CSIR-CIMAP

वार्षिक प्रतिवेदन
२०१९-२०२०

Annual Report
2019-2020

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।

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(Council of Scientific and Industrial Research)

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CSIR-CIMAP

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Special Thanks
Anirban Pal for providing cover page photograph & other important photographs

Cover page
Depicts the different species of Ocimum *viz. O. basilicum*, *O. sanctum* and *O. africanum*

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From The Director's Desk....

CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), a frontier plant research laboratory of the Council of Scientific and Industrial Research (CSIR), is steering multidisciplinary high quality research in biological, agricultural and chemical sciences, and extending technologies and services to the farmers and entrepreneurs of medicinal and aromatic plants (MAPs. Within 60 years, since its inception as Central Indian Medicinal Plants Organisation (CIMPO) in 1959, CSIR-CIMAP has made great progress in fundamental research, technology and product development, extension activities and human resource development.

It is a matter of pride for me in presenting the Annual Report 2019-20 of the CSIR-CIMAP before all of you. I joined the institute as the Director on February 14, 2020 which has given me an opportunity to witness the institute's achievements closely. However, the institute's achievements and accomplishments in the R & D sector, the huge societal impacts it has made, and the strong outreach to stakeholders truly speak about the tireless efforts of our scientists, technical staff, students, post-docs, and other supporting staff, including administration.

We had been at the forefront, as a nodal laboratory, in disseminating our aroma-based technologies to the farmers, entrepreneurs, and industries under CSIR-Aroma Mission, and our efforts have immensely benefitted the various stakeholders. Our reach-out to the unreached in the most challenging areas, intense and closer contacts with our poor and tribal farmers, regular interactions with the user industries have made our interventions extremely fruitful. This has resulted in the enhanced income of the farmers even from unutilized lands, which has received the national lauds at various points of time. More importantly, the huge amounts of essential oil produced under the mission have helped our country to become 'Atmanirbhar' to some extent. We would like to take these activities forward with greater zeal and vigour under Phase-II of the mission. Our contributions to the successful completion of CSIR-Phytopharmaceutical Mission were also commended for promoting the cultivation of the plants used in phytopharmaceuticals. Under the same Mission, CMC (chemistry, manufacturing, and controls) of 5 medicinal plants, 24 phytochemicals reference substance (PRS) and a monograph of Andrographis paniculata were also prepared by CSIR-CIMAP under this Mission. CSIR-CIMAP contributed in development of nutraceutical formulations for increased absorption of vitamin B12 using standardized plant extract, developed nutri-foods for breakfast and triphala based validated formulation for compromised immunity under CSIR-Nutraceutical Mission Program. In addition, we also successfully completed a number of projects under FBR/NCP/FTT/FTC categories under various themes. I am sure that the outcome of these would improve the organization's visibility.

During the year under report, CSIR-CIMAP published 96 papers in the SCI journals and a few non-SCI articles and book chapters. Institute established a sustainable way of stabilizing highly acidic mines using Biochar aided aromatic grass vegetation. Physicochemical, scavenging, and anti-proliferative activities of *P. ovata* husk and seed polysaccharides were studied and documented. The modulation of the Nrf2 and iNOS activity by medicinally important molecule, Rutin, leading to the protection against t-butyl hydroperoxide-induced oxidative impairment, was also studied in detail. CSIR-CIMAP carried out detailed analysis and suggested an important role of a plastid localized geranylgeranyl diphosphate synthase in monoterpene indole alkaloid biosynthesis in *Catharanthus roseus*. The possibility of using morphological, molecular, and chemical analysis for differentiating *O. gratissimum* complexes was also proposed. In yet another work, the occurrence of morphological and molecular diversity present among the 51 accessions of Indian opium poppy germplasm was estimated using Mahalanobis D2 and SCoT markers. Besides, our computational biology group revealed the anticancer activity of flavones analogs through Tankyrase inhibition using QSAR, Docking, ADME/Tox studies.

On the societal front, CSIR-CIMAP continued its efforts with greater enthusiasm by developing several agro-techniques, which may benefit a large number of farmers. The same was rigorously transferred through several awareness and training programmes conducted during the period. I feel elated in declaring that CSIR-CIMAP is now NABL accredited laboratory (ISO/IEC 17025:2017) for fulfilling "General Requirements for the Competence of Testing & Calibration Laboratories" towards testing of Ayurvedic drugs and formulations, and essential oils. During this period, we also developed and released seven high yielding varieties of Cymbopogon, Ocimum, Mentha, Pogostemon, and Catharanthus, possessing capabilities of enhanced synthesis and accumulation of important phyto-constituents and/or essential oil than the existing varieties. Four new products *viz*. PsoriaCIM (a cream formulation for mitigation of psoriasis; patent filed), MENTHOFRESH (a herbal oral cleaner), CIMKESH (a herbal hair oil) and CIM-Mridashakti (a natural soil enhancer from Agri-waste) were released during this period. Further, five product technologies have been transferred for commercialization, and the CSIR-CIMAP pilot plant supported the manufacturing of four of its products for various start-ups/ budding entrepreneurs. In total, 37 students of the institute were awarded PhD degree from the Academy of Scientific and Innovative Research (AcSIR) and Jawaharlal Nehru University (JNU) within this time . Our scientists' and scholars' works have been recognized through various awards like the ICMR prize, Newton-Bhaba, and Raman Research Fellowships.

I take the opportunity to congratulate team CSIR-CIMAP for their contribution to the institute's progress and express my gratitude to all my predecessors for their supervision to bring the institute at its present level. This year 28 new members have joined our CIMAP family, of which 8 each are scientists and technical staff. During 2019-20, 14 staff members, including one scientist and three technical support staff have superannuated. I sincerely hope that our new and young brigade will fill the vacant space left by our old guards, and together, we will take CSIR-CIMAP to new heights in the coming years.

CSIR-CIMAP thanks the Director General, CSIR for the valuable advice, suggestions and encouragement in the management of CSIR-CIMAP activities. I am grateful to the Chairman and other members of the Research Council, and Management Council for valuable inputs in advancing R&D activities and overall management. In addition, CSIR-CIMAP has been supported and advised by several well-wishers to reach to this reputation in research and development activities. I thank you all and look forward to continued support and encouragement to make CSIR-CIMAP a world leader in medicinal and aromatic plants research.

(Prabodh Kumar Trivedi)

निदेशक की कलम से......

सीएसआईआर–केंद्रीय औषधीय एवं सगंध पौधा संस्थान (सीएसआईआर–सीमैप), वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद (सीएसआईआर) का एक अग्रणी पादप शोध संस्थान है, जो जैव, कृषि एवं रसायन विज्ञान के क्षेत्र में उच्च गुणवत्ता युक्त बहुआयामी शोध कर रहा है एवं अपनी प्रौद्योगिकियों तथा अन्य सेवाओं को औषधीय एवं सुगंधित पौधों के क्षेत्र में काम करने वाले किसानों एवं उद्यमियों तक पहुंचा रहा है। सन् 1959 में केंद्रीय भारतीय औषधीय पादप संगठन (CIMPO) के रूप में स्थापित होने के 60 वर्षों के भीतर, सीएसआईआर–सीमैप ने मौलिक अनुसंधान, प्रौद्योगिकी एवं उत्पाद विकास, विस्तार तथा मानव संसाधन विकास के क्षेत्र में महत्वपूर्ण प्रगति की है।

आज मुझे सीएसआईआर–सीमैप के वार्षिक प्रतिवेदन 2019–20 को प्रस्तुत करते हुए गर्व का अनुभव हो रहा है। मैंने इस संस्थान में 14 फरवरी 2020 को निदेशक के रूप में कार्यभार ग्रहण किया जिससे मुझे शोध के क्षेत्र में संस्थान की उपलब्धियों, सामाजिक विकास में इसके योगदान और हितधारकों तक पहुंच, संस्थान के वैज्ञानिकों, तकनीकी कर्मचारियों, शोधार्थियों एवं अन्य सहयोगी कर्मचारियों के अथक प्रयासों को नजदीक से समझने व उन्हें नयी ऊचाईयों तक ले जाने का अवसर प्राप्त हुआ है।

सीएसआईआर–एरोमा मिशन के अन्तर्गत, सीएसआईआर–सीमैप, नोडल संस्थान के रूप में किसानों, उद्यमियों, और उद्योगों को सुगंध आधारित प्रौद्योगिकियों को प्रसारित करने में अग्रणी रहा है, और हमारे प्रयासों ने विभिन्न हितधारकों को अत्यधिक लाभान्वित किया है। दुर्गम जगह पर हमारी पहुंच, गरीब और आदिवासी किसानों के साथ निकट संबंध तथा उद्योगों के साथ नियमित संपर्क ने हमारे हस्तक्षेपों को अत्यंत फलदायी बनाया है। अनुपयोगी जमीन में कृषि के द्वारा किसानों की आय में वृद्धि हुई है, जिसकी समय–समय पर राष्ट्रीय स्तर पर प्रशंसा की गई है। इससे भी महत्वपूर्ण बात यह है कि मिशन के तहत अधिक मात्रा में उत्पादित सुगंधित तेल हमारे देश को आत्मनिर्भर बनने में योगदान दे रहा है। हम इन गतिविधियों को मिशन के दूसरे चरण के तहत अधिक उत्साह और जोश के साथ आगे ले जाना चाहते हैं। सीएसआईआर– फाइटोफार्मास्यूटिकल मिशन के अंतर्गत औषधीय पौधों की खेती को बढ़ावा देने में सीएसआईआर–सीमैप ने सराहनीय योगदान दिया है। इसी मिशन के तहत, 5 औषधीय पौधों के CMC (रसायन, विनिर्माण और नियंत्रण), 24 फाइटोकेमिकल्स संदर्भ पदार्थ और कालमेघ का एक मोनोग्राफ भी तैयार किया गया है। सीएसआईआर–सीमैप द्वारा न्यूट्रास्युटिकल मिशन के तहत पौष्टिक नाश्ता और त्रिफला आधारित प्रतिरक्षक फार्मुलेशन एवं विटामिन बी12 के अवशोषण में वृद्धि के लिए औषधीय पौध आधारित अर्क विकसित किये गये हैं। इसके अलावा, हमने विभिन्न विषयों के तहत एफबीआर/एनसीपी/एफटीटी/एफटीसी श्रेणियों के तहत कई परियोजनाओं को भी सफलतापूर्वक पूरा किया। मुझे विश्वास है कि हमारे यह प्रयास संगठन की दृश्यता में वृद्धि करेंगे। इस वर्ष के दौरान, सीएसआईआर–सीमैप ने वैज्ञानिक शोध पत्रिकाओं (SCI Indexed) में 96 पत्र और कुछ अन्य लेख और पुस्तक अध्याय प्रकाशित किए। संस्थान ने बायोचार एवं सुगंधित पौधों द्वारा अत्यधिक अम्लीय खाद्यानों से प्रदूषित मृदा को स्थिर करने का तरीका विकसित किया। इस दौरान संस्थान के द्वारा *P. ovata* की भूसी और बीज पॉलीसेकेराइड्स के भौतिक–रासायनिक गुण स्केवंजिग एवं एन्टी प्रोलिफिरेटिव एक्टिविटी पर अध्ययन किया गया। औषधीय रूप से महत्वपूर्ण अणु, Rutin द्वारा Nrf2 और iNOS गतिविधि के मॉड्यूलेशन, tBHT-प्रेरित ऑक्सीडेटिव स्ट्रेस के खिलाफ सुरक्षा प्रदान करने की शक्ति का अध्ययन किया गया। सीएसआईआर–सीमैप ने सदाबहार के पौधों में monoterpene indole alkaloid के जैव

संश्लेषण में एक प्लास्टिड में मौजूद GGPPS की भूमिका का अध्ययन किया। *O. gratissimum* के विभिन्न जीनोटाइप में रूपात्मक, आणविक और रासायनिक भिन्नता का पता लगाया। अफीम–पोस्ता की 51 जर्मप्लाज्म की रूपात्मक और आणविक विविधता का महालनोबिस डी2 और SCoT मार्करों द्वारा पता लगाया गया। इसके अलावा, हमारे कम्प्यूटेशनल जीवविज्ञान समूह ने QSAR, डॉकिंग, ADME /टॉक्स अध्ययनों का उपयोग करके टैंकिरेज–निषेध के माध्यम से फ्लेवोन एनालॉग्स की कर्करोधी गतिविधि का पता लगाया।

सामाजिक क्षेत्र में भी सीएसआईआर–सीमैप ने कई कृषि तकनीकों को विकसित करके अपने प्रयासों को पूरे जोश के साथ जारी रखा जिससे बड़ी संख्या में किसान लाभान्वित हुए। इन तकनीकों को कई जागरूकता और प्रशिक्षण कार्यक्रमों के माध्यम से भी किसानों तक व्यापक रूप से पहुंचाया गया। मुझे यह बताने में हर्ष की अनुभूति हो रही है कि अब सीएसआईआर–सीमैप एक एनएबीएल (NABL) मान्यता प्राप्त प्रयोगशाला है जो आयुर्वेदिक दवाओं और फॉर्मूलेशन एवं सुगंधित तेलों के परीक्षण के लिए अनिवार्य ''परीक्षण और अंशांकन प्रयोगशालाओं की सामान्य आवश्यकताओं'' को पूरा करता है। इस अवधि के दौरान हमनें सिम्बोपोगान, तुलसी, मेंथा, पोगोस्टिमॉन एवं सदाबहार की सात उच्च उपज वाली किस्मों का विकास एवं विमोचन किया जिनमें मौजूदा किस्मों की तुलना में महत्वपूर्ण रासायनिक घटक या सुगंधित तेलों की अधिक मात्रा है। इसी दौरान 4 नए उत्पाद सोरियासिम (psoriasis के शमन के लिए एक क्रीम फॉर्मूलेशन, पेटेंट दायर) मेंथो–फ्रेश (एक हर्बल ओरल़ क्लीनर) सिम–केस (एक हर्बल हेयर ऑयल) और सिम–मृदाशक्ति (प्राकृतिक रूप से मिट्टी की उपजाऊ शक्ति को बढ़ाने वाला) भी विकसित किये गये। इसके अलावा सीएसआईआर–सीमैप ने व्यवसायीकरण के लिए 5 उत्पाद प्रौद्योगिकियों को हस्तांतरित किया और अपने पायलट संयंत्र द्वारा विभिन्न स्टार्टअप एवं नवोदित उद्यमियों के लिए अपने 4 उत्पादों के निर्माण में सहयोग प्रदान किया है। इस समयावधि में संस्थान के 37 छात्रों को वैज्ञानिक और नवीन अनुसंधान अकादमी (AcSIR) और जवाहरलाल नेहरू विश्वविद्यालय (JNU) से पीएचडी की उपाधि प्रदान की गई है। हमारे वैज्ञानिकों और शोधार्थियों के उत्कृष्ट कार्यों को ICMR पुरस्कार, न्यूटन भाभा और रमन रिसर्च फेलोशिप जैसे विभिन्न पुरस्कारों द्वारा मान्यता प्राप्त हुई है।

मैं इस अवसर पर टीम सीएसआईआर–सीमैप को संस्थान के विकास में महत्वपूर्ण योगदान देने के लिए बधाई देता हूँ एवं संस्थान के पूर्व निदेशकों के प्रति अपना आभार व्यक्त करता हूँ जिनके मार्गदर्शन एवं सहयोग से संस्थान एक महत्वपूर्ण स्थान प्राप्त कर सका है। इस वर्ष 28 नए सदस्य हमारे संस्थान में शामिल हुए, जिनमें 8 वैज्ञानिक एवं 8 तकनीकी कर्मचारी हैं। वर्ष 2019–20 के दौरान 14 कर्मचारी सेवानिवृत्त हुए जिनमें एक वैज्ञानिक तथा तीन तकनीकी सहायक कर्मचारी हैं। मुझे पूरी आशा है कि हमारे नए एवं युवा वैज्ञानिक न केवल पूर्व वैज्ञानिकों द्वारा किए गए कार्यों को आगे बढ़ाएंगे बल्कि उन्हें एक नया आयाम भी देंगे। मुझे पूर्ण विश्वास है कि हम सब एक साथ मिलकर आने वाले वर्षों में सीएसआईआर–सीमैप को नई ऊंचाइयों पर ले जाएंगे।

सीएसआईआर–सीमैप, सीएसआईआर के महानिदेशक का सीमैप की गतिविधियों के प्रबंधन में उनके मूल्यवान सुझावों एवं प्रोत्साहन के लिए धन्यवाद करता है। मैं अनुसंधान परिषद एवं प्रबंधन परिषद के चेयरमैन एवं अन्य सदस्यों का सीमैप की शोध एवं विकास संबंधित गतिविधियों को आगे बढ़ाने एवं सीमैप के समग्र प्रबंधन हेतु दिए गए मूल्यवान सुझावों के लिए आभार प्रकट करता हूँ। इसके अलावा, सीएसआईआर–सीमैप के अनुसंधान और विकास संबंधित गतिविधियों को इस प्रतिष्ठा तक पहुंचाने में कई शुभचिंतकों का सहयोग मिला है। मैं आप सभी का हृदय से धन्यवाद करता हूँ और आशा करता हूँ कि सीएसआईआर–सीमैप को औषधीय एवं सुगंधित पौधों के अनुसंधान के क्षेत्र में विश्व में अग्रणी बनाने के लिए आपका निरंतर समर्थन और प्रोत्साहन प्राप्त होता रहेगा।

(प्रबोध कुमार त्रिवेदी)

Phytochemistry

Highlights of Phytochemistry

Phytochemistry Division has been actively engaged in all the aspects of chemistry-related activities in the field of Medicinal and Aromatic Plants (MAPs) ranging from phytochemical-exploration, semisynthesis of high-value molecules from naturally occurring molecules, nature-inspired synthesis of bio-actives, development of novel chemical processes, and quality assurance of natural products, etc. Besides, multi-disciplinary support within the Institute, the division extended the testing and analysis facilities to the common public, industries, farmers, and academics. The division has been actively engaged and made several successes in the three mission projects namely "Aroma mission (HCP-007), Phytopharmaceutical mission (HCP 010) and Nutraceutical mission" Several consultancy projects (CNP-357, CNP-391, CNP-384, CNP-419, CNP-438, CNP-427) were executed during this period.

During this tenure, efficient chemical processes for transformation of low valued constituents of essential oils such as eugenol, sclareol, citral, vetiverol, etc., and ricinoleic acid from castor oil to high valued molecules (vanillin from eugenol, ambrox from sclareol, vetiveryl acetate from vetiverol, citral to beta-ionone, (+)-ϒ-deca-lactone from ricinoleic acid) were developed. Other value addition technologies for the fractionation of lemongrass oil, Palmarosa oil, Ocimum oils were optimized and upscaled. Using class 3 and class 4 solvents, extraction and isolation of Lutein (90-95% purity) from waste tagetes flowers was also developed at the pilot-scale level (at 20 kg/batch). The directly fired type, cohobation, boiler operated and mobile type improved distillation units of varying capacities and designs were successfully fabricated, installed, and commissioned at different sites covering 26 states throughout India for the distillation of the various aromatic crops being cultivated in the different clusters of CSIR-Aroma Mission. 43 units have been installed and 25 units are still under fabrication and installation. Further, a new, eco-friendly solar steam aroma distillation apparatus is designed and developed for producing controlled distillation of essential oil crops.

During this period under CSIR-Phytopharmaceutical Mission, efficient processes for the preparation of standardized extracts with defined CMC (chemistry, manufacturing and controls) of *Andrographis paniculata, Phyllanthus amarus, Silybum marianum,Curcuma longa, Berberis aristata, Glycyrrhiza glabra* and *Gymnema sylvestre* were established. The standardized extract with defined CMC of *Glycyrrhiza glabra* was studied for its biological potential against diabetes-related complications and safety profile in animal models. A monograph on *A. panniculata* has also been prepared. Some furostene carbamates, aryl indanones, and cinnamic acid derivatives were designed and synthesized as anticancer agents against prostate, colorectal, lung, and breast cancers.

A series of stilbenes was characterized as a novel osteogenic agent. The structure-function relationship (SAR) of these osteogenic stilbene based amides through chemical synthesis was -Boswellic acid was isolated from?established. 3-hydroxy-11-keto- *Boswellia serrata* resin and its crystallographic structure was established the first time.

A fast, sensitive, and reliable ultra-performance liquid chromatography-photodiode array (UPLC–PDA) method has been developed for the simultaneous quantification of five marker compounds-acteoside, isoacteoside, durantoside-I, quercetin, and methyl apigenin-7-O-β-D-glucopyranuronate in *D. erecta*. Chemotaxonomic differentiation of *Clerodendrum* species based on high-performance thin-layer chromatographic (HP-TLC) fingerprinting was developed. Multi-directional investigations were performed to evaluate chemical composition, nutritional values, ameliorative, and protective potential of Aromatic ginger (*Kaempferia galanga)* rhizome (KGR).

During this tenure, Phytochemistry Division published a total of 20 publications and two patents were filed while three patents were granted. The research group of Dr. Karuna Shanker was awarded Dr. P.D. Sethi Memorial National Award 2018 for the Best Research Paper, while Ms. Sonali Mishra, Ph.D. Scholar, received the Newton-Bhabha Fellowship Jointly funded by the Department of Science and Technology, Govt. of India and British Council, UK.

Er. PV Ajayakumar, HOD, Chief Scientist
Dr. Arvind Singh Negi, Sr. Principal Scientist
Dr. Sudeep Tandon, Sr. Principal Scientist
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Dr. Karuna Shanker, Principal Scientist
Dr. RC Padalia, Principal Scientist
Dr RS Verma, Principal Scientist
Dr. KVN SatayaSrinivas, Principal Scientist
Dr CS Chanotiya, Principal Scientist
Dr. PK Rout, Principal Scientist

Dr Atul Gupta, Senior Scientist
Er. A D Nannaware, Senior Scientist
Dr Hariom Gupta, Scientist
Dr. Kapil Dev, Scientist
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Input: Sudeep Tandon सुदीप टंडन

In the second and final year of the project 69 directly fired type, cohobation, boiler operated and mobile type improved distillation units of varying capacities & designs were designed for the distillation of the various aromatic crops being cultivated in the different clusters of CSIR-Aroma Mission covering 28 states throughout the country. Forty units have been successfully installed & commissioned whereas 28 units are still under fabrication and installation. Based on the oil & crop characteristics, the area under cultivation and location, units were designed with special emphasis on type, capacity, and material of construction of the units. The units this time have been technically improved and have also been provided with a chain pulley system for ease of unloading so that multiple batches can be done per day. In some areas like Vidharbha for lemongrass and Dudhwa where mint cultivation is being carried

out in the large area the CIMAP Mobile Distillation Unit was deployed.

A Consultancy project on providing technical services for setting up distillation facilities for geranium, lemongrass, and other aromatic crops being grown by the farmers under the Meghalaya Basin Development Authority (MBDA), Shillong was undertaken. Under this project, four stainless steel cohobation type directly fired type distillation units were designed and fabricated. These units were consisting of the stainless steel tank, shell & tube condenser, cohobation column, and oil separator. For the first time, such units were incorporated with a specially designed chain pulley material unloading system working on cantilever principle on a single pillar which was appreciated for the ease in operation of the units. All four units were installed at 1. Cham Cham Village, East Jaintia Hills, Kheliriat, 2. Tura Lower Chandmari, West Garo Hills, 3. Niangbari Lum 20th Mile, RiBhoi, 4. Byrwa Village, RiBhoi. These units were successfully commissioned.

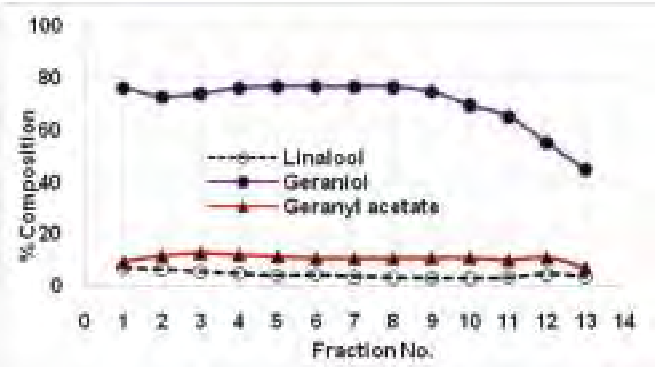
Skill upgradation training on *Aloe vera* processing technologies:

Skill upgradation training on *Aloe vera* processing was organized from 16-19 January, 2019. A of total 30 participants from all over India attended this training. Through this training, Rs. 3.60 lakhs were generated as ECF. The Hands-on training included practical exposure on cultivation and processing technologies for aloe vera juice, sap, gel, cream, and shampoo. Complete know-how along with details of plant, machinery, preservatives, and quality was conveyed to the participants.

Input: G.D. Kiran Babu
जी.डी. किरन बाबू

Variation in the chemical composition of Palmarosa oil during hydro-distillation

Palmarosa foliage (*Cymbopogon martinii* var. Trishna, 3 kg) harvested from CRC, Hyderabad fields were distilled for 6h 45 min till complete exhaustion of oil and oil fractions were collected at different interval of time. The individual fractions were measured, dried over anhydrous sodium sulphate and then analyzed by GC. It is evident from the Figure that the geraniol, one of the major constituents, is present in 74-76% up till 9th fraction i.e. up to first 95 min and thereafter it gradually declined to 44.4% at the end of the distillation, i.e. 6h 45 min. Similarly, geranyl acetate, the second major compound, almost remained constant throughout the process at an average of 10%, except at the end of the distillation; whereas linalool, the third major compound, gradually decreased from 6.9% to 3% from the beginning till at the end of the distillation. The sum of the concentration of these 3 major chemical constituents varied from 54.67 to 92.15%. The total composition, of the said 3 major components, in the first 9 individual fractions which were collected upto 95 min declined steadily from 92.6%to 87.8%. The average composition of the first 9 individual fractions is 90.21%, which drastically reduced to 54.7% at the end of the distillation.



Optimization of Palmarosa oil production

The chemical composition of cumulative fractions of Palmarosa oil was studied to understand and standardize the quality of oil produced. In the first 5 min, about 15% of the oil with the highest concentration of geraniol (~76%)was distilled. In the early 15, 30 and 60 minutes of distillation, about 32%, 50%, and 70% oil was recovered,respectively. After 1½h distillation, approximately 80% of the Palmarosa oil was recovered. Two-and-half hour distillation can achieve about 90% of the oil recovery that contained 75% geraniol, 10.9% geranyl acetate and 4.5% linalool. Thereafter, the rate of oil accumulation was extremely low, and the composition of the major chemical constituents also gradually decreased. Therefore, it is proposed that the distillation can be carried out at least for 1½ h and may be terminated any time before 2½ h for minimizing the fuel consumption.

A total of 26 different constituents were identified, comprising of 97.52 to 98.94%. Apart from the major chemical constituents, i.e. geraniol, geranyl acetate, and linalool (which constitute from 89.1 to 92.2%), *trans-β*-ocimene, geranial, citronellol + nerol, neral, *β*-myrcene, *cis-β*-Ocimene, (*E,Z*)-farnesol, *β*-caryophyllene, are other minor constituents.In these cumulative fractions, a gradually increase in the concentration of (*E,Z*)-farnesol (from 0.1 to 1.35%), *β*-caryophyllene (from 0.15 to 0.82%), geranyl hexanoate (0.03% to 0.53%), geranyl heptanoate (from 0.01 to 0.12%), geranyl butyrate (from 0.02 to 0.22%), geranyl isobutyrate (from 0.04 to 0.12%), was recorded in contrast to *cis-*

β-ocimene (from 0.7 to 0.5%), γ-terpinene (from 0.07 to 0.02%) which gradually decreased as distillation is proceeded. Not much variation was observed in the concentration of *trans-β*-ocimene (3.46 – 4.29%), *β*-myrcene (0.33-0.42%), geranial (0.43 - 0.63%), citronellol+nerol (0.36-0.48%), neral (0.21 – 0.31%), α-terpinene (0.01 to 0.02%), α-phellandrene (0-0.03%), (*E*)- linalool oxide (furanoid) (0.01-0.02%), citronellal (0.03 to 0.05%). Some of the compounds which were detected in trace amounts in the early fractions and were vanished in the later fractions include α-pinene (0-0.01%) and (*Z*)-linalool oxide (0-0.02%). In contrast, caryophyllene oxide (0-0.03%), geranyl isovalerate (0-0.01%) and (*Z,Z*)-farnesol (0.01-0.02%) were found in the last fraction(s). In general, the compounds eluted after geranyl acetate,i,e. from *β*-caryophyllene onwards, consistently found to be increased as distillation proceeded and this characteristic may be attributed due to high boiling points of these later eluting components.

Skill Development Training Programs

A skill development-cum-training program on "cultivation and primary processing of economically important aromatic crops" during 19th-21st June 2019 at CRC, Research Centre, Hyderabad was conducted under CSIR-Aroma Mission. About 54 participants, including entrepreneurs/farmers, attended the program. A practical demonstration on the production of essential oils was imparted to the trainees during the training on 20th June 2019.

Documentary on lemongrass oil distillation

A documentary was telecasted in Suman TV Rythu on "Lemongrass Oil Distillation Process" for the Telugu speaking farmers in Andhra Pradesh and Telangana States which is published in YouTube Channel at https://www.youtube.com/watch?v=r-Xl_CC93YU.

Entrepreneurial development in the field of essential oil production

Under Aroma Mission Project and with the guidance of CSIR-CIMAP, Research Centre, Hyderabad, about 35 acres of land was brought under the cultivation of Palmarosa by the farmers of Mupparam & Somwarigudem villages, Nalgonda District, (TS). The

crop harvesting started in the first week of January 2020. The essential oil production technology was demonstrated to the farmers on mobile essential oil distillation unit in their fields. During this first harvest, 66 kg Palmarosa oil was distilled from 13.4-ton fresh material with an average yield of 0.5%. With these efforts, 2 x 1 ton per batch capacity distillation unit has been commissioned as a central facility to support this venture and the farmers in this region.

Dr. G.D. Kiran Babu & his team

Input: Arvind Singh Negi
अरविन्द सिंह नेगी

Development of bivalent carbamates as pseudo-natural products from *Dioscorea floribunda* sapogenin

Dioscorea floribunda L. is a tuberous medicinal plant rich in steroidal saponin dioscin. We designed pseudo-natural products starting with saponin rich fraction of *D. floribunda*. The basic furostene core was obtained from diosgenin, the aglycon part (sapogenin) of dioscin. Diosgenin was modified towards furostene framework with carbamate spearhead. Carbamate derivatives have been synthesized at C26 of furostene ring after opening the spiroketal bond (F-ring) of diosgenin (Figure 1). Compound **1** possessed significant antiproliferative activity against human breast cancer cells by arresting the population at the G1 phase of the cell division cycle and induced apoptosis. Induction of apoptosis was observed through the caspase signaling cascade by activating caspase-3. Moreover, carbamate **1** exhibited moderate anti-inflammatory activity by decreasing the expression of cytokines, TNF-α, and IL-6 in LPS-induced inflammation in primary macrophage cells. Furthermore, compound **1** significantly reduced Ehrlich ascites carcinoma (65% tumour reduction) at 75 mg/kg i.p. dose in mice. It was well tolerated and safe up to 1000 mg/kg oral dose in acute oral toxicity in Swiss albino mice. The concomitant anticancer and antiinflammatory properties of carbamate **1** are unique and much desired in anticancer investigational drugs. (J. Steroid Biochem. Molecular Biology 2019, 194: 105497)

3-Arylindanones and related compounds as antiproliferative agents against colorectal cancer

Colorectal cancer is a therapeutically challenged multifaceted disease, which has caused about 1.80 million human deaths in 2018. A specific motif 3,4,5-trimethoxyphenyl has been placed at ring A of indanone pharmacophore to induce antitubulin effect. Some of the naturally occurring anti-tubulin compounds like colchicine, podophyllotoxin, and combretastatin A4, etc. possess this fragment which interacts with the β-tubulin at α/β junctions to elicit antitubulin effects. Further, we have diversified the indanone based anticancer pharmacophore, especially for nitrogen moiety. Twenty-six diverse 3-arylindanone based compounds were prepared and evaluated against a battery of human cancer cell lines. Two of the analogues i.e. **2** and **3** exhibited significant antiproliferative activity against several human cancer cell lines. Both the compounds possessed antimitotic activity and induced

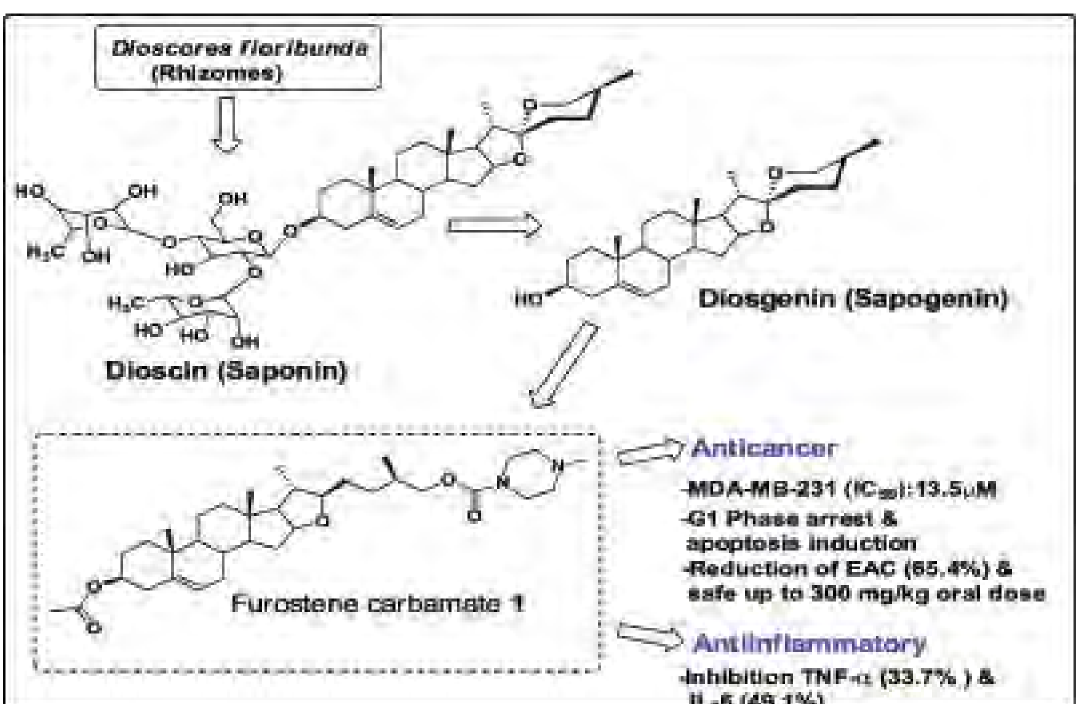


Figure 1: Antiproliferative and antiinflammatory furostene carbamates as pseudo-natural products

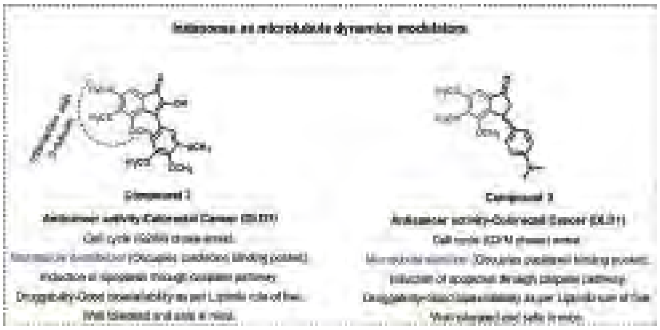


Figure 2: Indanone based potent anticancer compounds

apoptosis in DLD1 colorectal adenocarcinoma cells through the activation of caspase pathways. In cell cycle analysis, both the compounds induced predominantly G2/M phase arrest in DLD1 cells. Molecular docking studies revealed that compound **2** occupies colchicine binding pocket of β-tubulin. Both the compounds were safe up to 1000 mg/kg dose in acute oral toxicity in rodents (Figure 2). (*Chemical Biology and Drug Design* **2019**, 941: 1694-1705)

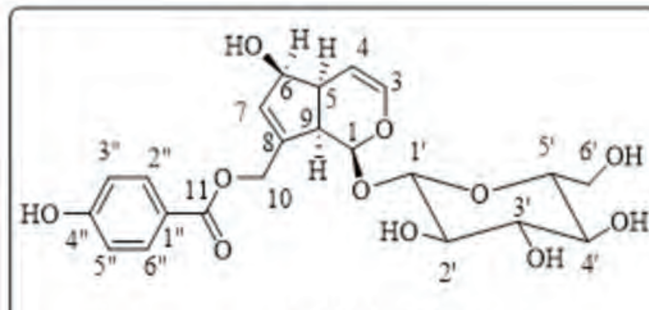
Input: J Kotesh Kumar जे. कोटेश कुमार

Phytochemical exploration on medicinal plants of the Deccan Plateau region

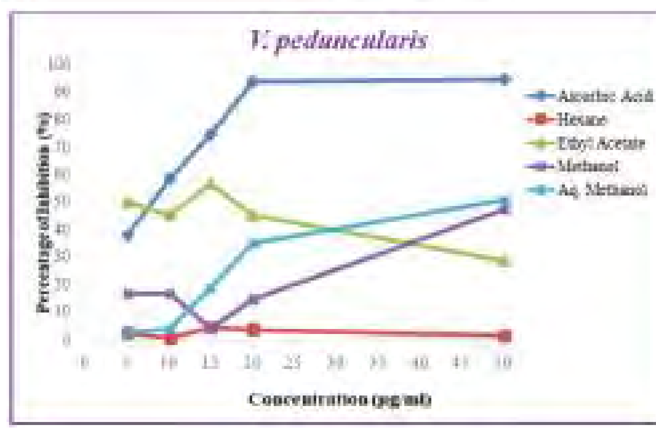
(a) Extraction and isolation of Phytomolecules from *Vitex peduncularis*

Bark and leaves of *Vitex peduncularis* (Verbenaceae family) are used to treat diabetes, malaria, chest pain, and jaundice. Malarial fever and black water fever were successfully treated with the infusion of the leaves.

The leaves of *V. peduncularis* were extracted with ethyl acetate and methanol successively using hot percolation method. These extracts were purified by column chromatography using silica gel and eluted with hexane, the mixture of ethyl acetate and hexane, ethyl acetate, Acetone, 10% methanol in acetone which yielded eight compounds. The characterization of compounds was done using NMR spectroscopy. One compound has been characterized as Buddlejoside A. The structure elucidation of remaining compounds is in progress. In-vitro antioxidant activity of different extracts was evaluated using the DPPH method. The anti-oxidant activity was observed to be more in ethyl acetate of *V. peduncularis* extract followed by other extracts.

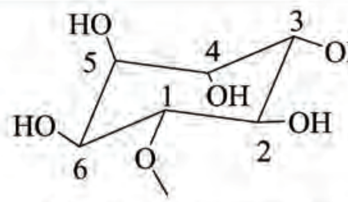


Buddlejoside A

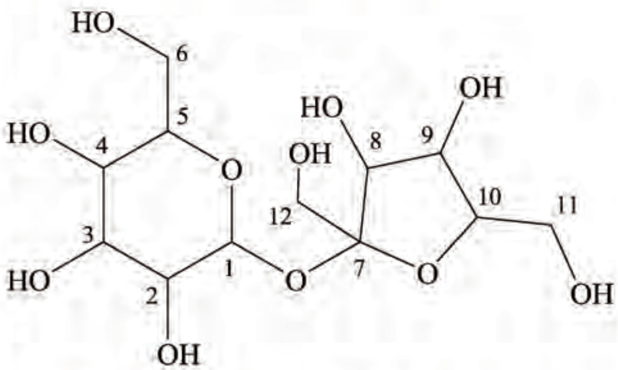


Extraction and isolation of phytomolecules from *Bauhinia purpurea* L.

The leaves of Bauhinia purpurea L. (family Fabaceae) were extracted with organic solvents of different polarity. The leaf hexane, ethyl acetate, and methanol extracts were purified by column chromatography, using silica gel, eluting with hexane, and mixtures of ethyl acetate in hexane and ethyl acetate yielded nine pure compounds. The structure of the two compounds was elucidated based on NMR spectra and confirmed as O-methyl-myo-inositolandα -D-Glucopyranoside,



O-Methyl-Myo-Inositol



α-D-Glucopyranoside, β-D-Fructofuranosyl

β-D-Fructofuranosyl respectively. In-vitro antioxidant activity of different extracts was evaluated using the DPPH method. The anti-oxidant activity was observed to be more in ethyl acetate extract followed by other extracts.

Effect of drying on the composition and yield of essential oils of *Curcuma longa* leaf.

Generally, turmeric farmers treat leaf left after harvesting of rhizomes as waste and utilize it for making of compost or cooking purpose. The essential oil present in the leaf materials can add additional income to the farmer. Three Turmeric varieties Mydukur, Kasturi, and Manapasupu collected from Telangana were divided into four batches (200 grams Each) and dried under shade, oven, and sun. The fourth one was processed as fresh. These samples were hydro distilled using a Clevenger apparatus. The yields and composition of the essential oils were analyzed by Gas Chromatography. Results showed that the major chemical constituents were observed in fresh material while drying of leaves in different conditions lowered the composition. The yield of essential oils was high in the shade dried materials (calculated on a dry weight basis) compared to oven-dried and sun-dried samples.

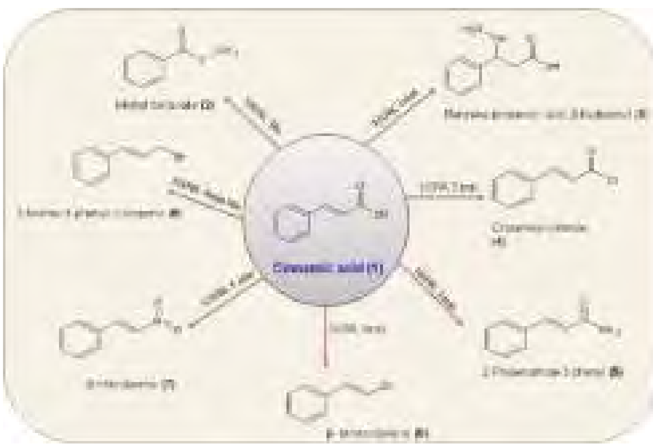
S. No	Sample Code	Chemical Constituents				Essential oil Yields (%)
		Alpha Phellandrene	Para Cymene	1,8 Cineole + Limonene	Terpinolene	
Mydukur						
1	Fresh*	3.415	4.258	4.522	81.080	0.42
2	Shade Dry	4.145	3.374	5.066	75.968	2.60
3	Oven Dry	3.503	3.623	4.585	75.287	1.80
4	Sun Dry	3.608	1.631	5.705	76.536	2.18
Kasturi						
5	Fresh*	5.068	3.241	3.710	81.820	0.35
6	Shade Dry	3.915	3.593	5.468	75.701	2.40
7	Oven Dry	6.634	3.770	5.822	73.778	2.33
8	Sun Dry	3.184	3.782	5.642	73.579	2.80
Manapasupu						
9	Fresh*	57.408	5.271	8.363	10.504	0.17
10	Shade Dry	51.998	5.877	9.139	15.825	1.60
11	Oven Dry	51.188	5.759	9.264	17.219	1.50
12	Sun Dry	53.590	5.956	8.706	14.197	1.60

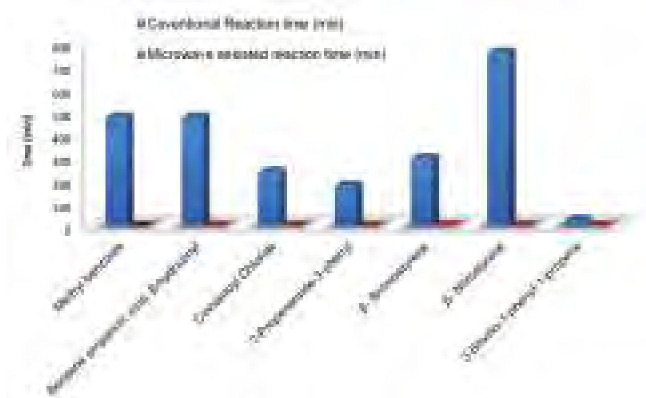
***Note:** The yields of the essential oils were calculated on a fresh weight basis.

Input: Karuna Shanker करुणा शंकर

Microwave-assisted single step derivatization of cinnamic acid for potential cytotoxic lead

Microwave-assisted single-step modification in cinnamic acid (CA) was found as a fast, reliable, and robust method with better yields. The resultant compounds were evaluated for the potential *in-vitro* anticancer property against six human cancer (K-562, WRL-68, A549, A431, MCF-7, and COLO-201) and two normal (L-132 and HEK-293) cell lines.

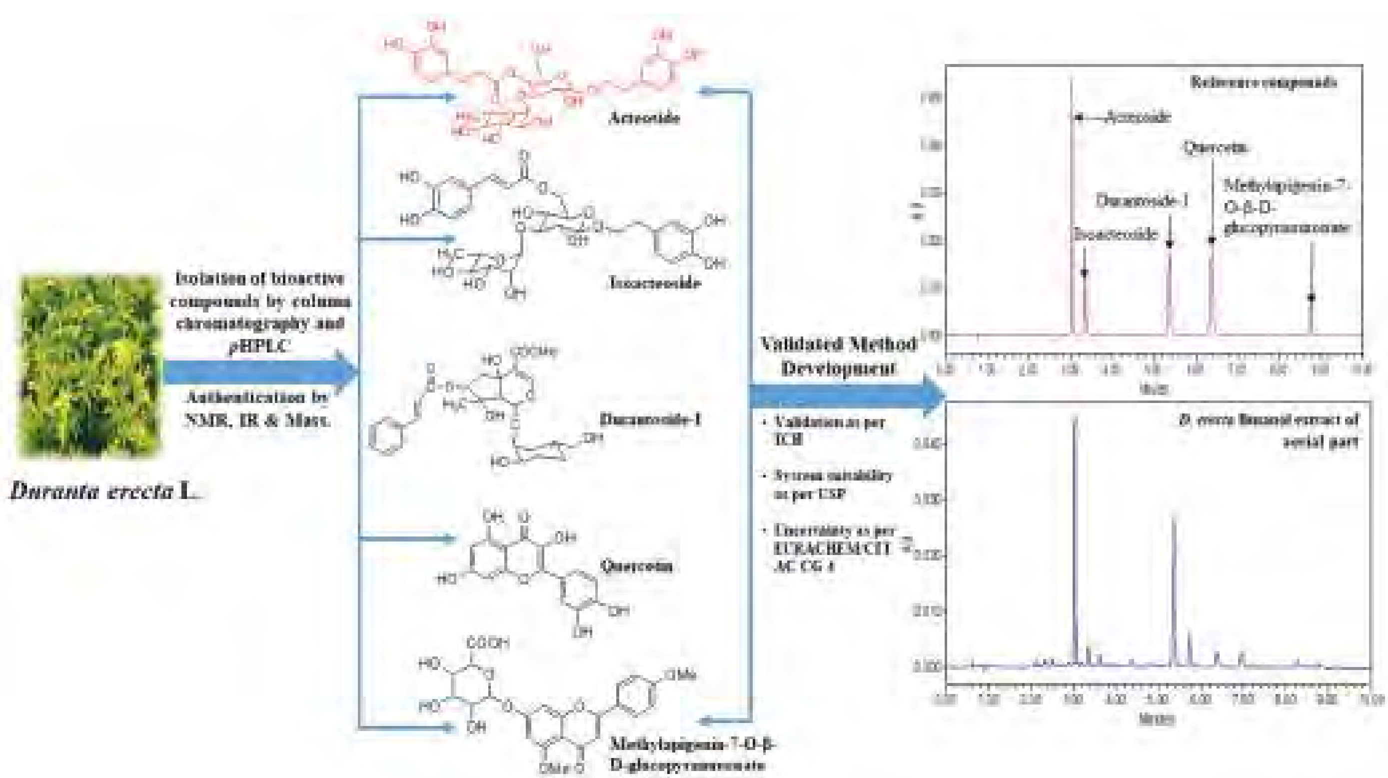




β-bromostyrene and β-nitrostyrene presented inhibition with IC_{50} values ranging from 0.10-21 μM and 0.03-0.06 μM, respectively. β-bromostyrene was the most potent anticancer derivative of CA with better cellular safety and biocompatibility. [DOI:10.2174/1389201020666191015161429]

UPLC-PDA method for the quality analysis of *Duranta erecta* L.

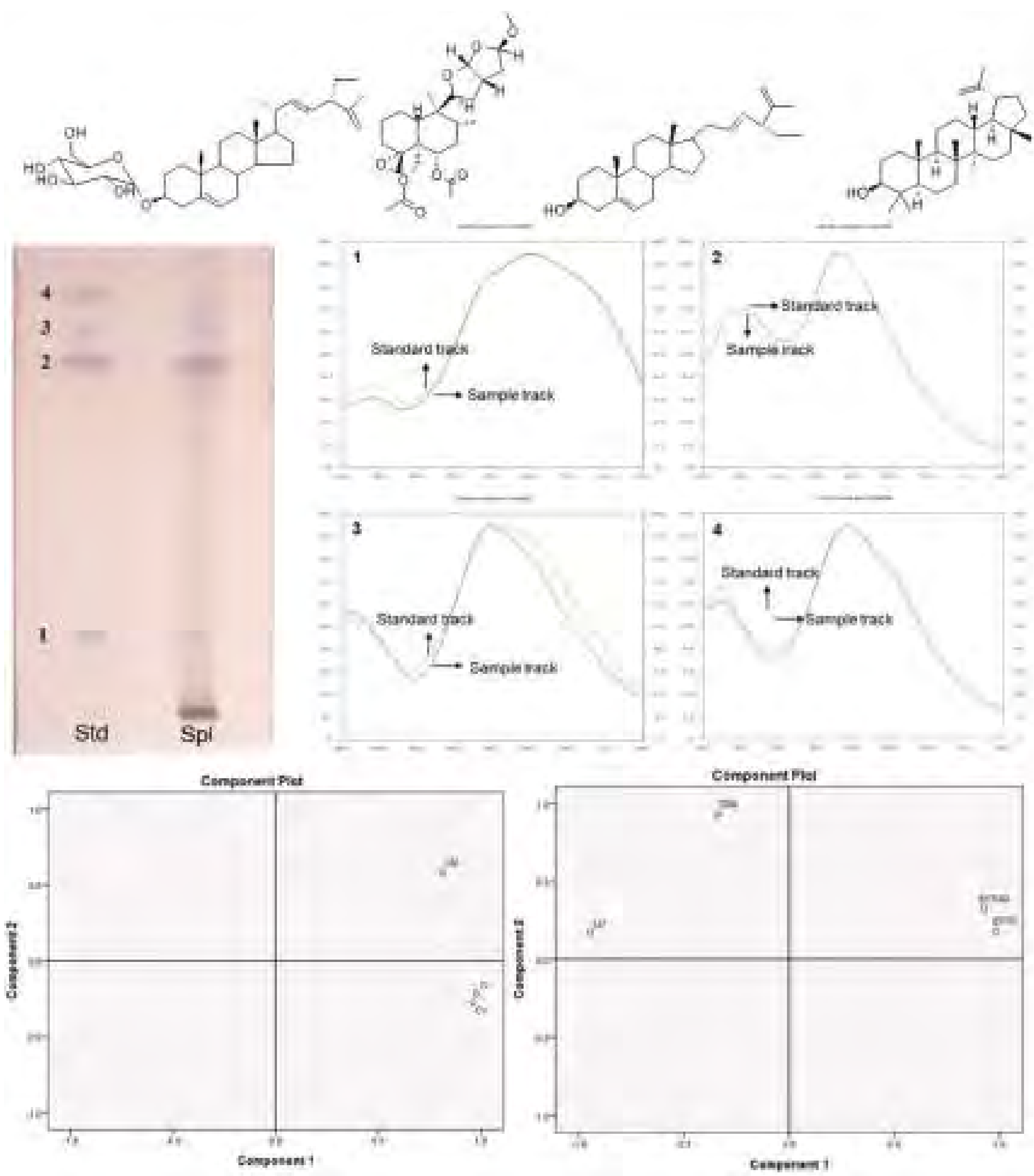
A fast, sensitive, and reliable ultraperformance liquid chromatography-photodiode array (UPLC–PDA) method was developed for the quantification of five marker compounds-acteoside, isoacteoside, durantoside-I, quercetin, and methylapigenin-7-O-β-D-glucopyranuronate in *D. erecta*. Validation

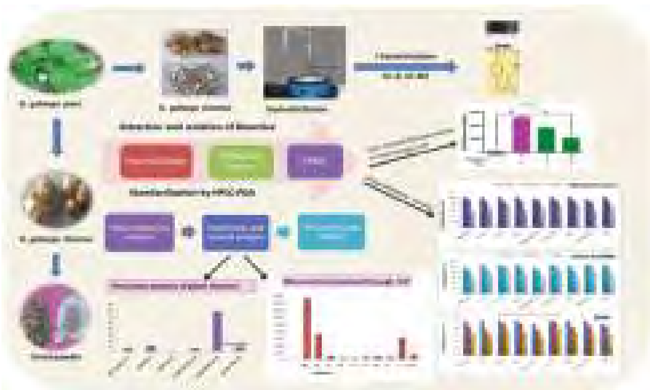


characteristics viz. linearity ($r^2 > 0.999$), accuracy (%RSD < 2.0), precision (%RSD, 1.62-2.59), recovery (97-99%), and sensitivity (LOD- 0.27-0.40 μg mL^{-1}; LOQ- 0.90-1.35 μg mL^{-1}) were satisfying the ICH criteria. Uncertainty in the measurement was also estimated using method validation data and other sources to fulfill the technical requirement of ISO 17025:2017. It is the first validated method that provides the simultaneous and accurate analysis of five bioactive phytoconstituents of *D. erecta* in a short time with defined traceability and accuracy profile for holistic quality analysis of raw medicinal herb and its preparation.[DOI:10.1016/j.jpba.2019.06.044].

