2016 Jan	CIMAP/ 2016/002	Studies On Effect Of Charcoal Rot Disease Caused By *Macrophomina Phaseolina*, On *Mentha Arvensis* (Menthol Mint) Cultivation In Indo-Gangetic Plains And Its Sustainable Management	01-10-2021	JNU
13.	Karishma Agarwal	Dr. Atul Gupta	2015 Aug	10CC15A10009	Value Addition of Flavonoids and Related Compounds for Pharmacological Activities	08-10-2021	AcSIR
14.	Raja R	Dr. Vikrant Gupta	2014 Jan	10BB14J10001	Molecular cloning and studies on the isoprenoids pathways genes and gene regulatory components from *Azadirachta indica* and *Artemisia annua*"	29-10-2021	AcSIR
15.	Ritesh Kumar	Dr. Ajit Kumar Shasany	2011	CIMAP/11/024	Isolation and Characterization of Cytochrome P450 Involved in Abscisic Acid (ABA) Metabolism in *Artemisia annua*	12-11-2021	JNU
16.	Sneha Sinha	Dr. M.P. Darokar	2015 Jan	CIMAP/14/013	Deciphering the mechanism of natural products possessing bacterial drug resistance reversal potential	23-11-2021	JNU

17.	Vereena Rodrigues	Dr. V Sundaresan	2015 Aug	10BB15A10003	Biotechnological interventions for conservation and modulation of 2-Hydroxy-4-methoxybenzaldehyde biosynthesis in *Decalepis salicifolia*,a RET plant	15-12-2021	AcSIR
18.	Dikki Pedelna Bomzan	Dr. Dinesh A Nagegowda	2015 Aug	10BB15A10011	Decoding the role of genes related to geranylgeranylation in the modulation of alkaloid biosynthesis in *Catharanthus roseus*"	15-12-2021	AcSIR
19.	Poornima R Ranganathan	Dr. Venkata Rao DK	2015 Jan	10BB15J10007	Role of altered lipid metabolism in the regulation of ergosterol biosynthesis and its application for enhanced production of medicinally important triterpenoids in yeast."	21-12-2021	AcSIR
20.	Manoj Semwal	Dr. Rajesh Kumar Verma **Co-Guide:** Dr. T S Rana (CSIR-NBRI)	2016 Aug	10BB16A10008	Application of Remote Sensing Technologies for Precision Agriculture in Menthol Mint (*Mentha arvensis* L.).	27-12-2021	AcSIR
21.	Saumya Shah	Dr. Ajit Kumar Shasany	2015 Aug	CIMAP/15/006	Prospecting Gene(S) Of Flavonoid Biosynthesis In *Ocimum* Spp.	01-02-2022	JNU
22.	Shilpashree HB	Dr. Dinesh A. Nagegowda	2016 Jan	CIMAP/2016/004	Identification and characterization of withanolides biosynthetic genes in *Withania somnifera*	17-02-2022	JNU
23.	Sarita Singh	Dr. Atul Gupta	2018 Jan	10CC18J10013	Structural modifications of flavonoids for evaluation of their pharmacological activity	15-02-2022	AcSIR
24.	Bhavana Gangwar	Dr. M.P. Darokar	2015 Aug	CIMAP/15/002	Expression analysis of transcriptional regulators and genes responsible for multidrug resistance in response to selected phytochemicals active against *Staphylococcus aureus*."	21-02-2022	JNU

*AcSIR- Academy of Scientific and Innovative Research, Ghaziabad *JNU-Jawaharlal University, New Delhi

Glimpses from the CIMAP History*

CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) is a premier multidisciplinary research institute of Council of Scientific and Industrial Research (CSIR), India with its major focus on exploiting the potential of medicinal and aromatic plants (MAPs) by cultivation, bioprospection, chemical characterization, extraction, and formulation of bioactive phytomolecules. With a strength of 100 scientists, 162 technical officers, 129 support staff and nearly 300 doctoral and post-doctoral scholars at its HQ in Lucknow and research centers at Bengaluru, Hyderabad, Pantnagar, and Purara, CSIRCIMAP has played a key role in positioning India as a global leader in production of mints, vetiver and other aromatic grasses, and in ensuring indigenous production of artemisinin - a WHO approved anti-malarial. CSIR-CIMAP houses a National Gene Bank on MAPs, which is one of the three of its kind in India. CSIR-CIMAP has played a key role in successfully commercializing an ayurvedic herbs-based anti-diabetic formulation, which has now benefitted millions. The institute is presently accredited by ICS-UNIDO and Indian-Ocean Rim Association (IORA) as a focal point for research and training on Medicinal Plants among 21 participating member countries.

History at a Glance

- Initially set up as Central Indian Medicinal Plants Organisation (CIMPO) in the year 1957 with a mandate to work and stimulate research on medicinal plants; subsequently aromatic plants also brought under its ambit
- CIMPO started functioning from 26th March 1959 with the appointment of late Shri P.M. Nabar its first Officer Incharge and rechristened as Central Institute of Medicinal and Aromatic Plants (CIMAP) in the year 1978
- The institute shifted to its present campus near Kukrail forest, Lucknow in the year 1980

Our Mandate

- CSIR-CIMAP is engaged in multi-disciplinary high-quality research in agricultural, biological and chemical sciences and extending technologies and services to the growers and entrepreneurs of MAPs with the following mandate:
- Genetic improvement, cultivation, production and chemical processing of economically important MAPs
- Characterization and conservation of genetic resources
- Production of planting material of the improved cultivars
- Bioprospecting plants and their constituents for various biological activities using different in vitro and in vivo techniques
- Metabolic pathway studies for identifying and modulating yield determinants
- Herbal products and formulations for better life
- Knowledge management for the enhancement and dissemination of R&D
- Human resource development for R&D in the basic and applied areas of MAPs

**cited from the 2018 brochure of the CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP)*

Salient Contributions of CSIR-CIMAP

- Catalysed transformation of India from menthol importing country to the largest global producer and exporter of menthol mint oil by spreading *Mentha* cultivation in more than 300,000 hectares, developing short-duration and high yielding varieties, and superior agro and processing technologies which enhanced the income of nearly 600,000 farmers.

- Ensured 'Make in India' of the anti-malarial drug artemisinin by developing high yielding varieties of *Artemesia annua,* chemical process for extraction and derivatization of artemisinin and promoting cultivation of improved varieties in farmers field.

- Profitable utilization of salt-affected and flood-prone coastal and river bank areas by developing and deploying short duration and high yielding varieties of Vetiver (Khus).

- Development and deployment of improved varieties of lemon grass, palmarosa, ashwagandha, and tulsi for cultivation in under-utilized rain deficit areas like Bundelkhand, Vidharbha, Kutch and Marathwada regions.

- Developed one of the most successful & popular herbal formulation for the management of diabetes type 2 (With CSIR-NBRI) using medicinal plants mentioned in Ayurveda and ensuring clinical efficacy and safety.

- Leading CSIR Aroma Mission to empower Indian farmers and aroma industries by encouraging cultivation, processing, value addition and marketing of aromatic crops.

- Coordinating promotion of exchange of knowledge and trade of medicinal plants among IORA member states of Indian-Ocean Rim Association.

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मुख्यालय, लखनऊ Head Quarter Lucknow

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