Chemotaxonomic differentiation of *Clerodendrum* species based on high-performance thin-layer chromatographic (HPTLC) fingerprinting

The *Clerodendrum* species under study, exhibit various phytochemical and morphological similarities. Therefore, it is very challenging to distinguish raw powdered materials used for therapeutic purposes. Three closely related Clerodendrum species *C. Inerme* (CI), *C. multiflorum* (CM) and *C. viscosum*(CV)





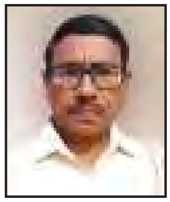
were distinguished *via* the four marker compounds 24β-ethylcholesta-5,22*E*,25-triene-3β-*O*-D-glucoside (1/ECTOG), clerodinin-A (2/CDA), 24β-ethylcholesta-5,22*E*,25-triene-3β-ol (3/ECTO) and lupeol (4/LU). The chemotaxonomic differentiation was established by similarity analysis of the obtained TLC fingerprints using hierarchical clustering analysis (HCA) and principal component analysis (PCA). [DOI:10.1556/1006.2019.32.3.6]

Aromatic ginger (*Kaempferia galanga* L.): A functional food with ameliorative and protective potential

Multi-directional investigations have been performed to evaluate chemical composition, nutritional values, ameliorative, and protective potential of Aromatic ginger (*Kaempferia galanga)* rhizome (KGR). KGR contains beneficial nutraceutical properties viz. potassium, phosphorous, and magnesium in higher amounts with the appreciable quantity of iron, manganese, zinc, cobalt, and nickel. No toxic metals traced in the KGR. High calorific value and carbohydrate content equivalent to some reported cereals and higher than reported *Zingiberous* plants (except *C.zedoaria*) and leguminous plants could serve as a healthy and alternative source for supplementing the human diet. A high energy value, good proximate composition and minerals, tolerable anti-nutritional, and absence of cyanogenic glycosides demonstrated that culinary spice has all essential qualities to be developed as a flavored phytoceutical food.[DOI:10.1016/j.toxrep.2019.05.014]

Dr. Karuna Shanker & his team

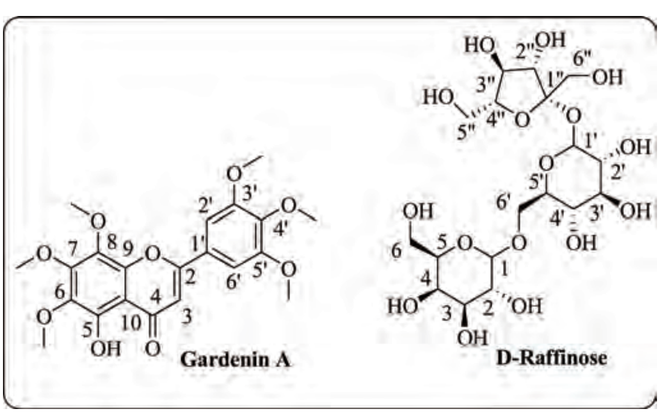
Input: K.V.N. Satya Srinivas
के.वी.एन. सत्या श्रीनिवास

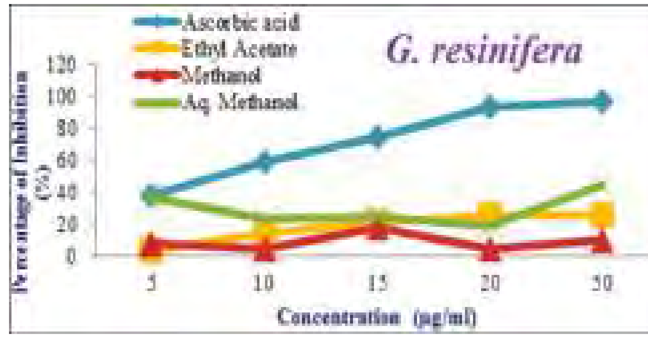


Phytochemical exploration on medicinal plants of the Deccan Plateau region

Extraction and isolation of phytomolecules from *Gardenia resinifera* (Roth)

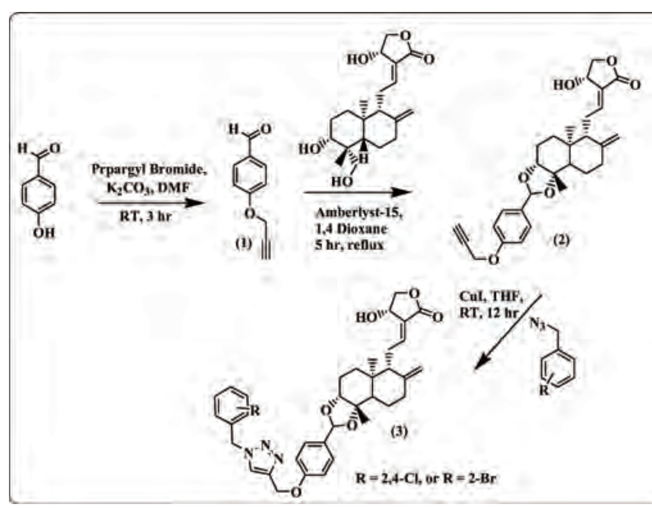
Dikamali or cumbi gum excreted on the stem and buds of *Gardenia resinifera* (family Rubiaceae)contain a bitter substance and essential oil. It is antispasmodic, expectorant, carminative, and stimulant. The stem part of *G. resinifera* was extracted with hexane (cold maceration), ethyl acetate, and methanol successively using hot percolation method. The ethyl acetate and methanol extracts were purified by column chromatography which yielded eleven compounds. Two compounds were identified as gardenin A and D-rafinoseon the basis of IR, NMR, and Mass spectroscopy data. The structure elucidation of the remaining compounds is under progress. In-vitro antioxidant activity of different extracts was evaluated using the DPPH method. The anti-oxidant activity was observed to be more in aq.methanol extract followed by other extracts.





Synthesis of Andrographolide1,2,3- tri-azole derivatives

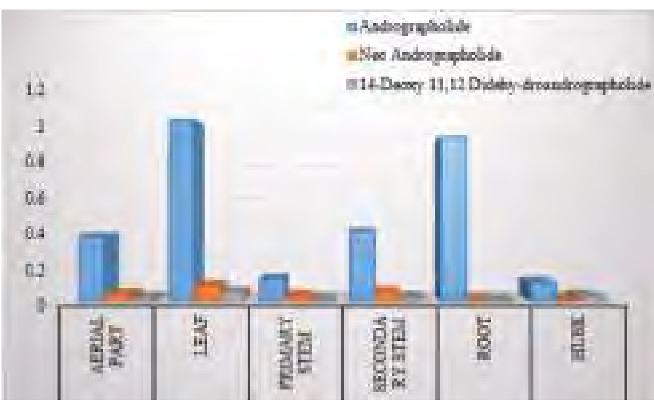
Semi-synthetic modifications of andrographolide were accomplished to prepare andrographolide1,2,3-triazole derivatives. The synthesis was started with the protection of 4-Hydroxy benzaldehyde using propargyl bromide in the presence of anhy. K_2CO_3-DMF to



yield 4-propargyloxybenzaldehyde**(1)** which was subsequently reacted with andrographolide in presence of Amberlyst-15 in dry 1,4-dioxane at reflux for 5 h under N_2 atmosphere. After purification intermediate (**2**) was obtained in good yield. Finally, target compounds **3a-b** were synthesized from **(2)** and substituted benzyl azides applying 1,3-dipolar cycloaddition in the presence of CuIin dry THF at room temperature for 12-14 h.

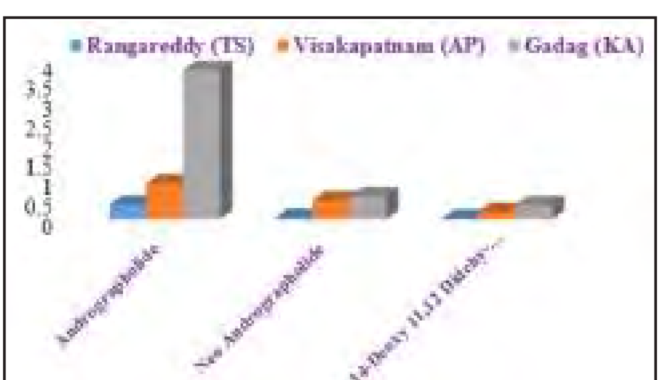
Comparative studies on different parts of *Andrographis Paniculata* (Burm.f.) Nees through HPLC analysis (MLP-02 &HCP-010).

Six plant parts (Aerial, Leaf, Primary Stem, Secondary Stem, Root, and Husk) were analyzed by HPLC. Andrographolide, Neo andrographolide, and 14-deoxy andrographolide were used as marker compounds in qualitative and quantitative HPLC analysis and process development. Results showed that andrographolide is more in leaf part followed by root, secondary stem, aerial part, primary stem, and husk. Neo andrographolide also followed a similar pattern except for root which contains a very less percentage. Whereas 14-Deoxy-11,12-Didehydroandrographolide observed more in the leaf part and least was noticed in the husk part of the plant. Root and husk contain a considerable amount of andrographolide so these parts are also useful for the isolation of andrographolide.



Comparative studies on different cultivars of *Andrographis paniculata* (Burm. f.) Nees.

A. paniculata aerial parts samples were collected from different places i.e Visakhapatnam of Andhra Pradesh, Rangareddy of Telangana, and Gadag of Karnataka. These plant materials were analyzed by HPLC. The marker compound andrographolide is more in Gadag area of Karnataka compared to other regions. Similarly, other major marker compounds, Neo andrographolide, and 14-Deoxy-11,12-Didehydroandrographolide, also observed in more percentage in Gadag area of Karnataka compare to other regions.



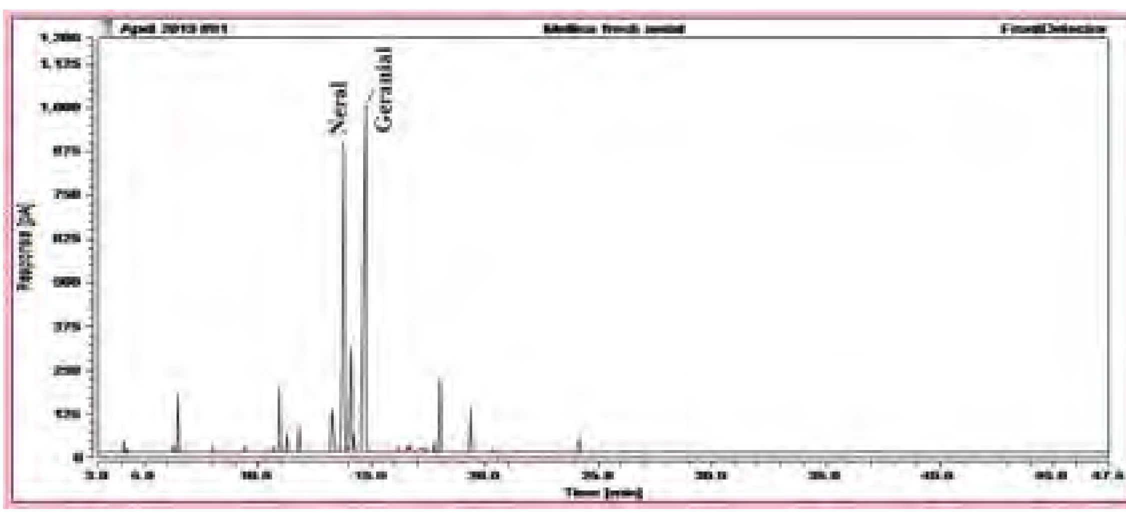
Input: RC Padalia आर.सी. पडालिया

Effect of plant spacing and harvesting mode on yield and quality of the essential oil of *Melissa officinalis* L.

Melissa officinalis L. commonly known as 'Lemon balm' is a perennial herb belonging to family Lamiaceae. It is cultivated throughout the world for its lemon-scented

herb is used for culinary and medicinal purposes. Given the potential of this plant for commercial cultivation, an experiment was conducted to evaluate the herb yield, essential oil yield, and quality of essential oil of *M. officinalis* grown in foot hills agroclimatic conditions of Uttrakhand as a function of harvesting in four different plant spacing viz. 45cm × 30cm, 45cm × 45cm, 45cm × 60cm and 60cm × 60cm. The crop harvested after six months of transplanting has better herb and oil yield compared to crop harvested after four months of transplanting. Moreover, the herb yield and essential oil yield was found to vary with the subsequent second harvest of four-month crop in different plant density. The quality of the hydrodistilled essential oils of *M. officinalis* in different plant density

and harvesting periods was ascertained and total 28 components were identified, with citral (52.6-77.9%) as a major constituent, represented by neral (21.2-33.4%) and geranial (31.4-45.6%). Other constituents

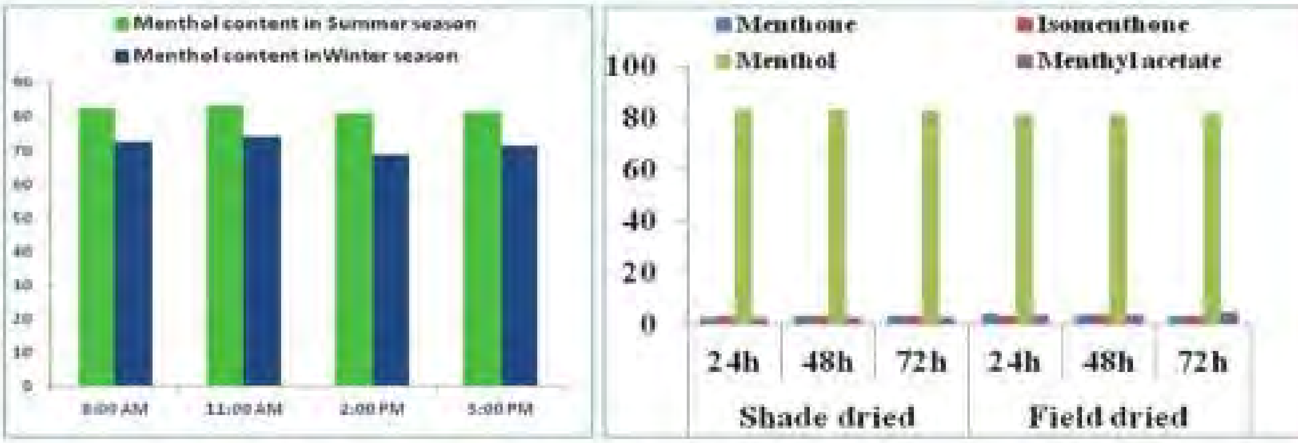


were identified as geraniol (1.9-7.1%), piperitone (0.7-5.8%), β-caryophyllene (0.4-5.6%), caryophyllene oxide (0.7-4.6%) and nerol (1.0-4.3%). Citral content was found higher in the second harvest compared to the first harvest. Moreover, 45 cm × 45 cm plant density spacing was found optimal for high yield of herb and essential oil with a significant content of citral.

Harvesting and post-harvest studies on *Mentha arvensis* var. CIM-Kranti for quality essential oil production in winter and summer cropping seasons

Menthol-mint (*M. arvensis*) is cultivated worldwide for its essential oil, menthol, and dementholized oil in flavour, fragrance, and pharmaceutical industries. Different varieties of *M. arvensis* have been developed for its large scale cultivation in India and to meet out its quality essential oil production. The present experiment was designed to study the influences of cropping seasons, harvesting times, and drying conditions on yield and quality of essential oils of prevalent variety 'CIM-Kranti' of *M. arvensis*. It was observed that essential oil content varied from 0.9-1.1% and 0.6-0.7% in summer and winter crops, respectively. Altogether, a total of 21 constituents, comprising 96.2-99.5%, were identified using gas chromatography–flame ionization detector and gas chromatography-mass spectrometry analysis. Menthol (68.7-83.4%), menthyl acetate (2.5-5.3%), menthone (3.1-8.6%), and isomenthone (3.4-5.9%) were identified as major constituents in both cropping seasons. Significant quantitative variation in yield and content of menthol was noticed as a function of harvesting periods and drying conditions in summer and winter crops of *M.* arvensis var. CIM-Kranti. In terms of essential oil yield and menthol content, the summer cropping season was better than the winter season for M. arvensis var. CIM-Kranti. Moreover, the wilting of the harvested crop in the field up to 72 h had no adverse effect on the yield and quality of essential oil.

Dr. RC Padalia & his team

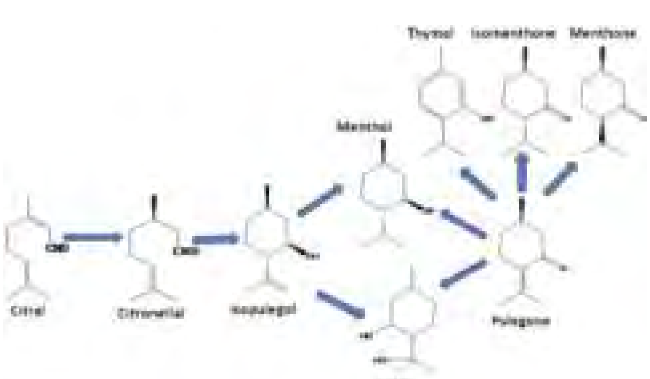


Essential oil quality as per harvesting time and dying conditions

Input: PK Rout पी.के. राउत

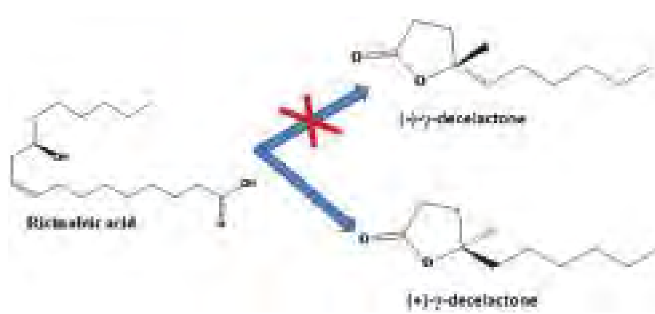
Value addition of essential oils

India occupied the first position in the production and exporting of dementholized oil (DMO), which is obtained from *Mentha arevensis*. DMO contains 1-3% of pulegone and this compound is completely prohibited by USFDA in food and cosmetics applications. Therefore, a catalytic process was optimized for the chemical transformation of pulegone to menthone, isomenthone, thymol, and menthol. After Mentha, the next major crop is lemongrass, which contains citral (65-77%) as a major compound. As presented in Scheme, in this study, catalytic semi-synthesis of citral to menthol was performed in three steps; (1) citral to citronellal, (2) citronellal to isopulegol, (iii) isopulegol to menthol. Similarly, p-Menthane-3,8-diol (PMD) was synthesized from citronellal and this PMD is well known as a natural mosquito repellent. All these synthesis steps (Scheme) were very selective and more than 90% of conversion recorded.



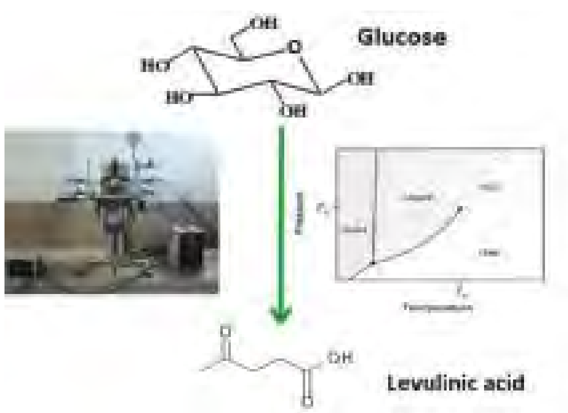
Value addition of castor oil

(+)-g-Decalactone, an important food-flavor with GRAS status is produced from ricinoleic acid through microbial biotransformation. As it is produced through biotransformation, therefore, it is classified as natural (labeled as natural flavors, in accordance with CFR21 Sec. 101.22 and EU Flavor Regulation 1334/2008/EC). In the present study, a two-step novel process for (+)-g-Decalactone preparation from castor oil was established. The first step of the process involved enrichment of ricinoleic acid (94%, approx) from castor oil through the solvent-solvent partition. In the subsequent step, the enriched ricinoleic acid was bio-transformed into (+)-g-decalactone significantly, using newly isolated *Yeast* strain (non-pathogenic). More than 60% of (+)-g-decalactone was obtained from ricinoleic acid in 70-80 h of inoculation. Chiral-GC-FID analysis revealed that it possessed 99% of enantiomeric pure food-flavor important (+)-g-decalactone.



Value addition of distillation waste

A novel chemical process has been developed for the isolation of cellulose from after distilled mentha biomass (US patent 10287527). Previously, we have developed a green process for the synthesis of hydroxymethylfurfural from this isolated cellulose (India patent 326942). In recent work, isolated cellulose is used for the production of glucose (about 65%) using *Cellic Ctec2* and *Trichoderma reesei* enzymes. This glucose is used for the synthesis of levulinic acid. The reaction was carried out at 150°C and 15 bar pressure in subcritical-ethanol for 90 min using Lanthanum(III) trifluoromethanesulfonatehydrate as a heterogeneous catalyst. Levulinic acid is treated as a model compound for the manufacturing of commodity products such as MTHF (methyl-tetrahydrofuran), a compound of high



calorific value clean fuel; d-aminolevulinic acid (DALA), a potential and biodegradable herbicide; succinic acid, a gasoline additive, etc. Similarly, the distillation condensate was collected for recovering of water-soluble compounds to check the loss of essential oil at the time of distillation. The scheme for the production of glucose from isolated cellulose is presented in the figure.

Dr. PK Rout & his Team

Input: Ram Swaroop Verma
राम स्वरूप वर्मा

Essential oil composition of the sub-aerial parts of eight species of *Cymbopogon* (Poaceae)

The genus *Cymbopogon* (Poaceae) comprised of many species of grasses that grow in tropical and subtropical regions around the world. Some of the commercially important aromatic species of *Cymbopogon* are cultivated for the extraction of the essential oils from their aerial-parts. In spite of wide distribution and large scale cultivation, the essential oils of the sub-aerial parts (root/rhizome) of these species have not been systematically studied so far. In this study, the hydro-distilled essential oil from the sub-aerial parts of eight species of *Cymbopogon*, namely *C. flexuosus* (Nees ex Steud.) W. Watson, *C. khasianus* (Hack.) Stapf ex Bor, *C. pendulus* Nees ex Steud, *C. khasianus* × *C. pendulus*, *C. winterianus* Jowitt ex Bor, *C. martini* (Roxb.) W. Watson, *C. distans* (Nees ex Steud.) W. Watson, and *C. jwarancusa* (Jones) Schult. was analyzed by GC-FID and GC-MS. A total of thirty-three terpene C-skeleton types were identified. Among these *p*-menthane, myrcane, elemane, eudesmane, and agarospirane C-skeletons dominated in the examined species. A multivariate statistical comparison by principal component analysis and agglomerative hierarchical clustering grouped the examined essential oils in to four clusters (cluster I: geraniol, and piperitone/ geraniol chemotypes; cluster II: high elemol and low elemol chemotypes; cluster III: limonene chemotype; and cluster IV: 5-*epi*-7-*epi*-*α*-eudesmol/ eudesmanediol/ hinesol, and *cis*-*p*-menth-2-en-1-ol/ *trans*-*p*-menth-2-en-1-ol/ eudesmanediol chemotypes) (Figure 1). The sub-aerial parts, a waste material of cultivation can serve as good source of valuable and rare lead molecules, such as elemol, 5-*epi*-7-*epi*-*α*-eudesmol, *β*-eudesmol, eudesmanediol, hinesol, agarospirol, 7-*epi*-*α*-eudesmol, *α*-eudesmol, *γ*-eudesmol, shyobunol, selina-6-en-4-ol, and *p*-menth-2-en-1-ols.

Chemical composition and antimicrobial activity of Java citronella (*Cymbopogon winterianus* Jowitt ex Bor) essential oil extracted by different methods

The essential oil of Citronella (*Cymbopogon* spp.) is an important component of various fragrances, cosmetics,

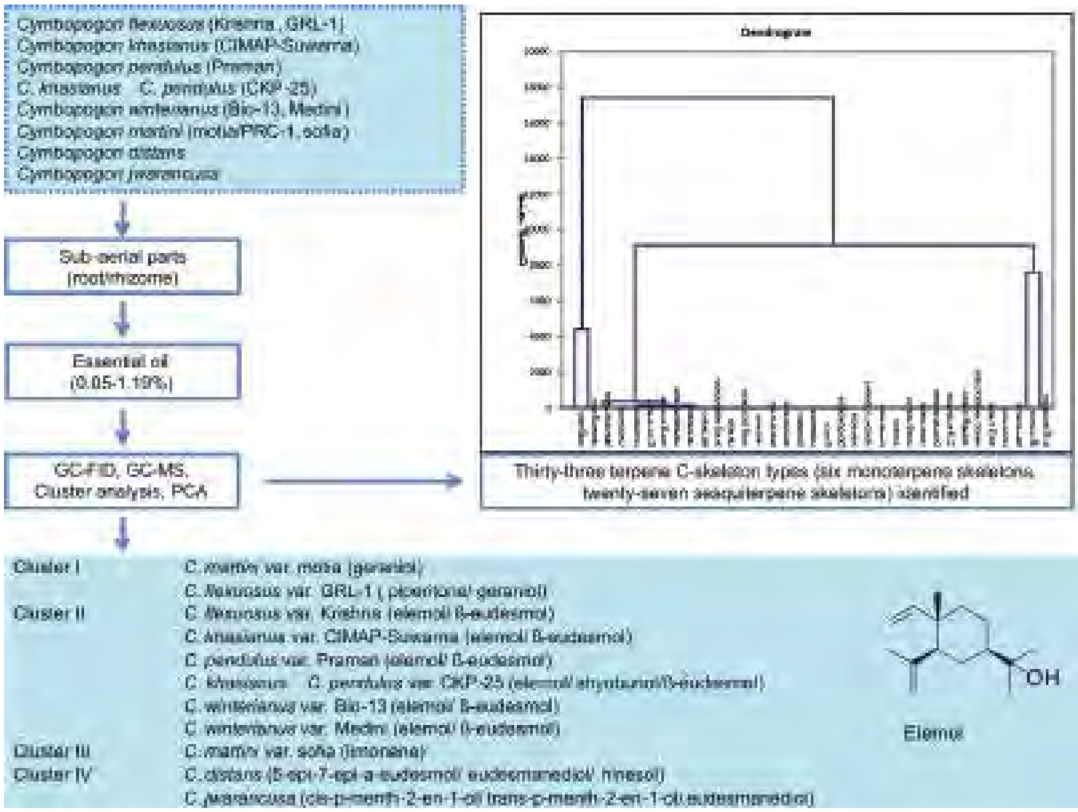


Figure 1. Chemical diversity in the root/rhizome essential oils of *Cymbopogon* spp.

and household products. In this study, comparative chemical composition and antimicrobial activity of Java citronella (*Cymbopogon winterianus* Jowitt ex Bor) essential oils, extracted by hydro-distillation, steam-distillation and recovered from distillate water, were determined by GC-FID, GC-MS, disc diffusion assay and microdilution broth assay. Major components of the essential oil extracted by hydro-distillation with cohobation process were citronellal (36.1%), geraniol (20.1%), citronellol (10.3%), and elemol (8.2%). Major constituents of the essential oil obtained by the field steam-distillation process were citronellal (55.4%), geraniol (14.2%), citronellol (8.2%) and limonene (5.0%). However, the essential oil recovered from the aqueous-distillate of field steam-distillation process was characterized by the presence of higher amounts of monoterpenes alcohols, geraniol (47.0–53.0%), citronellol (15.9–16.4%), isopulegol (9.0–12.6%) and linalool (4.0–5.9%). The essential oils showed inhibition of test bacteria with minimum inhibition concentration (MIC) in the range of 250–1000 μg/mL and showed anticandidal activity with MIC in the range of 125–500 μg/mL. In general, the oils were moderately active against Gram-positive and Gram-negative bacterial strains and also showed good activity against Candidal strains. The essential oils extracted from the herbage by different techniques exhibited variations in their yield, chemical composition, and antimicrobial activities.

Input: CS Chanotiya सी.एस. चनौटिया

Enantiomer differentiation of α- and β-pinene in *Limonia acidissima* essential oil

Studies on differentiation of chiral monoterpene hydrocarbons in *Limonia acidissima* essential oil has been carried out. Enantiomeric study revealed (-)-β-pinene as predominant enantiomers (ee 98.6%) followed by (-)-α-pinene (ee 92.1%). The oil contained mainly phenylpropanoids marked by the presence of methyl chavicol (93.5%). To the best of our knowledge, (-)-β-pinene is being reported for the first time as predominant enantiomers in essential oils. (JMAPs 41(1-4), 2019; 58-63.)

Antifungal action of *Lippia alba* essential oil on *Rhizoctonia solani*

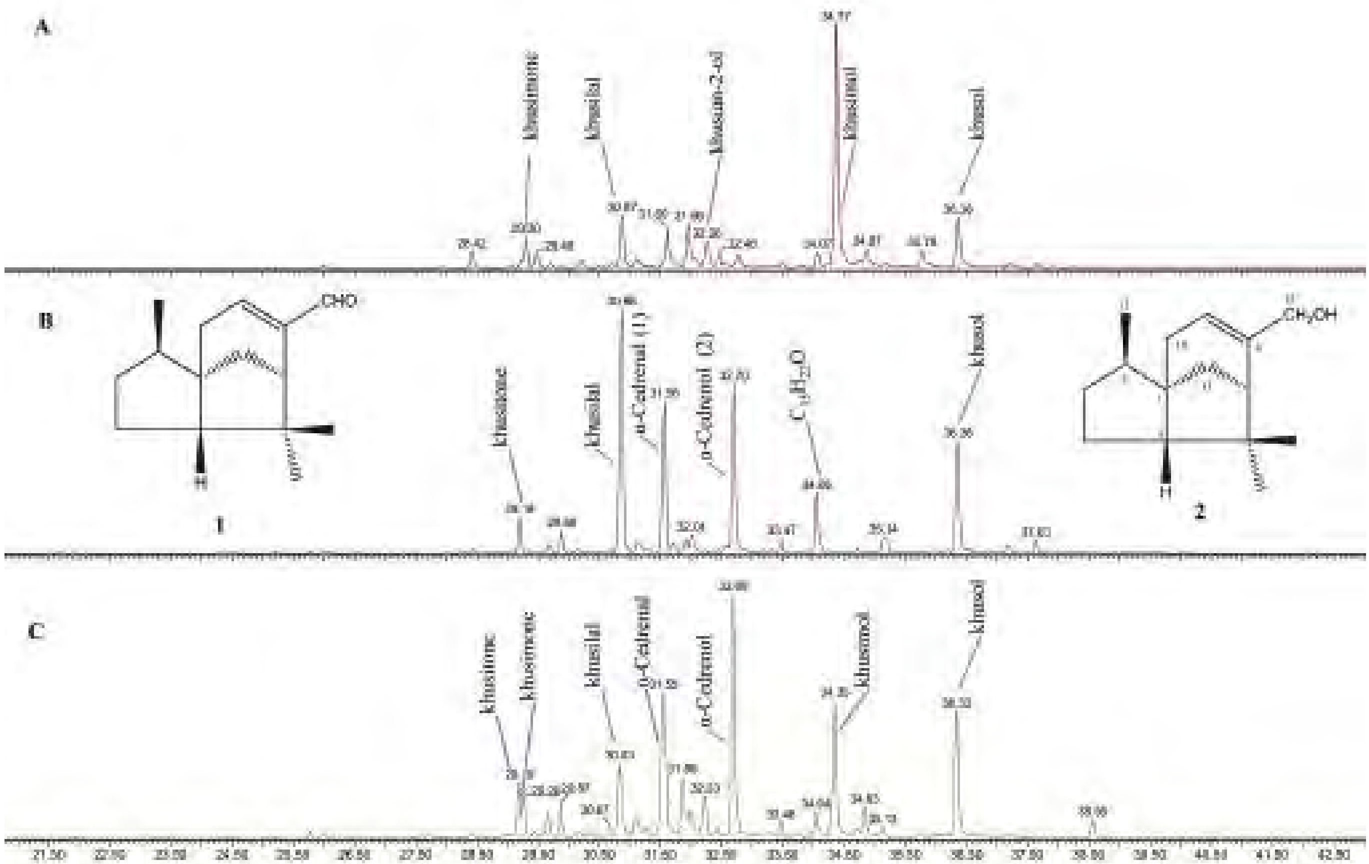
Present study was conducted to find out alternative of disease managements strategies against *Rhizoctonia solani* damping off. The rationale was to study the effect of linalool rich Lippia essential oil against two *R. solani* isolates infecting *Ocimum basilicum* and *Plantago ovata*. Current study revealed that the use of essential oil emulsion can enhance the survivability of seedlings up to 98% and 92% in treated *O. basilicum* and *P. ovata* pots as comparison to non-treated pots 20% and 15%, respectively. Herein, we demonstrated a successful management of damping off disease on two commercially important crops for two consecutive years at nurseries. The isolates of *R. solani* were further characterized up to sub group level for the first time. (**SN Appl. Sci.** (2019) 1: 1144. https://doi.org/10.1007/s42452-019-1207-8).

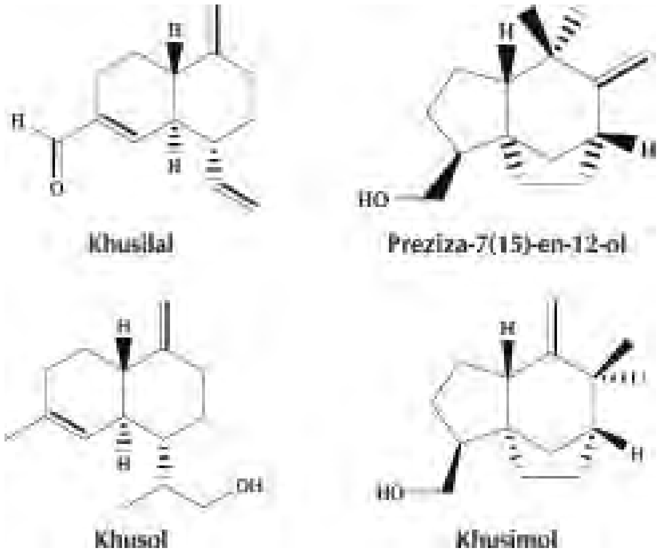
NMR characterization of cedrene derivatives in Indian vetiver (*Chrysopogon zizanioides* (L.) Roberty)

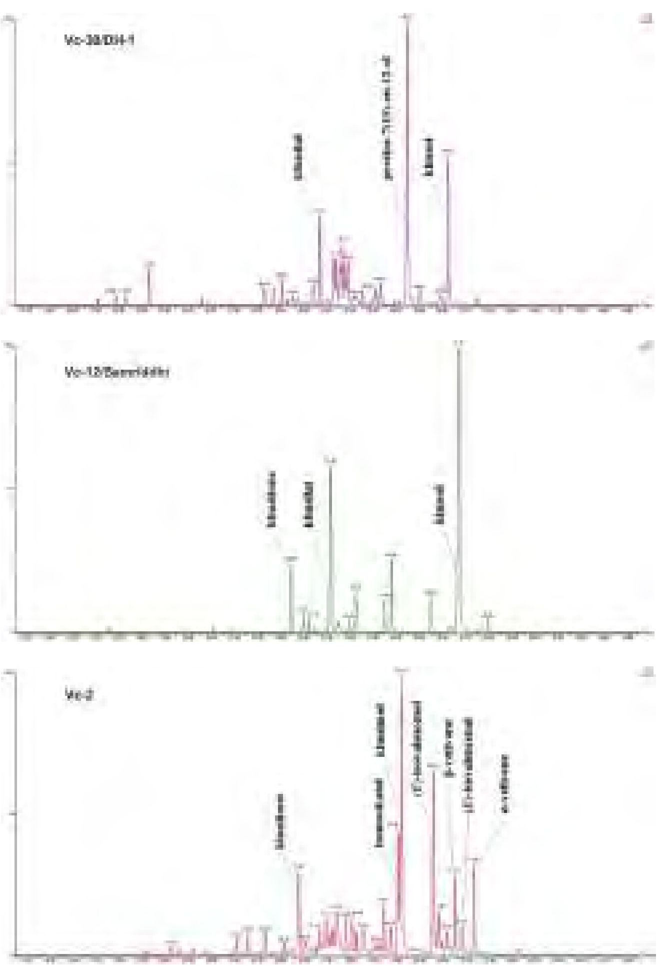
Three best stable essential oil rich genotypes of vetiver (A: G 10, B: G 14 and C: G 15) were identified using GC, GC/MS and NMR experiments. Khusimol, Khusol, khusimone, and khusian-2-ol in type A; khusilal, α-cedrenal, α-cedrenol, khusol, khusitone in type B, and khusilal, khusimol, α-cedrenal, α-cedrenol, khusol, khusitone in type C, were reported. Two new compounds, namely, α-cedrenal (**1**) and α-cedrenol (**2**) were identified first time in the Indian *Chrysopogon zizanioides* (L.) Roberty while, the genotype type B possessed khusilal and khusol as the major compounds.

On carbon sequestration efficient clones selection for high essential oil yield over environments in Khus (*Chrysopogon zizanioides* (L.) Roberty)

About sixty-five diverse collections of *Chrysopogon zizanioides* (L.) were collected from twenty different places in India and five from abroad and studied in seven physiological and quantitative characters in the consecutive three years). The genotypes, environments, genotypes × environments, years + (genotypes × environments), genotype × environments (Linn.) related pooled ANOVA and deviations were found highly significant. The predictable and unpredictable







components were significantly contributed to stability. Both Eberhart and Russell and GGE biplot models, the four promising stable clones identified, namely Vc-42, Vc59, Vc-22, Vc-2, and Vc-60 for high essential oil yield and the three highly stable clones, namely Vc-12, Vc-14, and Vc-58 were also selected for the high photosynthesis rate/net CO_2 assimilation rate. The essential oil of the clones Vc-2, Vc-12, and Vc-30 were also found rich in khusilal, preziza-7(15)-en-12-ol, khusol, and khusimol. These stable clones were further recommended for commercial cultivation. (**RK Lal et al., Industrial Crops & Products** 145 (2020) 11213).

Input: Atul Gupta अतुल गुप्ता

Synthesis and evaluation of substituted 8,8-dimethyl-8*H*-pyrano[2,3-*f*]chromen-2-one derivatives as vasorelaxing agents

Taking structural leanings from scopoletin and glabridine, a series of substituted 8,8-dimethyl-8*H*-pyrano[2,3-*f*]chromen-2-ones (chromeno-coumarin hybrids) was synthesized from scopoletin, isolated from major bio-waste of *Artemisia annua* L. cv CIM sanjeevani, as vasorelaxing agents (Figure 1). The synthesized compounds and scopoletin were evaluated for vasorelaxation in endothelium intact rat main mesenteric artery (MMA). Seven compounds showed significant vasorelaxation in precontracted MMA within the range of EC_{50} values 1.58-5.02 μM. These derivatives presented 29.40-70.89 fold increased sensitivity for experimental tissue compared to scopoletin, the parent molecule. The lead molecule significantly blocked its relaxation response in MMA pre-contracted with high potassium depolarizing solution and in pre-incubated arterial rings with TEA, Figure 1 and 2). These mechanistic evaluations showed that lead molecule exerted vasorelaxation through Ca^{2+}- activated K^+

Lead compound

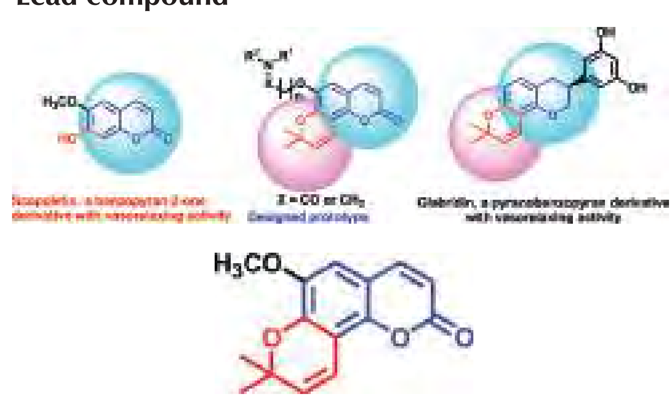


Figure 1 Structures of scopoletin and glabridin, designed prototype, and lead compound.

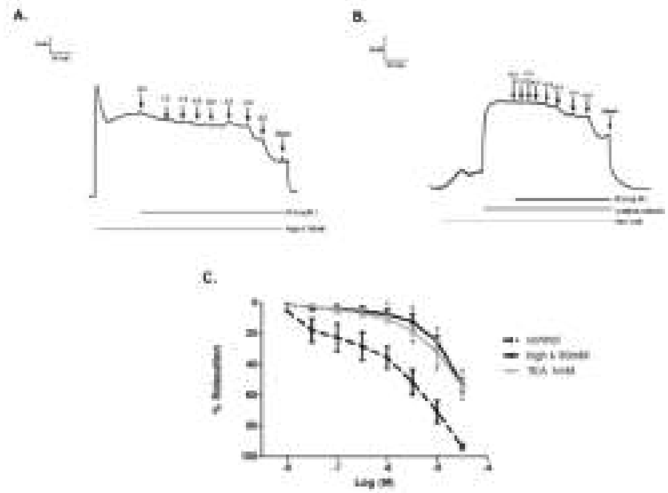


Figure 2. Traces showing lead compound induced concentration-dependent relaxation in rat mesenteric arterial rings preconstricted with 80 mM High K^+ containing MKHS **(A)** and pre-incubated with potassium channel blocker; Tetraethyl ammonium (TEA, 1 mM), for 20 min and preconstricted with U46619 (100 nM) Tracing **(B)**. Graph shows the sigmoidal concentration-response curve **(C)**. Relaxation is expressed as the Mean ± S.E.M. percentage reversal of contraction. **[Bioorganic & Medicinal Chemistry Letters (2020), 30, 1, 126759]**

(BKca) channel and the effect was endothelium-independent. The observed vasorelaxation in MMA by lead compound was validated through the *in-silico* docking study.

Induced osteoblast differentiation by amide derivatives of stilbene: the possible osteogenic agents

A series of amide derivatives of stilbene was synthesized and investigated for osteogenic activity. Out of sixteen, seven compounds showed significant osteoblast differentiation within 1 pM – 1 μM concentrations. The lead compound presented effective mineralization of osteoblasts and expression of mRNA of osteogenic marker genes such as BMP-2, ALP, and Runx-2 at 1 pM (Figure 1 and 2). In estrogen-deficient balb/c mice, the lead compound showed significant osteogenic activity at 5 mg-kg^{-1} bodyweight dose. The protein expression study for estrogen receptors α and β (ER-α & ER-β) using mouse calvarial osteoblasts (MCOs) and molecular docking analyses showed preferential expression of ER-β by lead compound indicating the possibility of ER-β mediated osteogenic activity.

Dr. Atul Gupta & his team

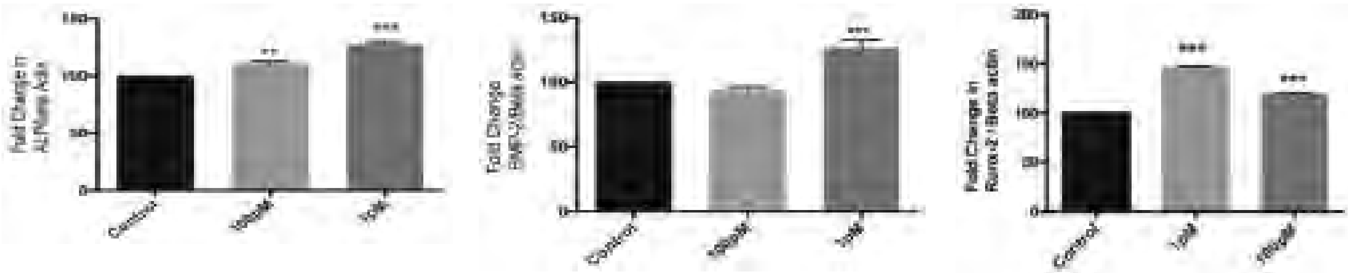


Figure 1. Mouse calvarial Osteoblast cells were treated with lead compound (at 1 pM and 100pM) for 24 h and 48 h. qPCR analysis showed an increase in mRNA expression of osteogenic marker gene alkaline phosphatase (ALP), BMP-2, and Runx-2 compared with control. qPCR data represent the mean ± SEM from three independent experiments. ; (*)P < 0.05, (**)P < 0.01, (***)P<0.001

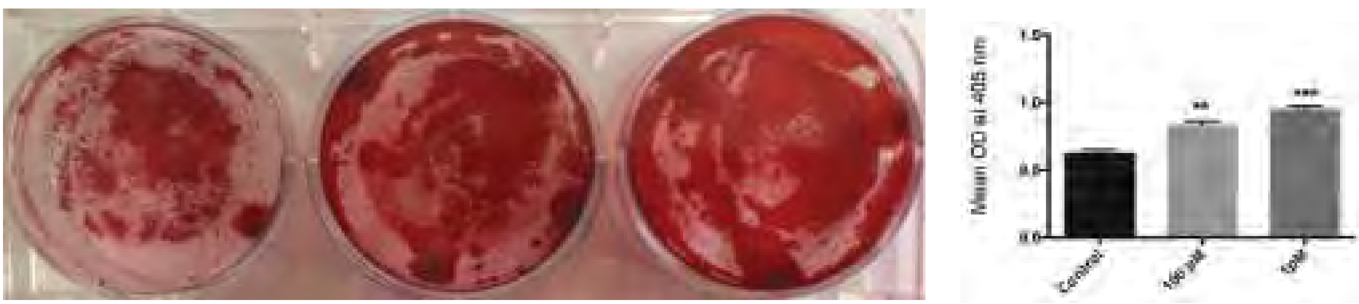


Figure 2. Mineralization of osteoblast cells by the lead compound. MCOs were seeded in 12 well plates at a density of 2x10^3 cells per well in differentiation medium and treated with and without lead compound at 1μM and 10μM, for 21 days. At the end of the incubation, cells were fixed and stained with alizarin red-S. The stain was extracted, and the optical density was measured calorimetrically. Data shown as mean ±SEM; n = 3; ***p<0.001. [Bioorganic & Medicinal Chemistry Letters (2020), 30, 11, 127138]

Input: A D Nannaware ए.डी. नन्नावरे

A new solar steam distillation technology for processing of aromatic crops (Er. A D Nannaware, Dr. CS Chanotiya & Dr. PK Rout)

The newly designed solar steam aroma distillation technology has a high degree of innovation with an integrated concept of designing a new intensifying solar distillation apparatus for essential oil extraction from aromatic plants for assisting the Indian farmers and end beneficiaries with the objective to develop sustainable agribusinesses. This solar steam distillation apparatus will pave the way in systematic scientific insight into the distillation of essential oil from the aromatic and medicinal plants. High and fast distillation performance ability with zero CO_2 emission and protection offered to thermolabile constituents are some of the attractive features of this new promising solar steam distillation apparatus design. This environmental-friendly centralized solar distillation technology will maximize the benefits of farmers cultivating aromatic crops in India and abroad with superior distillation features which give higher oil quality and improved yield. This new solar distillation unit was successfully demonstrated to farmers in Kisan Mela on 31st January 2020.

Promotion of aromatic crops in the aspirational and drought-affected areas of Maharashtra

As a co-coordinator of Maharashtra State under CSIR-Aroma Mission, we have conducted six awareness programs on "Cultivation of Aromatic Crops" in different aspirational district and drought-affected areas of Gondiya (Morgaon-Arjuni), Amravati (Adgaon), Akola (Atkali), Palghar and Jawhar of Maharashtra. We initiated the plantation, cultivation, and distillation of Aromatic and Medicinal plants in these areas which will increase farmer's income and will directly reduce the suicidal cases in these drought-affected regions. In

Maharashtra, more than 50 acres of new land is under cultivation of these aromatic crops such as palmarosa, lemongrass, citronella, geranium, and vetiver. During this year, three distillation units are installed in drought and aspirational districts affected villages of Wai (Yawatmal), Gawaraa (Gondiya), Pimpalkhuta (Nandurbar) for the farmers to distilled the valuable essential oil.

Input: Hariom Gupta हरिओम गुप्ता

NMR investigation of poly-saccharide obtained from seed (SPS) and husk (HPS) of Psyllium

Psyllium (*Plantago ovata* Forssk) is a rich source of natural antioxidants. Psyllium husk is commonly used as a laxative and dietary supplement to promote the regulation of bowel movement. Polysaccharides obtained from psyllium seed husk have been widely studied however, characteristic properties of polysaccharides present in seeds have not been evaluated and comparatively studied with husk polysaccharides. In this part of study, polysaccharides were extracted from husk and seed of psyllium, which were purified and evaluated for comparative chemical characteristics using NMR analytical tools. These characterized polysaccharides of husk and seeds were further used to evaluate the antioxidant, free radical scavenging, and anti-proliferative activities.

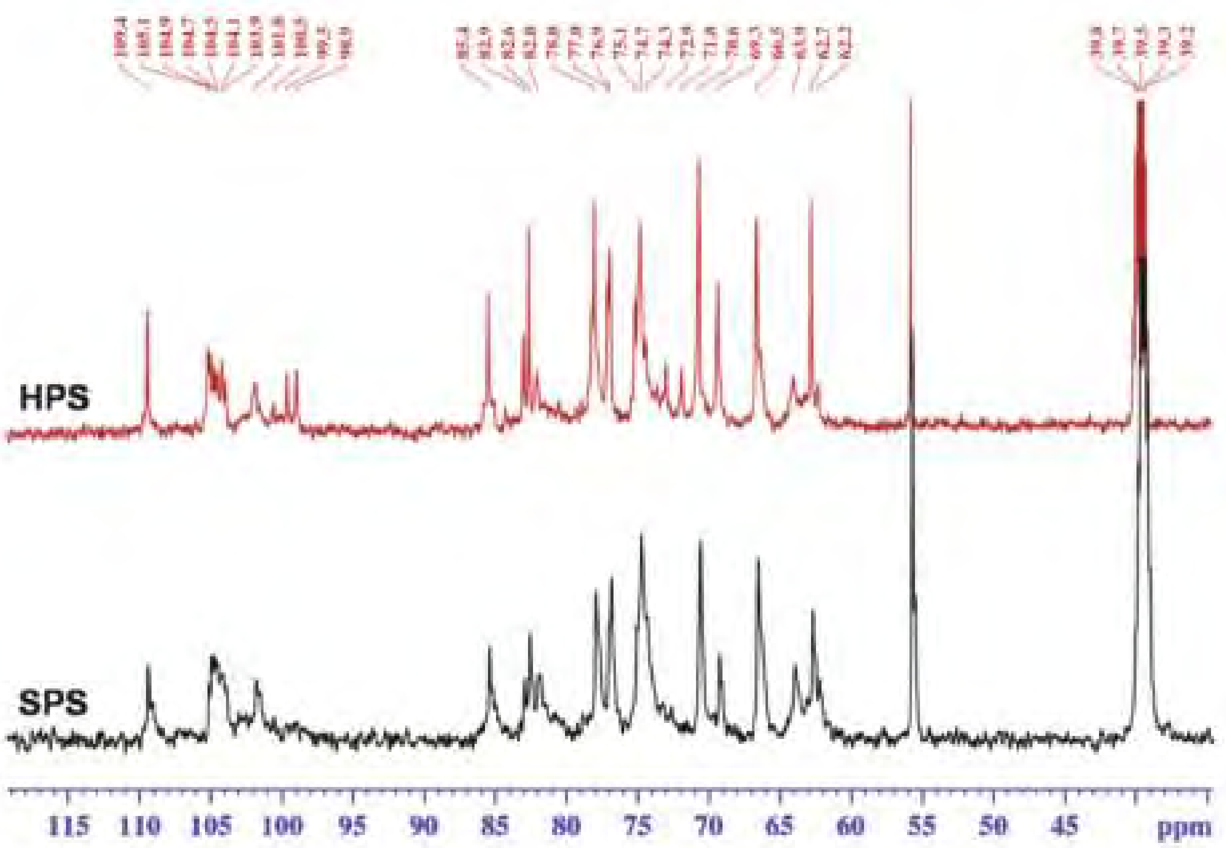


Figure: 13C NMR spectra of SPS and HPS representing the characteristic peaks of constituting sugar units

The ^{13}C NMR spectra of polysaccharide obtained from seed (SPS) and husk (HPS) of psyllium is shown in Figure. The spectra for polysaccharide obtained from SPS and HPS were similar. ^{13}C peaks were assigned to the characteristic functional group of various constituting sugars: arabinose, xylose, galactose, and rhamnose and were consistent with the literature reported for psyllium husk and seed. NMR peaks corresponding to terminal α-arabinofuranose, terminal β-xylopyranose units, 3-linked β-xylopyranose, and branching xylopyranose units were observed. These results further suggest that polysaccharides obtained from seeds and husk of psyllium are comprised of xylose, arabinose, and their interlinked units.

Synthesis and characterization of ferrite nanoparticle-based hybrid system

Ferrite nanoparticles with three different doping concentrations were synthesized. The crystalline phase, structure, and material morphology were characterized by XRD, SEM, and FTIR technique. Ferrite nanoparticles based hybrid systems with mentha oil were prepared. The activity of prepared hybrid combinations was tested with fungus strains and found an improvement in the activity compared to native essential oil.

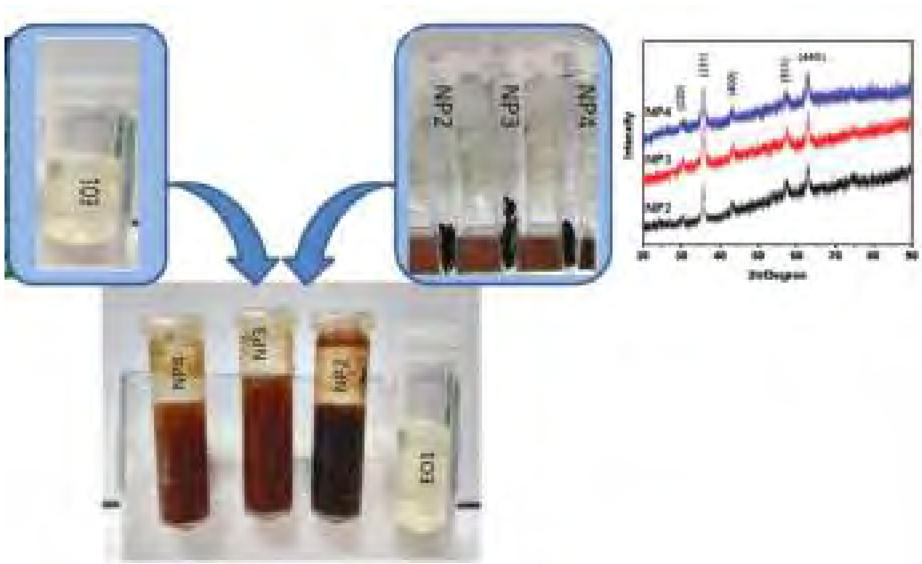


Figure. Representing ferrite nanoparticles based hybrid system of essential oil

Dr. Hariom Gupta & his team

Input: Kapil Dev कपिल देव

Phytochemical 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

tridosh nashak *i.e.* Vata, Pitta, and Kapha. Previous preclinical studies found that *guava* leaves and its isolates have potentials as anti-cancer, antioxidant,

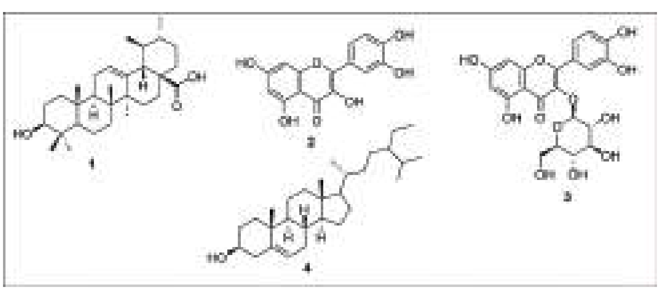


Figure 1. Chemical structures of the isolated compounds

anti-inflammatory, antibacterial, antidiabetic and hypolipidemic activities, etc. 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 the 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 yielded four compounds (**1-4,** figure 1). The structure of the purified compounds was established by using 1D and 2D-NMR spectral data. All the isolated and characterized compounds as ursolic acid (**1**), quercetin (**2**), Isoquercitrin (**3**), *β*-sitosterol (**4**). Further, work is under progress.

Input: V S Pragadheesh
वी.एस. प्रगधीश

Working to develop quality parameters for aromatic plants, essential oils, and enantiomeric compounds from the varieties developed by CSIR-CIMAP. Also involved in identifying the flower-pollinator interaction in various aromatic plants and to explore the role of floral scent in *Jasminum grandiflorum* for their defense and pollination. Further, chemical ecological strategies will be developed using essential oils for pest control in various aromatic crops.

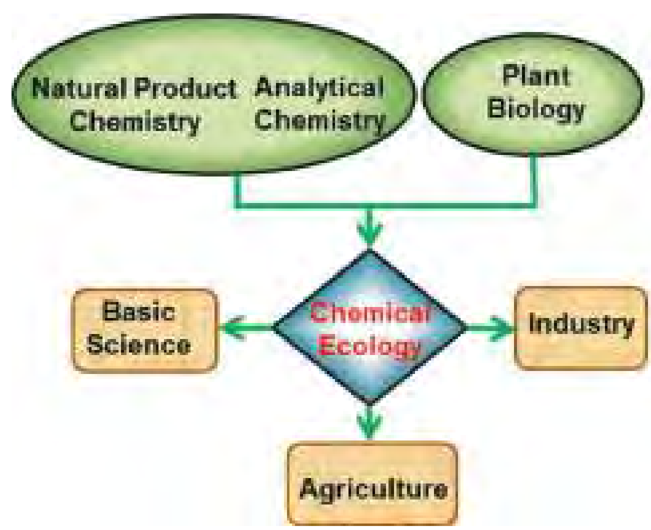


Figure: Schematic representation of the research work

Bio-Prospection and Product Development

Highlights of Bio-Prospection and Product Development

Biorpospection is the search and examination of biological resources (plants, animals, microorganisms etc.) that have features which might be of value for overall health and well being of the society leading to commercial development. Technological advancements in biotechnology, pharmaceutical, agriculture and other key areas helping in rapid growth of bioprospecting. India is a prime target for bioprospecting because of its unique biodiversity and traditional knowledge. Major programmes on bioprospecting phytochemicals for their use as drugs and agrochemicals were initiated during 1993-94. The present focus of Bioprospecting group is on infectious diseases, metabolic disorders and safety evaluation of MAPs using modern tools.

Research activities at Bioprospection and Product Development are aimed at 'Bioprospecting natural resources for novel bioactive molecules and value added products for the better health and life. While achieving the goals, efforts are focussed at finding the solutions for drug resistant infections (bacterial, fungi, malaria parasite) and some of the metabolic disorders such as hepatoprotection, inflammation, immunomodulation, cancer, hypertension etc. The efforts are also directed towards finding the safety limits of herbal preparations/ products.

Areas of Research

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

Major scientific outputs/technologies

1. Development and commercialization of traditional knowledge based plant based formulation for the management of Type-2 diabetes mellitus in collaboration with CSIR-NBRI.
2. An Indian Traditional Knowledge based formulation coded as "IVT-15" for Rheumatoid Arthritis has been developed and pre-clinical studies have been completed.
3. Identification of phyto-extracts/fractions/molecules that are active against sensitive and drug resistant bacteria -
    - Having potent antibacterial activity against drug resistant bacteria (clinical isolates) targeting the resistance mechanism pathways.
    - Showing synergy with standard antibiotics thereby producing better antibacterial effect at reduced doses especially against drug resistant strains/clinical isolates.
    - Enhancing the efficacy of standard antibiotics by increasing their bioavailability.
4. Identification of leads showing potent efficacy against sensitive and drug resistant strains of malaria parasite *Plasmodium falciparum*.
5. Scientific validation of *Ocimum basilicum* which is traditionally used for skin related problems was achieved and established its wound healing property.
6. Safety profile of ayurvedic drug 'Trikatu' has been determined using small animal model.
7. Translation of research in to products for general healthcare utilizing medicinal and aromatic plants (MAPs) based research leads.
8. Industrial collaborations for translational research in the area of antimicrobial resistance (AMR) for replacing the use of existing antibiotics by plant derived antimicrobial agents especially in fermentation industry.
9. Transfer of technologies for their commercial utilization promoting new entrepreneurships and start-ups.

Linkage with Industry

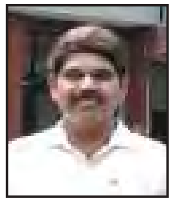
The value added products of human utility that were developed based on medicinal and aromatic plants for type-2 diabetes mellitus, pain & inflammation, disinfection, skin & hair care, nutraceuticals, personal hygiene, mosquito repellent etc. have been transferred to different industries for commercial utilization.

Research Facilities:

- Biosafety level II containment facility for *in-vitro* drug testing using.
- Automated TB drug sensitivity workstation
- Anoxomat mark II system for anaerobic microbes
- Flowcytometry for drug kinetics and mechanism of action studies
- Animal cell culture facility
- Spectrofluorometer / UV-Vis spectrophotometers and ELISA reader
- Ultra Centrifuge and High speed refrigerated centrifuge
- Animal House facility for *in vivo* efficacy and safety studies.
- Small animal models for testing drug safety and efficacy
- Animal isolators for *in-vivo* drug testing
- Microtome, Plethysmometer and Analgesiometer
- Modern Biology instruments for routine experimentation in the area of Molecular Biology, Microbiology, Biochemistry, Biotechnology.

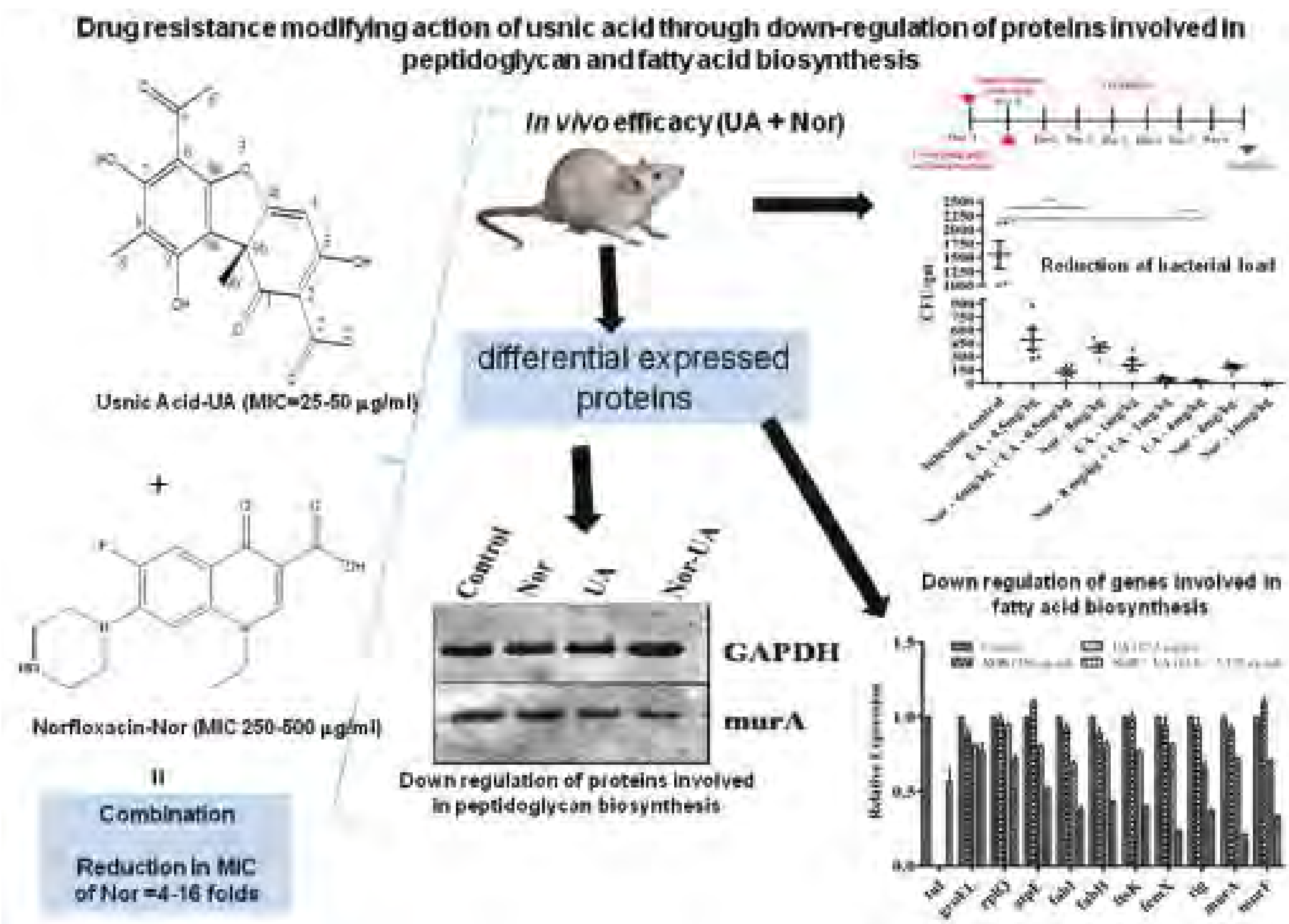
Left to right: Dr. D. Chanda, Dr. D.N. Mani, Dr. Abha Meena, Dr. M.P. Darokar, Dr. D. Saikia, Dr. A. Pal, Dr. N.P. Yadav, Dr. S. Luqman, Dr. D.U. Bhawankule

Input: MP Darokar एम.पी. दारोकर



Usnic acid modifies MRSA drug resistance through down-regulation of proteins involved in peptidoglycan and fatty acid biosynthesis

Multidrug-resistant *Staphylococcus aureus* (MRSA) infections place a huge burden on the healthcare sector and the wider community. An increasing rate of infections caused by MRSA has necessitated the development of alternative agents. Previously, it was reported that usnic acid (UA) exhibits activity against MRSA, here we report the effect of UA in combination with norfloxacin on the drug resistance of MRSA clinical isolates. It was observed that the combination of UA–norfloxacin significantly reduces the bacterial burden in mouse models infected with *S. aureus*, without causing any detectable associated toxicity. Proteomic analysis indicated that UA–norfloxacin induces oxidative stress within cells, which leads to membrane damage and inhibits metabolic activity and biosynthesis of peptidoglycan and fatty acids. Collectively, this study provides evidence that UA in combination with norfloxacin may be a potential candidate for development into a resistance-modifying agent for the treatment of invasive MRSA infections (FEBS Open Bio, 9 (12):2025-2040. doi: 10.1002/2211-5463.12650).



Input: D. Saikia डी. सैकिया

Isodon melissoides (Benth.) H. Hara is an herbaceous, perennial plant belonging to the Lamiaceae family, distributed mainly in the hilly regions (1300–2000m) of China, Bangladesh and India. Traditionally, it is used by local people for healing cuts and wounds. Several diterpenoids and lignan glycosides have been isolated from the aerial-parts of *I. melissoides*. The essential oil has been found to be stored-grain protectant and also demonstrated significant antidermatophytic activities. Major components of the essential oil are reported as thymol, carvacrol, b-bisabolene p-cymene, menthol, and piperitone, etc.

Previously, the essential oil of *Isodon melissoides* was evaluated for several biological activities; however, information on its bactericidal kinetics, mechanism of action and anti-inflammatory activity were lacking. The current study was aimed at addressing these aspects and only the bactericidal kinetics is presented here.

Bactericidal kinetics of the essential oil against *Staphylococcus aureus* (SA), *Staphylococcus epidermidis* (SE), and *Enterococcus faecalis* (EF) were determined and compared at 2MIC and 4MIC with those of Log-phase culture (1-2 × 10^7 CFU/mL). Aliquots of sample were removed after 0.5, 1, 2, 3, and 6 h and diluted in sterile normal saline solution before plating on Mueller-Hinton agar plates, CFU were counted after 24 h of incubation at 37°C. The experiment was repeated three times and the results presented here are from one of the three independent experiments.

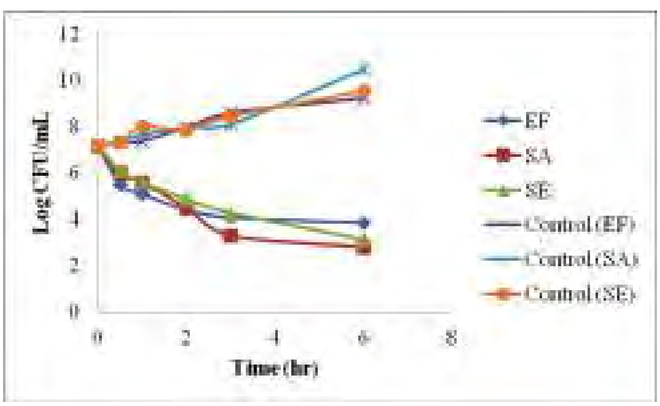


Figure 1: Bactericidal kinetics of *Isodon melissoides* essential oil at 2MIC

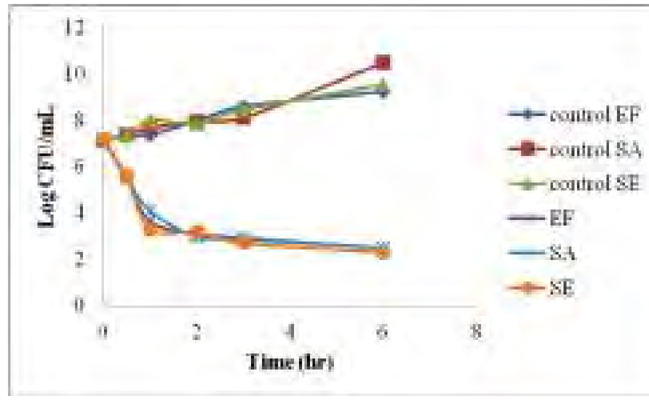


Figure 2: Bactericidal kinetics of *Isodon melissoides* essential oil at 4MIC

At 2MIC about 27.21%, 29.83% and 31.0% reduction in population were observed in *S. aureus, S. epidermidis, and E. faecalis*, respectively after 1 h of treatment. However, after 6 h treatment, about 73.4%, 67.3% and 58.3% reduction in populations were achieved against these strains. Further, at 4MIC, about 46.6%, 58.9% and 50.8% reduction in population were observed in *S. aureus*, *S. epidermidis*, and *E. faecalis*, respectively after 1 h of treatment. However, reduction in population reached about 76.3%, 75.9% and 73.2% against these strains after 6 h treatment. Thus, *Isodon melissoides* oil could act as effective anti-bacterial agent due to its short killing time (*Natural Product Research*, 2019).

Dr. D. Saikia & his team

Input: Anirban Pal अर्निबन पाल

Malaria-Typhoid co-infection accomplishes a septic shock like condition as evidenced by cytokine expression and vascular reactivity

Impairment of host immune response in malaria favours bacteremia caused by typhoidal or non-typhoidalserovars of *Salmonella enterica*. In our previous study (Patel et *al.,* 2018), we concluded that infection with *Plasmodium* aggravates the secondary infection of *Salmonella* serovars and the control of septicemia is critical in recovery of the co-infected subjects. In continuation of the studies, we further investigated the collateral observations of inflammation and vascular hypo-reactivity through main mesenteric artery (MMA) of experimental mice co-infected with malaria parasite and *Salmonella* inoculum.

We compared the bacterial loads in spleen after oral infection of mice with *S.* typhimurium with or without preceding *P. yoelii* co-infection. Co-infected mice have 40-50 times higher bacterial load on spleen then *S.* typhimurium infected mice. The increased microbial load (40-50 times) in co-infected mice (Fig.1) is indicative of the impairment of host resistance caused by hemolytic malaria which increases the severity of the bacterial sepsis. Treatment of the co-infected mice with combination of ofloxacin and artesunate was efficiently control the proliferation of the bacterium and the parasite.

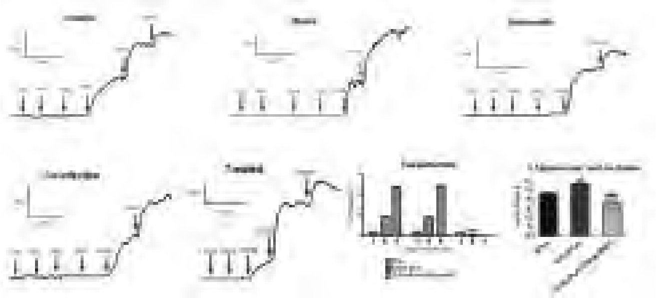


Figure 1. Induction of significant vascular hyporeactivity upon co-infection with Plasmodium and Salmonella

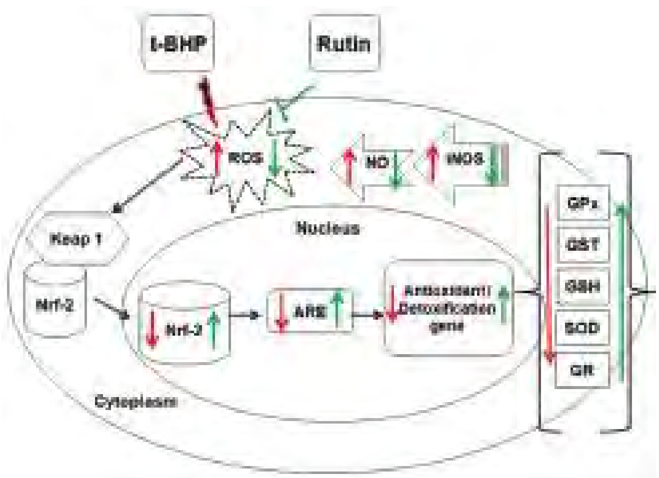
Exposure of animals to infection with *Plasmodium*, *Salmonella* typhimurium and co-infection with both organisms induced significant level of vascular hypo-reactivity. It was observed that the contractile response to U46199 treatment at 200nM was significantly reduced in *Plasmodium*, *Salmonella* and co-infected groups of animals when compared to control. Treatment with the combination of ofloxacin and artesunate increased contractile response to near normal levels. The *Emax* values for contraction obtained with U46199 (200nM) were 6.78 ± 0.45, 5.27 ± 0.43, 4.57 ± 0.50, 4.54 ± 10.48 and 6.9 ± 0.66 mN $(n = 6)$ for control, malaria, *Salmonella*, co-infection and treatment groups respectively. The pD2 values were also significantly decreased in groups of experimental mice exposed to pathogens compared to control. The mean and SEM of pD2 values presented in figure are indicative that the treatment of mice with combination of artesunate and ofloxacin could improve the pD2 values and *Emax* values.

Dr. Anirban Pal & his team

Input: Suaib Luqman शोएब लुकमान

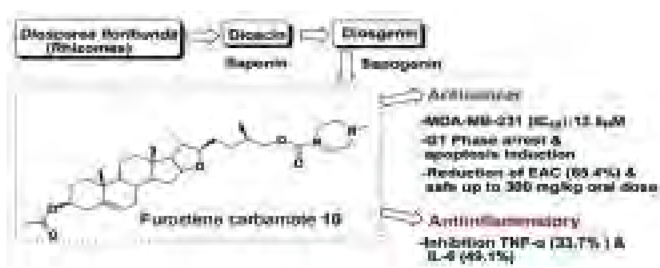
Rutin protects t-butyl hydroperoxide-induced oxidative impairment via modulating the Nrf2 and iNOS activity

Rutin (quercetin-3-O-rutinoside) is a flavonoid present in citrus fruits, berries and buckwheat. We revealed attenuation of oxidative stress by rutin and its possible mechanism of action in restoring the detrimental effect of t-BHP. We also provide evidence that rutin potentiates its beneficial aspect by displaying a profound role in iNOS-Nrf2 signalling pathway and protects the antioxidant status of erythrocytes and liver from oxidative stress (Phytomedicine 2019; 55: 92-104)



Bivalent furostene carbamates as antiproliferative and anti-inflammatory agents

Diosgenin and related compounds including carbamate derivatives possess significant antiproliferative activity against triple negative breast cancer cells by arresting G1 phase of cell cycle and induced apoptosis by activating caspase-3. One of the derivatives (carbamate 10) exhibited moderate anti-inflammatory activity by decreasing the expression of TNF-α and IL-6 in LPS-induced inflammation in primary macrophage cells. Besides, compound 10 significantly reduced Ehrlich Ascites Carcinoma in mice and it was safe in acute oral toxicity upto 1000 mg/kg body weight. The concurrent anticancer and anti-inflammatory properties of the derivative are promising which could further be optimized for a better anti-breast cancer candidate (*The Journal of Steroid Biochemistry and Molecular Biology* 2019; 194: 105457).

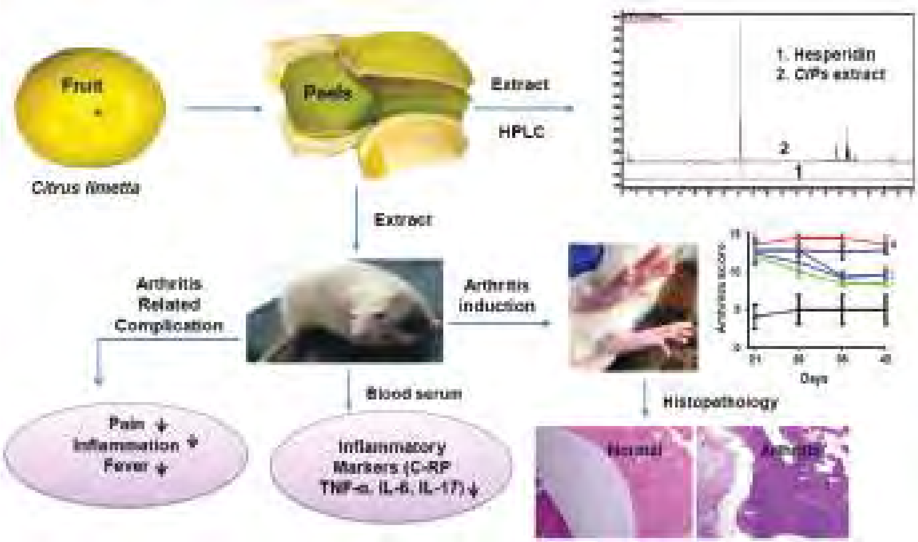


Dr. Suaib Luqman & his team

Input: DU Bawankule डी.यू. बावनकुले

Hesperidin rich extract from waste peels of *Citrus limetta* mitigate arthritis and related complication

The aim of this study was to explore the possible pharmacological effects of fruit waste which may have a key role in converting the fruit waste into pharmaceutical agents. *Citrus limetta* (Rutaceae) is an important commercial citrus fruit crops used by juice processing industries. *C. limetta* peels are perishable waste material creates a big challenge in juice processing industries. *In-vitro* study revealed that the ethanol extract (*ClPs)* has promising anti-inflammatory activity. HPLC profile of *ClPs* indicated the presence of hesperidin in large quantity. *In-vivo* experimental pharmacology profile of *ClPs* against arthritis and related complications revealed that, oral administration of *ClPs* significantly reduced the arthritis score and arthritis index in elbow and knee joints against collagen-induced arthritis (CIA) in rats. Biochemical parameters include proinflammatory cytokines (IL-17A, TNF-α, IL-6) and C-RP level in blood serum of CIA rats further confirmed the anti-arthritic profile of *ClPs*. Further individual experiments related to arthritis related complications in experimental animals demonstrated the analgesic, anti-inflammatory and anti-pyretic potential of *ClPs* in dose-dependent manner. Result of this study suggests the suitability of *ClPs* as a drug-like candidate for further investigation towards the management of arthritis and related complications.

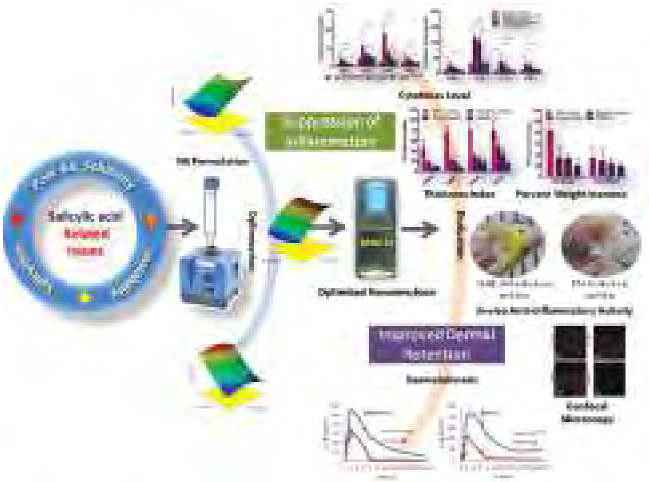


Dr. DU Bawankule & his team

Input: NP Yadav एन.पी. यादव

Dermal controlled release of salicylic acid for improved anti-inflammatory action: Combination of Hydrophilic-Lipophilic balance and Response Surface Methodology

In the present study, salicylic acid (SA) loaded nanoemulsion was developed by implementing response surface methodology (RSM) and hydrophilic-lipophilic balance (HLB) approach, in amalgamation, and the controlled dermal release of salicylic acid for improved anti-inflammatory action was successfully achieved (*Journal of Drug Delivery Science and Technology*, 2019, 52: 870–884).



Pharmacokinetic study of hepatoprotective Cliv-92 from *Cleome viscosa* in mice using validated HPLC-PDA method

The present research delineates the HPLC-PDA detection for quantification of Cliv-92 (composition of three structurally similar coumarinolignoids, cleomiscosins A, B, and C) in mice plasma and its application to a preliminary pharmacokinetic study of Cliv-92 after intravenous bolus administration (*Phcog Mag*, 2019, 15:270-6).

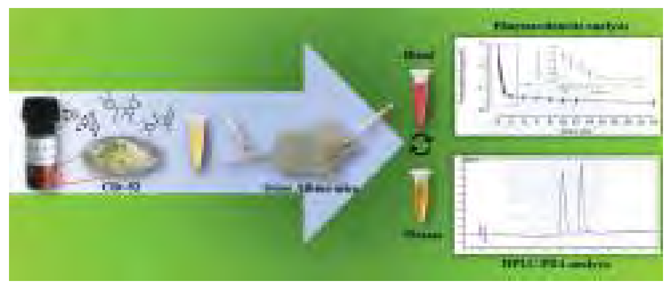
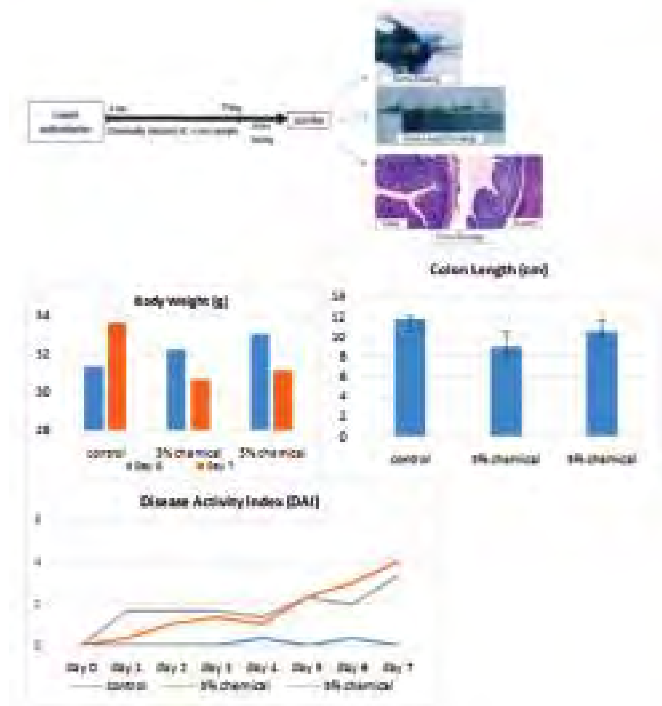


Figure: Pharmacokinetic study of hepatoprotective Cliv-92

Dr. NP Yadav & his team

Input: DN Mani डी.एन. मणि

Establishment of *in vivo* model of ulcerative colitis [Inflammatory Bowel Disease (IBD)] for the screening of potent plants described under *Ayurveda*



IBD is a chronic or remitting/relapsing gut inflammation, which includes primarily ulcerative colitis (UC) and Crohn's disease (CD). UC and CD are inflammation of gut mucosa, associated with microbiota dysbiosis of the gastrointestinal tract, weight loss, abdominal pain, diarrhea and rectal bleeding. Pathologically IBD impairs epithelial barrier integrity or cause loss of tight junction complex, facilitate bacterial infiltration and increase intestinal epithelial permeability. Upregulation of transcription of genes encoding pro-inflammatory cytokines and interleukins leads to increased level of IL-1β, IL-6, IL-12 and IL-23. Presently there is no standard regimen available for the management of IBD. The approach to treatment depends upon disease severity, anatomic location, previous response to medication and side effects of medication and co-morbidities. In modern therapy, anti- inflammatory drugs, immunomodulators and antibiotics are prescribed. According to *Ayurveda*, gut inflammation is known as *Grahani* (ulceration of the intestine or duodenum), which symptomatically includes *Atisara* (diarrhoea). According to *Vaghbhatta*'s *Astanga Hridyam*, *Atisara* caused by grief (*Shokaj* and *Bhayaja Atisara*), when left untreated leads to *Grahani*. The treatment for *Grahani* is similar to that of *Atisara*. In gut inflammation the patient often shows signs of emaciation, weakness and low energy. Thus, palliative care, known as *shamana chikitsa*, is necessary as *Ojas* (mental and emotional stability) is low but *ama* is high. Medicinal plant-based formulations provide a silver lining for management of IBD. In future the developed *in vivo* model will enable comparative analysis of *Ayurvedic* plants for efficacy against IBD.

Dr. DN Mani & his team

Input: D. Chanda डी. चन्दा

Antihypertensive activity of novel neolignan1 in rats:

The present study reports that neolignan1 (Diethyl-4,4-dihydroxy-8,3-neolign-7,7-dien-9,9-dionate) relaxes the superior mesenteric artery in a concentration dependent manner. The relaxation response of neolignan1 was found to be endothelium independent and sensitive to 1H-[1,2,4] oxadiazolo [4,3-a]quinoxalin-1-on (ODQ; 1 μM) and tetraethyl ammonium (TEA; 1 mM). Further, neolignan1 significantly decreased the systolic blood pressure, diastolic blood pressure and mean arterial pressure in the Nω-Nitro-L-arginine methyl ester hydrochloride (L-NAME; 50 mg/kg) treated Wistar rats at the dose of 30 and 100 mg/kg given once orally for 15 days. In addition, neolignan1 is well tolerated upto 100 mg/kg when given as a repeated dose, once orally for 28 days in Swiss albino mice and was well absorbed from oral route, reached peak at 4 h and eliminated below detection level by 12 h after administration.

The report concludes that neolignan1 produced relaxation in superior mesenteric artery by opening of BK_{Ca} channel and produced significant antihypertensive activity in L-NAME treated Wistar rats and was well tolerated by the experimental animal (Singh et al., 2019; Eur J Pharmacol. 2019 Jun 21;858:172482).

Safety evaluation of standardized extract of *Silybum marianum* in Swiss albino mice

Acute and sub acute oral toxicity of standardized extract of *Silybum marianum* seed were carried out in Swiss albino mice following OECD test guidelines and IAEC approved protocols. The standardized extract was well tolerated by the experimental mice upto 2000 mg/kg as a single acute oral dose and upto 200 mg/kg as a repeated daily oral dose for 28 days in sub acute toxicity experiment.

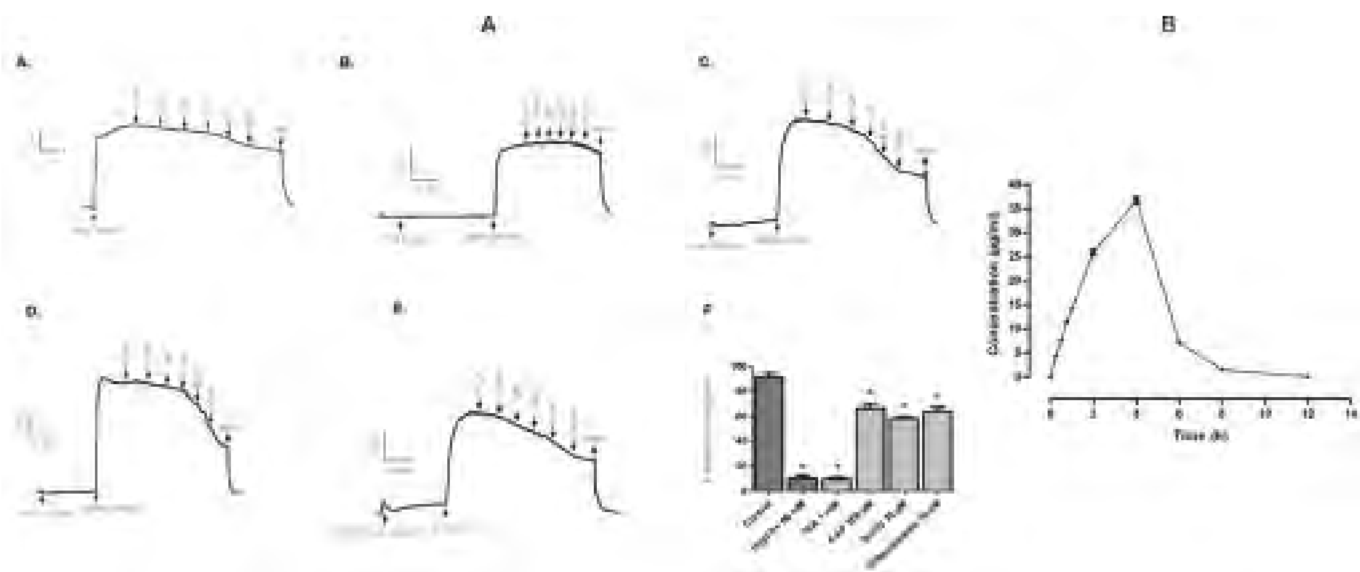


Figure : A: Traces showing neolignan1-induced concentration dependent relaxation in rat mesenteric arterial rings preconstricted with 60 mM High K^+ MKHS,A and pre-incubated with different potassium channel blockers; Tetraethylammonium (TEA, 1 mM), 4-Aminopyridine (4-AP, 300 μM), Glibenclamide (10 μM) and Barium chloride ($BaCl_2$, 30 μM) for 20 min and preconstricted with U46619 (100 μM) and NE (10 μM), Tracing B-E, Relaxation is expressed as the Mean ± S.E.M. percentage reversal of contraction. Figure B: Time-concentration curve of neolignan1 in rat plasma after oral administration (Mean ± S.E.M., n=6).

Table 1: Effect of standardized extract of *Silybum marianum* as a single acute oral dose at 2000 mg/kg on body weight, haematological, serum biochemical and tissue biochemical parameters in Swiss albino mice (Mean ± SE; n = 6).

Parameters	Single acute oral dose at 2000 mg/kg body weight	
	Control	ATG-SM E01
Body weight (gm)	30.28 ± 1.86	30.47 ± 1.32
Haemoglobin (gm/dL)	13.10 ± 0.71	13.87 ± 0.57
RBC (million/mm^3)	5.79 ± 0.29	6.44 ± 0.34
WBC (1000*/mm^3)	4.65 ± 0.71	4.71 ± 0.46
ALP (U/L)	113.62 ± 15.28	112.62 ± 10.17
Albumin (g/dL)	2.92 ± 0.17	3.24 ± 0.13
Creatinine (mg/dL)	0.76 ± 0.15	0.76 ± 0.15
Triglycerides (mg/dL)	84.59 ± 7.51	76.80 ± 3.16
Serum Protein (mg/ml)	4.99 ± 0.66	4.78 ± 0.43
Total Cholesterol (mg/dL)	126.13 ± 10.68	131.06 ± 7.34
SGOT	25.53 ± 5.37	22.95 ± 3.08
SGPT	35.06 ± 3.69	34.98 ± 5.48
Hepatic tissue GSH (μM/mg protein)	2.82 ± 0.11	2.86 ± 0.27
Mepatic tissue malonaldehyde (n mole/mg protein)	1.43 ± 0.41	1.28 ± 0.13

Dr. D. Chanda & his team

Input: Abha Meena आभा मीणा

Lemongrass cellulose nanofibers for the controlled release of problematic drugs

The lemongrass (LG) leaves could be a useful source of cellulose after its oil extraction, which is still either dumped or burned, not considered as a cost-effective approach. The synthesis of cellulose nanofibers (CNF) from LG waste has emerged as a beneficial alternative in the value-added applications. The non-toxicity, biodegradability, and biocompatibility of CNF have raised the interest in its manufacturing. In the present study, we have isolated, characterised CNFs using enzymatic hydrolysis. We also explored the cytotoxic properties of the final material (Figure 1). Further, an application of cellulose nanofibers has been established for the controlled release of an anticancer drug,*i.e.*, camptothecin. The camptothecin is known for its antitumor activity. However, it has certain limitations like instability, low solubility in aqueous solution, and biological fluids. In conclusion, the results confirmed that LG waste-derived CNF is a potential sustainable material and could be employed may also be an optimal carrier for the controlled drug release formulation without any chemical excipients.

Targeting Ca^{2+} signalling through phytochemicals to combat cancer

Cancer is amongst the life-threatening public health issue worldwide, hence responsible for millions of death every year. It is affecting human health regardless of their gender, age, eating habits, and ecological location. Many drugs and therapies are available for its cure still the need for effective targeted drugs and therapies are of paramount importance. In the recent past, Ca^{2+}signalling (including channels/transporters/ pumps) are being studied as a plausible target for combating the cancer menace (Figure 2). In addition, there are numerous phytomolecules which can be exploited as a potential Ca^{2+} (channels/transporters/ pumps) modulators in the context of targeting Ca^{2+} signalling in the cancer cell. A list of plant-based

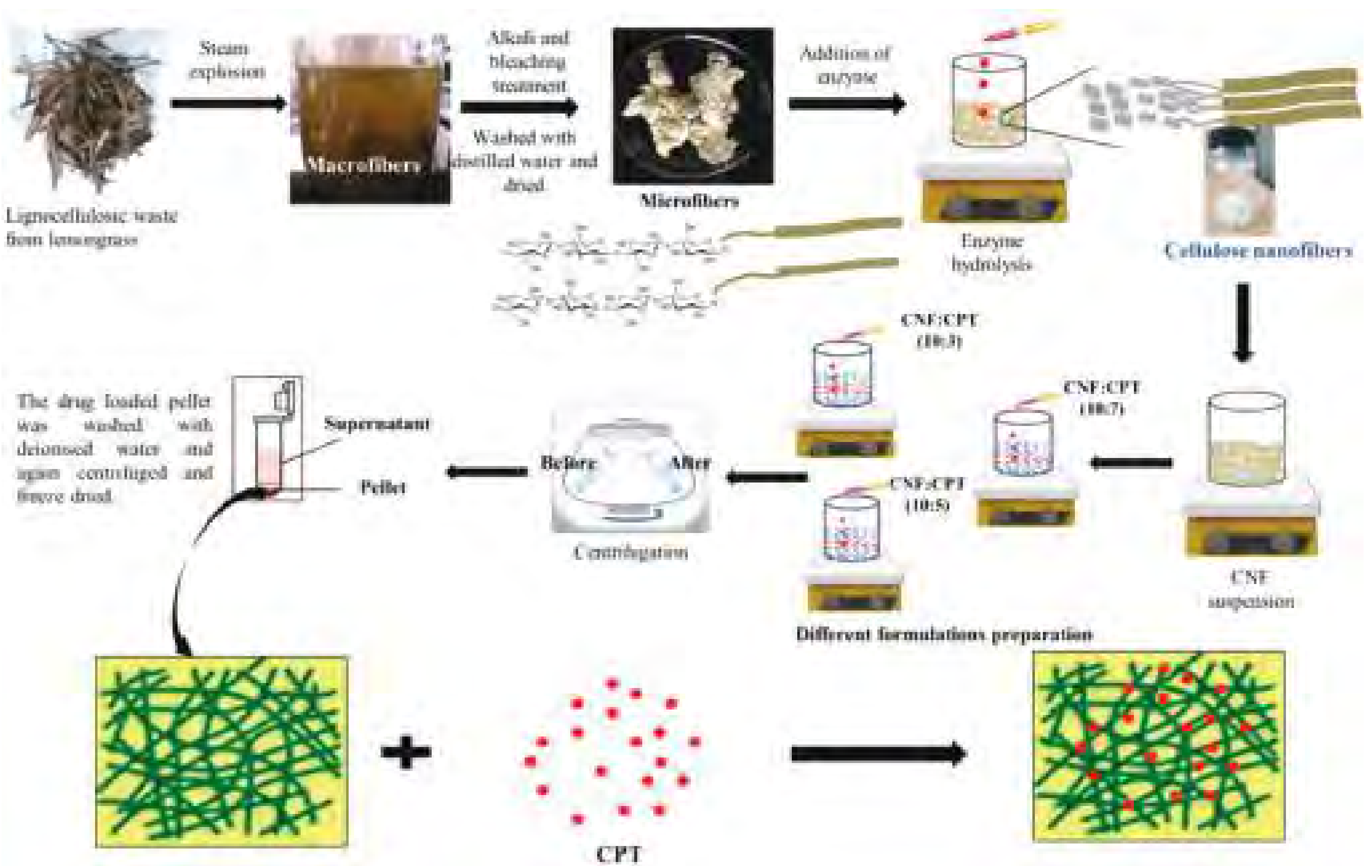


Figure 1. Schematic representation of the formation of cellulose nanofibers using enzymatic hydrolysis from lemongrass biomass waste and its application in drug release using camptothecin as a model drug (Note: CNF- Cellulose nanofibers, CPT- Camptothecin)

potential Ca^{2+} (channel/transporters/pumps) modulators has been reported which could have application in the framework of repurposing the potential drugs to target Ca^{2+} signalling pathways in cancer cells.

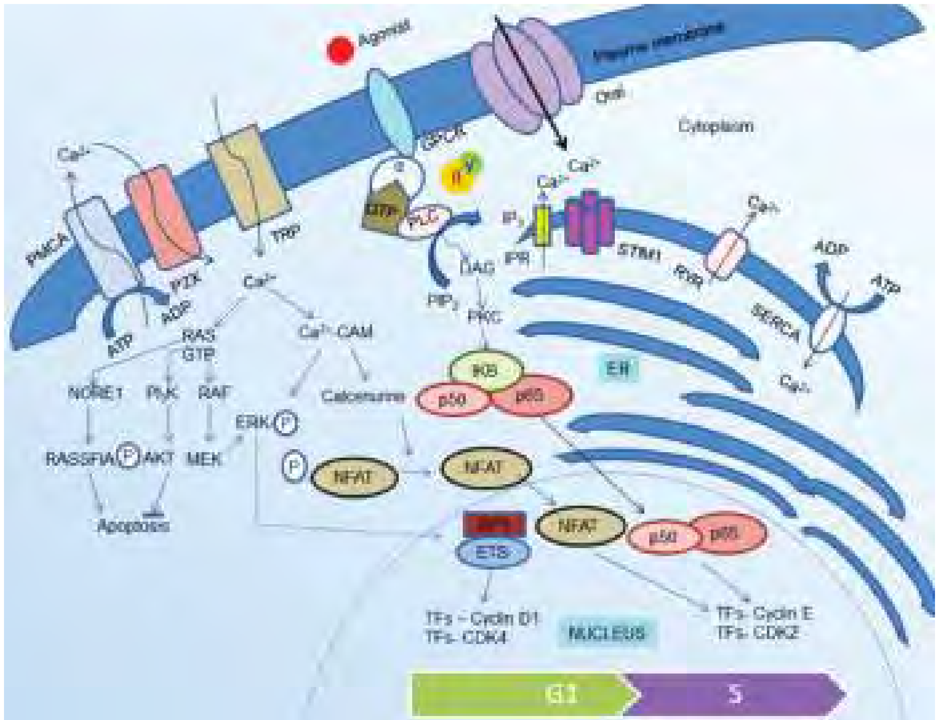


Figure 2: Regulation of cell growth and apoptosis *via* Ca^{2+} molecular toolkit. Arrows represent the specific pathways in normal cells. Intracellular Ca^{2+} ion activates various signalling pathways such as the RAS pathway and Ca^{2+}-CAM pathway. Ras.GTP results in phosphorylation of ERK and AKT promoting cell proliferation and preventing apoptosis. It also activates RASSFIA protein which then promotes apoptosis. Phosphorylated NFAT also promotes cell-cycle. Furthermore, GPCR mediated activation of PLC leads to the breakdown of PIP_2 into DAG and IP_3, further IP_3 bind to its IP_3Rlocalised in ER membrane and results in the release of Ca^{2+}, while DAG leads to the activation of the P50-P65 complex that follows to the nucleus and promotes cell proliferation. This diagram also represents Ca^{2+} channels, pumps, receptors present on PM and ER.

Dr. Abha Meena & her team

Plant Biotechnology

Highlights of Plant Biotechnology

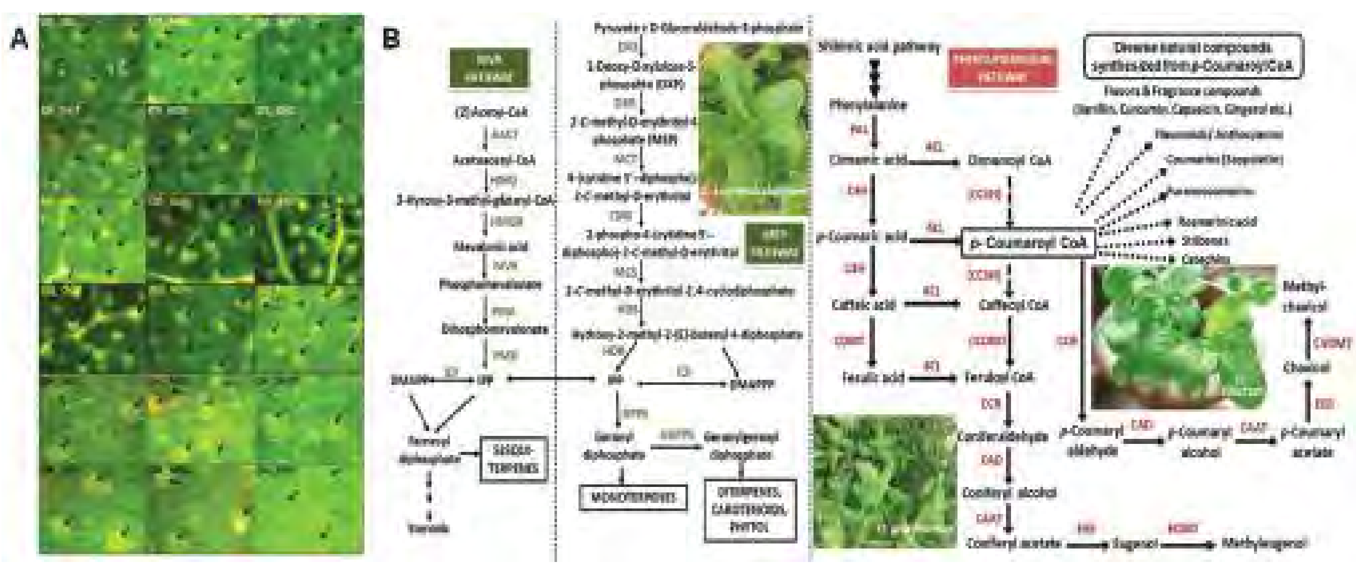
The Plant Biotechnology group of CSIR-CIMAP is working on a wide aspect of MAPs with a strength of 12 labs, 10 in Lucknow and two at Bengaluru research centre. In all, the group published 17 articles this year of which 12 are in SCI journal. This year we differentiated three commonly occurring Ocimum species (*Ocimum sanctum*, *O. gratissimum* and *O. kilimandscharicum*) having the high medicinal value, on the basis of temporal changes in number leaf trichomes, essential oil composition, phenylpropanoid pathway genes expression and the activity of important enzymes. In quest to understand the biosynthesis and regulation of monoterpene indole alkaloids in Madagascar periwinkle (*Catharanthus roseus*), we have identified a bonafide and plastid-localized GGPPS (CrGGPPS2) that makes C20 GGPP but plays an essential role in anticancer monoterpenoid(C10)-indole alkaloids (MIA) biosynthesis. In order to perceive the mechanism of action of three earlier identified peroxidase-coding genes (*Aa547, Aa528* and *Aa540*) from *A. annua* we carried out tertiary structure homology modelling of the peroxidases for docking studies. Moreover, Aa547 expression was related inversely to artemisinin content and directly to total lignin content as indicated by its transient silencing and overexpression in *A. annua*. Further, we carried out research for *in silico* identification and validation of miRNA and their targets from *Chrysopogon zizanioides* (L.), differential transcriptome analysis in relation to essential oil yield in commercial varieties of *Mentha arvensis* and for developing adaptable specific chemotype /genotype in *Ocimum* species. We also employed a combined transcriptomics, metabolomics and biochemical approach to functionally define a suite of oxidosqualene cyclases (OSCs) that catalyzed key reactions towards *triterpene scaffold diversification* in *Terminalia arjuna*. In continuation with our earlier published report of *Asparagus racemosus* tissue specific transcriptome analysis in that we characterized a root specific rate limiting enzyme squalene epoxidase, *ArSQE*. Our group has demonstrated the role of two essential lipid, diacylglycerol and phosphatidate, in the regulation of mevalonate (MEV) pathway in yeast. For the betterment of root quality and withanolide abundance, our group have also generated root growth stage specific transcriptome and cloned a few genes for further characterization. We have also initiated efforts on applying CRISPR-Cas technology from the improvement of MAPs. Our tissue culture lab has established the micro-prapagation protocol for *Selinum tenuifolium,* an important MAP apiaceae family. Our group also conducted a crystallographic study to explore the effect of introduction of a carbonyl functionality in the side chain of an amino acid residue at the N-terminus of short oligo-peptides. During this period, our division earned 6 projects and successfully completed 4 projects under GAP/SSP/CSIR-MLP/NWP categories. Head of the Division led the CSIR-Phytopharmaceutical Mission as PI from CIMAP which was completed successfully during this time period. Under the leadership of our Scientist, CIM-Sushil variety of *Catharanthus* was developed. We also contributed in the development of CIM-Unnati, a variety of *Mentha* and CIM-Mridashakti, soil fertility enhancer product. Our scientist delivered 16 lectures (including the invited ones) outside CIMAP on various scientific platforms. Total 11 students were awarded Ph.Ds and 10 students joined our group under AcSIR/JNU Ph.D program. Our students have also won awards like NASI young scientist platinum jubilee awards and others for various poster presentations.

Input: Ajit Kumar Shasany
अजीत कुमार शासनी

Comparative temporal metabolomics studies to investigate interspecies variation in three *Ocimum* species

Ocimum is one of the most revered medicinally useful plants which have various species. Each of the species is distinct in terms of metabolite composition as well as the medicinal property. Some basil types are used more often as an aromatic and flavoring ingredient. It would be informative to know relatedness among the species which though belong to the same genera while exclusively different in terms of metabolic composition and the operating pathways. In the present investigation the similar effort has been made in order to differentiate three commonly occurring *Ocimum* species having the high medicinal value, these are *Ocimum sanctum*, *O. gratissimum* and *O. kilimandscharicum*. The parameters for the comparative analysis of these three *Ocimum* species comprised of temporal changes in number leaf trichomes, essential oil composition, phenylpropanoid pathway genes expression and the activity of important enzymes. *O. gratissimum* was found to be richest in phenylpropanoid accumulation as well as their gene expression when compared to *O. sanctum* while *O. kilimandscharicum* was found to be accumulating terpenoid. In order to get an overview of this qualitative and quantitative regulation of terpenes and phenylpropenes, the expression pattern of some important transcription factors involved in secondary metabolism were also studied.(*Sci Rep*, 2020; 10:5234).

Figure: Comparative temporal metabolomics in three Ocimum species (A) Trichome densities and their representative microscopic images for six months in three panels for *Ocimum sanctum* (OS) *Ocimum gratissimum* (OG) and, *Ocimum kilimandscharicum* (OK) (B) Pathways leading to the generation of terpenes and phenylpropenes in *Ocimum* sp. giving an overview of the MVA (mevalonate) and MEP (2-C-methyl-D-erythritol-4-phosphate) pathways localized in the cytosol and the plastids, respectively. DXS, DXP synthase; DXR, DXP reductoisomerase; MCT, 2-C-methylD-erythritol-4-(cytidyl-5-diphosphate) transferase; CMK, CDP-ME kinase; MCS, CMEPP synthase; HDS, HMBPP synthase; HDR, hydroxy-2-methyl-2-(E)-butenyl 4-diphosphate reductase; IDI, IPP isomerase; AACT (acetoacetyl-CoA thiolase), HMGS (HMG synthase), HMGR (HMG reductase), MVK, MVA kinase; PMK, phosphomevalonate kinase; PMD, MVA diphosphate decarboxylase; and GGPPS, GGPP synthase; C4H, cinnamate 4-hydroxylase; 4CL, 4-coumarate: CoA ligase; C3H, p-coumarate 3-hydroxylase; COMT, cafeoyl O-methyl transferase; CC4H, cinnamoyl-CoA 4-hydroxylase; CC3H, p-coumaroyl- CoA 3-hydroxylase; CCOMT, cafeoyl-CoA O-methyl transferase; CCR, cinnamoyl-CoA reductase; CAD, cinnamyl alcohol dehydrogenase; CAAT, coniferyl alcohol acetyl transferase; EGS, eugenol synthase; EOMT, eugenol O-methyl transferase and CVOMT, chavicol O-methyl transferase. Te enzymes for 4- and 3-hydroxylation of CoA esters have not been demonstrated yet and hence [CC4H] and [CC3H] are indicated in brackets to indicate their probable role (Gang et al. 56) [adapted from Iijima et al. 41 and Rastogi et al. 38].



Dr. AK Shasany & his team

Input: Laiq-Ur-Rahman
लईक–उर–रहमान

Establishment of micropropagation protocol in *Selinum tenuifolium*

Selinum tenuifolium is an important medicinal and aromatic plant (MAP) of the Apiaceae family. The species grow in humus rich mountain slopes of the Himalayas and distributed between 2200-4000 msl. Plants of genus Selinum are aromatic and possess antispasmodic and diuretic properties. Aerial parts of the plants are useful as stimulant and carminative whereas essential oil of roots showed antimicrobial properties. Major constituents reported in roots are nona- 3,5-diyne (85.6% of the total volatiles), followed by nona-3,5-diyn-2-one, nona-4,6-diyn-3-one, nona-3,5-diyn-2-ol, and nona-4,6-diyn-3-ol, respectively.; Polyacetylenic compounds are widely distributed among various plants of Apiaceae family. From an industrial point, polyacetylenes are flavoring compounds utilized in the preparation of fragrances, suitable as flavor enhancers of cosmetic and toiletry articles such as perfumes, colognes, soaps, bath powders, etc. The smoke produced from roots is also used for repelling or killing insects. Cultivation of such important MAPs will improve socio-economic status of rural farmers. On the other hand, lack of quality planting material and potential germplasm source are major problems in the cultivation of such MAPs. Considering the problem of cultivation and application of plants, micropropagation protocol has been developed.

Leaf and petiole explants of Selinum were collected from glass house and surface sterilised with $HgCl_2$ (0.1%) for 3-5 minutes. Then explants were rinsed thoroughly three to four times with sterile distilled water. The sterilised explants were inoculated on Murashige and Skoog's (MS) medium supplemented with hormones such as BAP, NAA and 2,4-D were tried to optimized the regeneration frequencies in *S. tenuifolium*. Leaf explants gave the best result. Direct regeneration was observed on MS medium supplemented with BAP and NAA along with callus. However, on MS medium with 0.75mg/l BAP and 0.75mg/l NAA showed maximum regeneration frequencies (5-8 plant/explant). The putative regenerants were showed roots in half strength MS and full MS medium.

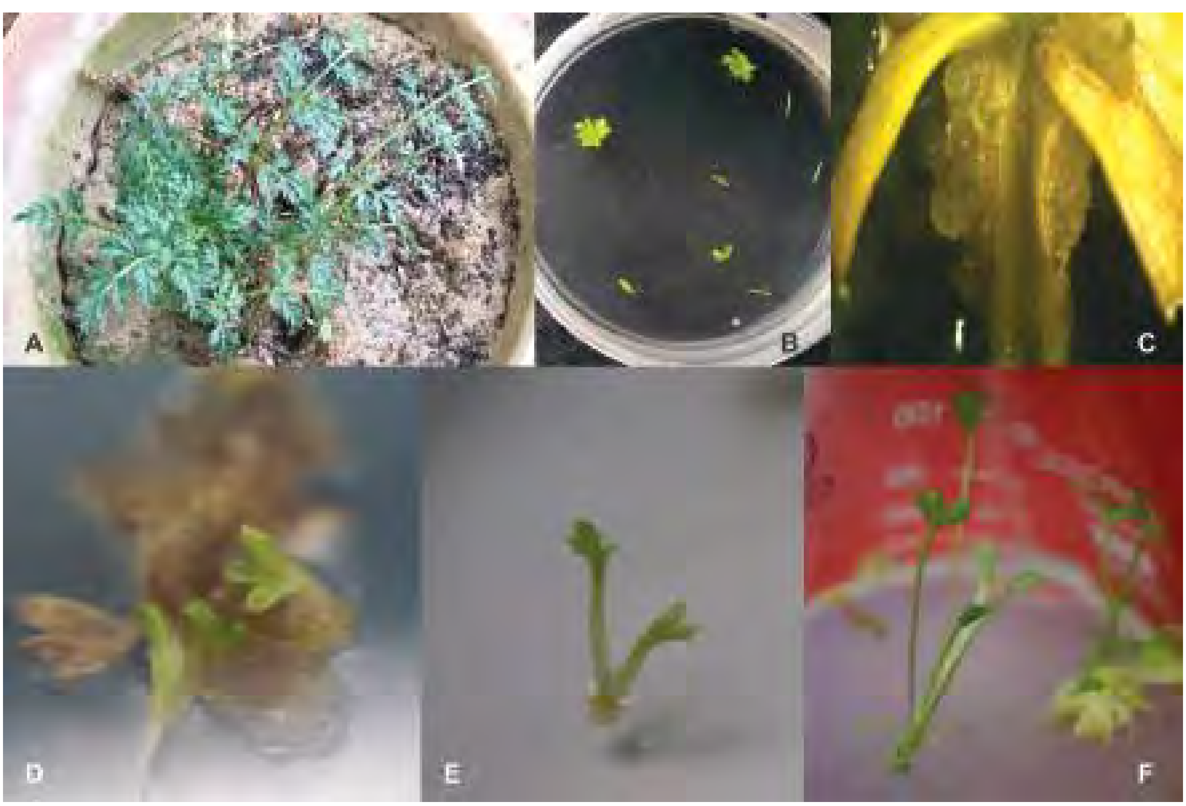


Fig. *In-vitro* establishment of *Selinum tenuifolium* plant. (A) *S. tenuifolium* in Glass house. (B) Leaf and petiole explants on regeneration medium. (C) Callus induction in explant. (D) Direct regeneration from leaf and petiole explants. (E) Single plant of *S. tenuifolium*. (F) Root induction on half strength MS medium.

Input: Dinesh A. Nagegowda
दिनेश ए. नागेगौड़ा

In plants, geranylgeranyl diphosphate (GGPP, C_{20}) synthesized by GGPP synthase (GGPPS) serves as precursor for vital metabolic branches including secondary metabolites. In our on-going research to understand the biosynthesis and regulation of monoterpene indole alkaloids in Madagascar periwinkle (*Catharanthus roseus*), we have identified *abona fide*and plastid-localized GGPPS (CrGGPPS2) that makes C_{20} GGPP but plays an essential role in anticancer monoterpenoid(C_{10})-indole alkaloids (MIA) biosynthesis (Kumar et al., 2020). The expression of *CrGGPPS2* was not induced in response to methyl jasmonate (MeJA) and was similar to the gene encoding type-I protein geranylgeranyltransferase_β subunit (*CrPGGT-I_β*), which modulates MIA formation in *C. roseus* cell cultures. Downregulation of *CrGGPPS2* by virus-induced gene silencing (VIGS) significantly decreased the expression of transcription factors (TFs) and pathway genes related to MIA biosynthesis, resulting in reduced MIA. Chemical complementation of *CrGGPPS2*-vigsleaves with geranylgeraniol (GGol, alcoholic form of GGPP) restored the negative effects of *CrGGPPS2*silencing on MIA biosynthesis. In contrast to VIGS, transient and stable overexpression of *CrGGPPS2*enhanced the MIA biosynthesis. Interestingly, VIGS and transgenic-overexpression of *CrGGPPS2* had no effect on the main GGPP-derived metabolites, cholorophylls and carotenoids in *C. roseus* leaves. Moreover, silencing of *CrPGGT-I_β*, similar to *CrGGPPS2*-vigs, negatively affected the genes related to MIA biosynthesis resulting in reduced MIA. Overall, this study demonstrated that plastidial CrGGPPS2 plays an indirect but necessary role in MIA biosynthesis. Our results not only establish a link between C_{20} metabolic intermediates (GGPP) made by the plastidial CrGGPPS2 and monoterpene (C_{10} isoprenoid) indole alkaloids biosynthesis, but also demonstrate additional level of complexity thereby providing new insights into anticancer MIA biosynthesis in *C. roseus*. We propose that CrGGPPS2 might be involved in providing GGPP for modifying proteins of signaling pathway involved in MIA biosynthesis (Figure 1).

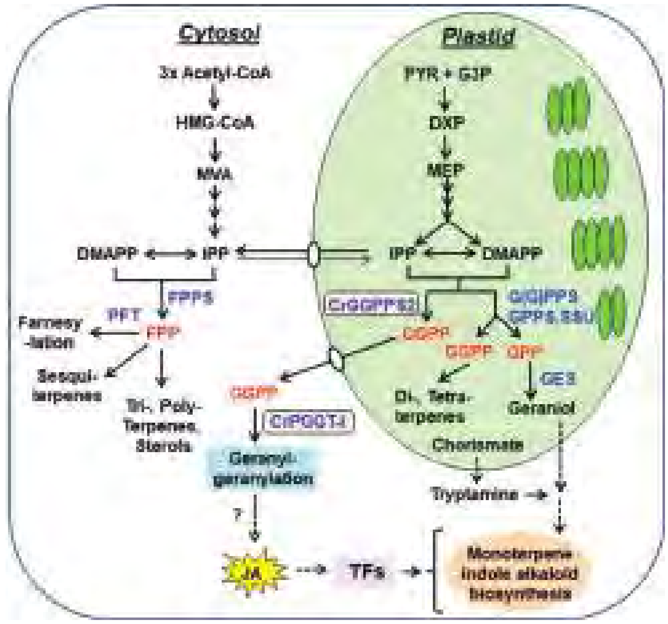


Figure 1. A simplified model depicting the role of CrGGPPS2 in *C. roseus* MIA biosynthesis. The plastidial CrGGPPS2 likely provides prenyl precursor for CrPGGT-I, which in turn could modulate jasmonatesignaling leading to activation of TFs and genes related to MIA biosynthetic pathway, thereby enhancing the accumulation of MIA. DMAPP, dimethylallyl diphosphate; DXP, 1-Deoxy-D-xylulose 5-phosphate; FPP, farnesyl diphosphate; FPPS, FPP synthase; HMG-CoA, 3-hydroxy-3-methylglutaryl-CoA; GPP, geranyl diphosphate; GGPP, geranylgeranyl diphosphate; GPPS, GPP synthase; GGPPS, GGPP synthase; G3P, D-glyceraldehyde 3-phosphate; IPP, isopentenyl diphosphate; MEP, 2-C-methyl-D-erythritol 4-phospahte; MVA, mevalonate; PFT, protein farnesyl transferase; PGGT-I- protein geranylgeranyl transferase I; PYR, pyruvate; TFs, transcription factors.

Dr. Dinesh A. Nagegowda & his team

Input: Vikrant Gupta विक्रांत गुप्ता

Molecular Studies on root-development related gene(s) homologs in *Withania somnifera* for the improvement of root quality and biomass

Withania somnifera is an important medicinal plant, commonly known as Ashwagandha or Indian Ginseng, belonging to the family Solanaceae. In Indian traditional systems of Medicine, Ayurveda and Unani, Ashwagandha is used alone or in combination with other medicinal plants to treat human diseases and health disorders. The plant produces a myriad of economically important secondary metabolites. All parts of Ashwagandha like root, stem, leaf, flower and seeds have one or the other medicinal importance. Medicinal value of different parts of *W. somnifera* is due to the presence of pharmaceutically active steroidal lactones i.e. withanolides including withanolide-A and withaferin-A as major bioactive molecules. Root of *W. somnifera* is rich in withanolide-A, however, withaferin-A is present in large amounts in the leaf and also in traces in its root. Withanolides are synthesized in plants by using the precursor isoprenoids which are produced *via* mevalonate (MVA) and 2-C-methyl-D-erythritol-4-phosphate (MEP) pathway operating in the cytosol and plastids, respectively. The quality and quantity of root produced by the plant of utmost concerns, as the plant material is assessed by root parameters to be used in the medicine system.

In order to study the molecular aspects of the root biology of *W. somnifera*, attempts have been made to identify the genetic components that are expected to govern the root biosynthesis in this plant. Few candidate genes, e.g. *BIG-BROTHER* (*BB*), *DWARF4* (*DWF4*) and

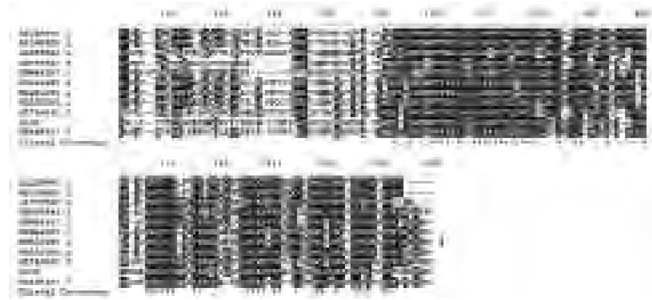


Figure: A snapshot of amino acid alignment of *WsBB* and related proteins in other taxa, identified from NCBI GenBank. WsBB protein is closely related to RING-finger domain.

SHORT-ROOT (*SHR*) have been reported to play an important role in the root development in *Arabidopsis thaliana*. Transcripts of homologs of the above putative candidate genes were identified in the transcriptome dataset of *W. somnifera* that is available in NCBI. Nested primers were designed and synthesized from the sequence of the contigs identified in the database. Total RNA was then extracted from the *W. somnifera* seedlings, cDNA was made, followed by nested RT-PCR to amplify the selected candidate gene homologs. Successful amplifications were achieved in secondary PCR (nested) and finally cDNA fragments of 1386 bp, 1922 bp and 1818 bp were cloned in pGEMT-Easy vector for *BIG-BROTHER* (*WsBB*), *DWARF4* (*WsDWF4*) and *SHORT-ROOT* (*WsSHR*) genes, respectively. After successful cloning, the fragments were sequenced from both ends using M13F and M13R vector-specific sequencing primers for confirmation. After confirming the fragments by sequencing, alignment, and BLAST analysis, primers were further designed and synthesized for their further cloning in pBI121 binary vector for over-expression in model plants like tobacco and Arabidopsis. Attempts are now being done to further clone these candidate genes in binary vector. Once cloned, they would be functionally characterized at the molecular level.

Dr. Vikrant Gupta & his team

Input: Sunita Singh Dhawan
सुनिता सिंह धवन

In Silico identification and validation of miRNA and their Targets from *Chrysopogon zizanioides* (L.)

microRNAs are small non-coding RNA molecule that plays an important role in metabolism. *Chrysopogon zizanioides* (L.) Roberty is an important aromatic plant used in perfumery industries, soil, water conservation, and agricultural practices. In this study, the transcriptomic sequence of vetiver leaf and root was subjected to miRNA identification by the computational methods. miRNA identification was carried out using a homology-based method by C-mii software with several other online tools. A total of 80 miRNA were identified from both leaf and root sequences. Target identification was done by identified miRNA sets. A total of 25 and 31 miRNA families were identified in both leaf and root, respectively, with ten common families involve in different ontological function. miR169 and miR5021 regulate most of the target in leaf and root. In vetiver, many primary and secondary metabolism elements are regulated by miRNA as photosystem, transcription factor, terpenoid metabolism, etc. This the first in silico study revealing the specific miRNAs and their target genes for corresponding root and leaf tissues respectively in *C. zizanioides*.

Differential transcriptome analysis in relation to essential oil yield in commercial varieties of *Mentha arvensis*

Different commercial Menthol mint varieties were used to study the developmental regulation of trichome, essential oil yield and its chemical constituent and morphological parameters with gene expression in randomized block design. Simultaneously, RNA sequence based transcriptomics study was done to reveal the transcription factor and differential gene analysis which are responsible for biosynthesis of essential oil as well as trichome development. Plant growth show maximum transition between 35 to 50 days stage while essential and its metabolite bioconversion was reported in between 70 to 100 days stage. Glandular trichome were maximally increase between 50 to 70 days and 100 days stage in *var.* Kosi followed by *var.* Saryu which has rapid growth in oil content. Menthol reductase activity was found to be a regulatory element during development as it follows inverse trend of menthol content and lead to menthol accumulation in subcuticular space. It could be clearly visualized that constituents of essential oil of menthol mint are synchronized at numerous phases including many processes.

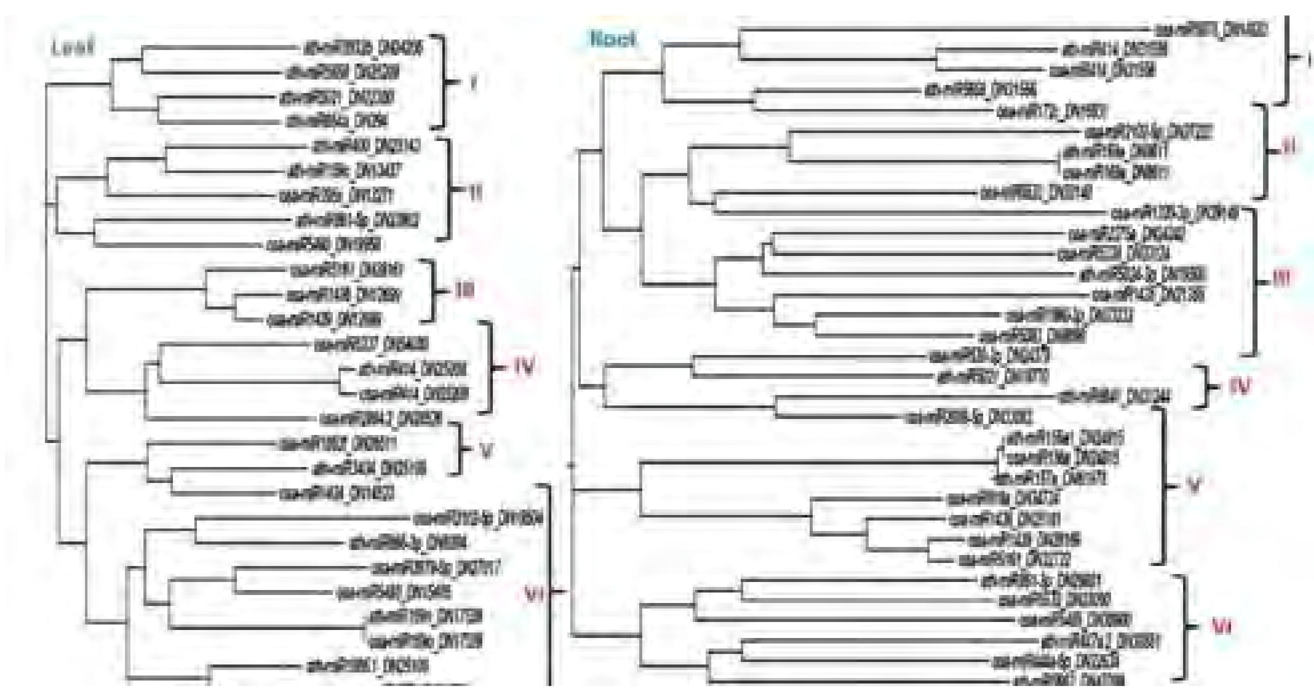


Fig 1: Phylogenetic tree of miRNA in leaf and root showing different groups in *C. zizanioides*.

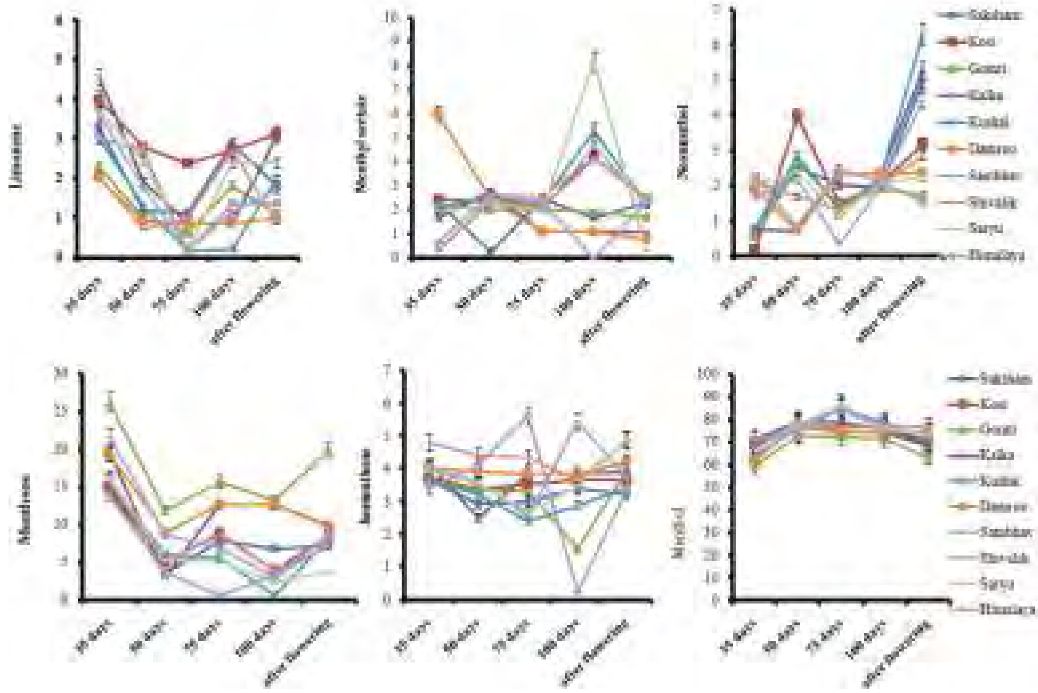


Figure 2: Variation of essential oil constitution in *M. arvensis* genotypes during development.

Studies on developing adaptable specific chemotype /genotype in Ocimum species

Cold tolerance is major problem in Genus Ocimum as it is highly susceptible to cold, therefore, it is required to develop a cold tolerant variety in Ocimum. The developed genotype showed cold tolerance in winter season compared to other varieties which was further evaluated in cold stress treatment at 4°C. Trichome numbers and their density, essential oil yield and content were analysed during cold stress treatment and normal temperature as well as physiology and gene expression analysis. MDA content, proline content, membrane permeability and pigments were measured and compared under low temperature at 4°C (0-72 hrs). Expressions of key genes associated with cold tolerance were analysed, all studied in var. CIM Shishir showed high expression of *WRKY53, ICE1, HOS1, COR47, LOS15, DREB5, CBF4, LTI6, KIN45 and ERD2* genes compared to control. All the physiological changes show positive correlation under low temperature in CIM-Shishir compared to control. The cold stress caused increase in the gene expression levels of the cold tolerant pathway genes under cold stress. The need of winter tolerant high-yielding genotype is of high importance for future as this will add to the income of farmers as well as many industries which are dependent on bioactive constituents of *Ocimum*.

Dr. S.S. Dhawan & her team

Input: Ashutosh K. Shukla
आशुतोष कुमार शुक्ला

Characterization of a class III peroxidase from *Artemisia annua*

Artemisia annua derives its importance from the antimalarial artemisinin. The –O–O– linkage in artemisinin makes peroxidases relevant to its metabolism. Earlier, we identified three peroxidase-coding genes from *A. annua*, whereby Aa547 showed higher expression in the low-artemisinin plant stage whereas Aa528 and Aa540 showed higher expression in the artemisinin-rich plant stage. Here we carried out tertiary structure homology modelling of the peroxidases for docking studies. Maximum binding affinity for artemisinin was shown by Aa547. Further, Aa547 showed greater binding affinity for post-artemisinin metabolite, deoxyartemisinin, as compared to pre-artemisinin metabolites (dihydroartemisinic hydroperoxide, artemisinic acid, dihydroartemisinic acid). It also showed significant binding affinity for the monolignol, coniferyl alcohol. Moreover, Aa547 expression was related inversely to artemisinin content and directly to total lignin content as indicated by its transient silencing and overexpression in *A. annua*. Artemisinin reduction assay also indicated inverse relationship between Aa547 expression and artemisinin content. Subcellular localization using GFP fusion suggested that Aa547 is peroxisomal. Nevertheless, dual localization (intracellular/extracellular) of Aa547 could not be ruled out due to its effect on both, artemisinin and lignin. Taken together, this indicates possibility of localization-based role diversity for Aa547, which may have implications in artemisinin catabolism as well as lignification in *A. annua*. (Nair et al., 2019, *Plant Molecular Biology* 100: 527-541). (Figures 1 and 2).

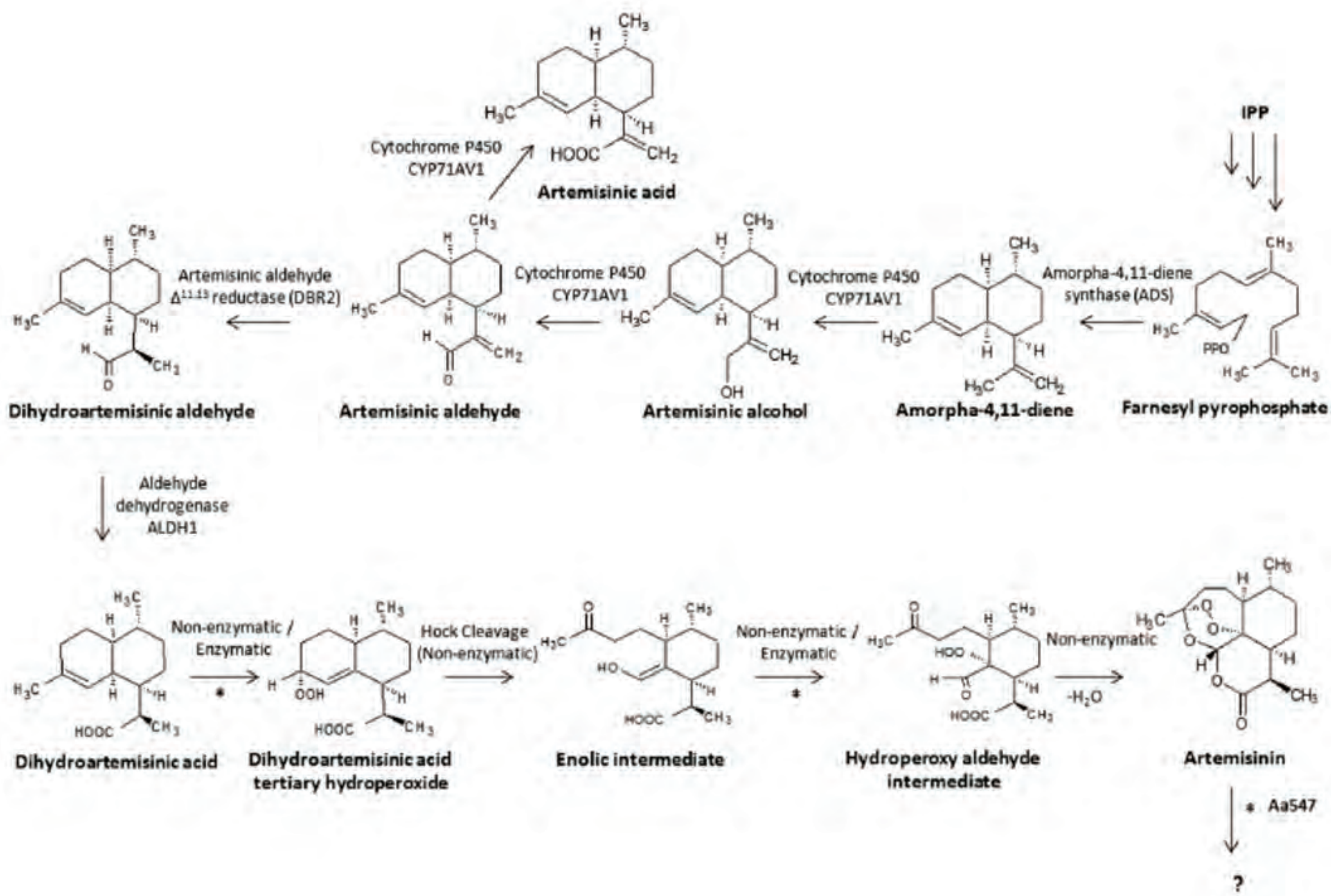


Figure 1: Artemisinin metabolism in *A. annua*. Steps that may have involvement of peroxidases are indicated by an asterisk. Aa547, which may be possibly involved in the post-artemisinin part of the pathway, is indicated. The downstream products of artemisinin catabolism/reduction are not clearly defined and are indicated by a question mark.

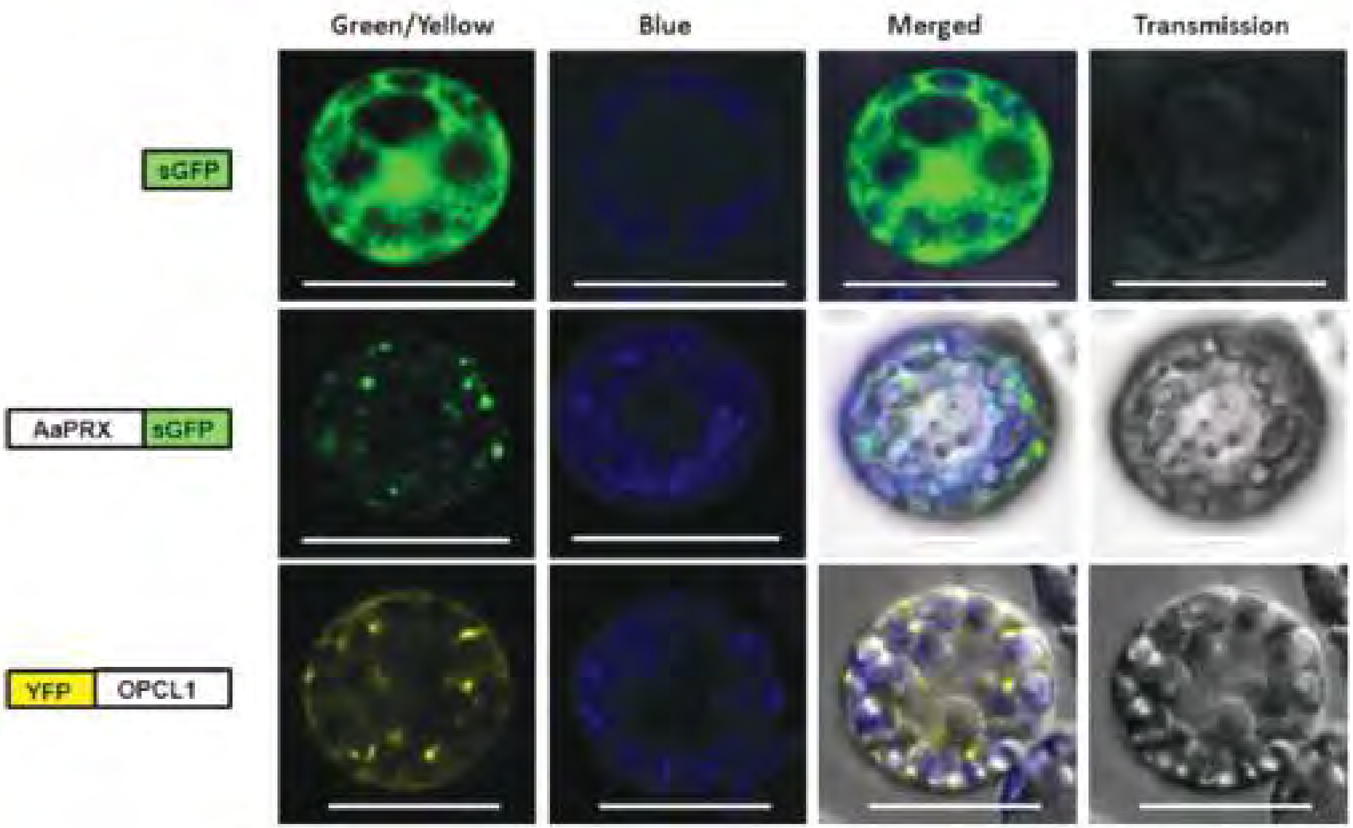


Figure 2: Subcellular localization of Aa547 (Aaprx). The schematic diagram of the fusion constructs is shown on the left, and the corresponding transient expression in *Catharanthus roseus* leaf protoplasts detected by confocal laser scanning microscopy is shown on the right. GFP fluorescence is shown in green and chlorophyll autofluorescence in blue. The YFP fluorescence of the peroxisomal marker, *Arabidopsis* OPCL1 is shown in yellow. The merged column shows the combined fluorescence from the fluorescent protein and chlorophyll autofluorescence. The morphology is observed with differential interference contrast (DIC) in the transmission column. In each case, the result of one of the two independent transformations are presented. Bars = 20 μm

Dr. Ashutosh K. Shukla & his team

Input: Sumit Ghosh सुमित घोष

Identification and characterization of oxidosqualene cyclases of the arjuna triterpene saponin pathway

Arjuna (*Terminalia arjuna* (Roxb.) Wight and Arn.), a tree species of the Combretaceae family native to the Indian subcontinent, has been popular since the Vedic period (1500-500BC) for the treatment of cardiac ailments (Figure 1A). In Ayurveda, arjuna bark is being recommended as a cardiotonic agent to treat various cardiovascular disorders. Bark is traditionally consumed as alcoholic decoction or taken along with clarified butter or boiled milk. The tree accumulates bioactive triterpene glycosides (saponins) and aglycones (sapogenins), in a tissue-preferential manner. Oleanane triterpenes/saponins (derived from β-amyrin) with potential cardioprotective function predominantly accumulate in the bark (Figure 1B).

The amount of major oleananes (arjunetin, arjungenin, arjunolic acid and arjunic acid) in dried bark ranges from 0.02-0.2%. The limited availability of bioactive triterpenes in the natural host and unavailability of a viable chemical process for their synthesis restrict the development and commercialization of arjuna-based drugs. The biological synthesis of phytochemicals in heterologous plant and microbial hosts appears to be a promising approach to achieve commercial scale production of phytochemicals that have limited availability in the natural hosts. Since multiplication of tree species remains a cause for concern, production of arjuna triterpenes in heterologous host might provide an appropriate solution to this problem. However, to achieve this goal, a complete knowledge on the enzymes that catalyze the stereo- and regio-specific reactions in the arjuna triterpene saponin pathway is crucial.

We employed a combined transcriptomics, metabolomics and biochemical approach to functionally define a suite of oxidosqualene cyclases (OSCs) that catalyzed key reactions towards triterpene scaffold diversification. *De novo* assembly of 131 millions Illumina NextSeq500 sequencing reads obtained from leaf and stem bark samples led to a total of 156650 reference transcripts (NCBI accession number SRP099812). Four distinct OSCs (TaOSC1-4) with 54-71% sequence identities were identified and functionally characterized. TaOSC1, TaOSC3 and TaOSC4 were biochemically characterized as β-amyrin synthase, cycloartenol synthase and lupeol synthase, respectively. However, TaOSC2 was found to be a multifunctional OSC producing both α-amyrin and β-amyrin, however showed a preference for α-amyrin product. Both TaOSC1 and TaOSC2 produced β-amyrin, the direct precursor for oleanane triterpene/saponin biosynthesis; but, *TaOSC1* transcript expressed preferentially in bark, suggesting a major role of TaOSC1 in the biosynthesis of oleanane triterpenes/saponins in bark.

To our knowledge, this study for the first time presented transcriptome analysis and functional characterization of the triterpene saponin pathway enzymes of arjuna. Overall, this study advanced our understanding on the roles of OSCs towards tissue preferential accumulation of triterpenes/saponins in arjuna and provided a foundation for further work towards elucidation of the complete biosynthetic pathway for cardioprotective triterpenes/saponins (Plant Science (2020) 292: 110382).

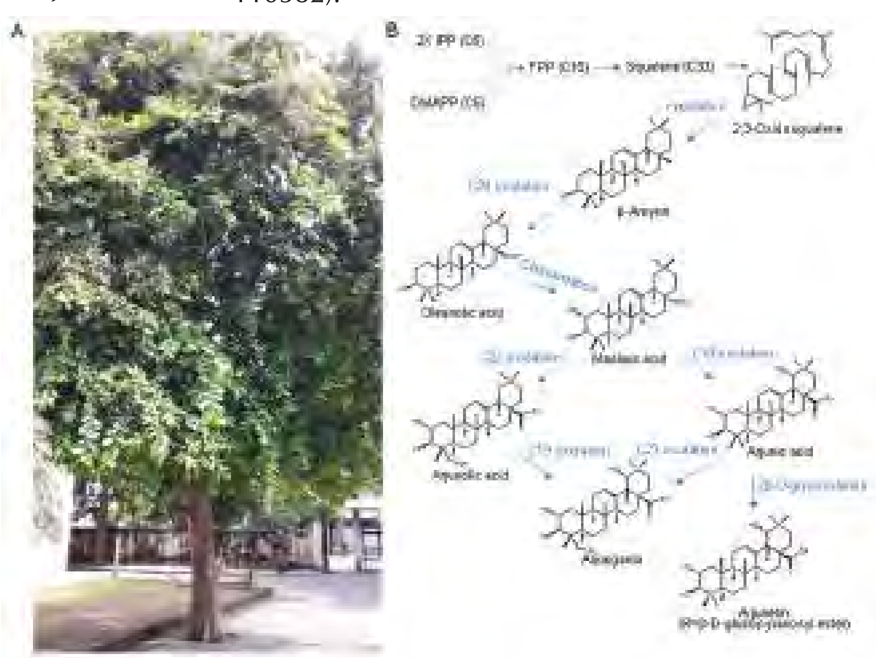


Figure 1. (A) Arjuna tree. (B) A proposed pathway for the biosynthesis of arjunetin, the major triterpene saponin in arjuna. IPP, isopentenyl pyrophosphate; DMAPP, dimethylallyl pyrophosphate; FPP, fernesyl pyrophosphate.

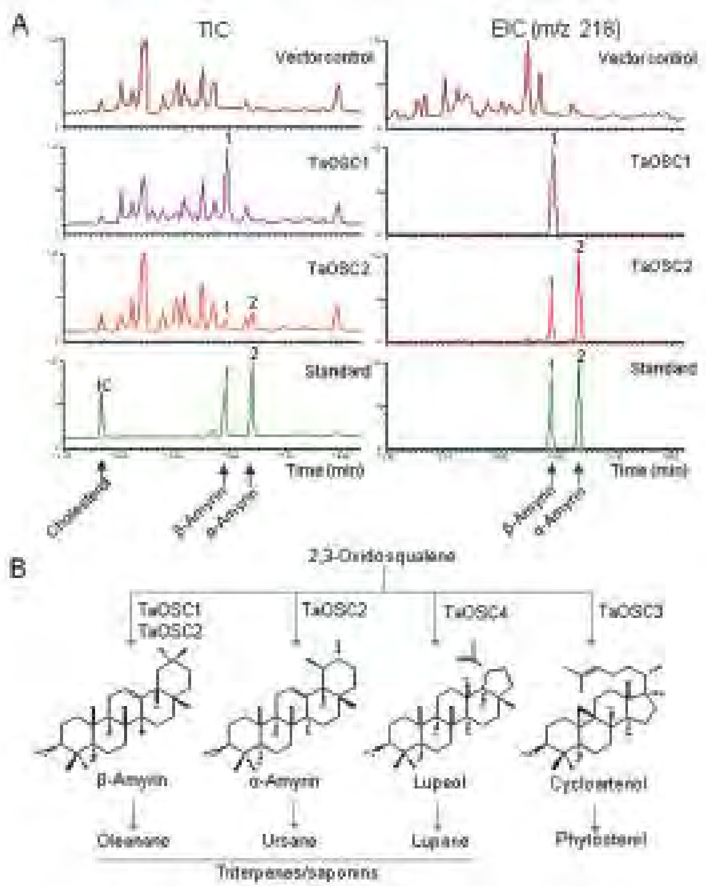


Figure 2. Characterization of TaOSCs. (A) GC-MS total ion (TIC) and extracted ion (EIC at m/z 218) chromatograms of yeast metabolites. Hexane extracts of yeast strains transformed with TaOSC1/TaOSC2 expression plasmid or empty vector (pYES2/NTB) were analyzed. TaOSC1 and TaOSC2 products are marked as (1) β-amyrin and (2) α-amyrin. IC denotes internal control cholesterol. (B) The proposed roles of TaOSCs in the arjuna triterpene saponin pathway.

Dr. Sumit Ghosh & his team

Input: Prema G. Vasudev
प्रेमा जी. वासुदेव

Peptides are attractive as building blocks for self-assembling materials because they are based on biocompatible and biodegradable amino acids. Self-assembly is a process governed by interaction between different molecules, and therefore improvement in the intermolecular interaction possibilities in a peptide molecule can help in modifying their self-assembly properties. The self-assembling properties of helical secondary structures, in which the side chain groups are projecting from a rod-like helix backbone, can be modulated by modifications on the side chain. We conducted a crystallographic study to explore the effect of introduction of a carbonyl functionality in the side chain of an amino acid residue at the N-terminus of short oligopeptides. Crystal structure analysis of six peptides containing side chain modified amino acidswere analysed, which showed that the modification did not affect the secondary structure of these peptides.All the peptides adopted helical conformation in the crystal, as expected. Detailed analysis of the intermolecular interactions in the molecular packing suggested that the modified side chain at the N-terminus favour interactions between backbone carbonyl group to side-chain C-H in a head-to-tail assembly of helices. A unique side chain... side chain C-H...O interaction in one of the peptides facilitated lateral association of helices. Together with the results obtained in a surface aggregation analysis, the observation suggested the possibility of this unique C-H...O contacts in directing the lateral assembly of peptide helices through side-chain interactions.

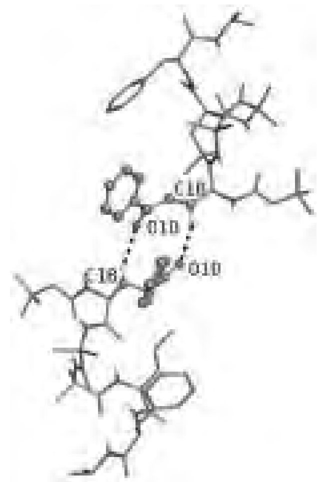


Figure: Unique C-H...O interactions between modified side chain groups in a synthetic pentapeptide determined using X-ray diffraction. (*J Pept Sci*. 2019, 25(3):e3148. doi: 10.1002/psc.3148)

Dr. Prema G. Vasudev & her team

Input: Rakesh Kumar Shukla
राकेश कुमार शुक्ला

In continuation with our earlier published report of *Asparagus racemosus* transcriptome analysis in a tissue specific manner (BMC genomics 15 (1), 1-13 2014). In the present study, we have selected one of the root specific rate limiting enzyme squalene epoxidase which we named as *ArSQE* for its characterization. ArSQE was able to complement ergosterol auxotrophy in *erg1* yeast mutants. Mutants were sensitive to the antifungal drug terbinafine, whereas *ArSQE* complementation made them tolerant to the terbinafine. *ArSQE* overexpression suggests its role in early germination in transgenic tobacco. The transgenic tobacco seedlings overexpressing *ArSQE* were tolerant to terbinafine and abiotic stress. Further, we have identified root specific methyl jasmonate responsive (MeJA) responsive *A. racemosus* bZIP transcription factors (TFs), ArTGA1 and ArTGA2, that binds to the MeJA responsive *cis*-element present in the upstream regulatory region of *ArSQE*. Characterization of *ArSQE* of *A. racemosus* provides new information about its regulation through MeJA responsive bZIP TF along with its role in the development and abiotic stress response in transgenic tobacco. (Plant Science (2020) 290, 110291).

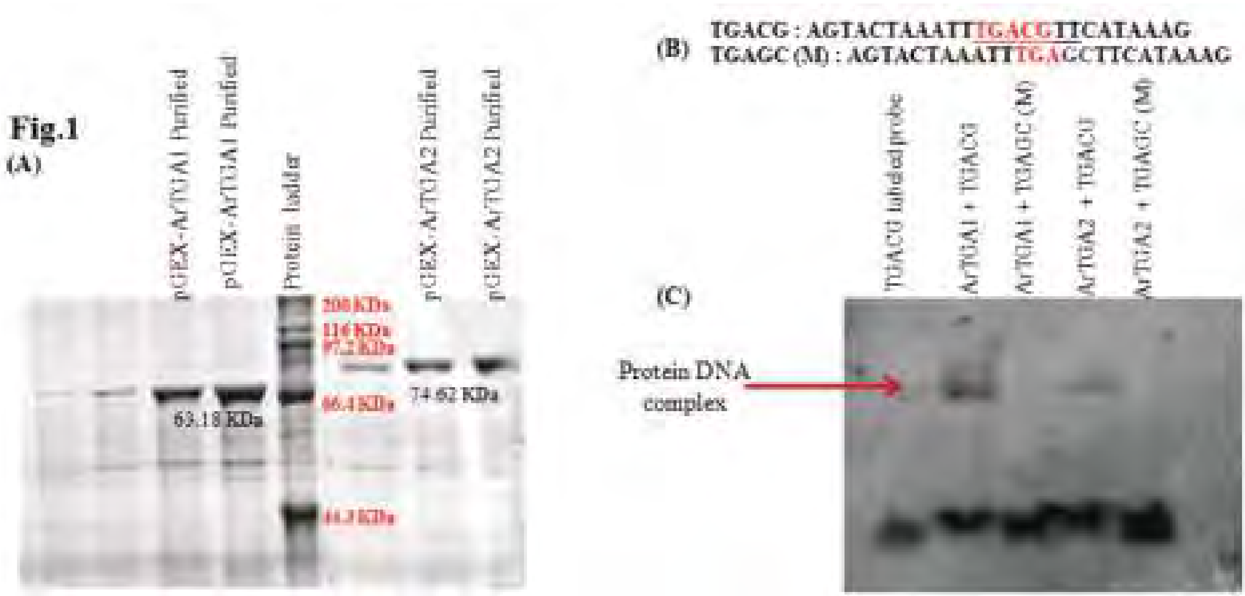


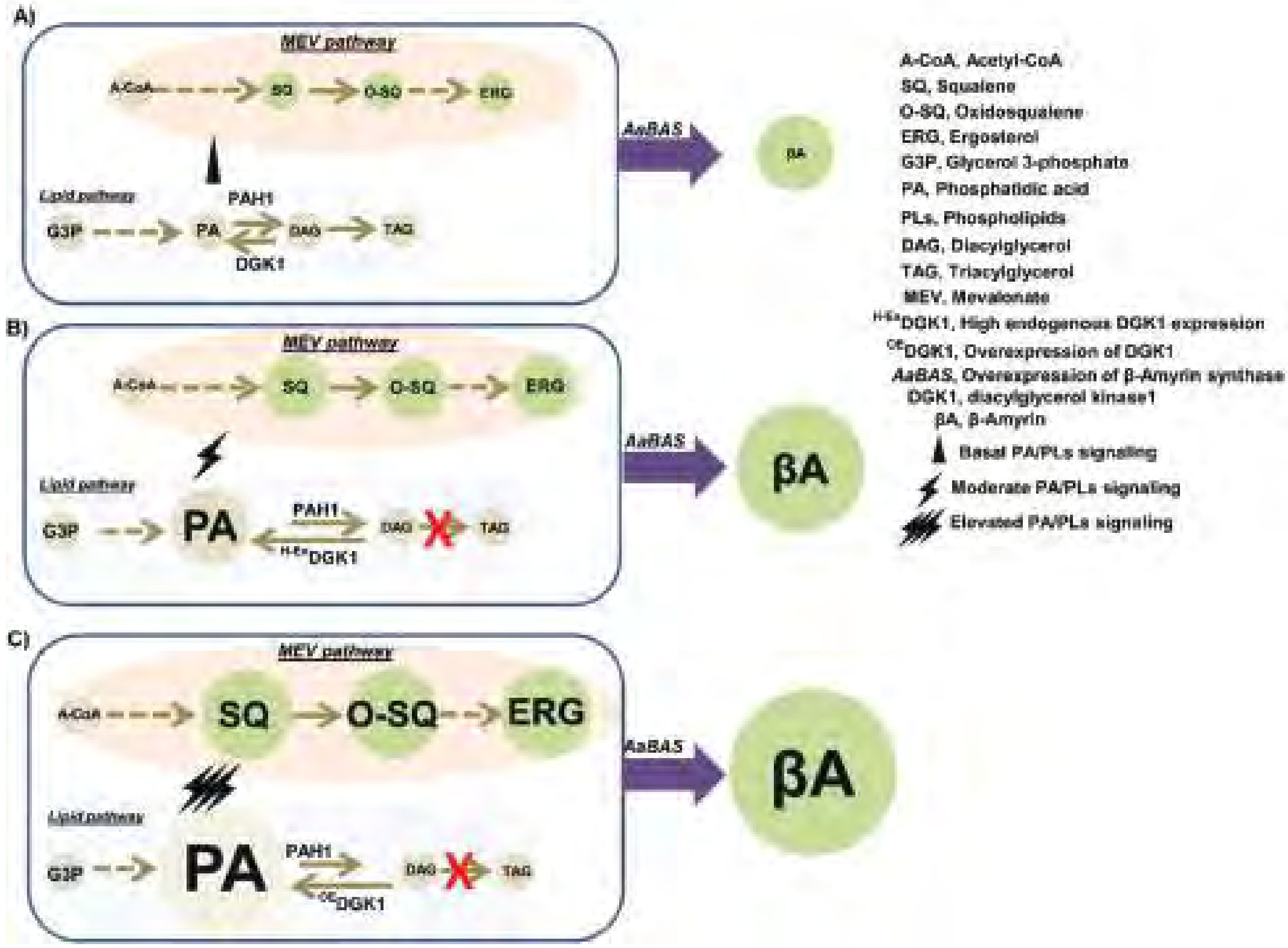
Figure 1. (A) 63.18 kDa and 74.62 kDa GST fused ArTGA1, and ArTGA2 proteins were expressed in E.Coli BL-21 (DE3) strain respectively and induced with different concentrations of IPTG and purified with sepharose GST beads. (B) The sequence of two different oligos used, cis-elements are represented in red color while mutation within them are represented with blue color used for Electrophoretic mobility shift assay (EMSA) of ArTGA1 and ArTGA2. The underlined region is the methyl jasmonate-responsive cis-element identified in ArSQE promoter. (C) EMSA of recombinant ArTGA1 and ArTGA2 showed it specifically interacts with TGACG *cis*-elements.

Team members of Dr. Rakesh Kumar Shukla

Input: Venkata Rao, D.K.
वेंकटा राव, डी.के.

Role of lipid signaling in Mevalonate pathway regulation

Apart from energy storage and membrane biogenesis, lipids have been known for their many biological functions, including cell signaling processes. The two essential lipids, diacylglycerol (DG) and phosphatidate (PA), have previously been shown to be associated with a cell signaling mechanism, and are responsible for lipid homeostasis. In recent study, we demonstrated the role of DG and PA in the regulation of mevalonate (MEV) pathway in yeast. The induced transcription of yeast MEV pathway is one of the key strategies used in the field of synthetic biology for enhanced production of terpenes. Our metabolite analyses showedasubstantial increase in ergosterol (ERG)and squalene (SQ) levels in DG-enriched yeast phenotypes. The *ERG*and *SQ* are the key indicator of MEV pathway activity. Further, qRT-PCR data revealed thata significant upregulation of MEV pathway was observed, as well asa high endogenous diacylglycerol kinase1 (DGK1) expression in DG-enriched yeast phenotypes. It is possible that high DG phosphorylation activity leads to increased PA pool that might be involved in MEV pathway regulation through cell signaling mechanism. Furthermore, overexpression of DGK1 in β-amyrin synthase expressing *DG-enriched* yeast caused a dramatic increase in β-amyrin production as compared to the control experiment. These data suggest that *DGK1* plays



FigureLegend: Diagrammatic representation of *DGK1's* role in MEV pathway upregulation. (A) Wild type yeast with *Aa-βAS* gene depicts the MEV pathway regulation by basal PA cell signalling. (B) TG-deficiency shows moderate increase in PA levels by the phosphorylation of excess DAG pool by increased *DGK1* activity. The moderately increased PA is involved in the upregulation of MEV pathway. (C) *DGK1* overexpressing TG-deficient phenotypes exhibit elevated PA cell signaling that significantly activates MEV pathway. The increase in β-Amyrin levels indicates high MEV pathway flux, and this increase is concurrent with increasing PA levels in cells. The metabolites are shown in spherical shape. The spherical size denotes endogenous levels of metabolites. The broken arrow denotes multiple steps involved in metabolic pathways.

a vital role in MEV pathway up-regulation. To conclude, our results provide a novel strategy to increase key metabolite precursors by inducing the MEV pathway through lipid modulation, thereby enhancing terpene biosynthesis in yeast.Overall, our data show that yeast strain combined with DG-enriched mutants and *DGK1* overexpression offers an excellent yeast-based platform for terpenoid biosynthesis.Also, this study provides new insight into the role of *DGK1* in synthetic biology applications.In this study we reportedfor the first time that the physiological alteration of intracellular lipid signaling molecule, PA, either by mutations or *DGK1* overexpression results inthe significant upregulation of MEV pathway. In conclusion, our findings demonstrate a critical link between the intracellular lipids and MEV pathway regulation.Further, understanding of the molecular mechanism of how PAis involved in regulating the MEV pathway remains an important study. The elevated endogenous MEV pathway yeast phenotypes are excellent strains for the production of terpenes in the field of synthetic biology, and these strains can be used as the base strains for further MEV pathway engineering, which can lead to high production of desired terpenes at a cheaper cost.

Dr. Venkata Rao & his team

Input: Pradipto Mukhopadhyay
प्रदीप्तो मुखोपाध्याय

Identification of genes involved in root development in *W. somnifera*

Root development in W. somnifera was studied systematically and different growth stages has been identified in Nagori and Poshita morphotype of *W. somnifera* showing distinct differences in root structure, length, width and secondary thickening (xylem fibre formation). For Nagori chemotype, these stages are 45 days plant growing in glass house in pots (which form thin excessively branched root), 45 days plant (from field which indicate single tuberous root initiation), 85 days (from field; indicate clear tuberous root formation at early stage), 110 days plants from field (with tuberous root initiating secondary thickening accompanied by lateral root formation) and 125 days plant with clear secondary thickening. Similar observations were also concurred for poshita chemotype, however, root

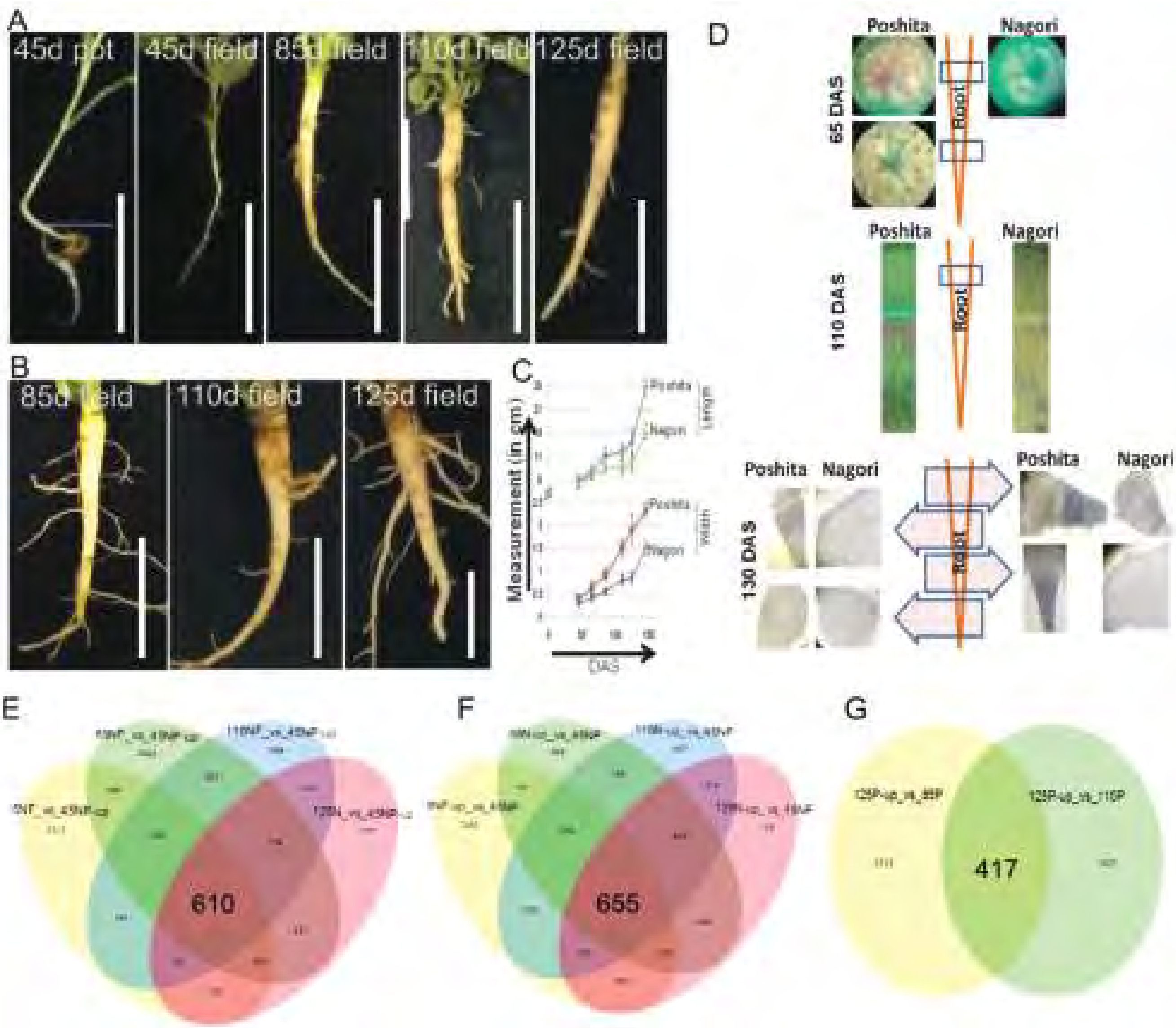


Figure 1: RNA-seq data generation and analysis from roots at different growth stages (DAS, days after sowing) in Nagori and Poshita morphotyes of *W. somnifera*. (A) Root stages and morphology of Nagori samples subjected to RNA-seq analysis. (B) Root stages and morphology of Poshita samples used for RNA-seq analysis. (C) Increase in root length and width in Nagori and Poshita with age. (D) Histochemical analysis of root by Saffranine O and Fast green indicating region secondary cell (E) Differential analysis of genes upregulated in tuberous in comparison to adventitious root of plants grown in pot in nagori. (F) Differential analysis of genes upregulated in adventitious root of plants grown in pot in nagori in comparison to tuberous roots. (G) Comparison of genes upregulated in poshita at 125 days.

growth and secondary thickening was much higher in this case especially at 85 days (root width and length only), 110 days and 125 days time points. These five growth stages from Nagori and three different growth stages from Poshita morphotypes were finally selected for further analysis (as shown in the fig. below). Transcriptome data (RNA-seq) has been generated from these growth stages in triplicates using Illumina novaseq 6000 platform following 150 by pair end protocol and de novo assembly. ≥26 million filtered reads were generated per sample (replicate). Two *de novo* transcript assemblies were generated and a total of 102665 transcripts in Nagori and 74176 transcripts in Poshita have been identified. The differential transcript analysis between growth stages Nagori and Poshita has been analysed at p(adjusted)-value 0.05 and log2 expression >2-fold. DEGs from different pairwise analyses were further analyzed groups and those genes were picked which showed common expression in at least three related differential. The final number of DEGs selected for further analysis for different phenotypes are shown below.

Standardization of DNA-free CRISPR delivery in rose-scented geranium:

Two sgRNA constructs against PgPDS, PgCESA4 and PgPMR6 each has been prepared in PUC57_sgRNA vector via golden gate cloning method. Recombinant His-tagged Cas9 protein and His Tagged eGFP has been purified from Eicoli. In vitro DNA cleavage assays have been standardized for the recombinant Cas9 protein and the cleavage efficiency in vitro transcribed sgRNA has been determined and found to be acceptable when compared to company commercially available CAS9. Both direct and callus mediated regeneration has been standardized protocol has been standardize in the tab using leaf and nodes as explants. Further for callus mediated regeneration, by altering the plant hormonal composition of the medium following a desired time period. Through gold microcarrier-mediated bombardment reconstituted RNP (in vitro synthesized molecules were delivered into explants (leaf pieces, nodes and callus). As a control, recombinant His-tagged

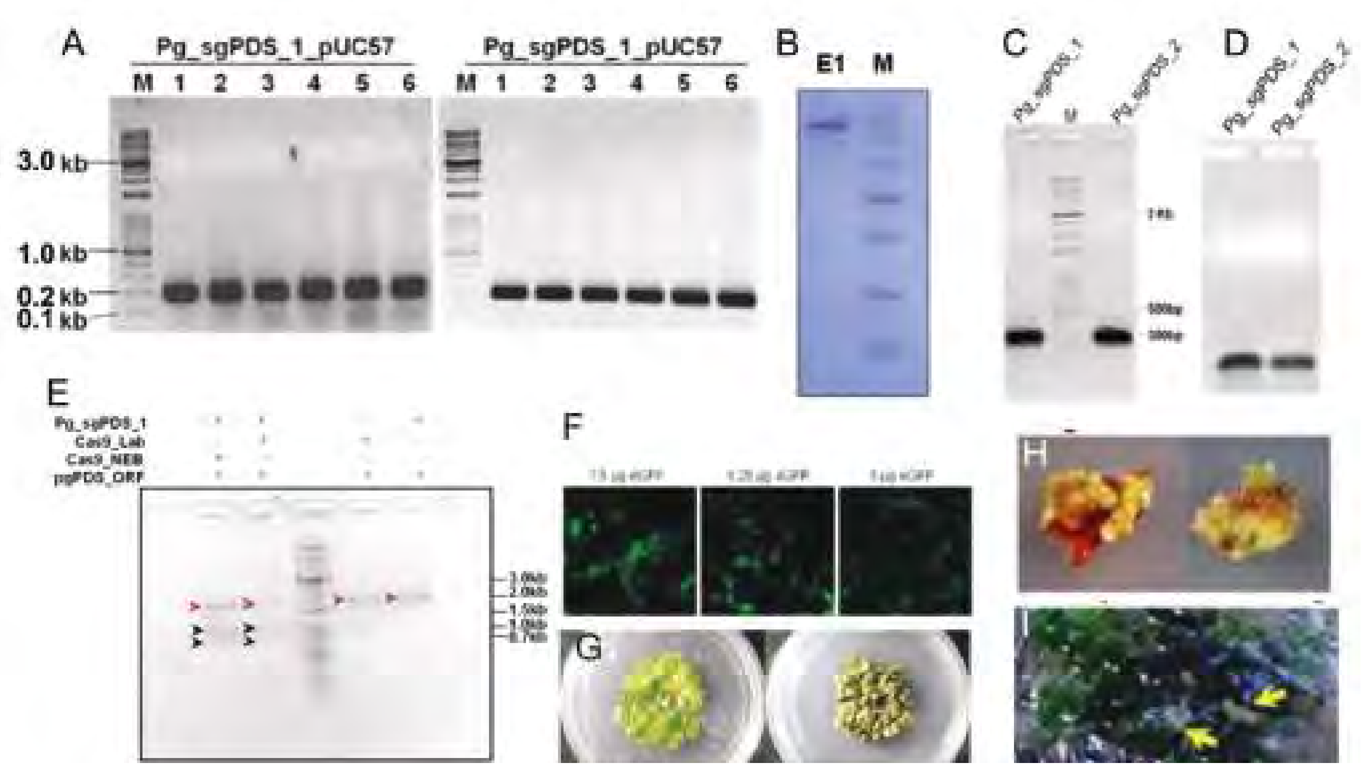


Figure 2: Silencing of PDS in Rose-scented Geranium. (A) Cloning of sgRNA1 and sgRNA2 against PgPDS gene in PUC57 vector bearing Casette for in vitro transcription of these sgRNA. (B) Purification of recombinant 6X-his tagged CAS9 from *E.coli*. (C) PCR amplification of sgRNA fragment (D) In vitro transcription of cloned sgRNAs. (E) In vitro DNA cleavage assay using transcribed sgRNA and CAS9 (lab purified and commercially available). (F) Standardization of protein bombardment on rose geranium leaves using prurified recombinant GFP protein. (G) bombardment of RNP complex on leaf and callus tissue. (H) regeneration of plants following bombardment. (I) generation of albino plants

eGFP protein was expressed and purified from E. coil and delivered in leaf and callus following particle bombardment. The GFP protein could be detected into plant cells indicating successful delivery of e-GFP and thus the RNP particles into the plant system. RNP particles were prepared with different ratios of PDS sgRNAs and recombinant NILS-SpCas9-6xHis and were coated on gold microcarrier (0.6tim diameter). The coated particles were bombarded on leaf and callus explants and were further incubated on regeneration medium as standardized before. From the bombarded callus tissue few of the regenerated plant appeared white or pale green. This indicates the occurrence of CRISPR events within the plants. The plants are being analyzed by molecular techniques for confirmation of true CRISPR events.

Dr. Pradipto Mukhopadhyay & his team

Crop Production and Protection

Highlights of Crop Production and Protection

The division of crop production and protection has been actively engaged in the identification of suitable Medicinal and Aromatic Crops (MACs) for different agro-climatic zones, development of the cost-effective packages for agro-practices, enhancing the resource use efficiency, assessing soil and water reclamation potential of medicinal and aromatic crops, innovating the ways for utilization of low value marginal, salt-affected, rainfed and waterlogged soils through the production of high valued MACs. The division has also been involved in studies on metal and pesticide tolerance of different medicinal herbs, intercropping of MACs with traditional food crops, identification of new diseases and their remedies, and development of pre and post-harvest agricultural machinery for improving the mechanization for the cost-effective production of MACs. Faculties of the division have been actively contributed to the Major National projects namely Aroma Mission and Phytopharmaceutical Mission, Namami Gange, and scored several successes. During this period, several externally funded projects from the National Medicinal Plant Board, New Delhi, Forest Department, UP, and Department of Biotechnology, New Delhi were also executed and 06 number of projects were granted. During this period, a total of 11 students were awarded Ph. D. under AcSIR (04) and JNU (7) Ph.D. program

During the year 2019-2020, agro-technology has been developed for the cultivation of senna as a summer crop in the Northern Plains of India. Novel methods for sucker production in menthol mint and saving of planting material of rose-scented geranium from heavy rains and humidity were developed. Benefits of intercropping of Kalmegh with pigeon pea, Phyllanthus with sponge guard and lemongrass, and lemon-scented basil crops showed encouraging results for providing good economic returns and better use of agricultural land. An integrated nutrient management system in *Withania somnifera* L. cultivars has been performed. Different genotypes of kalmegh were assessed for their metal tolerance without affecting metabolite content. The elite strain (RKU-KS-1) of lemongrass with higher essential oil content and yield has been developed which is proposed to be released as an improved variety of lemongrass for commercial cultivation. The chromium phytostabilization potential in the roots of CIMAP-suwarna variety of lemongrass grown in tannery sludge polluted soil has been reported. The proper harvesting time of Geranium varieties to ensure high content and good quality composition of essential oil has been estimated. To amend the acidic soil/mine waste, a combination of distilled waste-derived biochar and plantation of palmarosa, *Cymbopogon martini* (Roxb.) has been established for phytoremediation. Also, the application of hydrogel on growth, yield, and economics of senna and post-harvest technology for patchouli has been developed during this period.

Two major diseases namely mosaic disease by virus infection of CMV on *Ocimum gratissimum* and little leaf disease caused by phytoplasma on vetiver (*Chrysopogon zizanioides*) in the experimental fields of CSIR-CIMAP and major growing areas have been identified in this tenure. During 2019-20, sixty-three insect pests infesting MAPs and their natural enemies were identified at CIMAP Research farm, Lucknow as well as at farmer fields. Lace bug (*Cochlochila bulita*) appeared as a major pest of *Ocimum basilicum, O. sanctum O. africanum* and *O. kilimandscharicum*.

In *Caenorhabditis elegans* model, Tambulin, a natural flavonol, from *Zanthoxyllum aramatum* was identified as potential anti-aging and anti-Parkinsonian effects. Studies on the effect of native endophytes of *Bacopa monnieri* and *Ocimum sanctum* in enhancing the key metabolites of pharmaceutical importance of host plants is in progress. The development of molecular diagnostic tools for the detection of fungal plant pathogens affecting MAPs cultivation is also being carried out.

During this period, the division of plant production and protection published 33 of publications in high impacted journals such as Journal of Hazardous material (IF 9.03), Chemosphere (IF 5.77), The Science of Total Environment (6.55), Ecotoxicology and Environmental Saftey (IF 4.87), Industrial Crop and Products (IF 4.24) and Science Reporter (IF 3.99). The product **CIM-** Mrida Shakti: a nutrient-rich fertilizer has been released this year.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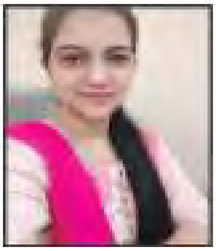
Dr. Akansha Singh
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Dr. Santoshkumar Chandappa Kedar
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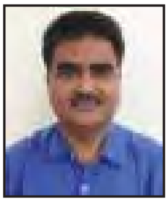
Input: Saudan Singh सौदान सिंह



Intercropping of Kalmegh (*Anrodraphis paniculata*) with traditional food crops for enhancing farm productivity and profit

The field experiment was conducted from July 2019 to January 2020 at the research farm of CSIR-CIMAP, Lucknow to study the compatibility of andrographolide content and andrographolide yield of Kalmegh (*Andrographis paniculata*) in the intercropping system, aiming to grow kalmegh as bonus crop with traditional food and agricultural crops. Grain crops *viz.* maize and pearl millet, pulse crop-pigeonpea and vegetable crop-okra were intercropped with kalmegh at their full (55,555 plants/ha), 75% (37,037 plants/ha) and 50% (27,777 plants/ha) plant population, with full plant population of Kalmegh (55,555 plants) in additive series. Results showed that intercropping of pigeon pea at 50% plant population gave the highest andrographolide content in leaves of kalmegh (3.68%) followed by pigeonpea at 75% plant population (3.53%) and lowest andrographolide content was found in maize at 100% plant population (2.23%). Andrographolide yield in leaves of kalmegh was recorded maximum (23.11kg/ha) in intercropping of pigeonpea at 50% plant population which was at par with okra at 50% plant population (20.07 kg/ha), pigeonpea at 75% plant population (18.99 kg/ha) while the minimum was

Figure 1: Field View of the experiment conducted on kalmegh intercropping with traditional crops

obtained in maize at 100% plant population (8.94 kg/ha). However, intercropping of kalmegh was found most advantageous with pigeon pea.

Agro-technology of Senna for its commercial cultivation as summer season crop in northern Indian plains

The authors have carried out investigation on suitability

Figure 2: Field View of senna crop

of northern plains for cultivation of *Cassia angustifolia* Vahl by optimizing dates of sowing, moisture regimes and date of harvest. The findings of investigation suggested that the *Cassia angustifolia* Vahl. can be cultivated in northern Indian Plain. Farming of this crop can provide higher net returns to the farmers and adequate availability of the quality raw material to the senna-based industries. Proper sowing in mid-March (15^{th}-22^{nd} March) when the environmental temperature is about 25-30°C and harvesting at 90 days of crop age and irrigation at 20% ASM (available soil moisture) can lead to better germination, crop growth, higher biological yield, more sennoside content, higher sennoside yield and high net returns. Timely sowing and harvesting before rains do not allow any insect and pest to infect the plant so that disease and fungal infection-free raw material can be obtained. Results also indicated that due to different moisture regimes and harvesting dates, secondary metabolites concentration, photosynthetic pigments, and electrolyte leakage varied significantly. By optimizing post-harvest primary processing techniques, the quality of senna produce (i.e., leaves and pods) can be maintained for longer periods of time. However, senna leaves are more prone to deterioration in comparison with the senna pods during drying which also affected by different packaging materials. 100% shade drying of senna pods followed by packaging of dried pods in black polybags can redcued deterioration up to 8-10 months.

Hence sowing of senna in mid-March (15^{th} - 22^{nd} March), irrigation at 20% ASM, harvesting after 90 days of sowing, drying under 100% shade and packing in the black polybag is recommended for obtaining optimum yield, acceptable quality and good economic returns, under northern Indian plains of India.

Evaluation of growth, yield and quality of *Cassia occidentalis* L. grown during summer season

Seeds of *Cassia occidentalis* L. which is reported to be grown as rainy season crop in different sub-tropical and tropical parts of the country were received from CDRI for evaluating its growth, yield and quality during summer season (February- June). The seeds were sown in the second week of march and crop was harvested in the third week of June 2019. The crop growth was good during summer season and dry herb of 24.11q/ha was recorded from single cutting. The stem which is reported to be useful part was 20 q/ha.

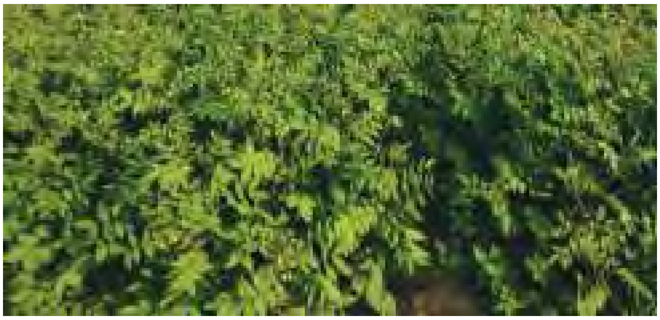


Figure 3: Field view of *Cassia occidentalis* L. grown at CSIR-CIMAP research farm Lucknow as summer season crop

50% NPK through fertilizer + 5.0 t VC ha^{-1}

Figure 4: Field view of the *Withania Somnifeara* L. cv NMITLI-118 grown under 50% NPK through Fertilizer + 5.0 t ha^{-1} vermicompost

Comparative performance of *Withania Somnifera* L. cultivars at different levels of plant population and integrated nutrient management grown under optimized level of moisture stress (20 mm depth and 40% ASM)

Data of the experiments conducted at CSIR-CIMAP research farm Lucknow revealed that highest dry root yield 13.11 q ha^{-1} and 11.41 q ha^{-1} were recorded under 5.0 lakhs plant ha^{-1} and 50% NPK through fertilizer + 5.0 t ha^{-1} vermicompost followed by 3.33 lakhs plant ha^{-1} and 50% NPK through fertilizer + 5.0 t ha^{-1} vermicompost Whereas, minimum dry root yield was recorded in cv NMITLI-118 (4.84 q ha^{-1}) and Poshita (4.21 q ha^{-1}) under 1.66 lakh plants ha^{-1} + 10 t ha^{-1} vermicompost.

Figure 5: Collection of planting material from old crop

Figure 6: Plantlets selected from old crop for sucker production

Figure 7: Transplanting on Ridge

Studies on the phytoremediation potential of aromatic grasses with special emphasis on lemongrass (*Cymbopogon species*) in tannery sludge polluted soil

Results of the field experiment conducted at CSIR-CIMAP Research Farm, Lucknow suggest that lemongrass can accumulate lead and nickel in its harvestable plant parts. Hence, it can act as a suitable phytoextractor for the same metals. Moreover, we also found the chromium phytostabilization potential in the roots of CIMAP-Suwarna variety. Therefore, Suwarna variety might be suggested as the putative contender among lemongrass cultivars for cultivation in the heavy metal contaminated sites. Maximum uptake of metals in roots along with maximum biomass in tannery sludge was recorded in the Suwarna variety. Cultivation as lemongrass (especially Suwarna variety) in the tannery effluent contaminated sites at a priority is also suggested due high tolerance of metal stress

(i) A novel method for sucker production in menthol mint:

About 30,000 MT suckers are required per annum for the plantation in India and if these are produced by traditional method then productivity and per kg cost of sucker production comes about 1kg/m^2 and Rs. 2-2.5 / kg.

A novel method of sucker production has been developed under which ridges are prepared by potato planter at a spacing of about 50-55 cm. After that 6-9 inch, lengthy plantlets obtained from the old plantation are planted on ridges 25-30 cm apart as shown in Figure No. 7 and other management practices are followed as per requirement. About 2.5-3.0 kg suckers per m^2 (about double) can be produced by a new method at an expenditure of Rs. 1.0 to 1.5 (about half) of the conventional method. Apart from this about 50-55 kg/ha oil can be produced by adopting a new method which is not possible by the conventional method. Most important point is that early and healthy suckers

Figure 8: Sucker production by new method

are obtained by the new method as compared with the conventional method.

(ii) Agro-technology for the commercial cultivation of Rose scented geranium in northern Indian plains.

Rose-scented geranium is a beneficial crop to the farmers of northern Indian plains. It is propagated through vegetative cuttings and is cultivated as annual or perennial crop in hilly areas, but production is not enhancing in these areas due to low productivity as compared to plains.

A novel method developed in the Institute for the commercial cultivation of geranium and economic feasibility in north Indian plain was evaluated. The most beneficial and economically feasible month for starting geranium farming in northern Indian plains has found to be February because the cost of cultivation comes about 15-20% less, whereas net returns increased about 25-30% and per kg cost of oil production is also minimized when planting is done during this month.

Dr. Saudan Singh & his team

Input: Rajesh Kumar Verma
राजेश कुमार वर्मा

Evaluation of phytoremediation potential of some selected aromatic plants in multi metal contaminated ternary/sewage sludge

Palmarosa (*Cymbopogon martinii* (Roxb.) Wats. var. *motia* Burk

Cymbopogon martinii was grown in soil (s) amended with different ratios of sewage sludge (ss), that is, 100s:0ss (control), 80s:20ss, 60s:40ss, 40s:60ss, 20s:80ss, and 0s:100ss. The experiment was conducted in a plastic sack under an open environment for 1 year and harvesting was done thrice. Plant growth and essential oil yield were significantly increased with the increasing dose of sewage sludge. Accumulation of toxic metal (Cd, Cr, Pb, Ni) and micronutrient (Fe, Zn, Cu, Mn) increased significantly in the shoot tissues confirmed by estimation of bioaccumulation and bioconcentration, and scanning electron microscopy and X-ray microanalyses. Soil enzyme activities were significantly improved with the plant growth period and increased doses of sludge. Results showed *C. martinii* acts as hyper-accumulator and thus could be used for phytoremediation of sewage sludge.

Geranium (*Pelargonium graveolens*)

A field experiment was conducted to observe the effect of TS amendments on soil enzymes and the phytoremediation potential of two economically important cultivars of geranium. After harvest, both cultivars were examined to assess the impact of various treatments on their fresh herb, dry matter, essential oil yield, and HM accumulation. C/G ratio close to 1 was observed at 50 t ha^{-1} sludge treatment in both cultivars. Urease and β-glucosidase activities in soil were maximum at 50 t ha^{-1} whereas dehydrogenase and phosphatase activities were maximum at 100 t ha^{-1} in both cultivars. β-glucosidase, acid, and alkaline phosphatase, urease, and dehydrogenase activities were relatively higher after 85 days in both cultivars. Maximum metal uptake was found in the roots of cv. Bourbon followed by leaves. Geranium was observed to be a good candidate for phytoremediation as it mitigates metal toxicity by root absorption and cv. Bourbon is a better candidate for the same.

Lemongrass (*Cymbopogon flexuous*)

Under this investigation microscopic and quantitative investigations (by ICP-OES) were carried out in root and leaves of plant to examine the compartmentalization of heavy metals. Histochemical methods for Pb, Cd, and Ni detection revealed their significant accumulation in the root and leaf sections. Translocation factor <1 was recorded for Cr but greater than 1 for Ni and Pb. Moreover, bioaccumulation factor >1 was observed for Ni and Pb. Hence, this study provides a localization pattern of heavy metals in lemongrass plants and suggests that lemongrass can serve as a Ni and Pb phytoextractor when grown in ternary sludge contaminated soils. In addition, enhancement in the size of trichomes (observed in SEM analysis) was detected due to heavy metal stress which may prompt increment in essential oil yield thus; cultivation of lemongrass in heavy metal contaminated sites can also prove profitable economically.

Maize (*Zea mays* L.)

In the present study, fours arbuscular mycorrhizal fungi (AMF) i.e *Rhizophagus fasciculatus*, *Rhizophagus intraradices*, *Funneliformis mosseae* and *Glomus aggregatum* for cultivation of *Zea mays* L were used for the growth promotion of *Zea mays* L. in heavy metal-rich tannery sludge (HMRTS).The plant growth and phytoremediation potential were significantly influenced by AMF treatments. The shoot weight and root length of *F. mosseae* treated *Z. mays* plants were significantly increased by 113 and 49%, respectively as compared to control. Likewise, maximum level of proline accumulation, chlorophyll content of leaves and, phosphorous content of shoot and root were recorded in *F. mosseae* treatment. Interestingly, F. mosseae act as a bio-filter in the roots and modulate direct translocation of heavy metals (Cd, Cr, Ni, Pb) and micronutrients from soil to shoot (Bioaccumulation factor) as well roots to shoots (Translocation factor) of plant. In HMRTS, AMF inoculation were also found to significantly improve the soil enzymes activity like dehydrogenase, β-Glucosidase, acid and alkaline phosphatase. The finding of this study suggests that AMF-assisted cultivation of *Zea mays* is a promising approach for the phytoremediation of HMRTS.

Dr. Rajesh Kumar Verma & his team

Inputs: Puja Khare पूजा खरे

Arsenic induced differential expression of oxidative stress and secondary metabolite content in two genotypes of *Andrographis paniculata*

This study deciphers the effect of arsenic (As) on oxidative stress, tolerance, plant growth, and content of pharmacologically important *ent*-labdane-related diterpene (*ent*-LRD) secondary metabolites of *A. paniculata*. Three rates of As application (42, 126, and 200 mg kg^{-1}) in two genotypes (wild collection and mass selection line) of *A. paniculata* were used. Effect of As on antioxidant enzyme activities, bioconcentration factor, bioaccumulation in root and translocation factor, plant growth parameters, micronutrient uptake, and secondary metabolite content in *A. paniculata* were analyzed. Arsenic uptake in *A. paniculata* led to a significant ($p<0.05$) decrease in the plant biomass (33-41.5%) and a significant increase in the oxidative enzyme activities. Arsenic application reduced the andrographolide content in the plant leaves (ranging from 1.76-1.06%) but increased the content of neoandrographolide (0.60-0.88%), 14-deoxy-11,12-didehydroandrographolide (DDA) (0.05-0.10%), and andrograpanin (0.004-0.0197%). Arsenic induced the production of 5,7,2′,3′-tetramethoxyflavanone in the leaves. The mass selection line of *A. paniculata* exhibited lower BCF and higher content of *ent*-LRDs (2.70-2.56%). Quantitative Real-Time PCR analysis in the mass selection line indicated a significant increase in the expression of *ApCPS2*, a key gene involved in channeling the metabolic flux towards the biosynthesis of *ent*-LRDs, under As stress.

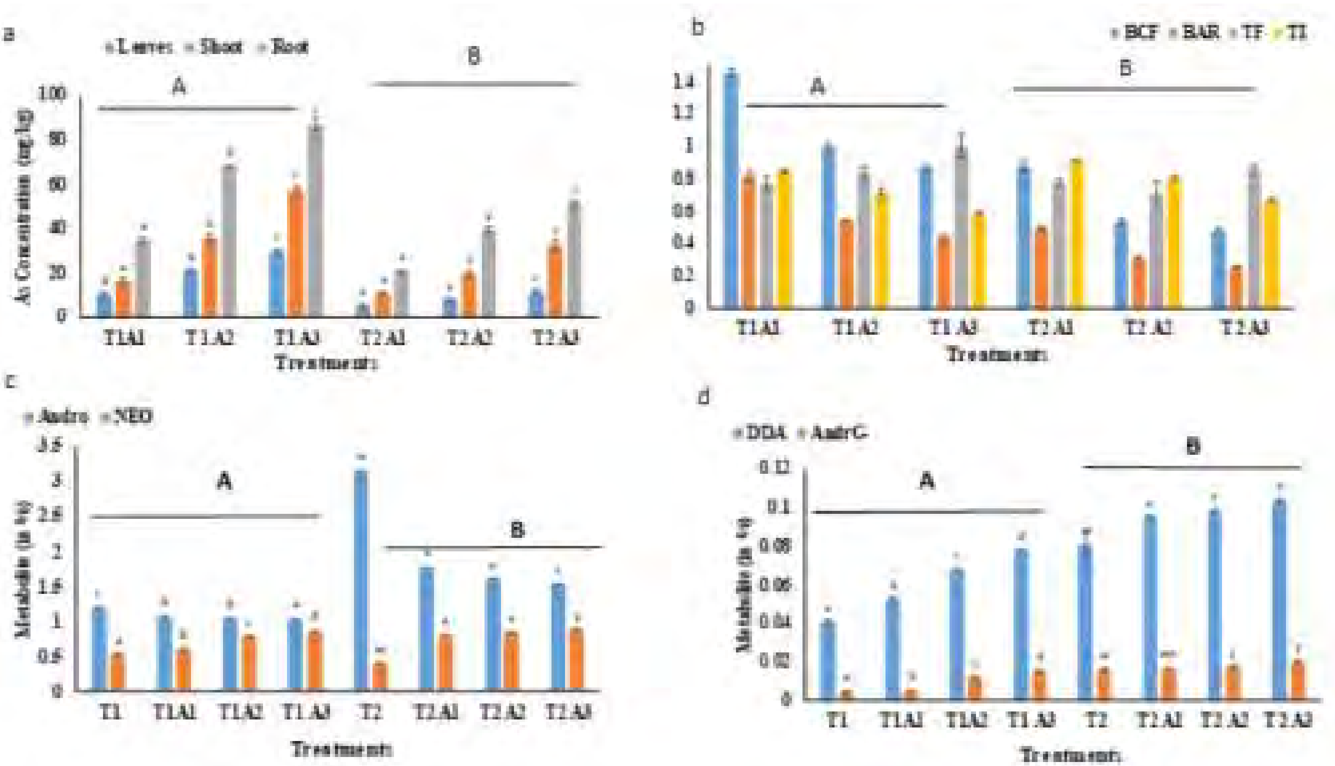


Figure 1: a. Arsenic content in leaves, shoot, and root; b. BCF (bioconcentration factor), BAR (bioaccumulation in the root) and TF (translocation factor) and TI (tolerance index) of *A. paniculata* in different treatments of arsenic; c. Andrographolide and neoandrographolide content in leaves; d. DDA (14-Deoxy-11,12-didehydroandrographolide) and andrograpanin content in leaves. [Error bars in each sample denotes standard deviation (n=3). Different letters on the bar in the same group indicate significant difference at $p < 0.05$ (for T1- a,b,c,d; T2- w,x,y,z); A and B indicates a significant difference at $p<0.05$ between the treatments. T1 treatments has wild genotype of *A.paniculata* (AP_{WC}); T1: soil control ; T1A1: soil + arsenic (40 mg kg^{-1}); T1A2: soil + arsenic (126 mg kg^{-1}); T1A3: soil+ arsenic (200 mg kg^{-1}); T2 treatments had mass selection line of *A.paniculata* (AP_{MS}); T2: soil control; T2A1: soil + arsenic (40 mg kg^{-1}); T2A2: soil + arsenic (126 mg kg^{-1}); T2A3: soil+ arsenic (200 mg kg^{-1})]

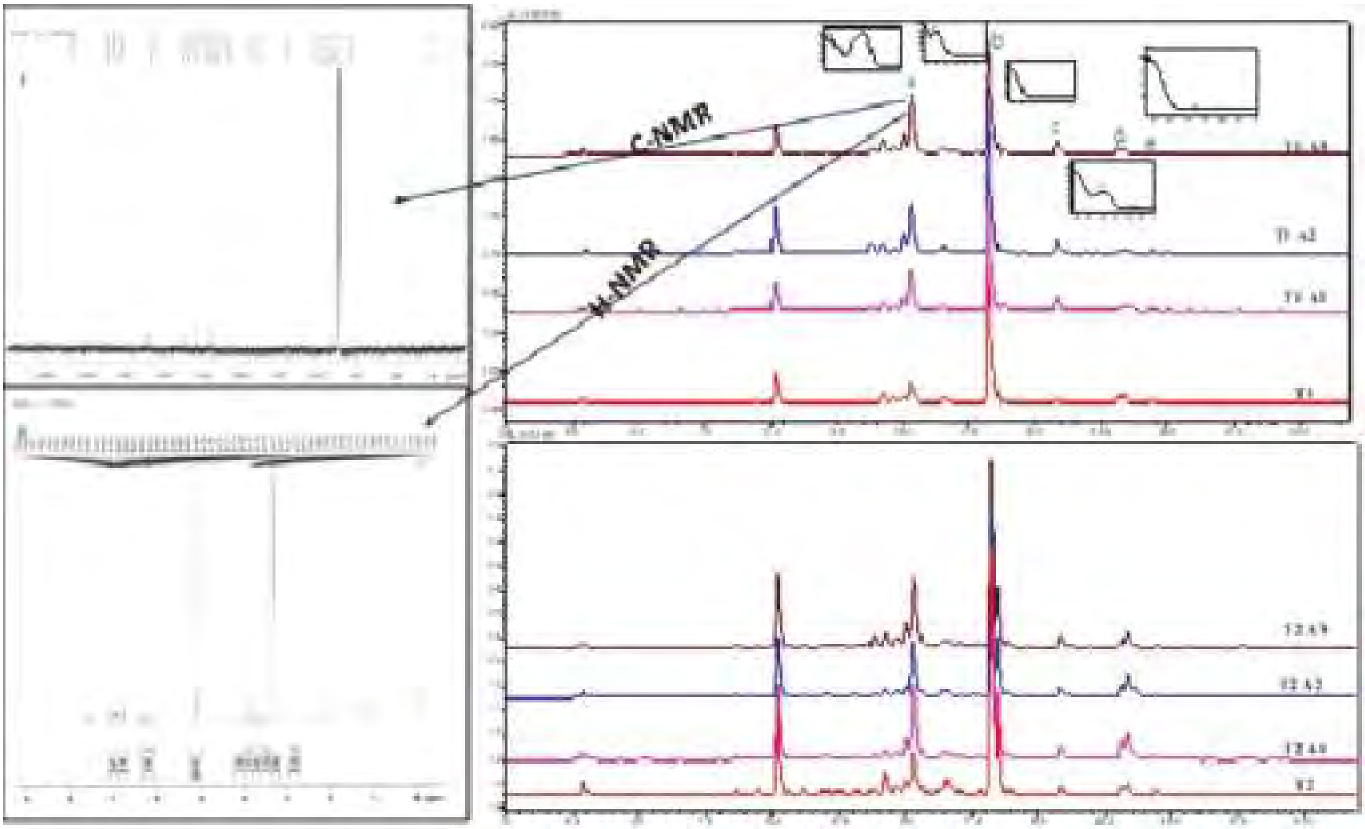


Figure 2: Chromatogram showing the five metabolites denoted as a, b, c, d, e in different treatments of (AP_{WC} and AP_{MS}) along with their respective UV spectra. a. UV spectra of 5,7,2′,3′-tetramethoxyflavanone; b. UV spectra of andrographolide; c. UV spectra of neoandrographolide; d. UV spectra of 14-Deoxy-11,12-didehydroandrographolide; e. UV spectra of andrograpanin. f. C-NMR spectra of 5,7,2′,3′-tetramethoxyflavanone; g. H-NMR spectra of 5,7,2′,3′-tetramethoxyflavanone; [T1 treatments has wild genotype of *A.paniculata* (AP_{WC}); T1: soil control ; T1A1: soil + arsenic (40 mg kg^{-1}); T1A2: soil + arsenic (126 mg kg^{-1}); T1A3: soil+ arsenic (200 mg kg^{-1}); T2 treatments had mass selection line of *A.paniculata* (AP_{MS}); T2: soil control; T2A1: soil + arsenic (40 mg kg^{-1}); T2A2: soil + arsenic (126 mg kg^{-1}); T2A3: soil+ arsenic (200 mg kg^{-1})]

Biochar aided aromatic grass [*Cymbopogon martini* (Roxb.) Wats.] vegetation: A sustainable method for stabilization of highly acidic mine waste

Dumping of acidic mine waste poses severe threats to the ecosystem due to high acidity, nutrient deficiency, and mobility of toxic metals. The present study has been undertaken on phytoremediation by amending the acidic soil/mine waste with biochar (BC) and plantation of palmarosa, *Cymbopogon martini* (Roxb.) Wats.A greenhouse experiment in different combinations of biochar and acidic mine waste was conducted to assess the phytoremediation efficiency of palmarosa by *BC* amendments. Results indicate that the palmarosa tolerates multiple stresses effectively with a 54% metal tolerance index (MTI) and capable of reducing acid production from the acidic mine waste alone. BC incorporation in the mine waste and soil treatments significantly enhanced the palmarosa biomass (1.11 to 3.3 times) and oil content by liming the acid, immobilization of metals, and improving the soil quality. BC addition in highly acidic mine waste amplified the phytoremediation efficiency and mitigates abiotic oxidative stress on plants (MTI 84% to >100%). BC aided palmarosa plantation shifted the soil from high-risk assessment code (RAC) to low RAC for vegetation. Biochar amendments along with palmarosa plantation offer a sustainable technology for phytostabilization of highly acidic mine waste along with the production of industrially important essential oil. (J. of Hazardous Material, 2020 IF:9.08)

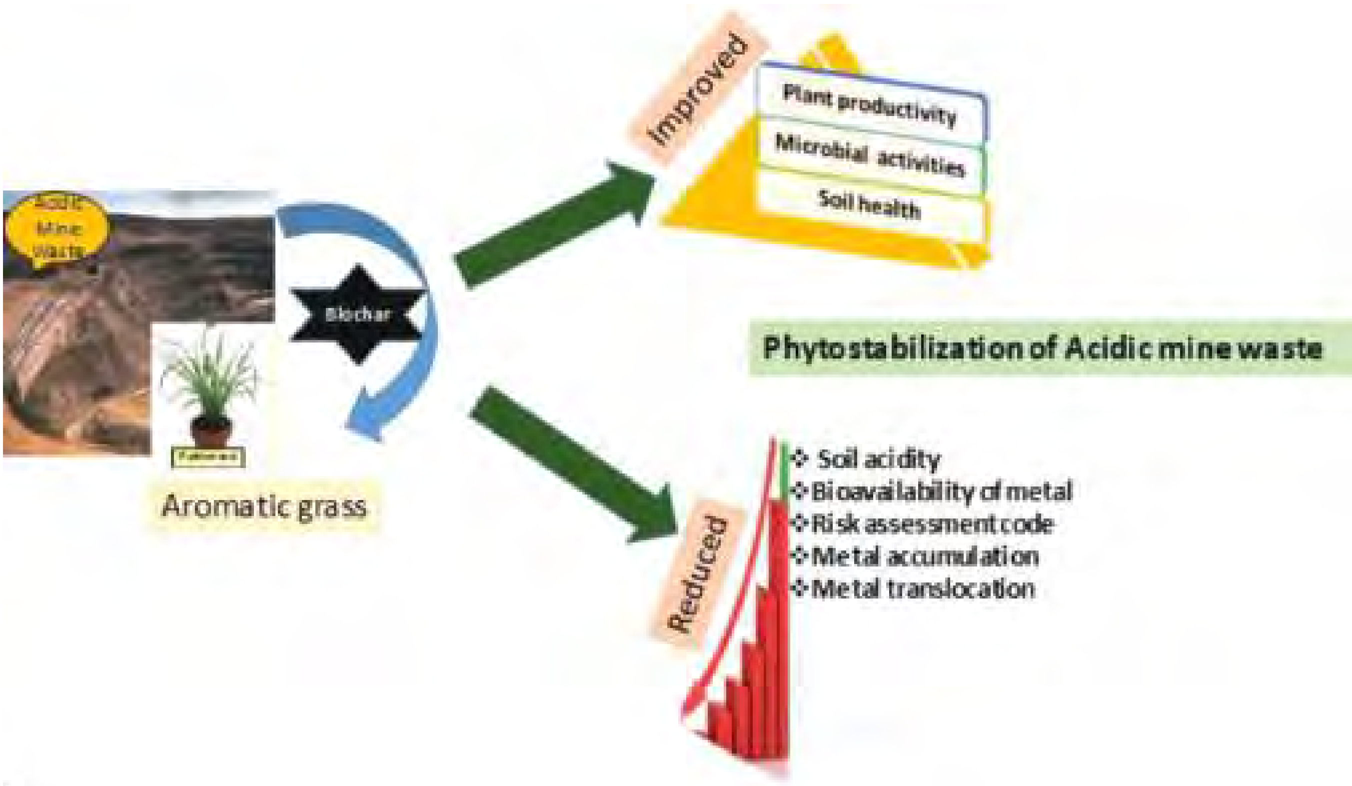


Figure 3: Impact of mine spoils properties by biochar aided aromatic grass [*Cymbopogon martini* (Roxb.) Wats.] vegetation

Disentangling the linking between bacterial diversity and enzymatic activities of soil from *Cymbopogon flexuosus* growing dryland

In the present study, seven sites used for cultivation of *Cymbopogon flexuosus* (six drylands with different soil properties and one irrigated land), their soil microbial community and enzymatic activities were evaluated. Multivariate analysis was applied to soil physicochemical properties, soil microbial community, and enzymes involved in carbon (β-glucosidase, phenoloxidase), nitrogen (N-acetyl glucosaminidase and urease), phosphorus (acidic and alkaline phosphatase), and sulphur (aryl sulphatase) mineralization to evaluate the soil biological processes under different conditions. The results showed that soil microbiota was dominated by Proteobacteria followed by Firmicutes and Acidobacteria.*Methylobacterium*, *Escherichia-Shigella*, *Sphingomonas*, *Microbacterium*, and *Brevibacillus* were dominated genera of these soil. The principal component analysis revealed the association of Proteobacteria phyla with a stoichiometry of C:N and C:P soil enzymes and carbohydrate metabolic profiling. Firmicutes phylum was involved in phosphorus, nitrogen, and oxidases cycling. The abundance of Acidobacteria was high in acidic soils having low nutrient availability. The abundance of *Escherichia-Shigella,* and *Sphingomonas,* was more in soil. Unlikely, the abundance of *Methylobacterium* was high in soil high higher microbial biomass and carbon content. This study provides an understanding of the association of nutrient acquisition and microbial community in different dryland soils.

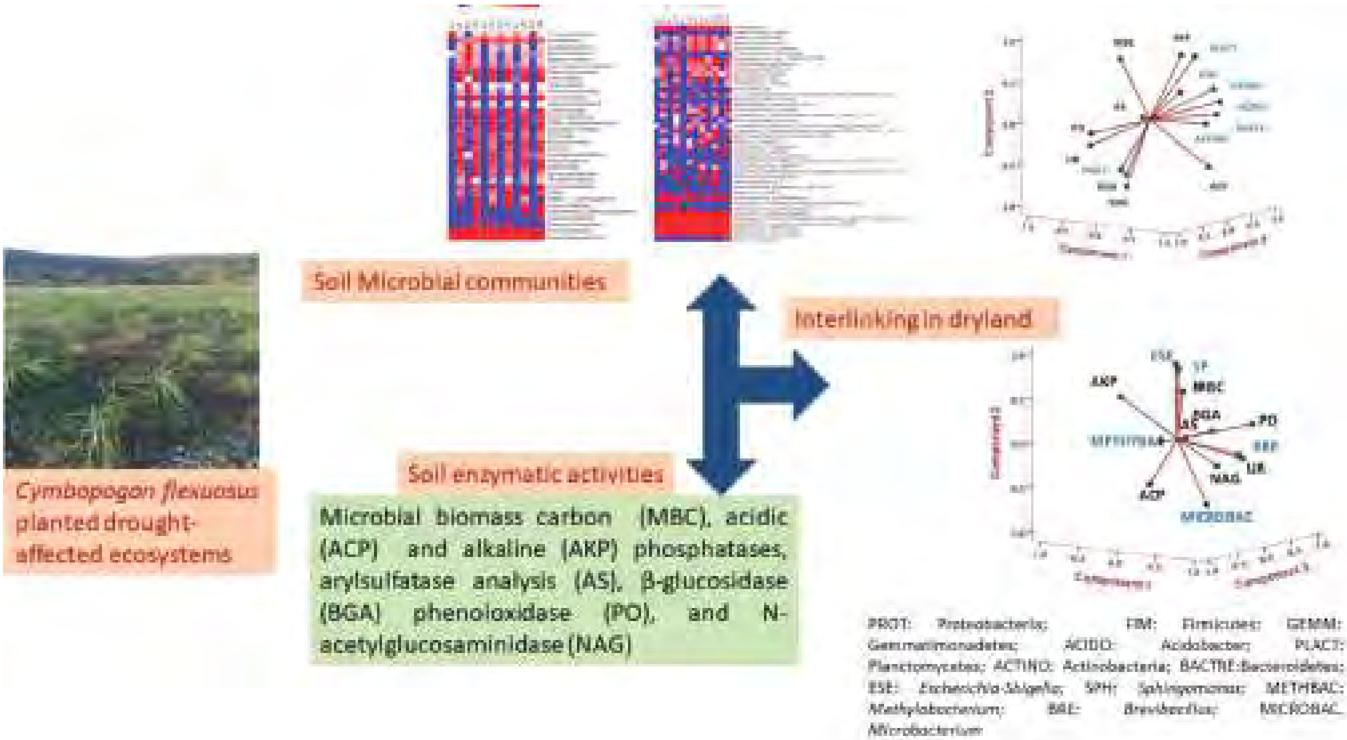


Figure 4: Impact of *Cymbopogon flexuosus* vegetation on microbial communities of different drylands

Dr. Puja Khare & her team

Input: Rakesh Kumar Upadhyay
राकेश कुमार उपाध्याय

RKU-KS-1: A high essential oil yielding strain of Lemongrass *Cymbopogon flexuosus* (Nees ex Steud.) W. Watson

The selected clone of lemongrass RKU-KS-1 was evaluated in 567 m^2 at a pilot scale trial with check varieties Cim-Shikhar and Krishna seven replicates (with bed size 6.0X4.5 m under randomized block design, 60X30 cm row to row and plant to plant spacing). The clone of lemongrass named RKU-KS-1 always maintained its superiority over the check for higher essential oil content and oil yield (Table 1). The elite strain (RKU-KS-1) is now proposed to be released as an improved variety for commercial cultivation of lemongrass towards doubling farmer's income by providing high yielding variety to the nation and farmers.

A B

Figure 1: A. Field view of RKU-KS-1 B. Essential oil of RKU-KS-1

Table 1: Comparative evaluation of characteristics of RKU-KS-1 with CIM-Shikhar and Krishna

Characters	RKU-KS-1	CIM-Shikhar	Krishna
Canopy	Bushy	Open	Open
Stature	Moderate	Moderate	Tall
Flowering	Not Flowering	Not Flowering	Flowering
Leaf Culm			
Length (cm)	20-25	28-35	30-40
Diameter (mm)	3.19	3.95	4.23
Colour	Light Brown	Dark Brown	Dark Brown
Leaf sheath			
Colour	Light Green	Dark Green (Turns brown in winter)	Dark Green
Length (m)	0.9-1.0	0.95-1.10	1.2-1.5
Width (cm)	1.2-1.5	1.5.2.0	1.5.2.0
Thickness (mm)	0.11	0.14	0.22
Yield parameters			
Fresh herb yield (q/ha/ year)	480-515	475-510	575-615
Oil content (%) Farm scale/ Filed distillation unit scale	1.50	1.04	0.83
Oil yield (kg/ ha/year)	700-750	490-525	450-500
Citral content (%) (Neral + Geranial)	82.79 (Neral: 33.45 Geranial: 49.34)	87.01 (Neral: 34.56 Geranial: 52.45)	83.59 (Neral: 34.01 Geranial: 49.58)

Validation of intercropping of *Phyllanthus amarus* L. with the traditional crop is a viable option to enhance farmer's income in a sustainable manner

The intercropping of Phyllanthus with sponge guard revealed that co-cultivation of these two crops provided the highest return per ha (Rs. 4,35,640/- including seed and Rs. 2,63,640/- per ha excluding seed) within the four months (July to October 2019) as compared to other intercropping and sole sponge guard provide Rs. 2,19,600/- per ha, while sole Phyllanthus provide only Rs. 3,32,000/- (including seed) and Rs. 1,08,000/- per ha (excluding seed) during 2019-20.

Figure 2: Integration of Phyllanthus with the traditional crop to enhance productivity, land-use efficiency, and return

New agro-technology to increase the productivity of wild marigold (*Tagetes minuta*)

A field experiment was conducted to standardize an economic and efficient dose of fertilizer applied on wild marigold (*Tagetes minuta*.) cultivation during rabi season in year 2019-20. For this purpose, four doses of Nitrogen fertilizer application were evaluated for their response with respect to plant height, essential oil content, fresh herb and essential oil yield of wild marigold. The experiment results revealed that different fertilizer application doses, the 120:60:40 kg NPK ha^{-1} recorded significantly highest attributes; plant height (137.62 cm), fresh herb yield (94.84 q ha^{-1}), oil content (0.33%), and oil yield (31.14 kg ha^{-1}). The control showed the lowest plant height (98 cm), fresh herb yield (42.52 q ha^{-1}), oil content (0.30%), and oil yield (12.76 kg ha^{-1}). On analysis, the major constituent dihydrotagetones (56.87 %) of essential oil sharply increases with an increase in the nitrogen dose.

Validation of new agrotechnology to increase the economic productivity of *Phyllanthus amarus* L.

The observation recorded revealed that transplanting of Phyllanthus at 50×20 cm row to row and plant to plant respectively (T_4) recorded significantly highest yield attributes and economic yield like; plant height (116.0 cm), number of branches (34.0), fresh herb yield (110.25 q ha^{-1}), dry herb yield (34.95 q ha^{-1}), seed yield (2.82 q ha^{-1}), as compared to T_3, and T_2; and the lowest was observed in T_1 plant height (89.0 cm), number of branches (14.0), fresh herb yield (54.92 q ha^{-1}), dry herb yield (17.73 q ha^{-1}), seed yield (1.50 q ha^{-1}), with spacing (20*20) cm spacing (T_1) during 2018-19. During next year 2019-20 validation experiment the observation recorded revealed that, transplanting of Phyllanthus at 50*20 cm row to row and plant to plant respectively (T_4) recorded significantly highest yield attributes and economic yield like; plant height (118.0 cm), number of branches (33.0), fresh herb yield (113.30 q ha^{-1}), dry herb yield (32.50 q ha^{-1}), seed yield (2.85 q ha^{-1}), as compared to T_3, and T_2; and the lowest was observed in T_1 plant height (93.0 cm), number of branches (14.0), fresh herb yield (55.10 q ha^{-1}), dry herb yield (18.58 q ha^{-1}), seed yield (1.52 q ha^{-1}), with spacing (20*20) cm spacing (T_1).

Input: Rakesh Kumar राकेश कुमार

Performance of plant geometry and fertilizer doses on growth and oil yield production in *Matricaria chamomilla*

The field experiment was conducted during 2018 and 2019 at the research farm of CSIR-CIMAP Research Centre, Pantnagar to evaluate the performance of plant geometry and fertilizer doses on growth, flower, and oil yield production under tarai region of Uttarakhand in CIM-Mohak cultivar of *Matricaria chamomilla*. The study involved three plant geometry (S1-50×30 cm; S2-50×45 cm and S3-50×60 cm) and three fertilizer doses (F1-100:50:30 kg NPK; F2-120:60:40 kg NPK and F3-150:75:50 kg NPK). The study revealed that planting at 50×30 cm was given a higher flower yield (5235.56 kg/ha) and oil yield (11.95 kg/ha). Among the fertilizer application showed a higher yield of flower (6066.67 kg/ha) and oil (12.53 kg/ha) was observed in S3 treatment.

Figure 1: Field view of *Matricaria chamomilla*

Table 1: Effect of spacing and fertilizer application on growth and oil yield in *Matricaria chamomilla*.

	Plant Height (cm)	Plant spread (cm)	No. of primary branches	No. of flowers / plant	Flowers yield/m^2 (kg)	Flowers yield/ ha (kg)	Oil (%)	Oil Yield (Kg/ha)
Planting distance								
S_1-(50×30 cm)	48.00	54.89	20.33	482.33	0.47	4748.89	0.21	10.53
S_2-(50×45 cm)	54.56	56.00	24.33	509.44	0.50	5002.22	0.22	10.87
S_3-(50×60 cm)	53.78	56.22	24.44	643.11	0.52	5235.56	0.22	11.95
Sem±	1.75	5.21	2.48	24.50	0.04	412.76	0.01	1.57
LSD 0.05	4.85	NS	NS	68.01	NS	NS	NS	NS
Fertilizer application								
F_1-(100:50:30 kg NPK)	48.67	57.89	19.11	471.67	0.41	4111.11	0.22	9.80
F_2-(120:60:40 kg NPK)	49.33	52.83	23.89	562.22	0.48	4808.89	0.23	11.02
F_3-(150:75:50 kg NPK)	58.33	56.39	26.11	601.00	0.61	6066.67	0.23	12.53
Sem±	2.12	1.64	2.68	42.56	0.03	309.87	0.01	0.90
LSD 0.05	4.61	3.58	NS	92.75	0.07	675.21	NS	1.95
Interaction	NS	NS	NS	NS	*	*	NS	*

Input: Jnanesha A.C. ज्ञानेशा ए.सी.

Variation in Lemon-scented basil and lemongrass mixed distillation on essential oil yield and chemical composition

Intercropping and sole cropping of Lemongrass and lemon-scented basil crops were evaluated to know the variation in lemon-scented basil and lemongrass mixed distillation on essential oil yield and chemical composition with the aim to increase the yield and income of the farmer by utilizing available space during the initial lag phase of lemongrass. The results showed that Intercropping of lemongrass with lemon-scented basil recorded significantly higher essential oil yield compare to sole cropping of lemongrass and lemon-scented basil and was on par with sole cropping of lemongrass. Meanwhile, the oil obtained after distillation of lemongrass, lemon-scented basil and both oil samples were analyzed for chemical composition and it is found that mixed distillation of lemongrass and lemon-scented basil recorded a higher percentage of citral I and citral II compared to lemongrass and lemon-scented basil and also camphor percentage is higher in the mixed sample compared to others. However, carophyllene, citronellol, and geraniol percent were higher in lemon-scented basil compared to other oil samples. The gross income obtained under intercropping of lemongrass and lemon-scented basil during the initial lag phase were significantly higher compared to sole cropping of lemongrass and lemon-scented basil and was followed by sole cropping of lemongrass. Intercropping of lemongrass with lemon scented basil gave significantly higher essential oil yield during initial lag phase and Co-distillation of lemon scented basil and lemon grass didn't impart off odour and alter the chemical profile of their essential oil .

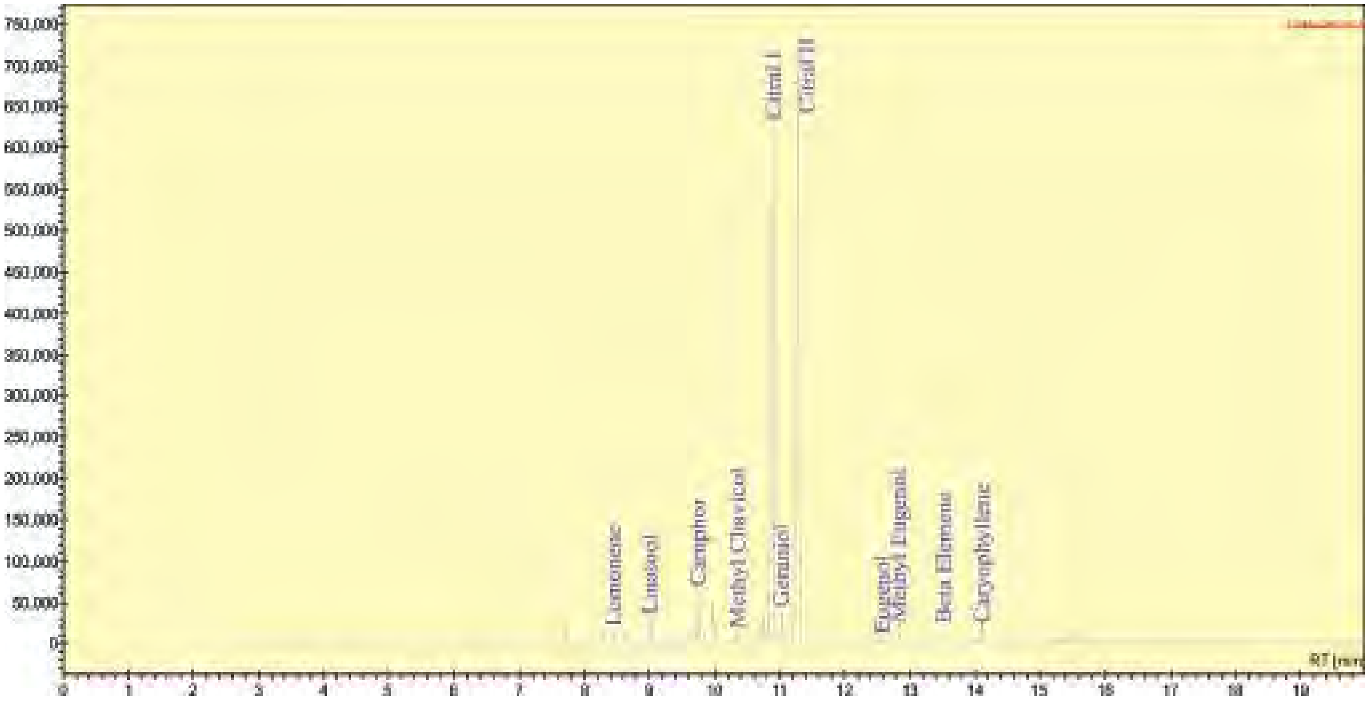


Figure 1: Gas Chromatograph of the essential oil of lemon-scented basil and extraction of essential oil with lemongrass plants

Effect of different dose of hydrogel on growth yield and economics of senna in semi-arid tropics regions of India

Water availability is one of the most important factors influencing plant growth. Water absorbing materials have been reported to be effective tools in increasing water holding capacity under moisture stress. So, a field investigation was carried out on red sandy soil in the semi-arid climate of south India at CSIR-CIMAP, Research Centre, Hyderabad, to study the effect of different dose of hydrogel on growth, yield, and economics of senna in semi-arid region of India. From the results it is concluded, that application of 1200 g of hydrogel per acre gave significantly higher leaf yield (988.75 kg/acre) and pod yield (287.50 kg /acre) compared to rest of the treatment and was on par with the application of 1000g of hydrogel (943.25 kg/acre and 265.25 kg/acre, respectively). Significantly lower leaf yield and pod yield was recorded in control (671.50 kg/acre and 182.50 kg/acre, respectively) and were on par with the application of 250 g of hydrogel (752.50 kg/acre and 212.75 kg/acre, respectively). Water use efficiency, water holding capacity of soil also significantly more in case of application of 1200 g of hydrogel (5.49 kg/ha mm, 51.33% and 19.7%). A similar trend was noticed with regard to the growth parameter. Similarly, Application of hydrogel @ 1200 g per acre recorded significantly higher gross return (₹ 72437.5) compared to the rest of the treatment and was on par with application of hydrogel to senna crop @ 1000 g per acre (₹ 70082.5). A similar trend was noticed regarding net return (₹ 52797.5). The benefit-cost ratio also significantly higher with the application of 1200 g of hydrogel (2.69) and was on par with T4 (2.61).

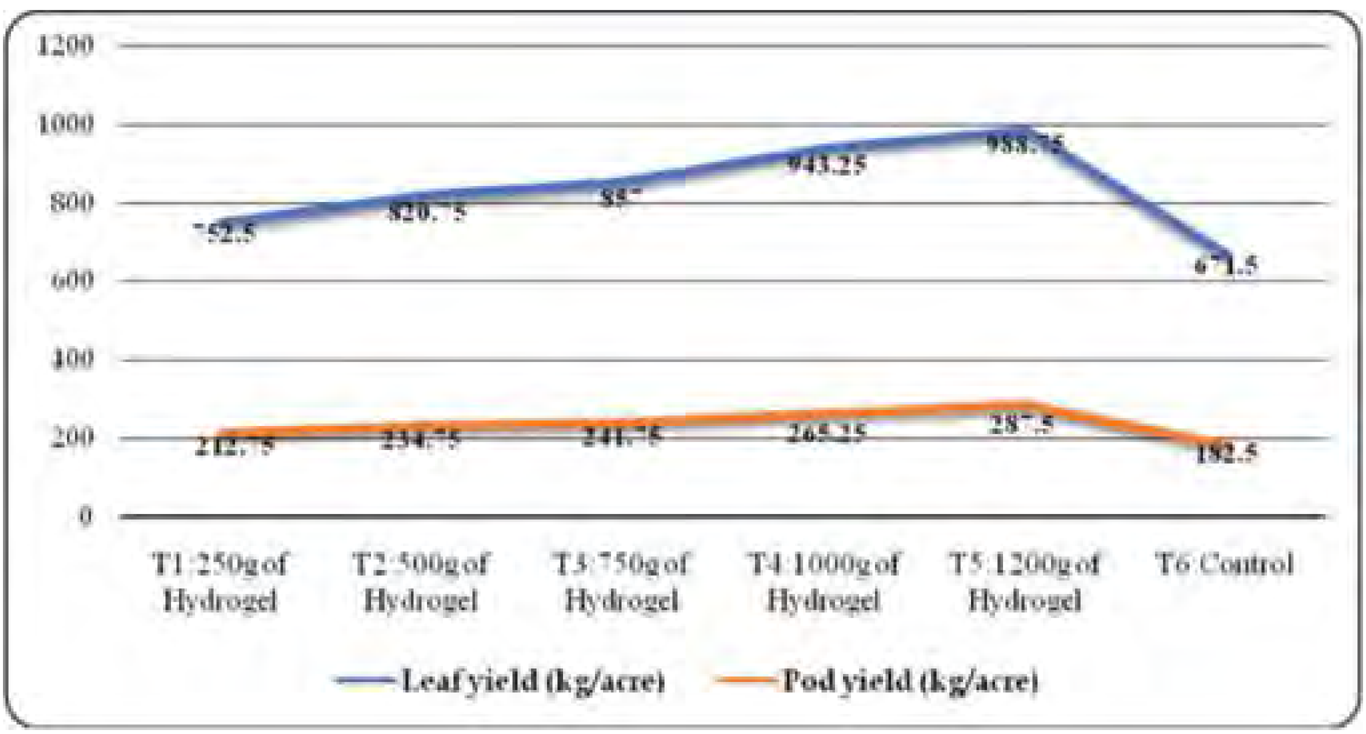


Figure1: Effect of different dose of hydrogel on leaf and pod yield of senna.

Input: Yogendra N.D. योगेन्द्र एन.डी.

Effect of different drying methods and storage on the volatile oil content of patchouli

The method of drying, drying temperature and sample preparation is significantly influence the quantity and quality of the active ingredients present in patchouli essential oil. Storage of well dried leaves up to 150-180 days yields highest oil recovery. To achieve better yield of patchouli oil at shorter drying time, hot air oven drying of the herbage is one of the option. Drying at 45°C temperature in a hot air oven would be ideal for patchouli drying with quicker drying and oil recovery of 2.20% compared to shade drying.

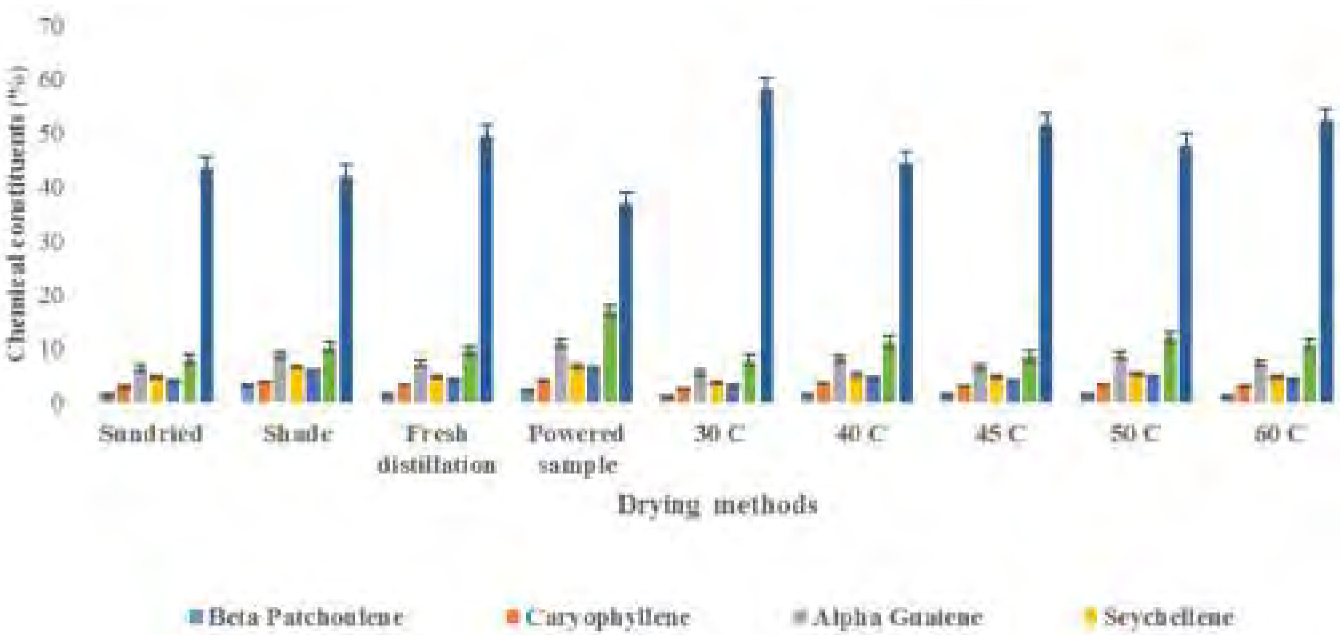


Figure 1: Volatile compound (%) of the essential oils of patchouli under different drying methods

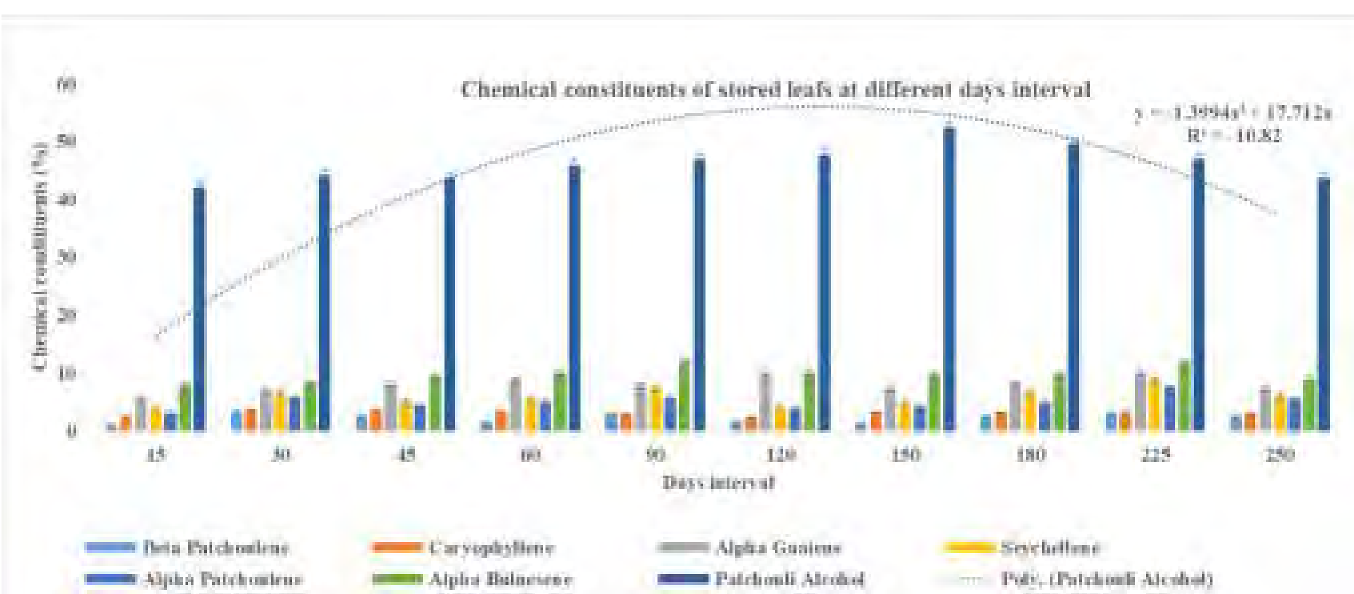


Figure 2: Volatile compounds (%) of the essential oils of patchouli under stored conditions

Performance of Lemongrass (*Cymbopogon spp*.) genotypes for growth, herbage, oil yield and quality under Southern region of Karnataka, Bengaluru

Significantly higher herb yield of lemongrass was recorded in CIM-Shikar>Krishna>CIM-Atal. Essential oil content varied from 0.70-1.35% (v/w) and essential oil yield varies from 133.56- 302.40 kg/ha/year in different cultivars. The amount of citral varied from 5.45% to 91.93% among eight lemongrass cultivars. The cultivar CIM- Shikar recorded significantly higher amounts of essential oil (302.40 L/ha/year) with market acceptable citral percentage of 80.70.

Table 1: Growth and yield parameters of lemongrass cultivars under Southern region of Karnataka, Bengaluru

Cultivar	Plant height (cm)	Number tillers/ clump	Number of leafs per tiller	Herb yield (t/ha/ year)	Oil recovery %	Oil yield (kg/ha/ year)
Krishna	128.87	47.53	5.08	22.50	1.20	269.98
Cauvery	108.47	39.53	5.08	17.85	0.85	151.44
Nima	111.73	38.13	5.25	18.35	0.90	164.90
OD-19	123.85	41.20	4.85	19.05	0.70	133.56
CIM-Suvarna	131.00	39.20	5.17	19.35	1.15	223.17
CIM-Shikar	136.75	47.60	5.65	24.25	1.25	302.40
CKP-25	115.87	42.13	4.93	20.72	1.20	247.82
CIM-Atal	122.87	40.67	5.45	20.35	1.35	275.44
SEm ±	**1.28**	**1.59**	**0.37**	**1.28**	**0.04**	**18.07**
CD at 5%	**3.89**	**4.83**	**NS**	**3.88**	**0.13**	**54.80**

Input: Dipender Kumar
दीपेन्द्र कुमार

Influence of harvesting time on essential oil content and composition in Geranium varieties in Tarai belt of Uttarakhand

The essential oil yield and oil composition of three Geranium varieties (Bourbon, CIM-Pawan and Bio-G-171) were evaluated and comparative analysis was done with respect to different harvesting times to optimize the harvesting time for obtaining maximum essential oil in terms of quantity and quality. In terms of quantity, data revealed that in varieties, CIM-Pawan and Bio-G-171, no significant variation in oil content

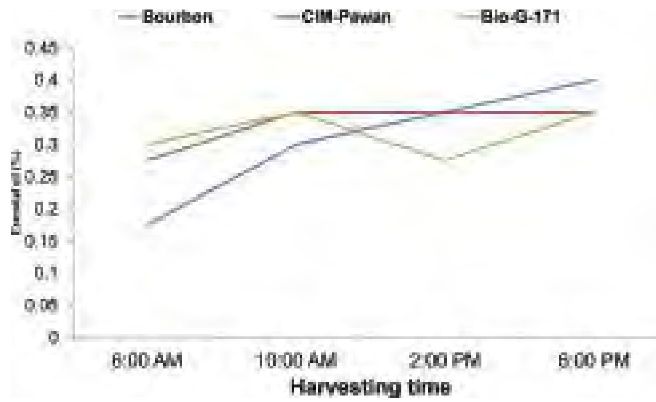


Figure 1: Essential oil content at different harvesting time in Geranium varieties

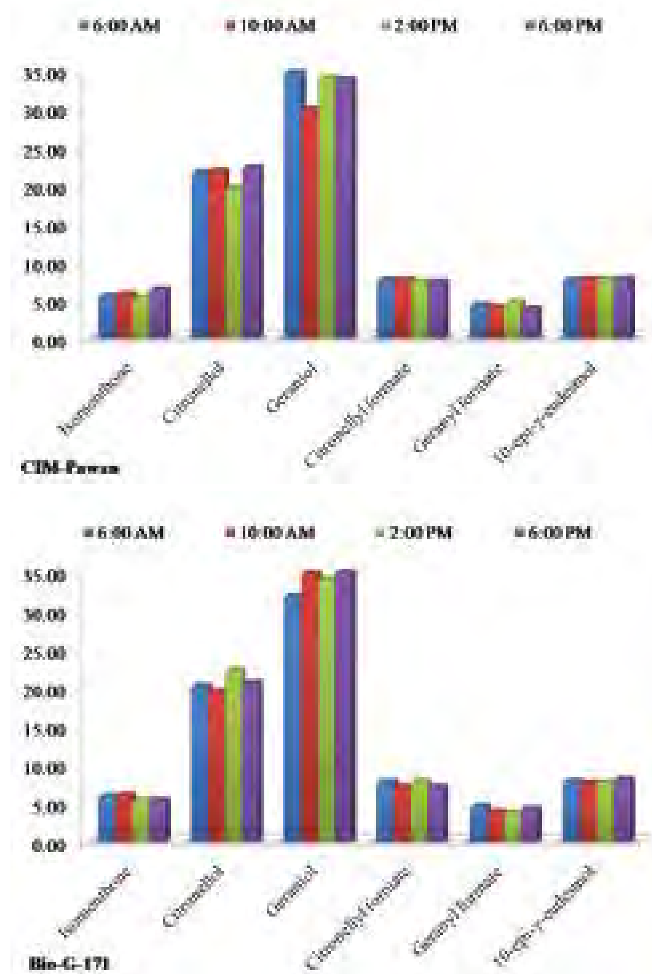


Figure 2: Marker compounds in the essential oil of Geranium varieties

was found when the crop was harvested at different times but in variety Bourbon, significant variation was found, the maximum oil content was found when the crop was harvested in the evening time (0.400%) and minimum in morning time (0.175%). In terms of quality, there were 24 compounds were identified, out of 24, Table : Essential oil content (%) in Geranium varieties influenced by harvesting time

(Harvesting time)	Essential Oil content (%)		
	Bourbon	CIM-Pawan	Bio-G-171
6 AM	0.175	0.275	0.300
10 AM	0.300	0.350	0.350
2 PM	0.350	0.350	0.275
6 PM	0.400	0.350	0.350
C.D. (at 5%)	0.059	NS	NS

six were marker compounds i.e. Geraniol, Citronellol, Citronellyl formate, 10-epi-γ-eudesmol, Isomenthone and Geranyl formate in the essential oil of CIM-Pawan, Bio-G-171, and Bourbon. No significant variation in the availability of marker compounds was observed at different harvesting times. So, from the results, it can be concluded that CIM-Pawan and Bio-G-171 can be harvested at any time during the day with respect to content and composition but a variety Bourbon should be harvest in the evening time for maximum oil content without deteriorating the quality of essential oil.

Input: Priyanka Suryavanshi
प्रियंका सूर्यवंशी

Working on developing a suitable region specific agro-techniques, integrated weed management along with exploring the role of allelopathy in biological weed management for medicinal and aromatic plants. Further, good agricultural practices related to organic farming in various medicinal and aromatic crops will be developed along with dissemination of these developed agro-techniques to the farmers.

Input: B. Shivanna बी. शिवन्ना

Effect of different rates of organic and inorganic fertilizers and distilled waste mulching on Citronella growth, yield and soil health

Citronella is an important aromatic crop grown in about 2000 ha. In India. Citronella is found to be high nutrient demanding crop. The chlorosis in the citronella is common during the growing period. The reasons for the chlorosis is not clear so far. It might be due to the unbalanced fertilizer application and loss of nutrients due to soil erosion and studies on the nutrient requirement of citronella are very scarce. Hence an experiment has been taken up in split-plot design at 3 levels of fertilizers and manures with two levels of mulching in two replications at CIMAP Lucknow to study the effect of mulching and different rates of organic and inorganic fertilizers on growth, the yield of Citronella and soil health.

The growth, and yield of *Ocimum basilicum* and residual soil fertility due to different rates of manure and fertilizers and mulching

Sweet basil is extensively cultivated as a commercial crop for essential oil production in India. Though the effect of mulching on weed and yield studied, the effect of mulching and different rates of fertilizers on crop yield, nutrient uptake, and residual nutrient status has not been found. Hence an experiment has been taken up at CIMAP Lucknow in 2 replications in RCBD to study the effect of mulching and different rate of fertilizers on crop yield and nutrient uptake and residual soil fertility.

Input: A. Samad ए. समद

Cucumber mosaic virus associated with Yellowing Mosaic Disease of African Basil (*Ocimum gratissimum*) in India

African basil or clove basil (*Ocimum gratissimum*), is a rich source of eugenol and is widely cultivated as a culinary perennial evergreen herb in tropical and warm temperate regions. In February 2017, leaf samples showing yellowing mosaic with shortened leaves, and nonsymptomatic leaf samples, were collected from the experimental fields of the CSIR-CIMAP, Lucknow. Disease incidence was estimated at around 20 to 25%. Sap was extracted from each of the 13 infected and healthy leaf samples in phosphate buffer, pH 7.2, and inoculated on to different hosts. Plants were maintained in a glasshouse at 28 to 30°C with ~70% relative humidity. After 13 days, *N. glutinosa*, *N. benthamiana*, and *N. tabacum* 'Xanthi' showed systemic mosaic symptoms, whereas *O. gratissimum* exhibited symptoms such as yellowing and mosaic similar to those observed in the field. To diagnose virus infection in the collected samples, total DNA and RNA were extracted from both the original field samples and the symptomatic indicator plants using a modified cetyltrimethylammonium bromide protocol and a spectrum total RNA kit (Sigma Aldrich). Nine of the 13 samples yielded PCR fragments of expected size (657 bp). All 13 samples were negative for *Begomovirus* and *Potyvirus*. All symptomatic inoculated indicator plants and *O. gratissimum* plants tested positive for CMV. The amplified PCR products were cloned into pGEM-T Easy vector and sequenced using M13F/R primers by ABI sequencer model 3730 at CIMAP, Lucknow. The sequence was deposited to GenBank (MH260401). A BLASTn analysis shared the highest similarity of 99% with the CP gene of CMV-CIMAP-India C18 isolate (EU310928). CMV causes substantial losses in over 1,200 plant species and is among the "top 10 plant viruses" owing to heavy economic and yield loss. Further confirmation of the presence of CMV was done by transmission electron microscopy (TEM). The virus was purified from infected *N. glutinosa* by polyethylene glycol precipitation and showed A_{260}/A_{280} as 1.7. Spherical virions ~28 nm in diameter similar to CMV was observed. To our knowledge, this is the first report of CMV subgroup IB naturally infecting African basil. CMV has been reported from many important medicinal and aromatic crops such as *Hyoscyamus muticus*, *Catharanthus roseus*, *Rauvolfia serpentina*, and so on, during the past 15 years in India. Virus diseases are becoming the limiting factors for the cultivation of medicinal and aromatic crops in India. More work is needed to determine the prevalence of CMV and its impact on the end product of the crop.

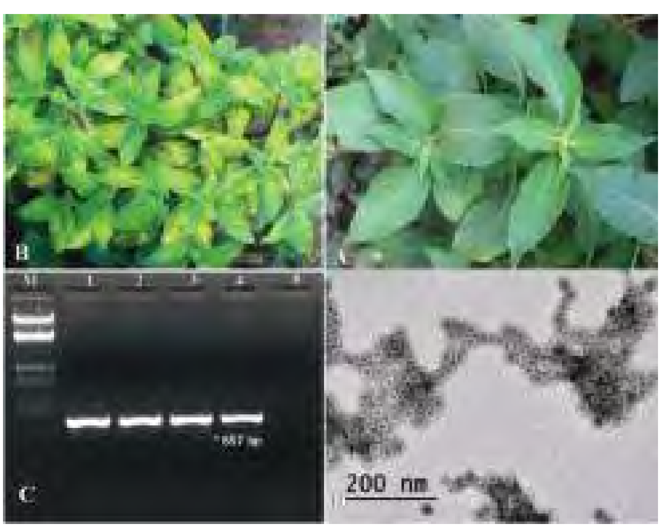


Figure 1: A. Healthy plants in the field. B. Yellow mosaic and deformed leaves of naturally infected *O. gratissimum* plant. C. Mechanically inoculated *O. gratissimum* plant with systemic symptoms. D. Gel image presenting RT-PCR product of CP gene (CMV) in 1.2 % agarose; M- λ DNA double digested *Eco*RI/ *Hind*III marker, 1- 3 samples from infected plant, 4- positive control, 5- sample from healthy plant D. Purified CMV particles under TEM (Bar = 200 nm).

Sugarcane grassy shoot Phytoplasma (16SrXI) associated with Little Leaf Disease of *Chrysopogon zizanioides* from India- new record

Vetiver (*Chrysopogon zizanioides*) or khus is a perennial grass produced in Haiti, Indonesia, China, Japan, India, and Brazil. During March 2016 at experimental fields of khus at CSIR-CIMAP, Lucknow, India (26°51′ N, 80°57′ E), many vetiver plants displayed characteristic symptoms such as yellowing, little leaves, malformed inflorescence, stunting, multibranch crowns, proliferation of the buds at the base of the stem into witches' broom, and poor root growth suggesting the presence of phytoplasma. Transmission electron microscopy (TEM) revealed the presence of pleomorphic bodies ranging from 400 to 750 nm in phloem tissue of symptomatic plants but not observed in asymptomatic samples. No evidence for viral and fungal etiology was observed. The incidence

Figure 2: Field view of healthy vetiver pants (a), Infected plants showing yellowing, little leaves, malformed inflorescence, stunting, multibranch crowns and proliferation of the buds at the base of the stem into a witches'-broom in the field (b) & in the glass house (c). Initial and nested PCR results of samples: Lane1 (Healthy), Lane 2 (infected) amplification with P1/P6., Lane 3, 4, 5- amplification with nested primers (R16F2n/R16R2) and Lane M: Lambda DNA/*Eco*RI + *Hind*III double digest Marker (d). The TEM image of phloem tissue with pleomorphic bodies ranging from 400 to 750 nm in the symptomatic samples (e).

of phytoplasma in those fields ranged from 20 to 30%, and diseased plants were scattered throughout the fields. Symptomatic and asymptomatic leaf samples from six locations of the field were collected and total DNA was extracted by a CTAB method, and polymerase chain reaction (PCR). As expected, the PCR products were generated from the samples of the symptomatic plant but not from the symptomless control samples. The amplicon of approximately 1.2 kb in size was cloned, and sequenced, and the data obtained were deposited in the NCBI GenBank database (MK481004). BLASTn analysis of the sequences revealed 99% identity with 16S rRNA of sugarcane grassy shoot phytoplasma (SGSP, HF 586651). The phylogenetic tree that the present phytoplasma is clustered under 16SrXI group of phytoplasma. To our knowledge, this is the first report of a natural presence of 16SrXI group of phytoplasma associated with the present little leaf disease of *C. zizanioides*. Phytoplasmas associated with khus may be easily spread to other khus growing areas through slips obtained from the infected stock; therefore, further study on identifying alternate host plants, potential vectors, proper sanitation, and geographic distribution will be helpful to control this phytoplasma disease.

Dr. A. Samad & his team

Input: Rakesh Pandey राकेश पाण्डेय

Anti-ageing and anti-Parkinsonian effects of natural flavonol, Tambulin from Zanthoxyllum aramatum promotes longevity in *Caenorhabditis elegans*

Parkinson's disease (PD) is marked with motor function decline, progressive neurodegeneration due to aggregation of insoluble α-synuclein in the dopaminergic neuron. Here we investigated the effect of tambulin (3,5-dihydroxy-7,8-dimethoxy-2-(4-methoxyphenyl) chromen-4-one), a hydroxy substituted flavanol isolated from fruits of Zanthoxyllum armatum DC (Family-Rutaceae) for its longevity promoting and neuromodulatory activities using *C. elegans* model system. Our results show that tambulin treatment significantly enhance lifespan and stress tolerance in worms, along with mitigation of ageing biomarkers like lipofuscin and protein carbonyl. In line with the alleviated ROS levels, tambulin treatment led to upregulated mRNA expression of ROS scavenging genes viz., sod-1, sod-3, and ctl-2. Upregulation in daf-16 gene indicates the involvement of insulin signaling

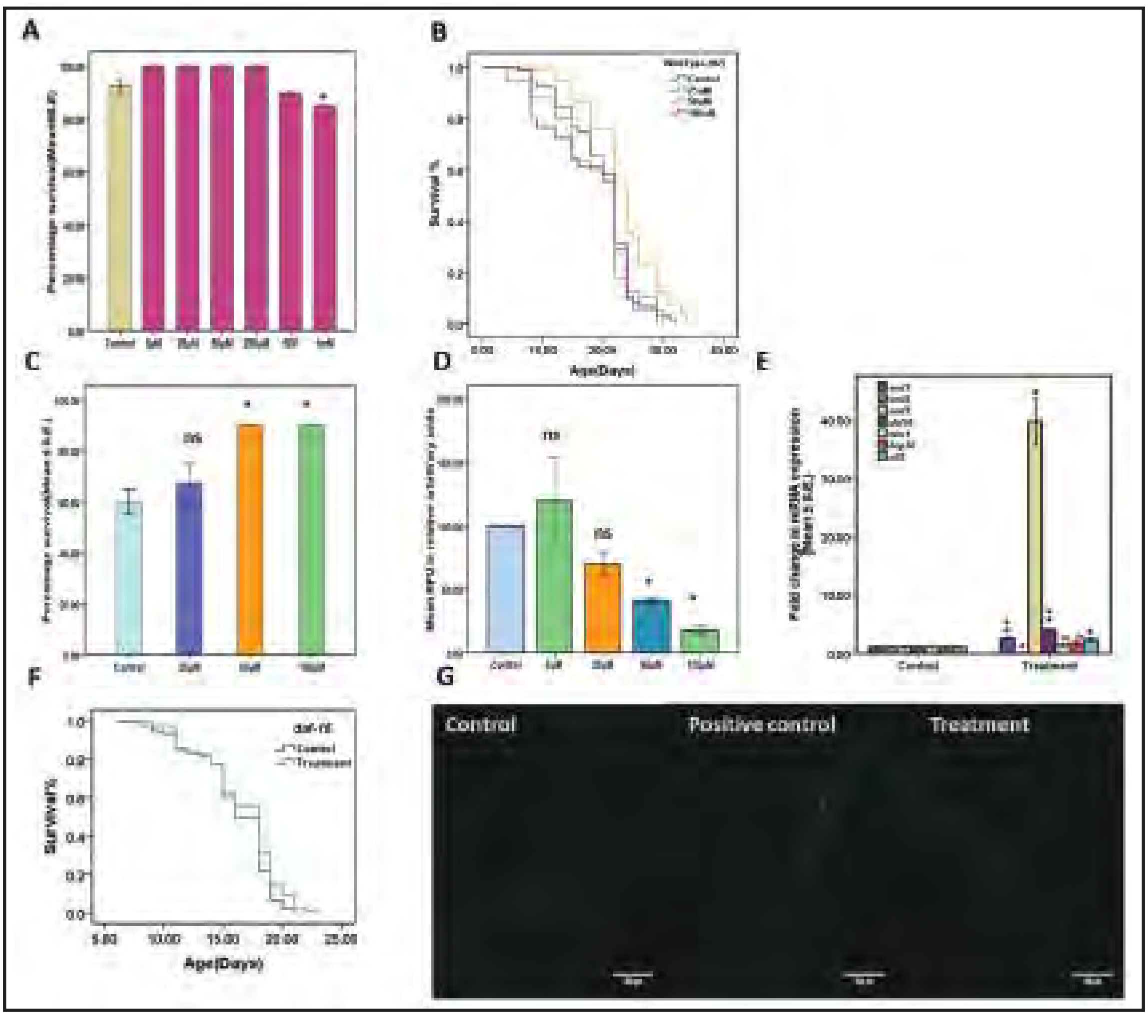
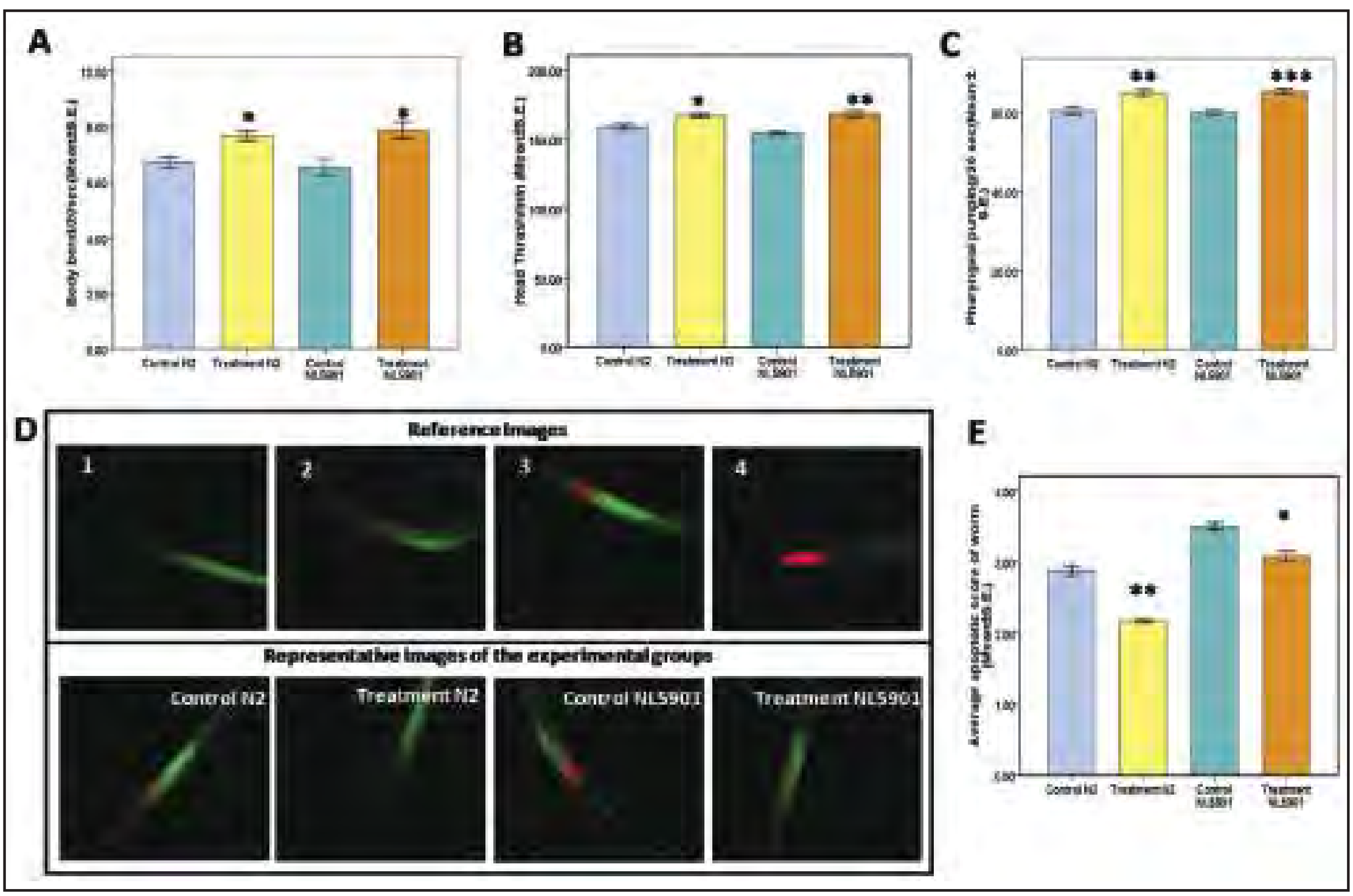


Figure 1: Effect of tambulin on ageing biomarkers (lipofuscin, protein carbonyl) and antioxidant enzyme level. (A) Representative microphotograph of auto-fluorescent lipofuscin in vehicle control and 50 μM tambulin treated worms. (B) The graphical representation shows a marked a decline in intestinal lipofuscin level after 50 μM tambulin treatment as compared to vehicle control group and quantification of the auto-fluorescent protein presented as mean RFU (C) Tambulin significantly decreased carbonylated protein content. (D) Fluorescent photomicrographs representing that tambulin significantly up-regulates expression of SOD-3:: GFP as compared to vehicle control group of worms (n = 30). (E) Graphical representation of SOD-3:: GFP expression. 30 worm/group were used in the above experiments in three replicates. The lipofuscin levels were quantified using the Image-J software. Protein carbonyl and lipofuscin were analyzed using an independent t-test. (*pvalue < 0.05, **p-value < 0.005, ***p-value < 0.0005, NS = Non-significant), Scale bar, 200 μm.

pathway in tambulin mediated longevity. Tambulin treatment exhibited curtailed PD manifestations in terms of reduced α-synuclein levels, lipid accumulation, improved locomotary behavior and dopamine levels. Altogether, our data suggest that tambulin mediated alleviation of PD manifestations possibly involved PD counter protective machinery as evident through upregulated mRNA expression of lagr-1, ymel-1, pdr-1, ubc-12, and lrk-1. Our studies present tambulin as a potential molecule for its properties against ageing and Parkinson's disease. Further studies are speculated to realize the mechanistic and pharmacological aspects of tambuli.

Assessment of toxicity, oxidative stress résistance and lifespan analysis at different doses of tambulin on wild-type N2 worms (A) Tambulin was non-toxic at various doses between 5 μM to 500 μM and slightly toxic at 1 mM. (B) Tambulin at 50 μM concentration displayed a significant upsurge in mean lifespan in wild-type N2 worms by 16.8% as compared to vehicle control worms. (C) Tambulin significantly increased oxidative stress resistance against juglone in wild-type N2 worms, exhibiting 67%, 90% and 90% survival for doses 25 μM, 50 μM and 100 μM respectively in comparison to 60% survival recorded in vehicle control. (D) Tambulin treatment at different doses (5 μM, 25 μM and 50 μM) led to marked reduction in intracellular ROS levels as compared to vehicle control while reduction at 100 μM was insignificant. (E) Tambulin treatment significantly augments the expression stress-responsive genes sod-1, sod-3, ctl-2 and daf-16 ageing-related gene in wild-type N2 worms (F) Tambulin increased the lifespan of daf-16 mutant marginally.(G) DAF-16::GFP nuclear localization after tambulin treatment; The toxicity and juglone assay were performed in with 40 worms/group while 120 worms/group, 30 worms/group were used in in-vivo oxidative free radicals assay and daf-16:: GFP reporter assay in three replicates. Data was analyzed by One Way ANOVA followed by Dunnet's test. Lifespan analysis was done by using Kaplan-Meier survival test. Data presented as Mean ± S.E. Data analyzed using Independent t-test (*p-value < 0.05, **p-value < 0.005, ***p-value < 0.0005) Scale bar, 200 μm. (*Experimental Gerontology* 120 (2019) 50–61).

Influence of tambulin on body bend, head trash, pharyngeal pumping, and apoptosis. (A) Treatment with tambulin increases body bend in both N2 and NL5901 (B) Tambulin causes a significant increase in



the head trash in N2 and respectively in comparisons to their vehicle control worms. (C) Tambulin increases pharyngeal pumping rate in day 5 wild-type N2 worms and NL5901worms. (D) The effect of tambulin on apoptosis. Cell exhibiting green fluorescence represents normal cell while cells with red fluorescence represents apoptotic cells. Representative images of apoptosis scoring system and images of treated/ untreated wild-type N2 and NL5901worms are shown (E) Graphical representation showing efficacy of tambulin in significantly decreasing the apoptosis in wild-type N2 and NL5901worms in comparison to their respective vehicle controls. The experiments were conducted with 20 worms per group in three replicates. Data were analyzed using an independent-test and One Way ANOVA was used where ever applicable. (*p-value < 0.05, **p-value < 0.005, ***p-value < 0.0005, NS = Non-significant).Scale bar, 200 μm.

Limonene attenuates oxidative stress and extends longevity in *Caenorhabditis elegans*

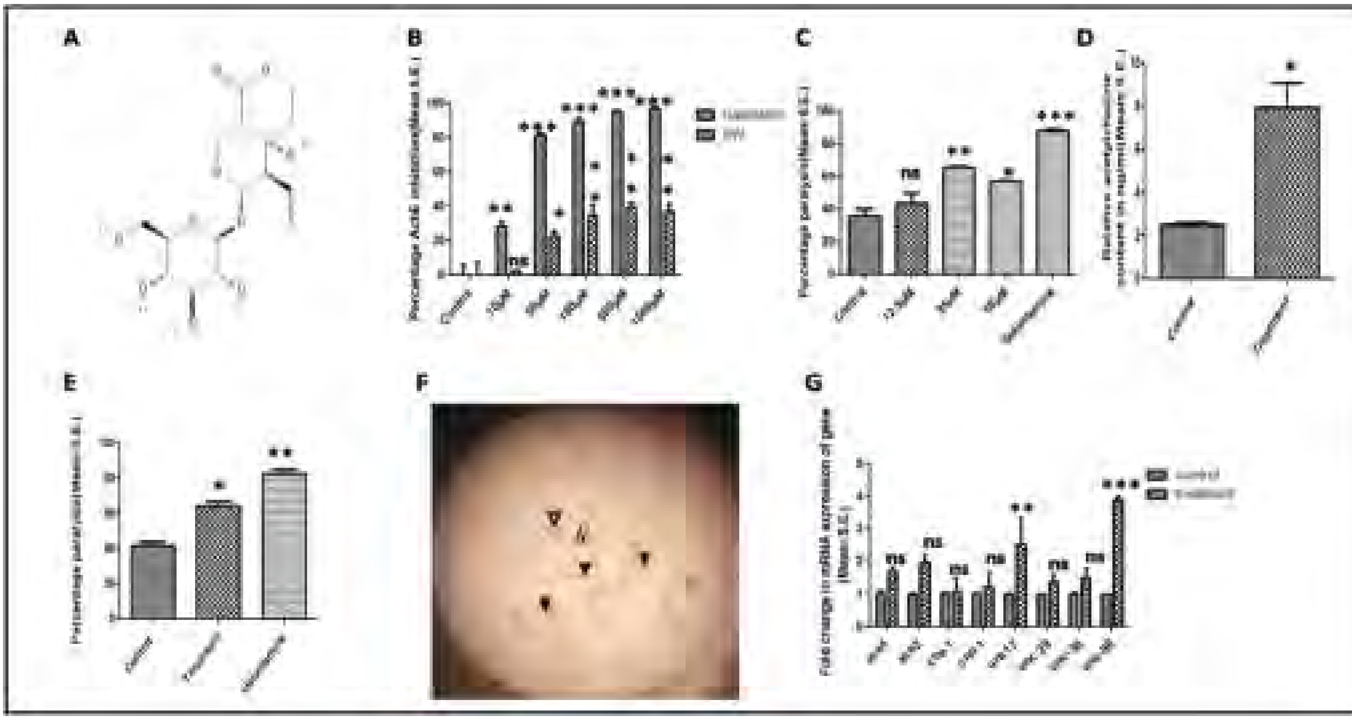
Aging is a multifaceted process characterized by various physiological changes along with gradual decline in function. Considering the therapeutic potential of limonene (C10H16), the principal component of the Rutaceae family plants, the present study was designed to decipher lifespan and stress-modulating potential of monocyclic terpene limonene (LM) employing genetically tractable model system *Caenorhabditis elegans*. Furthermore, we tested oxidative stress tolerance and *in vivo* reactive oxygen species build-up, which was monitored with or without exposure to LM. Additionally, involvement of transcription factor DAF-16 was examined in terms of nuclear localization. Overall, this study has implications for developing future anti-ageing pharmacological strategies in the future. Current Science (2019) 116(6): 959-965.

Computational Insights into the active structure of SGK1 and its implication for ligand design

Serum- and glucocorticoid-inducible kinase 1 (SGK1), a protein kinase, shares significant structural similarity with other members of the AGC protein kinase family. It has been reported that the inactive SGK1 structure lacks aC helix and this unique feature makes it distinct from other protein kinases. Activation of SGK1 by PDK1 requires phosphorylation at Thr256, but the structural insights of the activation remain unclear. The co-crystal structures of small molecule inhibitors, Magnesium (Mgþ2) and ATP bound to the inactive SGK1 are reported however the important regulatory domains such as aC helix are missing in these crystal structures. We modelled the missing aC domain and employed computational molecular dynamics simulations to study the conformational changes in the WT and phosphorylated human SGK1 to systematically investigate how the individual domain motions are modulated by the binding of substrate and Mgþ2. The MD results corroborate with the experiential findings and has shown that the inactive SGK1 lacks aC helix content. Surprisingly, we find that the active SGK1 structure closely resembles with other protein kinases and adopt the aC helix content up on SGK1 phosphorylation. However, the residues participating in aC helix formation are fewer than reported in protein kinase A structure, a close relative of SGK1. The computational binding analysis reveals that most of the SGK1 selective inhibitors have less binding affinity for active SGK1 than some FDA-approved kinase inhibitors such as Afatinib, Tofacitinib, Dabrafenib, and Palbociclib. Only EMD638683 was seen as a strong candidate for selective SGK1 inhibition. To our knowledge, this is the first dynamic study of SGK1 that provides new structural insights around the active site that would surely help the experimental biologists for the design of suitable selective ligands able to inhibit or activate SGK1 function. Biochimie (2019) 165: 57-66.

Swertiamarin, a secoiridoid glycoside modulates nAChR and AChE activity

The ailments related to a malfunction in cholinergic functioning currently employ the use of inhibitors for acetylcholinesterase (AChE) and N-methyl-D-aspartate (NMDA) receptors. The present study was designed to elucidate the potential of swertiamarin (SW), a secoiridoidal glycoside isolated from Enicostemma littorale in curtailing the cholinergic dysfunction. Using Caenorhabditis elegans as a model, SW was found to enhance neurotransmission by modulating AChE and nicotinic acetylcholine receptor (nAChR) activity; being orchestrated through up-regulation of unc-17 and unc-50. SW exhibited AChE inhibition both in vivo and cell-free system. The in silico molecular docking of SW and human AChE (hAChE) displayed good binding energy of −6.02. Interestingly, the increase in aldicarb and levamisole sensitivity post SW treatment was curtailed to a significant level in daf-16 and skn-



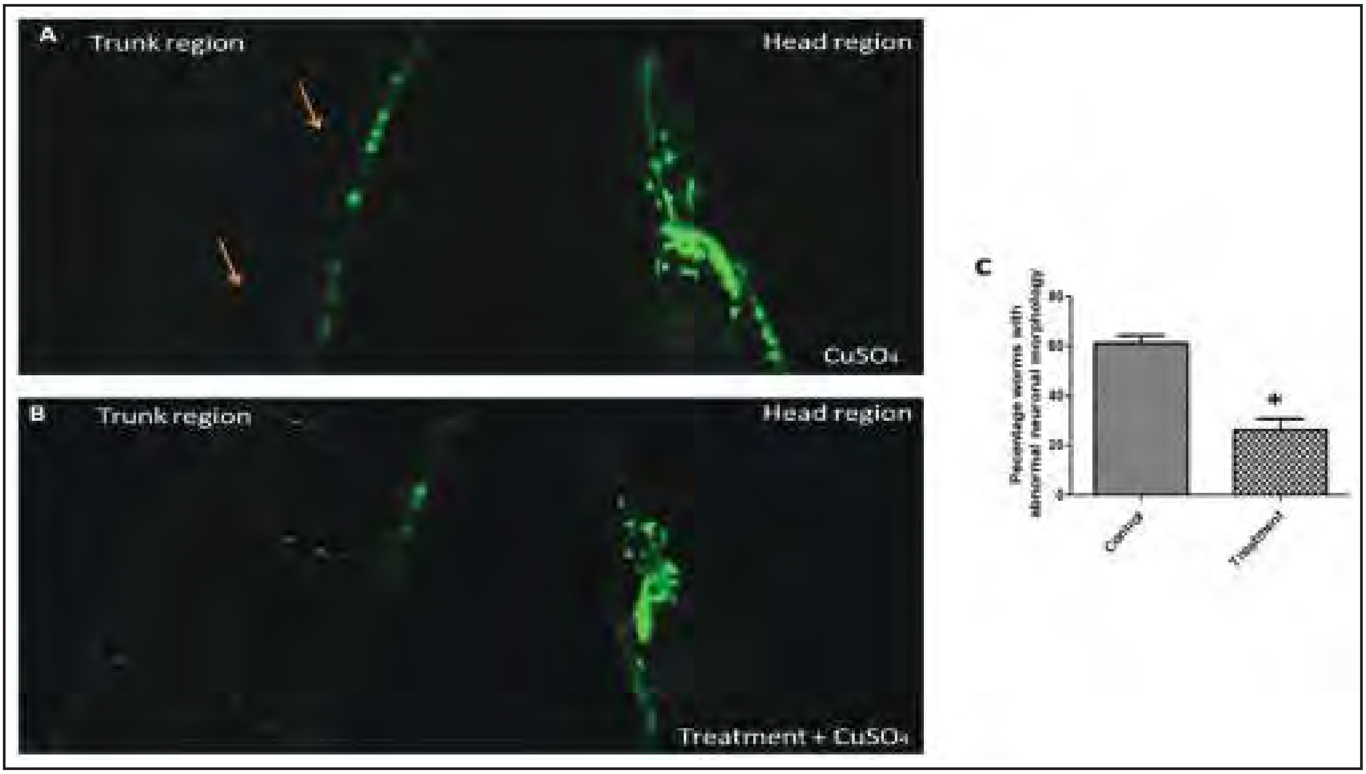
1 mutants. SW raised the level of the endogenous antioxidant enzymes through up-regulation of sod-3 and gst-4 that act downstream to DAF-16 and SKN-1, imparting protection against neurodegeneration.

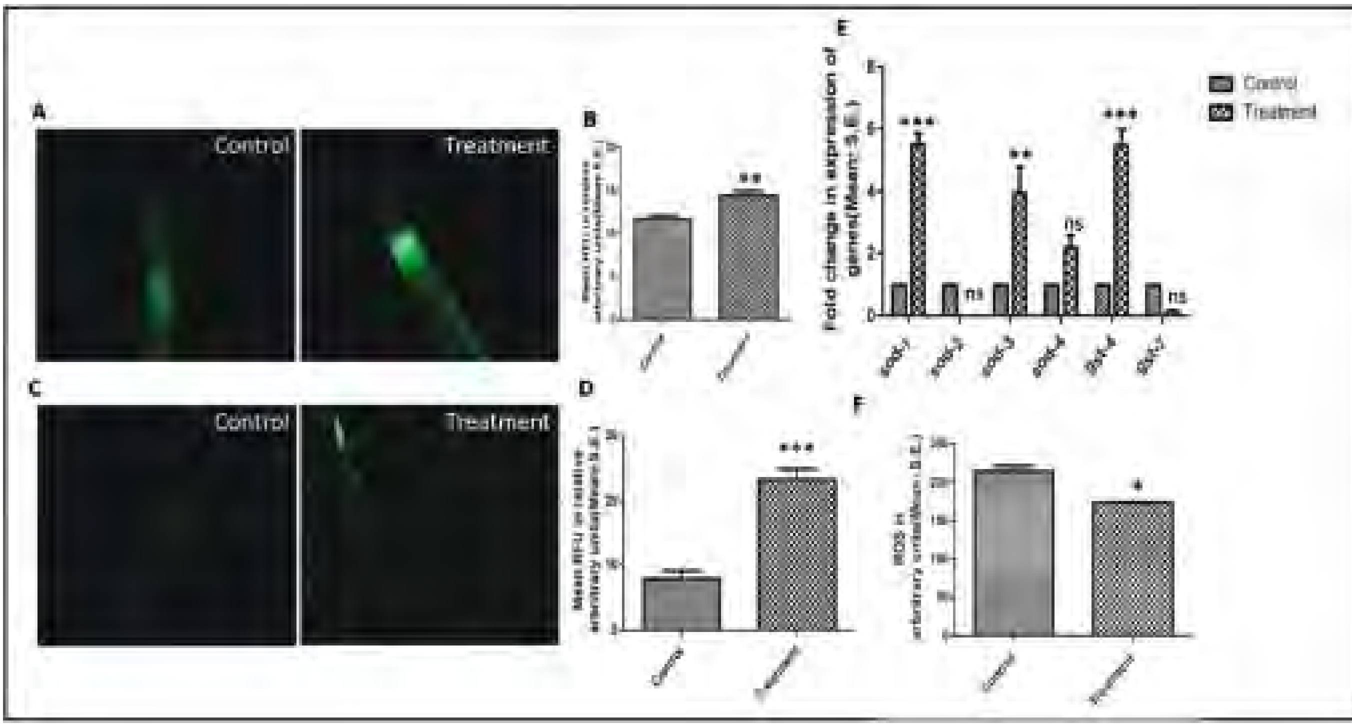
The outcome of our study displays SW as a potential natural molecule for the amelioration of cholinergic dysfunction. Moreover, the study also indicates that SW elicits antioxidant response via up-modulation of daf-16 possibly through unc-17 upregulation. Further research on SW pertaining to the underlying mechanism and potential is expected to significantly advance the current understanding and design of possible ameliorative or near ameliorative regimens for cholinergic dysfunction.

SW enhances cholinergic transmission by elevating synaptic ACh levels and positively modulating nAChRs. (A) Structure of swertiamarin, a secoiridoid glycoside (Courtesy PubChem, U.S. National Library of Medicine, National Center for Biotechnology Information). (B) SW and galantamine treatment showed a significant AChE inhibition activity 50 μM, 100 μM, 500 μM and 1000 μM. Galantamine was also effective at lower concentrations of 10 μM and 50 μM. (C) Treatment at 25 μM SW, 50 μM SW and 50 μM galantamine significantly elevated aldicarb induced paralysis and indicated towards an increase in synaptic ACh levels in a dose-dependent manner. However the paralysis at 12.5 μM was non-significant. (D) SW treatment increased acetylcholine content in worms as shown by LC/MS-MS analysis. (E) Treatment with 25 μM SW and 50 μM galantamine (standard with both AChE and nAChR modulating activity) increased the levamisole induce paralysis thus pointing towards the positive effect of SW on nAChR activity. (F) Representative image of worms with induced paralysis, the white arrow represents un paralyzed worm and black arrow paralyzed worm. (G) The qPCR studies showed an increase in mRNA expression of unc-17 (acetylcholine transporter) and unc-50 (regulator of nicotinic acetylcholine receptor). (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; NS = Non-significant).

SW provides protection against metal-induced cholinergic neurodegeneration (A) Representative photomicrograph of worms exposed with CuSO4. The damaged neurons are indicated through orange arrows. (B) Representative photomicrograph of worms with SW treatment + CuSO4. (C) Graphical representation of the effect of SW on Copper induced cholinergic neuron degeneration in LX929 worms. (*$p < 0.05$).

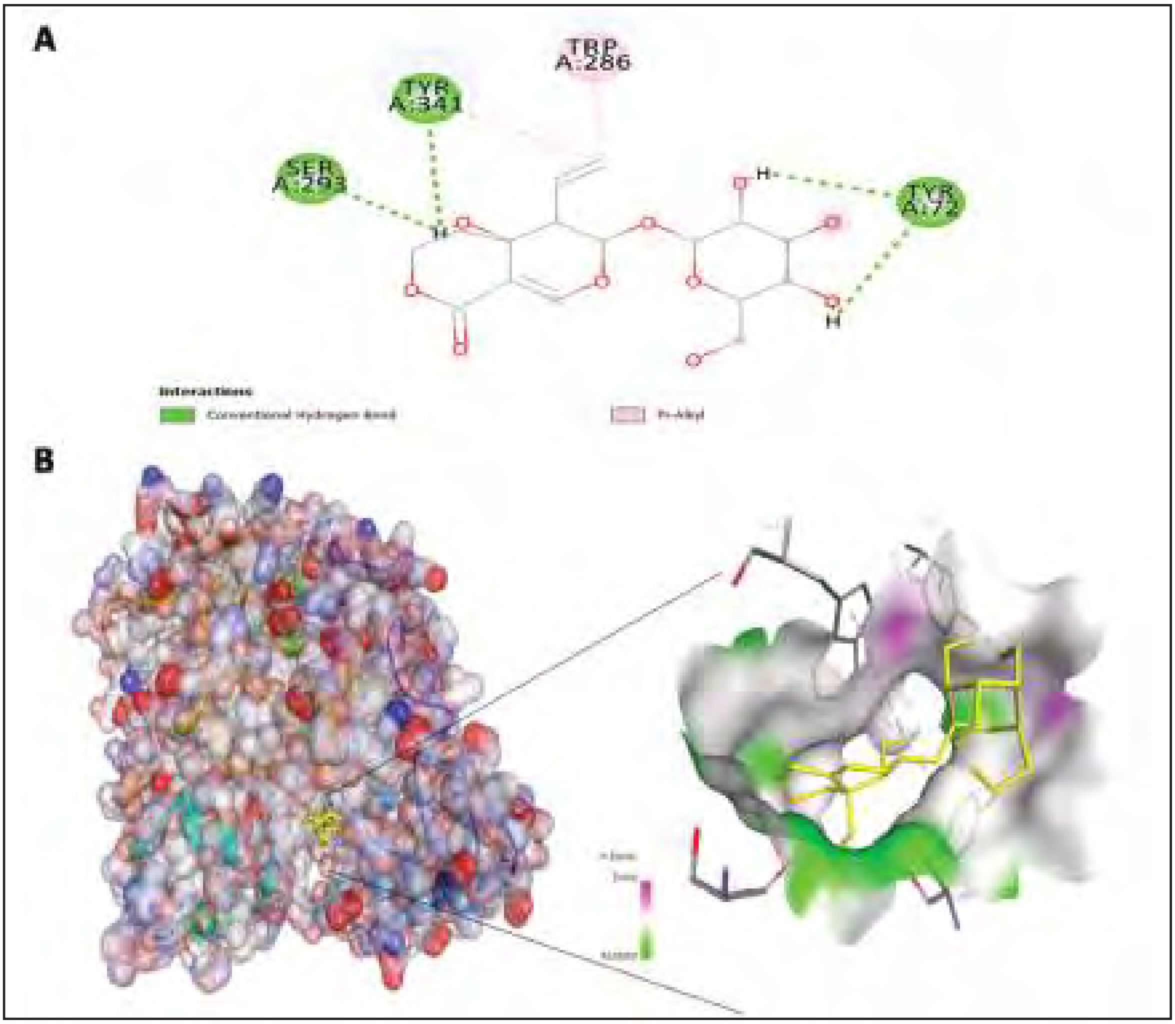
SW mitigates ROS levels in worms and increases antioxidant enzyme levels. (A) Representative photomicrograph of control and SW treated GST-4:: GFP worms. (B) Graphical representation of the increased expression of GST-4:: GFP post-SW treatment. (C) Graphical representation of elevated levels of SOD-3 expression in SOD-3:: GFP worms. (D) Representative photomicrograph of control and SW treated SOD-3::





GFP worms. (E) The qPCR studies showed an increase in mRNA expression of sod-1, sod-3, and GST-4 levels. (F) The treatment with SW curtailed ROS levels in N2 worms (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; NS = Nonsignificant).

Molecular docking analysis of SW and human AChE. (A) In-silico analysis: 2D representation of the binding mode of SW on the active site of hAChE. (B) The figure showing 3D structure of human AChE where the protein chain is displayed with a white solid ribbon. The CDD



(conserve domain database) identified active site amino acid residues are represented with stick form and the red sphere represents Discovery studio predicted binding site for human AChE. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Dr. Rakesh Pandey & his team

Input: Kishore Babu Bandamaravuri
किशोर बाबू बंदामारावुरि

Charcoal rot disease resistance screening of Mentha arvensis cultivars

In recent years the *M. arvensis* crop at different locations in northern Indian plains was found severely infected with *Macrophomina phaseolina*. The *M. arvensis* cultivars such as Kranti, Shivalik, Himalaya, Gomati, Saksham, Saryu, Kosi, and Kalka developed by CSIR-CIMAP were screened for the resistance source against charcoal rot disease caused by *M. phaseolina* under glasshouse and field conditions. The cultivars Kranti, Gomati, Saryu were resistant, while Shivalik, Himalaya, Saksham and Kalka were moderately resistant, and Kosi was moderately susceptible. The seven cultivars from eight, showed less significant damage by the *M. phaseolina*, while Kosi cultivars showed high damages. The studies support that Kranti, Gomati, and Saryu cultivars could be suggestible for sustainable cultivation under IGP region to reduce the *M. phaseolina* associated diseases and prevent yield losses (Table 1). *Indian Phytopathology* (2020). https://doi.org/10.1007/s42360-020-00205-2.

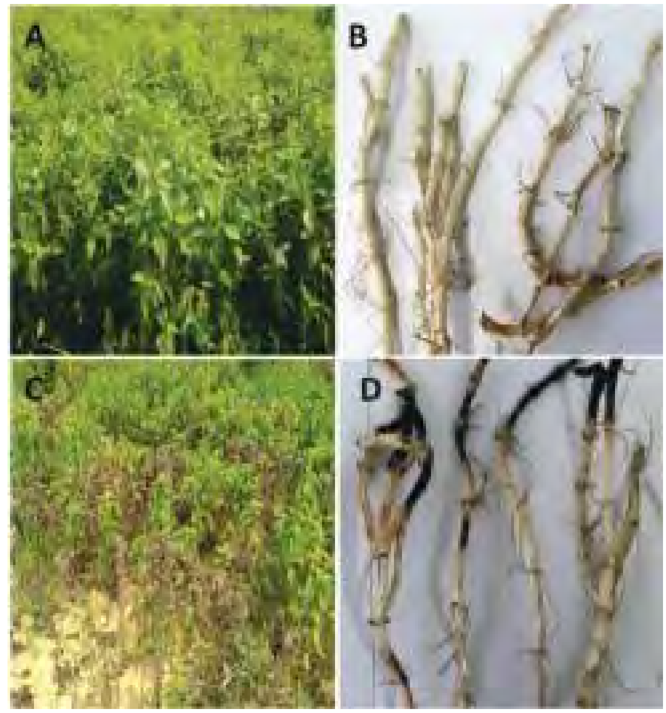


Figure 1: A-B. Indicating healthy plants and suckers of *M. arvensis* crop, C. Field view of infected *M. arvensis* crop and, D. infected suckers showing stolon rot symptoms.

Table 1: Disease incidence and severity of *M. phaseolina* (MpK01) on different cultivars of *M. arvensis* under glasshouse, and field conditions. * Standard deviation given in parentheses.

Sl. No	Cultivars	Disease incidence (%)						Severity scale		Reaction
		Glasshouse			Field			Glasshouse	Field	
		2016	2017	2018	2016	2017	2018			
1	Kranti	4	6	8	1.00 (0.16)*	1.33	2.33 (0.69) *	1	1	R
2	Shivalik	12	16	18	11.33	14.00 (0.59)*	13.33	2	2	MR
3	Himalaya	14	16	24	12.66	15.00	17.33	2	2	MR
4	Gomti	10	8	6	4.66	6.00	5.33	1	1	R
5	Saksham	24 (0.57)*	28	32	17.33	20.66	20.00	2	2	MR
6	Saryu	8	10	8	5.00	7.33 (0.60)*	4.66	1	1	R
7	Kosi	60	50	56	38.33	41.66	53.33	3	3	MS
8	Kalka	12	16	14	14.00	17.33	22.66	2	2	MR

Vascular wilt of *Mentha arvensis* caused by *Fusarium proliferatum* strain MaKf1 in Uttar Pradesh, India

Vascular wilt and Stolon rot of *M. arvensis* became an emerging threat to commercial cultivation as well as planting material propagation nurseries (Fig. 1). In the current study, three major varieties (Kranti, Himalaya and Kosi) widely cultivating in Barabanki, Raebareli, Sitapur and Lucknow districts of Uttar Pradesh were surveyed. Stolon rot and vascular wilt disease incidences were estimated up to 15 % in these districts. The districts Barabanki and Lucknow were recorded a high percent (13-15 %) of disease incidence on *M. arvensis* var. Kosi. Moderate incidence 7% and 11% of vascular wilt disease were observed on *M. arvensis* var. Himalaya in Barabanki and Lucknow, respectively. In comparison with other varieties, very fewer incidences (3-5%) were observed on Kranti variety at Sitapur, Raebareli, and Lucknow districts. Infected

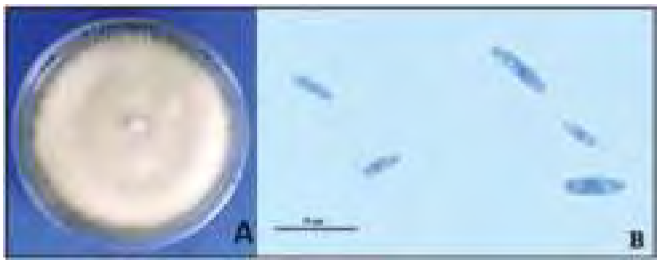


Figure 2: A. Isolate MaKf1 growth on PDA plates, B. septate microconidia

plant samples were collected and several fungal cultures were isolated. Pathogenicity assay of three representative isolates indicated that the isolate MaKf1 was the causative agent of the vascular wilt and stolon rot diseases on *M. arvensis*. Based on morphological, molecular and pathogenicity characters, the pathogen MaKf1was identified as *Fusarium proliferatum* (Fig. 2). JMAPS 42 (1-2), 2020.

Duplex-qPCR and HRM analysis for simultaneous detection of downy mildew and powdery mildew pathogens on *Cucumis sativus* and other cucurbits

Identification and detection of powdery mildew and downy mildew pathogens from field and plant material could be significant for the selection of resistant varieties and formulation of disease management strategies. In the present study, a duplex qPCR assay developed for simultaneous detection and quantification of both pathogens from different samples. Two sets of species-specific primers developed for the detection of *P. xanthii* and *P. cubensis* pathogens by targeting the internal transcribed spacer (ITS) region of the rDNA gene cluster. The specificity of designed primers was also evaluated against the different microbial, plant, soil, and environmental samples. The duplex PCR assay for *P. cubensis* and *P. xanthii* was validated using their corresponding species-specific primers, which amplified the prominent and distinctive products of ~705 bp and ~290 bp size, respectively (Fig. 3). SYBR green-based duplex real-time PCR assay was developed to detect and quantify both mildew pathogens from different field samples. The species-specific oligonucleotide primer sets showed high specificity with melt curve peaks at 85.83 ºC and 88.05 ºC, for *P. xanthii* and *P. cubensis*, respectively (Fig. 4). The species-specific PCR and qPCR assays in both simplex and duplex formats have been validated and these assays could be useful for efficient

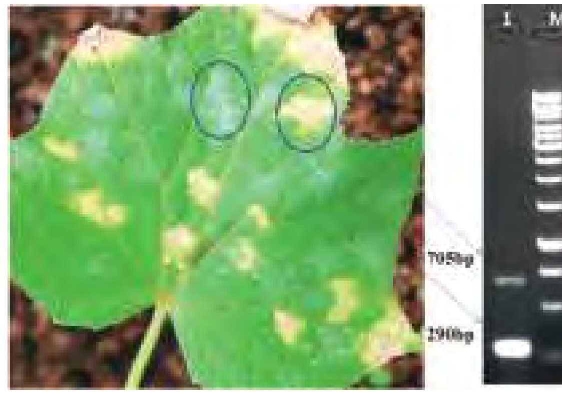


Figure 3: Species-specific duplex PCR assay: downy mildew and powdery mildew infection on *Cucumis sativus* leaf indicating simultaneous detection of *P. cubensis* and *P. xanthii*.

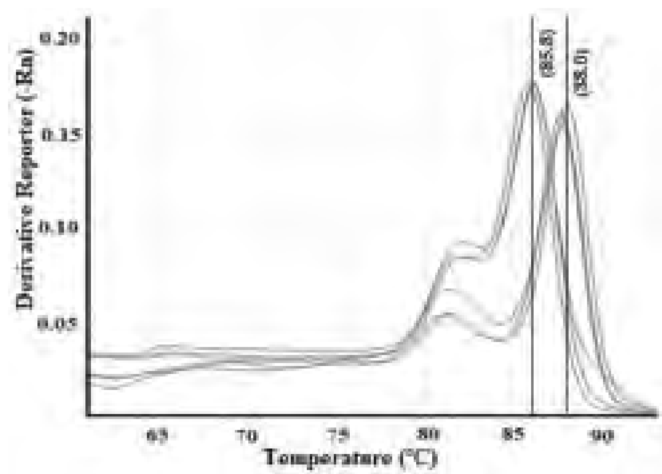


Figure 4: HRM analysis of duplex qPCR assay indicating two specific signature peaks at 85.8 ºC for *P. xanthii* and 88.0 ºC for *P. cubensis*.

detection and quantification of mildew pathogens from the cucumber and other cucurbit crops. AMB express: https://doi.org/10.1186/s13568-020-01071-x (In press)

Dr. Kishore Babu Bandamaravuri & his team

Input: Santoshkumar Chandappa Kedar संतोषकुमार चंदप्पा केदार

Insect pests of medicinal and aromatic plants (MAPs)

In total 60 insect pests infesting MAPs and their natural enemies were recorded during 2019-20. Ten insect pests were recorded on *Ocimum* spp. at CIMAP Research Farm, Lucknow. Seven hemipteran pests viz., lace bug, *Cochlochila bulita* (Tingidae), aphids, *Aphis gossypii*; *Aphis craccivora* (Aphididae), whitefly, *Bemisia tabaci* (Aleyrodidae), green bug, *Nezara viridula* (Pentatomidae), stink bug, *Dolycoris indicus* (Pentatomidae) and scale insect, *Icerya* spp. (Monophlebidae) were found infesting the *Ocimum* spp. Others insect pests includes leaf folder, *Syngamia abruptalis* (Lepidoptera: Pyralidae), termites, *Microtermes incertoides* (Isoptera: Termitidae) and unidentified species of chrysomelid beetle (Coleoptera: Chrysomelidae). Lace bug, *C. bulita* (Fig. 1) appeared as major pest of *Ocimum basilicum, O. sanctum O. africanum* and *O. kilimandscharicum*. Severe infestation of the pest leads to complete drying of *Ocimum* spp. plants.

Major insect pests of *Mentha* spp.

Nineteen insect pests' species were recorded on *Mentha* spp. along with their period of activity at CIMAP Research Farm, Lucknow and farmer fields. On Mentha, 15 species of defoliators, namely, *Spodoptera litura* (Fig. 2), *Helicoverpa armigera* (Fig. 3), *Thysanoplusia orichalcea* (Fig. 4), *Agrotis* sp. (Lepidoptera: Noctuidae) (Fig. 5), *Spilosoma obliqua* (Arctiidae: Lepidoptera)(Fig. 6),*Syngamia abruptalis* (Lepidoptera: Pyralidae)(Fig.7), *Olene mendosa* (Lymantriidae: Lepidoptera), *Hyposidra talaca* (Lepidoptera: Geometridae), *Raphidopalpa foveicollis,* unidentified species of chrysomelid beetle (Coleoptera: Chrysomelidae), termite, *Microtermes incertoides* (Isoptera: Termitidae) (Fig. 8), unidentified grasshoppers (3 species) (Orthoptera: Acrididae) and katydid, *Phaneroptera gracilis* (Orthoptera: Tettigoniidae) were recorded infesting different growth stages. Sucking insect pests were the second major group with *Bemisia tabaci* (Aleyrodidae: Hemiptera), *Myzus persicae* (Hemiptera: Aphididae), *Cochlochila bullita* (Hemiptera: Tingidae) and unidentified species of spittle bug (unidentified). Further, the survey studies of mentha growing areas of Lucknow, Barabanki,

Figure 1: Lace bug (*Cochlochila bulita*)

Figure 2: *Spodoptera litura*

Figure 3: *Helicoverpa armigera*

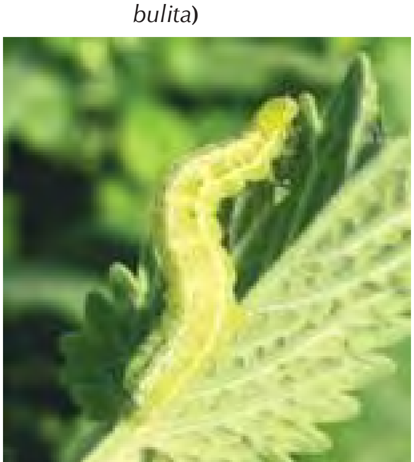


Figure 4: *Thysanoplusia orichalcea*

Figure 5: *Agrotis* sp.

Figure 6: *Spilosoma obliqua*

Figure 7: *Syngamia abruptalis*

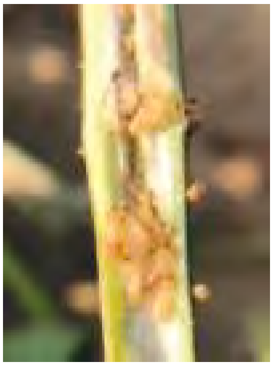


Figure 8: *Microtermes incertoides*

Sitapur and Raebareli districts also revealed that the *S. litura, H. armigera, T. orichalcea, S. obliqua, Agrotis* sp. and *B. tabaci* occurs on mentha as major regular pests. In menthaseven coccinellid predators, namely, *Coccinella septempunctata* (Fig.9), *Cheilomenes sexmaculata* (Fig.10), *Coccinella transversalis* (Fig.11), *Propylea dissecta* (Fig.12), *Brumoides suturalis* (Fig.13), *Illeis confusa* (Fig.14), *Micraspis* sp. (Fig.15) and syrphid fly (unidentified) (Fig.16) were found preying on aphids and whiteflies at CIMAP Research Farm and famers' fields. *C. septempuctata, C. sexmaculata, C. transversalis, P. dissecta* and *Micraspis* sp. were the most abundant predator species. The natural parasitization of *S. obliqua* by larval parasitiods, namely, *Glyptapanteles obliquae, Cotesia ruficrus* and *Meteorus* sp. (Hymenoptera: Braconidae) (Fig.18) was recorded during the study period. The major activity of these parasitiods was noticed from December to May during cropping season. The identity of insect pests and their natural enemies was confirmed by the taxonomist of respective insect groups.

Twenty five species of phytophagous insects belonging to Hemiptera (18), Coleoptera (3), Lepidoptera (2) and Orthoptera (2) orders were recorded on *Withania somnifera* at CIMAP Research Farm, Lucknow. The sap suckers includes mealybugs (*Phenacoccus solenopsis* and *Drosicha spp.*), bugs *(Nezara viridula, Dolycoris indicus, Agonosscelis nubilis, Eysarcoris montivagus, Eurysaspis flavescens, Plautia crossota, Spilostethus* sp., *Graptostethus servus, Nysius ericae* and *Dysdercus cingulatus*),aphids *(Myzus persicae, Aphis craccivora* and *Aphis gossypii)* and membracids (3 unidentified species) were found feeding on the growing shoots, flower buds, leaves and berries of ashwagandha.Hadda beetle (*Henosepilachna vigintioctopunctata),*unidentified weevil, chrysomelid beetle (unidentified), *Helicoverpa armigera, Acherontia*

Natural enemies of insect pests of *Mentha* **spp.**

Figure 9: *Coccinella septempunctata*

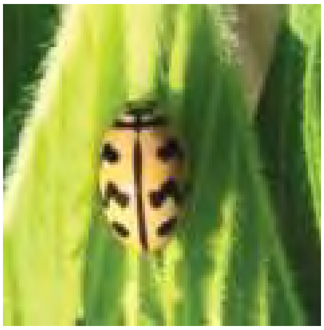


Figure 10: *Cheilomenes sexmaculata*

Figure 11: *Coccinella transversalis*

Figure 12: *Propylea dissecta*

Figure 13: *Brumoides suturalis*

Figure 14: *Illeis confusa*

Figure 15: *Micraspis* sp.

Figure 16: Syrphid fly

Figure 17: *Cotesia ruficrus*

Figure 18: *Meteorus* sp.

styx, and grasshoppers (two unidentified species) were the defoliators observed during early to late crop growth stages. (*Henosepilachna vigintioctopunctata* Fig.19), peach aphid (*Myzus persicae* Fig. 20*),* mealybug (*Phenacoccus solenopsis* Fig. 21) and seed bug (*Spilostethus* sp. Fig. 22*)* were the dominant insect pests among the reported insect pests. The natural parasitism of *Pediobius foveolatus* (Hymenoptera: Eulophidae) was recorded on the grubs of *H. vigintioctopunctata*. The infestation of peach aphid was observed on the plant during January-February. *Coccinella septempunctata, Cheilomenes sexmaculata, Coccinella transversalis*

Figure19: *Henosepilachna vigintioctopunctata* (grubs and adult)

Figure 20: *Myzus persicae*

Figure 21: *Phenacoccus solenopsis*

Figure 22: *Spilostethus* sp.

Figure 23: *Nezara viridula*

Figure 24: *Plautia crossota*

Figure 25: *Nysius ericae*

Figure 26: *Phenacoccus solenopsis*

and *Propylea dissecta* and syrphid fly (unidentified) were major predators found preying on aphids infesting ashwagandha. Natural parasitization of *Aenasius arizonensis* was recorded on *P. solenopsis*. Infestation of seed bug (*Spilostethus* sp.) was found on the growing shoots, flower buds and berries of plant.

Total nine species of insect pests were recorded on *Artemisia annua,* namely, *Nezara viridula* (Fig. 23), *Plautia crossota* (Fig. 24), *Dolycoris indicus* (Hemiptera: Pentatomidae), *Spilostethus* sp., *Nysius ericae* (Fig. 25) (Hemiptera: Lygaeidae), *Phenacoccus solenopsis* (Fig. 26) (Hemiptera: Pseudococcidae), *Hyposidra talaca* (Lepidoptera: Geometridae), *Helicoverpa armigera* (Lepidoptera: Noctuidae) and unidentified leaf webber (Lepidoptera). *Nezara viridula, P. crossota, P. solenopsis, N. ericae* and unidentified leaf webber were dominant pest species of *A. annua*. Natural parasitization of *P. solenopsis* by *Aenasius arizonensis* was also recorded during the observation period. Pentatomid bugs eggs were found to be naturally parasitized by unidentified parasitoid up to 75 percent.

Insect pests of medicinal and aromatic plants

Plant	Common name	Scientific name	Family	Order
Cannabis sativa	Stink bug	*Dolycoris indicus*	Pentatomidae	Hemiptera
	Green bug	*Nezara viridula*	Pentatomidae	Hemiptera
	Red spider mite	*Tetranychus urticae*	Tetranychidae	Trombidiformes
	Bihar hairy caterpillar	*Spilosoma obliqua*	Arctiidae	Lepidoptera
	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Nepeta cataria	Soybean looper	*Thysanoplusia orichalcea*	Noctuidae	Lepidoptera
	Red pumpkin beetle	*Raphidopalpa foveicollis*	Chrysomelidae	Coleoptera
	False chinch bug	*Nysius ericae*	Lygaeidae	Hemiptera
	Seed bug	*Spilostethus* sp.*	Lygaeidae	Hemiptera
Rosa damascena,	Rose aphid	*Macrosiphum rosae*	Aphididae	Hemiptera
Rosa moschata	Scale	*Icerya* sp.*	Monophlebidae	Hemiptera
	Whitefly	Unidentified*	Aleyrodidae	Hemiptera
	Grey weevil	*Myllocerus* spp.*	Curculionidae	Coleoptera
	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera

Lepidium sativum	Mustard sawfly	*Athalia lugens proxima*	Tenthredinidae	Hymenoptera
Tylophora indica	Semilooper	*Dichromia sagitta*	Noctuidae	Lepidoptera
Salvia sclarea	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Gymnema Sylvestre	Milkweed aphid	*Aphis nerii*	Aphididae	Hemiptera
Pelargonium peltatum	White grub	*Holotrichia* sp.*	Scarabaeidae	Coleoptera
Cymbopogon martinii	Thrips	*Haplothrips* sp.	Phlaeothripidae	Thysanoptera
Boerhavia diffusa	Mealybug	*Phenacoccus solenopsis*	Pseudococcidae	Hemiptera
Cymbopogon citratus	Mealybug	Unidentified*		Hemiptera
	Scale	*Icerya pilosa*	Monophlebidae	Hemiptera
Andrographis paniculata	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera
	Green bug	*Nezara viridula*	Pentatomidae	Hemiptera
Murraya koenigi	Common mormon	*Papilio polytes*	Papillionidae	Lepidoptera
	Blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera
Glycosmis pentaphylla	Leaf webber	*Omiodes* sp.*	Crambidae	Lepidoptera
	Common mormon	*Papilio polytes*	Papillionidae	Lepidoptera
	Lime butterfly	*Papilio demoleus*	Papillionidae	Lepidoptera
Asparagus racemosus	Leaf eating beetle	*Lema downsei*	Chrysomelidae	Coleoptera
	Root aphids	Unidentified*	-	Hemiptera
Senna angustifolia	White butterfly	*Catopsilia pyranthe*	Pieridae	Lepidoptera
	Green bug	*Nezara viridula*	Pentatomidae	Hemiptera
	False chinch bug	*Nysius ericae*	Lygaeidae	Hemiptera
	Stink bug	*Dolycoris indicus*	Pentatomidae	Hemiptera
Datura metel	Mealybug	*Phenacoccus solenopsis*	Pseudococcidae	Hemiptera
Solanum nigrum	Hadda beetle	*Henosepilachna vigintioctopunctata*	Coccinellidae	Coleoptera
Aegle marmelos	Flea beetle	*Amphimela picta*	Chrysomelidae	Coleoptera
	Lime butterfly	*Papilio demoleus*	Papillionidae	Lepidoptera
Glycyrrhiza glabra	Mealybug	*Phenacoccus solenopsis*	Pseudococcidae	Hemiptera

*Identification in progress

Input: Akanksha Singh आकांक्षा सिंह

Working towards deciphering the molecular mechanisms involved in endophyte mediated enhanced secondary metabolite biosynthesis, plant health, and productivity in medicinal and aromatic plants along with development of "customized" bio formulations for MAPs farmers for promoting organic farming.

Plant Breeding and Genetic Resource Conservation

Highlights of Plant Breeding and Genetic Resource Conservation

The division of plant breeding and genetic resource conservation is putting its systematic efforts on genetic improvement of Medicinal and Aromatic Plants (MAPs) through conventional and molecular biology approaches, development of new varieties and chemotypes of MAPs, the introduction of new crops for genetic improvement, estimation of genetic diversity among different germplasm accessions, studies on morphogenetic divergence and population structure of MAPs, mass multiplication of targeted Rare and Endangered Traits (RET) medicinal plants species, developing protocols for *in-vitro* propagation and synthetic seed production, Pharmacognostic standard of botanicals, maintenance herbarium of MAPs. Another important activity of the division is the curation of the National Gene Bank of Medicinal and Aromatic Plants (MAPs). In fulfilling the aspired objectives, the faculties of the division have been made significant achievements towards the development of improved varieties of all the major Medicinal and Aromatic plants and elucidation of genetic and cytogenetic principles for a better understanding of the genetics of target plants. Faculties of the division have been actively contributed to the Major National projects namely Aroma Mission and Phytopharmaceutical Mission, Namami Gange, and scored several successes.

During this period five varieties of differents MAP have been released. These varieties are CIM ATAL: A geraniol rich lemongrass variety Palmarosa; CIM AKSHAY: A high yielding thymol rich variety of *Ocimum gratissimum* L.; CIM MOHAK: An inter-specific hybrid spearmint variety, very distinct from other spearmint varieties in terms of its novel aroma (21-23% limonene, 58-61% carvone, 1.0-2.0% menthol, 1.0-1.6% iso-dihydro carveol acetate) of long lasting for use in flavour and fragrance; CIM SUKHDA: An inter-specific hybrid (*O. basilicum* X *O. africanum*), rich in linalool (75-80%) and suitable for South Indian climatic condition; CIM SUSHIL: A high vindoline yielding variety of Sadabahar (*Catharanthus roseus*); CIM UNNATI: An essential oil rich (1% content) variety of menthol mint (*Mentha arvensis* L.). Studied on genetic improvement of *Plectranthus vetiveroides* for developing a new variety / chemotype, Promising lines of Prishnparni (*Uraria picta*), *Swertia chirayita* accessions/genotype performing well under lower Himalayan altitude of Uttarakhand, Spearmint (*Mentha spicata*) lines with herb yield, essential oil yield, A high herb yielding citral rich breeding line (Neral and Geranial 60-75%) in *Ocimum basilicum* have been initiated. High amount of genetic variability for morpho-economic traits and chemo-diversity for 24 compounds among 16 accessions of different *Ocimum* species was observed.

Morphogenetic divergence and population structure in Indian *Santalum album* L. revealed the presence of low genetic variability. Population genetics coupled chemical profiling carried out for *Decalepis salicifolia*, an endemic and critically endangered species of Western Ghats, India. An efficient in vitro propagation and synthetic seed production protocol was established for the conservation of *Decalepis salicifolia* (Bedd. ex Hook.f.) Venter, an endemic and critically endangered ethno medicinal species. Attempts have been made for the mass multiplication of targeted RET medicinal plant species *Aristolochia tagala, Coscinium fenestratum, Trichopus zeylanicus, Utleria salicifolia and Decalepis hamiltonii*. Efforts on genetic improvement of *Eucalyptus citriodora* led to the identification of clones with higher oil content over the check.

A process for isolation of total withanamides was developed and "specific withanamide" content was quantified in a set of 124 breeding lines using RP-HPLC. Withanamide A, B, and C markers were also purified and characterized. Captive cultivation of newly released variety CIM Pushti of *Withania somnifera* was undertaken at fields of 21 progressive farmers of Rajasthan, Madhya Pradesh, and Uttar Pradesh under Phytopharma Mission.

CSIR-CIMAP National Herbarium of Medicinal and Aromatic Plants was enriched by 95 plant specimen collected from various loctaions such as Uttarakhand, Jammu and Kashmir, Haryana, Tamil Nadu and Uttar Pradesh. More than 25 new samples were included in crude drug repository. Pharmacognostic standards of botanicals (15 No) have been developed as per United States Pharmacopoeia (USP) guidelines for IND filing /

product development. During this period, three projects were sanctioned from various funding agencies such as Department of Revenue, New Delhi, NMPB, New Delhi, and ACi Bombay. One Ph.D was awraded under CIMAP-JNU Ph.D programme. During this period, the division of plant production and protection published 11 of publications.

Left to right : Dr. V.R. Singh, Dr. Birendra Kumar, Dr. A.K. Gupta, Dr. V. Sunderesan, Dr. Tripta Jhang, Dr. Narendra Kumar, Dr. Channayya Hiremath, Dr. Venkatesha K.T., Dr. Gunjan Tiwari

Input: A.K. Gupta ए.के. गुप्ता

Genetic diversity in Indian poppy (*P. somniferum* L.) germplasm using multivariate and SCoT marker analyses

A study was undertaken to estimate the morphological and molecular diversity present among the 51 accessions of Indian opium poppy germplasm using Mahalanobis D^2 and SCoT (Start Codon Targeted Polymorphism) marker analyses, respectively. A good range of morphological variations was observed among the accessions. The accessions were clumped into nine clusters and the morphological diversity recorded was 69%. Clusters VII and IX showed the maximum inter-cluster distance (117.97) whereas it was found to be minimum (21.53) in the case of clusters II and III. The morphological trait, seed weight per capsule, contributed maximum (17.30%) towards the genetic divergence followed by the baine content (14.56%) and papaverine content (14.06%). In contrast to the morphological diversity, genetic diversity at the molecular level was found to be limited (33%), although successfully detected by utilizing DNA markers targeting coding regions of the genome (SCoT markers). (*Industrial Crops and Products*. IF: 4.244)

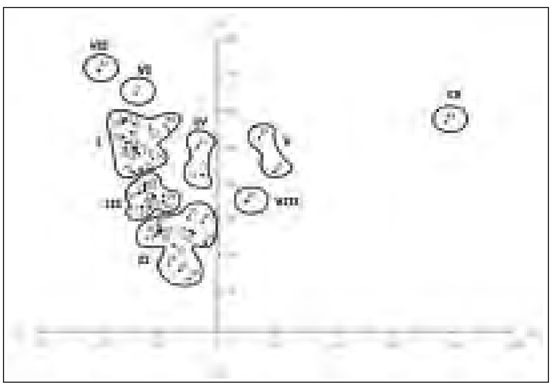


Figure 1: Spatial distribution of 51 genetic stocks of opium poppy in λ1-λ2 chart. The numbers 1-51 represents the 51 accessions taken in the study.

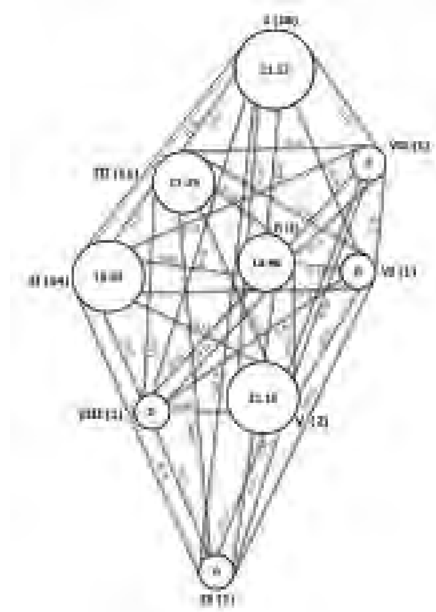


Figure 2: Cluster diagram with their genetic distances of 51 genetic stocks of opium poppy germplasm.

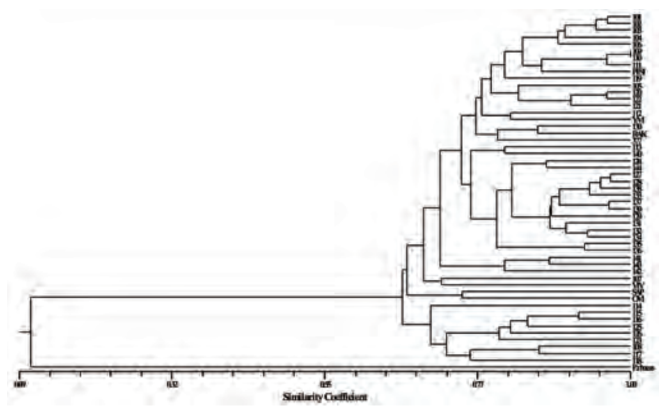


Figure 3: Clustering of opium poppy accessions based on SCoT marker analysis.

Dr. A.K. Gupta & his team

Input: Ved Ram Singh वेद राम सिंह

Quantification of genotypic and chemotypic diversity for elite clone selection with high quality essential oil traits in Vetiver [*Chrysopogon zizanioides*(L.) Roberty]

Vetiver (*Chrysopogon zizanioides*(L.) Roberty (Poaceae) is a perennial herbaceous grass. It is cultivated for the production of high-value essential oil, which imparts a robust and persistent woody odor escorted with different undertones such as earthy, grapefruit-like, flowery, smoked, ambery, etc. The study aims to determine the genotypic and chemotypic diversity in twenty-three genetic stocks of vetiver. The nature, proportion, and degree of genetic diversity were evaluated using

Figure 1: Spatial distribution of twenty-three genetic accessions of Vetiver in λ1-λ2 chart

Mahalanobis D2-statistics on seven agroeconomical quantitative traits. All the vetiver accessions were grouped into six clusters wherein, the intercluster distance was observed maximum in between I and III cluster pair (117.18) and minimum in II and IV cluster pair (64.98). Among seven economic characters, plant height (59.33 %) was found to be leading contributor toward genetic diversity, followed by essential oil yield (10.43 %). However, root length (2.77 %) showed the lowest contributing character towards genetic diversity. The genetic variability was also studied through the percentage chemical constituents present in the essential oils. The result of the present study concluded to enhance the traits of auspicious OPSPs accessions, responsible for high oil yields with specific chemical constituents to meet the market demand of khus essential oil. The accession VS-20 and VS-23 were found to be highly divergent genotypes among all and could be chosen for further exploitation in the hybrid breeding program to develop superior cultivars of vetiver. The clones rich in specific constituents like khusinol (VS-9), khusimol (VS-11), and khusilal (VS-17) and high essential oil could also be selected for further exploitation. (Journal of Essential Oil Bearing Plants, 22:4, 1150-1162)

Improvement of latex-less and low alkaloid variety of *Papaver somniferum* L. towards the development of phenotypically distinct variety for commercial exploitation as nutritive seed crop

Multi-location, trials were set at CSIR-CIMAP Lucknow and Research Centre Pantnagar to obtained pure seeds in bulk quantity of variety Sujata (opium less and alkaloids free) for R&D purpose.

Large scale screening and identification of variety 'Sujata': Individual self-pollinated capsules were checked for latex, based on latex study self-pollinated capsules were classified into three groups namely zero latex (OL), partial latex (PL), and latex capsules.

Screening of the desired recombinants: Growing of all the three segregating generations/ progenies (F_2, BC_1 and BC_2) would be in a large area to raise suitable populations for effective selections of the desired traits for low alkaloids and high seed yields.

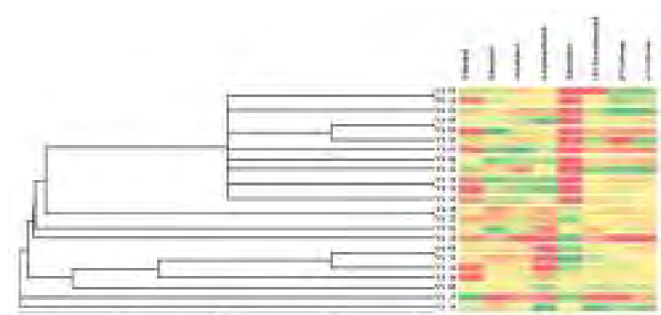


Figure 2: Bidimensional dendrogram representing the similarity among twenty-three accessions of Vetiver for the chemical composition of the essential oils.

Dr. Ved Ram Singh & his team

Input: Birendra Kumar बीरेन्द्र कुमार

Genetic improvement of MAPs using crop-specific breeding strategies: Radiofrequency cold plasma treatment enhances seed germination and seedling growth in variety CIM-Saumya of sweet basil (*Ocimum basilicum* L.):

Radiofrequency plasma method is a newly emerging physical seed treatment method for enhanced germination of various crops. Cold plasma seed exposure with different RF power such as T2 (30 W), T3 (90 W), T4 (150 W), T5 (210 W) and T6 (270 W) was applied to work out its stimulatory effect on sweet basil (*Ocimum basilicum*) seed. The T4 (150 W) cold plasma treatment had the highest stimulatory effect on germination and vigor among all the studied doses of treatments. An increase in the germination and seedling vigor of sweet basil might be a consequence of the increases in water uptake, seed reserve mobilization, and depletion rate at T4 treatment. [Journal of Applied Research on Medicinal and Aromatic Plants. 2019:12: 78-81 IF:1.966]

Conservation and genetic improvement of Prishnparni (*Uraria picta*)- a critically endangered Dashmool drug:

Uraria picta (Jacq.) Desv. ex DC. (Family Papilionaceae) is a critically endangered plant and one of the most important ingredients among the ten herbs used for ayurvedic formulation called as Dashmula. Considering the importance of the plant, the present investigation revealed that the accession UP-18 was found to be most promising as the rhoifolin content in the aerial part was 0.67 %, and in the root, it was 0.19 %. While the accessions UP-21 (1.01 %) followed by UP-19 (0.78 %), UP-11 (0.75 %) had highest rhoifolin content in aerial plant part. Based on growth and yield performance of the first year at CIMAP, Lucknow, UP-21, and UP-22 accessions performed well as compared to the rest of the accessions. The RAPD profiling also identified accessions UP-23, UP-21, and UP-01 more genetically diverse which could be utilized in a future breeding program to further broaden genetic variability and select the desired plant type in *Uraria picta*. [Journal of applied research on medicinal & aromatic plants: 2020: 16:100242 (1-7), IF-1.96]

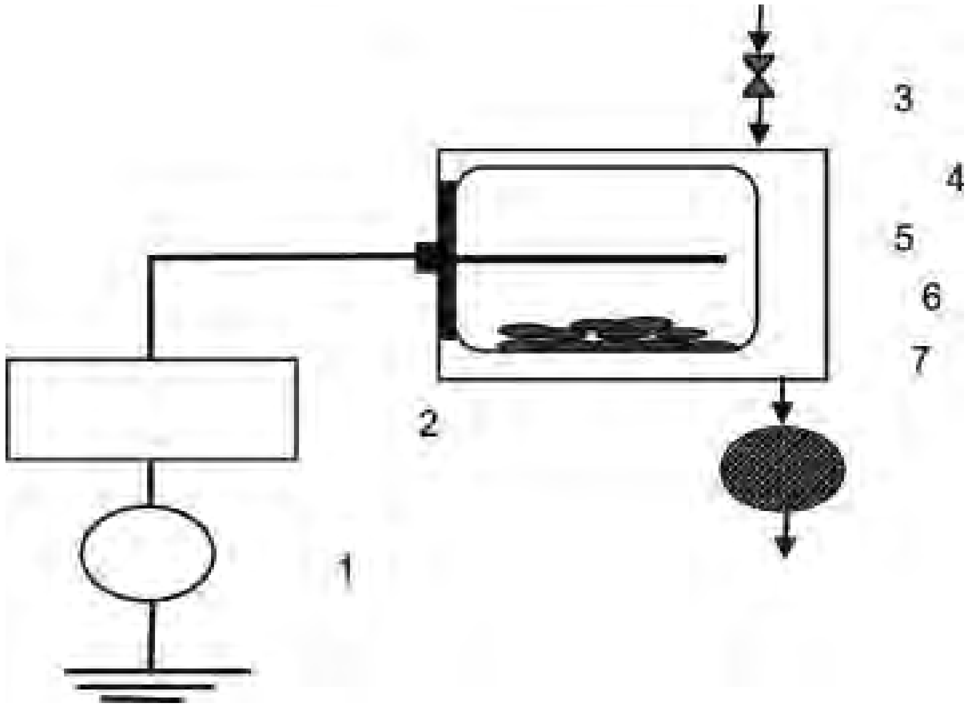


Figure 1: Schematic of Plasma Treatment System. 1 radio frequency generator, 2 matching network, 3 venting valve, 4 treatment chamber, 5 rotating glass jar, 6 radio frequency power electrode with gas inlet, 7 seeds, 8 vacuum pump.

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

Under Asheesh Concentrates International LLP, Mumbai sponsored project, surveyed major Cannabis growing areas of Uttarakhand, U.P., Himachal Pradesh, Haryana, and Jammu and collected about 113 accessions. During the first year, required data have been generated on plant height, length of inter-node, number of primary branches/plant, canopy diameter, Inflorescence length, number of inflorescence/plant, essential oil content(%), etc. for morpho-anatomically characterization of 38 accessions at CRC Pantnanagr and 18 accessions at CIMAP, Lucknow. Twenty-six accessions at the vegetative stage and 17 accessions at the flowering stage were analyzed for metabolite content. Chemical analysis results of first-year crops revealed that the CBD (mg/gm) was ranged from 0.19 to 28.9, THC (mg/gm) from 1.54 to 19.3, THCa (mg/gm) from 1.29 to 19.3 in *Cannabis* germplasm. The maximum number of seedling and seedling length was recorded in FYM+Cocopit (1:1) followed by sand + FYM + Cocopit (1:1:1) substrate.

Seed germination behavior of Cannabis sativa L. under different temperature regimes: Optimum temperature and time required for germination of *Cannabis sativa* seeds collected from Kausani, Uttarakhand have been studied at various temperatures regimes under the controlled laboratory conditions. The results revealed that the percentage of germination (87), germination energy (21), and seedling vigor index I and II (520.0 and 12.3, respectively) was reported maximum at a constant temperature of '25˚C' with having 3^{rd} - 4^{th} and 6^{th} day as its first and final count day, respectively. Therefore, it is suggested to the researchers/cultivators to raise the nursery of *Cannabis sativa* L. seed at '25˚C' to achieve healthy and maximum seedlings of the crop [Journal of Plant Development Sciences: 2020:12: 277-281].

Identification of *Swertia chirayita* genotype (s)/strain (s) performing well under lower Himalayan altitude of Uttarakhand: UPLC coupled with PCA of Swertia chirayita for adulteration check

Five ecotypes of *Swertia chirayita* (SC) (SC Sukhia-1, Darjeeling, WB; SC Sukhia-2, Darjeeling, WB; SC

Sukhia-3, Darjeeling, WB; SC Yuksom, Sikkim and SC Dehradun, Uttarakhand) and five possible substitutions, e.g., *Swertia bimaculata* (SB), *Swertia chordata* (SCH), *Swertia ciliata* (SCL), *Swertia paniculata* (SP), and *Halenia elliptica* (HE) collected from different Indian Himalayan region to standardize phytochemically and distinguish *Swertia chirayita* from that of possible substitution/adulteration using ultra performance liquid chromatography (UPLC) with photodiode array detector (PDA) and chemometric tools viz. principal component analysis (PCA) and hierarchical clustering analysis (HCA). Samples evaluated for 04 marker compounds- swertiamarin (SM), mangiferin (MF), gentiopicroside (GP), and sweroside (SW). Reverse phase column (Waters Acquity BEH C18, 50 mm × 2.1 mm, 1.7 μm) provided high resolution for all target analytes with binary gradient elution. The detector response was linear (concentration 2.5–125 μg/mL, $R^2 > 0.999$). The limit of detection (LOD) and quantification (LOQ) of targeted compounds was in the range of 1.40–2.06 and 4.57–6.27 μg/mL respectively. The combined relative standard deviation (%RSD) for intra-day and inter-day precision values were less than 2%. The recoveries study comply the method suitability. Chromatogram similarity analysis based on congruence coefficient was higher than 0.925 for the *S. chirayita* ecotypes while much lower than 0.629 for possible substitutes. HCA showed that the samples could be clustered (all 5 clusters in two-level) reasonably into different ecotypes and substitutes. HCA together with loading plots has indicated different chemical properties of all five groups. PCA results showed that the discrimination of *S. chirayita* ecotypes is because of the presence of SW while SM may have more influence on the targeted substitutes to discriminate from *S. chirayita* ecotypes. Therefore, UPLC fingerprint in association with chemometric tools provides a reliable and accurate quality assessment and detection of possible adulteration [Journal of Pharmaceutical & Biomedical Analysis : 2019: 164: 302-308, IF: 2.83].

Dr. Birendra Kumar & his team

Input: V. Sunderesan वी. सुंदरेसन

Delineation of *Ocimum gratissimum* L. complex combining morphological, molecular, and essential oils analysis

The presence of differences in the essential oil content, chromosome count, and morphology, led to consider *Ocimum gratissimum* as a polymorphic complex species often subcategorized into subspecies, varieties, and forms. Characterization of *O. gratissimum* complex is carried out using morphological, molecular markers combined with chemical analysis of essential oils in an attempt to resolve the complexity present. At the morphological level, the applied analysis of variance and Tukey's honestly significant difference test reveals that all the studied morpho-metric characters were effective in discriminating the *O. gratissimum* morphotypes. Molecular markers generated a total of 341 loci, of which 290 loci were polymorphic depicting 84.28% polymorphism. Chemo profiling of essential oils revealed eugenol (38.6–79.2%) and thymol (47.6–50.7%), as the major essential oil constituents distributed in *O. gratissimum* accessions studied. Pearson correlation coefficient (r = 0.482) suggested a moderate correlation between the genetic markers and essential oils content. (*Industrial Crops & Products*. 111536 (IF 4.2).

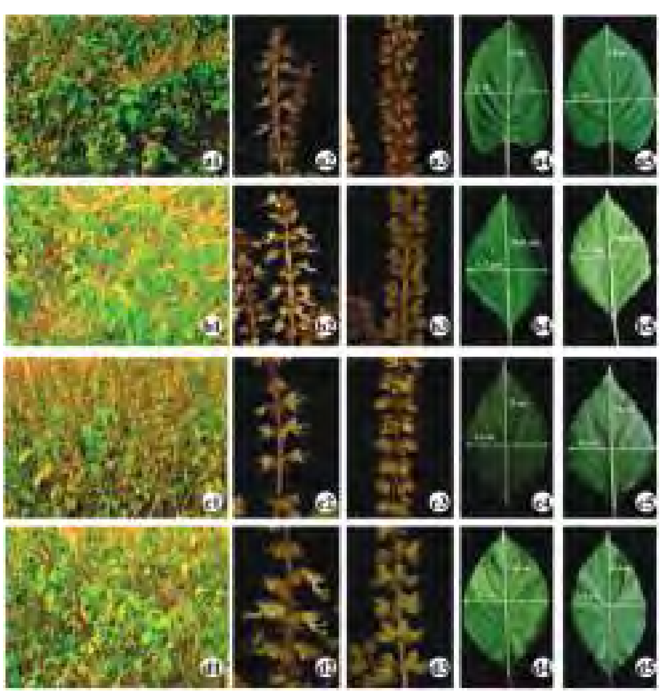


Figure 1: Morphological variations in *Ocimum gratissimum* L.

Typification of three names in *Garcinia* (Clusiaceae)

The tropical genus *Garcinia* L. (Clusiaceae) comprises nearly 250 species in the world. The genus is represented by c. 35 species in India. During a revision of *Garcinia* in India, it felt the necessity of typification of two varietal names viz., *Garcinia gummi-gutta* var. *conicarpa* (Wight) N.P. Singh and *Garcinia gummi-gutta* var. *papilla* (Wight) N.P. Singh and second step lectotypification of the name *Garcinia indica* (Thouars) Choisy. After consulting the protologues and types and other relevant specimens at A, ADB, B, BM, BR, CAL, G, K, L, MH and P, lectotypes have been designated here according to Art. 9.3 and Art. 9.17 of ICN. Epitypes for *Garcinia gummi-gutta* var. papilla and *Garcinia indica* are also designated following Art. 9.9 of ICN.(*Rheedea*. Vol. 29(4): 01-115 IF: 0.18).

Morpho-genetic divergence and population structure in Indian *Santalum album* L.

Santalum album L. is highly valuable among Indian forest tree species and is considered as the second most expensive wood in the world. The present study is the first of its kind that aimed to evaluate morphological and genetic variation as well as population structure of *S. album* using different markers assay from geographically widespread populations of India. The study revealed the presence of low genetic variability in *S. album*, which mandates immediate attention towards its sustainable utilization, propagation, and long term conservation.

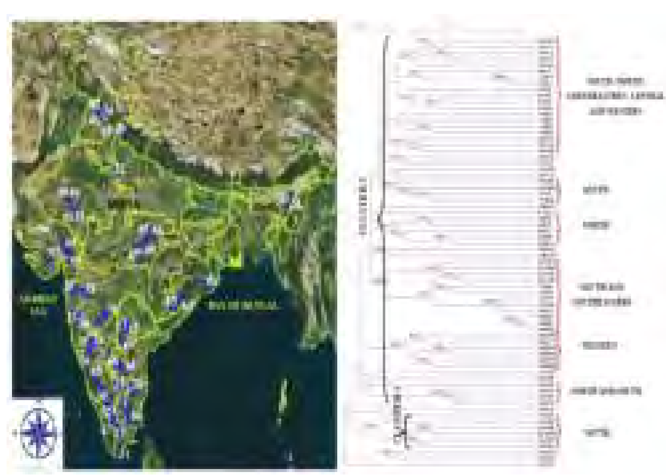


Figure 2: Morpho-genetic divergence and population structure in India *Santalum album*

Micropropagation, encapsulation, and conservation of *Decalepis salicifolia*, a vanillin isomer containing medicinal and aromatic plant

An efficient in vitro propagation and synthetic seed production protocol was established for the conservation of *Decalepis salicifolia* (Bedd. ex Hook.f.) Venter, an endemic and critically endangered ethnomedicinal species. The *in vitro* derived rooted plants were successfully hardened (92.8%) and established in the field with a 100.0% survival rate. Inter-simple sequence repeat markers proved the genetic fidelity among the in vitro grown plant showing 99.5% similarity with the mother plant. Micropropagation derived acclimatized plants produced 2-hydroxy-4-methoxybenzaldehyde in amounts similar to seed-derived field-grown plants of the same age. The *in vitro* propagation protocol developed for *D. salicifolia* can be utilized to reduce exploitation pressure from their natural habitats and augment ecorestoration, conservation, and cultivation of this critically endangered and industrially valuable plant. The synthetic seeds technique will serve as propagules in *ex situ* gene banks, as well as supports cost-effective germplasm conservation.

Figure 3: Micropropogation, encapsulation and conservation of *Decalepis salicifolia*

Population genetics coupled chemical profiling for conservation implications of *Decalepis salicifolia*, an endemic and critically endangered species of Western Ghats, India

Decalepis salicifolia (Bedd. ex Hook.f.) Venter is a steno-endemic and critically endangered species of the South Western Ghats of India. The present study used ISSR markers as well as essential oil profiling to reveal the extent and distribution of genetic as well as the chemical diversity of all the twelve known populations of *D. salicifolia*. The genetic similarity-based unweighted pair-group method with arithmetic average dendrogram grouped the populations according to their geographic locations, which was corroborated by principal component analysis and Bayesian clustering. Gas chromatography analyses of root volatiles showed significant variation in the percent content of 2-hydroxy-4-methoxybenzaldehyde. The Mantel test analyses showed a positive correlation between genetic versus geographic distances.

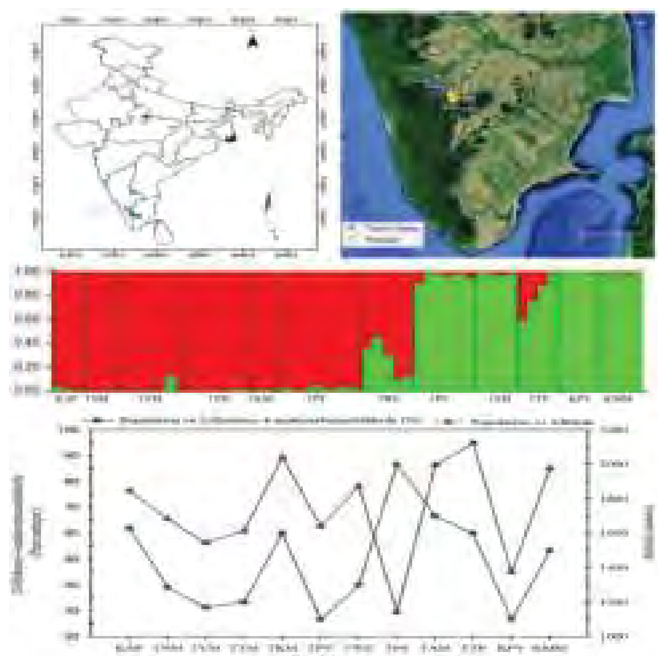


Figure 4: Population genetics coupled chemical profiling for conservation implication of *Decalepis salicifolia*

Genetic improvement of *Eucalyptus citriodora* (V. Sundaresan& K. Baskaran)

Eucalyptus citriodora is an important aromatic tree species. The essential oil obtained from fresh leaves is used in perfumery and cosmetic industries for improving the odor of germicidal and disinfectants. Due to the demand, it is required to produce high oil and high citronellal content varieties. Fresh herbage from 55 *Eucalyptus citriodora* trees was selected and individually distilled. The oil content ranged from 1.3 to 3.1% over the available check with 1.5% was selected for further analysis to estimate the chemical compositions. Citronellal composition ranged from 46.4% to 82.9% over the check with 63.9%. Based on high oil with citronellal content, five best trees were identified. Seeds were collected from these selected trees individually and sown separately. Well grown saplings were transplanted into the field for further studies. The oil and citronellal contents of the five selected trees are given below:

Table 1 Oil content and Citronellal contents in *Eucalyptus citriodora*

Code	Oil content (%)	Citronellal (%)
5	3.1	82.9
27	1.55	78.1
68	2.15	82.8
70	2.1	71.5
73	2.25	67.9
Control	1.5	63.9

Genetic improvement of *Plectranthus vetiveroides* (V. Sundaresan & K. Baskaran)

In the new crop introduction programme, *Plectranthus vetiveroides* is taken for further varietal development. It is a small profusely branched succulent herb with quadrangular stems and branches and deep straw-coloured roots. The roots are used as ingredients in compounds formulation of Ayurveda and Siddha for stomach aches, dyspepsia, nausea, vomiting, diarrhoea, leucoderma, fever, and also as a hair tonic. It is a potent emollient act as moisturizing, a natural antioxidant, and soothing agent. The dried roots are traditionally used in garlands in the temples. A new variety with high herb, high oil content and chemotype has been aimed. The fresh cuttings brought from wild and cultivated sources. After rooting, the cuttings were planted in the field. After four months, the plants were harvested; roots were washed and distilled for estimation of oil content. The per plant fresh root yield ranges from 25 to 75 gms. The average oil content observed was 0.2% and the analysis is in progress.

Figure 5: Picture of *Plectranthus vetiveroides*

Dr. V. Sunderesan & his team

Input: Tripta Jhang तृप्ता झंग

Commercialization of CIM Pushti

43 Kg of breeder seed was distributed among 21 progressive farmers of Rajasthan, Madhya Pradesh, and Uttar Pradesh farmers for captive cultivation on 2.5 ha. 42.5 quintals of dry roots, 500 Kg leaves, and 250 Kg of seed have been produced with a net profit of Rs 397500/Ha from dry root alone. The root powder of the same is available which is rich in Withanolide A (0.7-1%).

Isolation of total withanamides from *Withania somnifera*

As a collaborative work process was developed for the isolation of total withanamides, characterized and purified Withanamide A, B, and C markers as standard (Not available commercially at the global level). Quantified "specific Withanamide" content using RP-HPLC in a set of 124 breeding lines. Withanamide (total) rich, high berry mass, quality root breeding lines of Ashwagandha (*Withania somnifera*) under stabilization.

Citral rich breeding line in *Ocimum basilicum*

A Citral rich (Neral and Geranial 60-75%) breeding line in *Ocimum basilicum* with fresh herb yield 388q/ha, essential oil content 0.465%, and citral content 65-73%, and average essential oil yield is 163Kg/ha is developed.

Dr. Tripta Jhang & her team

Input: Narendra Kumar नरेन्द्र कुमार

Pharmacognostic study of *Messua ferrea* and its substitute *Ochrocarpus longifolius*

*Messua*Linn. belonging to the family Calophyllaceae is known in hindi as Nagakesar. It is used in several herbal formulations in Indian traditional systems of medicines *viz*. Chyawanprash, Candanabala-laksadiTaila, Kumaryasava, NagakesaradiCurna, Kankasava, Eladicurna, Jatiphaladicurna and Karpuradichurna, PushyanugCurna, Suparipak and Pradaranashakcurna etc. Now-a-days due to unavailability of *M. ferrea*, *O. longifolius* is used in various ayurvedic preparatory medicines as an adultrent or alternative ??. *Ochrocarpuslongifolius* Benth and Hook belonging to family Clusiaceae commonly known as Lal Nagakesar. In the present work, pharmacognostic studies of *Messua ferrea* and its substitute *Ochrocarpus longifolius*has been carried out. These plants having high commercial importance in Indian Herbal Drug industries. The data was generated as per the USP.

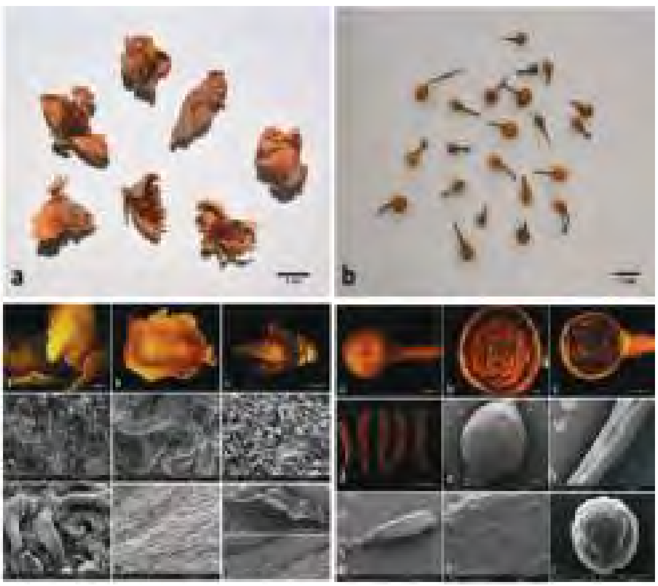
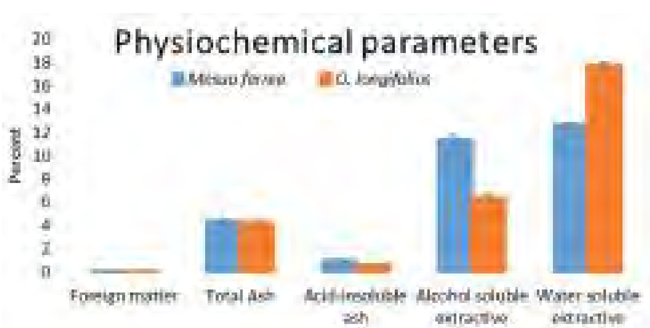


Figure 1: a) *Mesuaferrea*; b) *Ochrocarpuslongifolius*



In our studies, we found trichomes throughout the inner and outer surface of the sepal. These trichomes are short, thick with a blunt end. The base of trichomes is broad. These characterss are essential for distinguishing *M. ferrea*. Whereas in *O. longifolius* the surface of sepals is smooth, trichomes are absent. Trichomes characters are one of the vital traits in taxonomic characterization.

Input: Channayya Hiremath
चैन्नय्या हिरेमट

Genetic enhancement of kalmegh through Mutation breeding

Seeds of variety CIM-Megha were irradiated with gamma rays of different doses viz., 10 Kr, 12 Kr, and 14 Kr.Identified Chimera plants in M_1 generation like leaf variegation. In M_2 generation selected around 300 plants in different doses based on the estimated Andrographolide and Neo-Andrographolide content. Chemical content ranged from 2.00 to 6.20 % in the mutant population compared to control check parent CIM-Megha which is having 1.90-2.00%. Now the population in M_5 generation

Input: Venkatesha K.T.
वेंकटेशा के.टी.

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

Spearmint oil (*Mentha spicata)* is commercially used in food products, toothpastes, mouthwashes, and cosmetics. The present study was focused to develop a spearmint variety with high oil yield and high carvone content. At flowering, natural random matting was allowed among genetically different spearmint varieties like MSS-5, Arka, Neera, Neerkalka, Supriya, and Ganga. Matured seeds from each variety harvested separately and about 252 half-sib seed progenies were raised. Individual seed progenies were multiplied vegetatively and these were characterized for essential oil yield and its contributing traits. Plant height was varied from 13.33 cm to 85.00 cm, internod length was varied from 0.93 cm to 3.04 cm. Leaf length was varied from 2.00 cm to 16.17 cm and leaf width varied from 0.63 cm to 2.84 cm. Herb yield was varied from 0.2 kg to 1.8 kg per 4 m^2 area. Oil content was varied from 0.2% to 0.9% and carvone content was varied from 32.65% to 78.11%.

Figure 1: Morphological variability in newly generated half-sib progenies of spearmint.

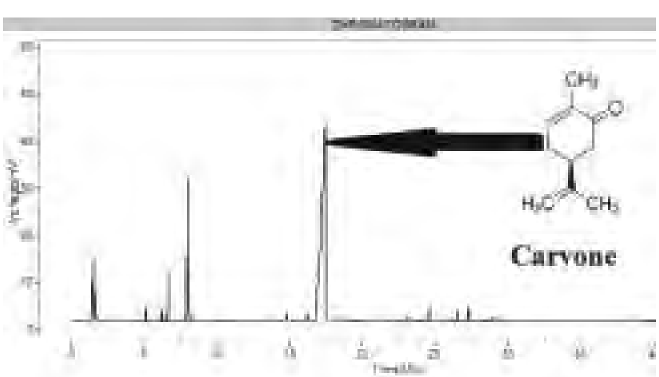


Figure 2: Gas chromatography profile of one of the half-sib progeny of spearmint.

Genetic variability of morpho-economic traits and chemo-diversity in *Ocimum* species

Ocimum is commonly called Tulsi or Basil and belongs to Lamiaceae family. Plants belong to this genus are annual, perennial, aromatic, branched herb, and shrubs. It consists of 30-150 species in tropical and sub-tropical regions and some found in India are *Ocimum basilicum*, *O. kilimandscharicum Gurke*, *O. tenuiflorum*, *O. gratissimum* L, *O. africanum*, etc. The present study aims at quantification of genetic variability, chemical diversity, and to study the association among oil yield and its contributing traits to successfully develop potential varieties. Sixteen Ocimum accessions were collected and evaluated for two consecutive years at CSIR-CIMAP, research center Pantnagar by using Randomized Complete Block Design(RCBD). Data on different morphological parameters were recorded and essential oil was extracted from each accession by using hydrodistilation and chemical constituents of essential oil were analyzed by using gas chromatograph. ANOVA analysis indicated highly significant differences among the genotypes for all the traits under study. A total of 24 compounds has been identified in the essential oils of the 16 Ocimum accessions.

Figure 3: Phenotypic variability in *Ocimum* accessions

Input: Gunjan Tiwari गुंजन तिवारी

Genetic Improvement in an underutilized aromatic herb Catmint (*Nepeta cataria*)

Catmint is an undomesticated, flowering plant of the Lamiaceae family. It is famed for its ability to attract cats and repel insects due to the presence of a volatile iridoid compound nepetalactone. Limited breeding efforts have been commenced to improve the oil quantity and quality of this crop. Also, no single commercial cultivars available in India. In this direction, eleven elite lines have been selected in the open-pollinated population of catmint based on oil content, herb yield, and oil yield. These selected lines will be further improved through a half-sib selection scheme and then evaluated in bench-scale and pilot-scale trials for the release of the first Indian catmint variety.

Technology Dissemination

Highlights of Technology Dissemination and Business Development

In the year, 13th January 2019- March 2020, A total number of eighteen technologies transfer agreements have been singed with different industries, and five consultancy projects were also received from various industries. In this period organized 15 various training programmes of Two to three days each in different parts of India under SIDBI and other projects. In these training programmes 616 farmers and entrepreneurs have participated. About 6276 farmers were made aware of the cultivation of medicinal and aromatic plants by organizing one-day programmes under MCX, GAP-408, HCP-0007, CNP-416, and other GAPs projects. 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 organized 25 training programmes attended by 1075 women during the period. After seeing the success of CSIR-Aroma Mission in Meghalaya, the Govt. of Meghalaya launched Megh-Aroma Mission on 27.05.2019 by Shri Konrad K Sangama, Honourable Chief Minister of Meghalaya.

On the occasion of National Technology Day on 11 May, 2019, about 450 students, farmers and entrepreneurs visited in this event and gained the knowledge on medicinal and aromatic plants through field visits and classroom lectures by the scientist of CSIR-CIMAP.

CSIR-CIMAP organized the annual Kisan Mela on 31st January, 2019. In this function, Dr. Mangla Rai, Former Director General, ICAR was the Chief Guest. More than 7000 farmers, entrepreneurs, representatives of industries, buyers of essential oil and herbs representing different states including Odisha, Bihar, West Bengal, Andhra Pradesh, Uttar Pradesh, Uttrakhand, Chhattisgarh, Rajasthan, Punjab, and Assam participated. A special CSIR pavilion was also arranged on this occasion in which several laboratories of CSIR including CDRI, NBRI, IITR, IHBT, CCMB, CMERI, CSMCRI, NEIST, and CIMAP have displayed their rural technologies, products, and services beneficial for farmers. Representatives from different industries as MCX, EOAI, Jindal Drugs, Herbochem, Ashri Essential oils, and several buyers of medicinal and aromatic plants and FFDC Kannauj (UP) also participated in this event.

Another CSIR-CIMAP Kisan Mela organized on 31st January, 2020 and more than 6500 farmers from various states of the country participated in this event. In the inaugural ceremony of the Kisan Mela Prof. Anil Kumar Gupta, Founder, Honey Bee Network, Creation, Knowledge, and National Innovation Foundation was Chief Guest and Prof. Ranjana Aggarwal, Director, CSIR-National Institute of Science, Technology and Development Studies, New Delhi, was the guest of honor. This year, 8 laboratories of CSIR, FFDC, SMPB, and NMPB demonstrated the technologies and schemes for farmers at the Kisan Mela. Stalls of industries, voluntary organizations, and women empowerment schemes were also put on the Kisan Mela.

Industry-scientist, the meet was organized at CSIR-CIMAP on September 24, 2019 to assess the market potential of the essential oils. About 35 leading industry representatives were participated and shared their view on the demand and supply of the essential oils in the domestic and international markets. Five research papers were published in this year from TBD.

Left to right: Dr. Rushikesh, Dr. R.S. Sharma, Dr. Sanjay Kumar, Dr. R.K. Srivastava

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

Inputs: Sanjay Kumar, Ramesh Kumar Srivastava, Ram Suresh Sharma, Bhise Rushikesh Nanasaheb, Deepak Kumar Verma, Manoj K. Yadav and PN Gautam

A. Technology transfer

S. No.	Name of the technology	Date of transfer of technology	Name of the Industry
1	Agreement for providing technical know-how and quality planting material for aromatic crops cultivation in Western Uttar Pradesh under CSIR-Aroma Mission (on royalty basis)	31.01.2019	Aromatic and allied chemicals, B-8, Industrial Estate, C. N. Ganj, Bareilly, Uttar Pradesh
2	For providing technical know-how for judicious utilization of flower offered at Shri Saibaba temple, Shirdi by Janseva Foundation Loni for making incense sticks under CSIR-Aroma Mission (on royalty basis)	31.01.2019	Janseva Foundation, Loni, (Shirdi) Ahmad Nagar, Maharashtra
3	For providing technical Know-how for judicious utilization of flower waste from Lucknow Municipal Corporation (LMC) by Making incense sticks and vermicompost by the Mango Foundation in Lucknow under Aroma Mission(on royalty basis)	31.01.2019	Mango Foundation, Lucknow
4	An agreement was signed for utilization of flowers at temples and ghats of Haridwar for making incense sticks and fragrant cones (on royalty basis)	09.07.2019	M/s Raibaar Samiti, Laldhang, Haridwar, Uttarakhand
5	An agreement was signed for making of Flower based Agarbatti and Cone	26.09.2019	M/s. Recycle Aastha LLP , S/F, F/S, Plot no.-9, R block Exten., Vani Vihar Uttam Nagar, West Delhi-110059 and Factory address JR Complex gate no.-4 , Village-Mandoli, Sevadham Road, Delhi-110093
6	An agreement was signed for making of Relexomap-pain relieving oil	13.12.2019	M/s. Nandan Impex Pvt. Limited, B-601, Lotus Corporate Park, Ram Mandir Lane, Jay Coach Junction, Western Express Highway, Goregaon (East), Mumbai-400063

7	An agreement was signed for making of Painzaa	13.12.2019	M/s. Nandan Impex Pvt. Limited, B-601, Lotus Corporate Park, Ram Mandir Lane, Jay Coach Junction, Western Express Highway, Goregaon (East), Mumbai-400063
8	An agreement was signed for making of Acne Preventive Face wash	13.12.2019	M/s. Nandan Impex Pvt. Limited, B-601, Lotus Corporate Park, Ram Mandir Lane, Jay Coach Junction, Western Express Highway, Goregaon (East), Mumbai-400063
9	An agreement was signed for making of PainChhoo	13.12.2019	M/s. Nandan Impex Pvt. Limited, B-601, Lotus Corporate Park, Ram Mandir Lane, Jay Coach Junction, Western Express Highway, Goregaon (East), Mumbai-400063
10	An agreement was signed for making of Flomop	13.12.2019	M/s. Nandan Impex Pvt. Limited, B-601, Lotus Corporate Park, Ram Mandir Lane, Jay Coach Junction, Western Express Highway, Goregaon (East), Mumbai-400063
11	An agreement was signed for making of incense sticks	24.01.2020	Shri Mata Vaishno Devi Shrine Board Katra J&K through Chief Executive Officer, SMVDSB
12	An agreement was signed for making of Sanitary Pad	31.01.2020	Janseva Foundation, Loni, (Shirdi) Ahmad Nagar, Maharashtra
13	An agreement was signed for making of incence sticks and fragrence cones	04.02.2020	Ekas Social Welfare Organization, H. NO. 12/16, Pragati Nagar, Nanakheda Indore Road, Ujjain-456010

A view of agreement exchange between industry and CSIR-CIMAP

A view of agreement exchange between industry and CSIR-CIMAP

Meeting with DG, CSIR and ITC for technology discussion on incense sticks along with CSIR-IHBT

A view of launching of product by industry after adopting CSIR-CIMAP's technology

B. Consultancy projects received

S. No.	CNP No.	Name of sponsoring Agency	Title of consultancy	Date of Start	Date of Completion
1.	CNP-427	Meghalaya Basin Development Authority (MBDA)	Providing technical services for setting up of distillation facilities for Meghalaya Basin Development Authority (MBDA) to support Aroma Mission.	23.4.2019	22.4.2020
2.	CNP-438	Vindhyachal Agrofarms Pvt. Ltd., Kalwari, Madihan-Mirzapur-231001	Providing technical guidance for planning and setting up of the processing facilities for the distillation of aromatic crops of the client.	08.11.2019	07.11.2021
3.	CNP-446	Indira Gandhi Krishi Vishwavidyalaya Raipur Krishi Vigyan Kendra, Korea (C.G.) Vill. Salka, Post Mansukh, Thana Baikunthpur	Providing consultancy for designing, Fabrication and setting up of Mild steel directly fired type field distillation unit of 500 kg capacity for essential oils based on CSIR-CIMAP Knowhow & design	29.01.2020	28.01.2021
4.	CNP-445	M/s Big Brother Nutra Care Pvt. Ltd. , 2- Mohakampur Complex Phase-1 Delhi Road, Meerut (UP)-250002	Development of Tobacco and Nicotine free chewable anti-oxidant granules with anti-microbial effect for oral health	07.02.2020	06.02.2021
5.	CNP-449	M/s. S.S. Solution India Pvt. Ltd. Lucknow	Providing consultancy and technical guidance for designing and development of mobile solar aroma distillation technology	03.03.2020	02.09.2021

C. Skill Development programmes

i. Training programmes on Medicinal and Aromatic Plants Production Technology

S. No.	Date	Place	No. of Participants	Sponsored by
1	03-05 January, 2019	CAZRI, Jodhpur, Rajasthan	57	HCP-0007
2	21-22 January, 2019	CIMAP, Lucknow (HCL)	46	CNP-416
3	31 January & 01 February, 2019	CIMAP, Lucknow (Palwal)	19	HCP-0007
4	04-06 February, 2019	CIMAP, Lucknow	20	HCP-0007 + ATMA
5	06-08 March, 2019	CIMAP, Lucknow	87	HCP-0007
6	12-14 March, 2019	CIMAP, Lucknow (JSLPS)	29	JSLPS+HCP-0007
7	24-26 April, 2019	CSIR-CIMAP, Lucknow (HCL)	39	HCL
8	27-29 May, 2019	CIMAP, Lucknow	30	JSLPS, Jharkhand
9	12-14 June, 2019	CIMAP, Lucknow	64	SIDBI
10	09-11 July, 2019	CIMAP, Lucknow	28	JSLPS, Jharkhand
11	17-19 July, 2019	IISR, Indore, Madhya Pradesh	48	SIDBI
12	19-23 August, 2019	CSIR-CIMAP, Lucknow	15	ICFRE
13	10-12 February, 2020	MPUA&T, Udaipur, Rajasthan	41	SIDBI
14	17-18 February, 2020	CSIR-CIMAP, Lucknow	36	DHO, Lucknow
15	12-14 March, 2020	NCL, Pune, Maharashtra	57	SIDBI
		Total	616	

A view of training programme for JSLPS, Jharkhand

SIDBI sponsored training programme at Lucknow

SIDBI Sponsored training programme at MPUA&T, Udaipur, Rajasthan from 10-12 February, 2020

ii. MCX sponsored one day awareness programmes on cultivation and marketing of Mentha Oil

S. No.	Date	Place	No. of Participants
1	28.03.2019	Atasuva, BKT, Lucknow	57
2	29.03.2019	Harauni, Lucknow	74
3	13.06.2019	Daulatpur, Barabanki	111
4	14.06.2019	CSIR-CIMAP, Lucknow	64
5	17.07.2019	Nipaniya, Rampur	69
6	18.07.2019	Jamshedpur, Dilari, Moradabad	81
7	04.09.2019	Khanipur, Sitapur	63
8	05.09.2019	Rasool Panah, Fatehpur, Barabanki	106
9	06.09.2019	Thangaon, Sitapur	93
10	12.11.2019	Bibipur, Barabanki	56
11	13.11.2019	Bandarbharari, Dudhwa Tiger Reserve, Lakhimpur Kheri	114
12	14.11.2019	Dhuskiya, Dudhwa Tiger Reserve, Lakhimpur Kheri	116
13	15.11.2019	Bhagauli, Barabanki	96
14	10.12.2019	Chaddha Farm, Harauni, Lucknow	87
15	11.12.2019	Lalupur, Rani Bazar, Barabanki	84
16	12.12.2019	Rampur, Munna Pathak, Bahraich	110
17	13.12.2019	Sarifabad, Barabanki	83
		Total	1464

Awareness programme at Dudhwa Tiger Reserve

Awareness programme at Bihar

Awareness programmes at district Barabanki

iii. One Day Awareness-cum-Training Programmes under CSIR Aroma Mission

S. No.	Date	Place	No. of Participants	Sponsored by
1	03.01.2019	Vill. Maura Baghla, Madhepura, Bihar	13	HCP-0007
2	03.01.2019	Vill. Bhairavpur, Madhepura, Bihar	35	HCP-0007
3	03.01.2019	Vill. Shripur, Madhepura, Bihar	10	HCP-0007
4	04.01.2019	KVK, Madhepura, Bihar	66	HCP-0007
5	20.01.2019	Vill. Loni, Ahmadnagar, Maharashtra	275	HCP-0007
6	13.02.2019	Vill. Nokha, Distt. Bikaner, Rajasthan	109	HCP-0007
7	13.02.2019	Vill. Daru, Distt. Hazaribagh, Jharkhand	71	HCP-0007
8	14.02.2019	Vill. Manika, Distt. Latehar, Jharkhand	47	HCP-0007
9	15.03.2019	Pipraula, Dudhwa Tiger Reserve, Lakhimpur Kheri	117	HCP-0007
10	16.03.2019	Dhuskiya, Dudhwa Tiger Reserve, Lakhimpur Kheri	109	HCP-0007
11	08.03.2019	Jingrai Bali Sapuri, Majuli, Assam	57	HCP-0007
12	11.03.2019	West Jaintiya Hills, Meghalaya	60	HCP-0007

13	11.03.2019	Majuli, Assam	62	HCP-007
14	04.04.2019	Laldhang, Haridwar, Uttrakhand	20	NASI
15	05.04.2019	Laldhang, Haridwar, Uttrakhand	27	NASI
16	27.05.2019	Malgan, Kondagaon, Chhattisgarh	98	HCP-0007
17	28.05.2019	Magar Road, Dhamtari, Chhattisgarh	55	HCP-0007
18	29.05.2019	Birwa Sumer, Re- Bhoi, Meghalaya	478	HCP-0007
19	05.08.2019	Khidrat, Jodhpur, Rajasthan	16	HCP-0007 / 0010
20	07.08.2019	Kolyari, Jhadol, Udaipur, Rajasthan	60	HCP-0007 / 0010
21	21.08.2019	Mahauli, Hodal, Palwal, Haryana	100	HCP-0007
22	25.08.2019	Peto, Daru, Hazaribagh, Jharkhand	42	CNP-384
23	25.08.2019	Jamdiha, Hazaribagh, Jharkhand	46	CNP-384
24	28.08.2019	Birkham, Chandan Kyari, Bokaro, Jharkhand	30	CNP-384
25	30.08.2019	Pipraula, Dudhwa, Lakhimpur Kheri	63	HCP-0007
26	31.08.2019	Dhuskiya, Dudhwa, Lakhimpur Kheri	61	HCP-0007
27	18.11.2019	Tunju, Ranchi, Jharkhand	36	HCP-0007
28	12.12.2019	Uthmad, Sirohi, Rajasthan	34	HCP-0007
29	14.12.2019	Bhat Khedi, Neemach, MP	40	HCP-0007
30	12.01.2020	Vihokhu, Dimapur, Nagaland	21	HCP-0007
31	17.01.2020	Amritsar, Punjab	150	HCP-0007
A		**Total**	2408	
Awareness programmes organised under HCL collaborative project				
S. No.	**Date**	**Place**	**No. of Participants**	**Sponsored by**
1	16.01.2019	Block Kachhauna, Hardoi, UP	70	HCL
2	18 01.2019	Block Behandar, Hardoi, UP	91	HCL
3	11.03.2019	Block Kothavan, Distt. Hardoi	103	HCL
4	14-15 .05. 2019	Kothavan, Distt. Hardoi	105	HCL
5	21-22.05. 2019	Dudhawa Tiger reserve	500	HCL
6	05.07.2019	Kachhauna, Hardoi, UP	85	HCL
7	09.12.2019	Kachhauna, Hardoi, UP	58	HCL
8	09.01.2020	Kachhauna, Hardoi, UP	49	HCL
9	10.01.2020	Kothavan, Distt. Hardoi	88	HCL
10	11.01.2020	Block Behandar, Hardoi, UP	51	HCL
11	25.02.2020	Kachhauna, Hardoi, UP (Buyer Seller Meet)	18	HCL + HCP-0007
12	27.02.2020	Kachhauna, Hardoi, UP	22	HCL + HCP-0007
B		**Total**	1240	
		Grand total A + B	**3648**	




View of different activities organised under (CNP – 416) HCL project


Awareness programmes at Dudhwa Tiger Reserve

Awareness programme at Majuli, Assam

Awareness programme at Rajasthan

Awareness programmes at Bihar

iv. Awareness programmes under DBT sponsored Bundelkhand Project

S. No.	Date	Place	No. of Participants
1	06.06.2019	Ingui, Jalaun, UP	75
2	07.06.2019	Tola Rawat, Rath, Hamirpur, UP	85
3	07.06.2019	Maudaha, Hamirpur, UP	50
4	08.06.2019	Singhpur, Banda, UP	61
5	08.06.2019	Archha Barethi, Chitrakoot, UP	59
6	09.06.2019	Mau(va), Chitrakoot, UP	72
7	10.06.2019	Brajpura, Chhatarpur, MP	29
8	10.06.2019	Richhai, Chatarpur, MP	71
9	11.06.2019	Devran, Panna, MP	44
10	11.06.2019	Hathkuri, Damoh, MP	42
11	12.06.2019	Baroda, Damoh, MP	34
12	02.01.2020	Sijjai, Chhatarpur, MP	50
13	03.01.2020	Nayagaon, Chhatarpur, MP	84
14	04.01.2020	Dharampura, Damoh, MP	39
15	04.01.2020	Hinauta, Damoh, MP	38
16	05.01.2020	Dwari, Panna, MP	83
17	10.02.2020	Kudari, Jalaun UP	50
18	11.02.2020	Niswapur, Jalaun, UP	57
19	11.02.2020	Sisolar, Hamirpur, UP	76
20	12.02.2020	Basela, Hamirpur, UP	65
		Total	**1164**

Awareness programme at Chhatarpur

Awareness programme at Damoh

Awareness programme at Jalaun

Awareness programme at Hamirpur

v. 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 25 training programmes attended by 1075 women. The dates of such trainings along with number of participants are given in the Table below. Based on the feedback received after training, it is estimated that about 40% women who took part in these trainings have started making of incense sticks and selling in the local market.

List of training programmes on making of incense sticks using floral bio resources under CSIR-Aroma Mission

S. No.	Date	Place	No. of Participants
1	27.02.2019	District Jail, Barabanki	35
2	28.03.2019	SMVSB, Katra, Jammu	25
3	22.05.2019	CSIR-CIMAP (Dehradun Woman)	07
4	29.05.2019	Jaipur, Odhisa	52
5	30.05.2019	Khordha, Odhisa	81
6	13.06.2019	District Jail, Lucknow	85
7	23.06.2019	Loni, Maharasthra	37
8	28.06.2019	Village Parsahiya, Itaunja, Lucknow	70
9	28.08.2019	Maiyar devi, Madhya Pradesh	60
10	29.08.2019	Maiyar devi, Madhya Pradesh	60
11	18.09.2019	District Jail, Lakhimpur	60
12	19.09.2019	Maiyar devi, Madhya Pradesh	42
13	01.10.2019	Recycle Astha, Uttam Nagar, New Delhi	35

14	09.10.2019	CIMAP, Lucknow MBDA, Shilong	06
15	11.10.2019	CIMAP, Lucknow Raibar Samiti, Uttrakhand	08
16	22.10.2019	District Woman Jail, Lucknow	35
17	04.11.2019	Maa Chandrika Devi Ji, Lucknow	05
18	13.11.2019	Navranganj, Odisa	60
19	14.11.2019	Navrangpur, Oddisa	58
20	19.11.2019	Daru Block, Hazaribagh, Jharkhand	83
21	12.12.2019	Navranpur, Oddisa	24
22	13.12.2019	Navarnpur, Oddisa	26
23	19.01.2020	Sai Baba Temple, Loni Maharastra	53
24	24.01.2020	SMVDSB, Temple, Katra, Jammu	20
25	06.02.2020	Masoorie, Uttrakhand	48
		Total	**1075**

A view of workshop at Shri Mata Vaishno Devi Shrine Board at Katra, J&K

Women making incense sticks at Peto village, Daru block, district Hazaribagh, Jharkhand

Demonstrating the technology for making incense sticks at Mussoorie, Uttrakhand

Women working for collection, segregation and making of incense sticks at Shri Shirdi Sai Temple, Ahmadnagar, Maharashtra

D. Launch of Megh-Aroma Mission:

With recommendation and successful implementation of CSIR-Aroma Mission by CSIr-CIMAP, Govt. of Meghalaya launched Megh-Aroma Mission on 27.05.2019 by Shri Konrad K Sangama, Honourable Chief Minister of Meghalaya. He appreciated the activities done by CSIR-CIMAP in the Meghalaya. In this occasion, Dr Abdul Samad, Acting Director and Dr RK Srivastava, Nodal, NER presented the activities of CSIR-CIMAP in this occasion.

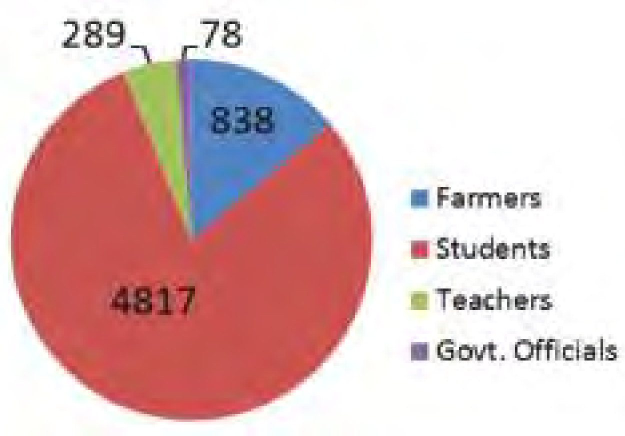
Launch of Megh Aroma Mission to support CSIR-Aroma Mission in Meghalaya by Chief Minister, Meghalaya

Hon'ble Chief Minister visited lemongrass fields developed under CSIR-Aroma Mission

Visitors:

More than Six Thousands visitors including students, teachers' farmers, government officials and others common people from society visited CSIR-CIMAP and were apprised about different activities of the institute.

Views of visitors visiting different spots in CIMAP



E. Major events organized

National Technology Day

On the occasion of National Technology Day on 11 May, 2019, about 450 students, farmers and entrepreneurs were participated in this event and gained the knowledge on medicinal and aromatic plants through field visits and class room lectures by the scientist of CSIR-CIMAP.

Releasing of Aus Gyanya

View of Participants

CSIR- CIMAP KISAN MELA – 2019

CSIR-CIMAP organized its annual Kisan Mela on 31stJanuary, 2019 in its campus located near Kukrail, Picnic Spot Road at Lucknow. Dr. Mangla Rai, Former Director General of ICAR was the Chief Guest. More than 7000 farmers, entrepreneurs, representatives of industries, buyers of essential oil and herbs representing different states including Odisha, Bihar, West Bengal, Andhra Pradesh, Uttar Pradesh, Uttrakhand, Chhattisgarh, Rajasthan, Punjab and Assam were participated. A special CSIR pavilion was also arranged on this occasion in which several laboratories of CSIR including CDRI, NBRI, IITR, IHBT, CCMB, CMERI, CSMCRI, NEIST and CIMAP displayed their rural technologies, products and services beneficial for farmers. Representatives from different industries as MCX, EOAI, Jindal Drugs, Herbochem, Arshi Essential oils and several buyers of medicinal and aromatic plants and FFDC Kannauj (UP) also participated in this event. Three improved varieties 'CIM-Sukhda, CIM-Akshay and CIM-Suwas' of *Ocimum basilicum* and one variety named CIM-Atal of lemongrass was released by the chief guest.

On the occasion of Kisan Mela, four MoUs were exchanged with different parties like Forest and wild life Department, Govt. U.P., Aromatic and Allied Chemical, Janseva Foundation Loni (For providing technical know-how for making of incense sticks in Shri Shirdi Sai Baba Temple) and Asheesh Concentrates International for Identification and selection of THC, CBD, cannabinoid terpene and THCa rich strains/lines/genotypes of Cannabis spp..

Kisan Mela-2020

As previous years, more than 7000 farmers from various states of the country gathered in one-day Kisan Mela organized by the CSIR-Central Medicinal and Aromatic Plants Institute in its campus Lucknow on 31 January 2020. Farmers participated in the kisan mela and seek information about beneficial cultivation of medicinal and aromatic plants and also shared their experiences. Team of scientists provided detailed information on advanced farming, varieties and processing and marketing of these plants to the farmers. In the inaugural ceremony of the Kisan Mela Hon'ble. Prof. Anil Kumar Gupta, Founder, Honey Bee Network, Creation, Knowledge and National Innovation Foundation was

Chief Guest and Prof. Ranjana Aggarwal, Director, CSIR-National Institute of Science, Technology and Development Studies, New Delhi, was the guest of honor.

Prof. Ranjana Aggarwal in her address said that we have collected information of the Aroma Mission's Impact Assessment by CSIR-NISTADS. She appreciated that farmers have benefited through this mission, especially in tribal, coastal and rain-fed farming areas and income of farmers reached almost doubled. In his welcome address, Dr. Abdul Samad, Director, CSIR-CIMAP, spoke about the efforts being made by CSIR-CIMAP for cultivation of medicinal and aromatic plants as well as the work being carried out under CSIR-Aroma Mission across the country. Dr. Samad informed that this year 500 quintals plant material of Mentha was made available on the occasion of Kisan Mela.

A booklet containing information on cultivation, distillation and marketing of MAPs 'Aus-Gyanya' was released on the Kisan Mela. On this occasion, an improved variety 'CIM-Unnati' of Menthol Mint and three value-added products' CIM-Kesh, Hair Oil, CIM-Soil Shakti and Soriacim Cream were also released. Convener of Kisan Mela, Dr. Sanjay Kumar conducted the program and propose vote of thanks. On this occasion, a discussion session for farmers was also organized in which farmers, scientists and industries' representatives participated. On this occasion, Chief Guest and Guest of honour also interacted with progressive farmers of CSIR Aroma Mission.

This year, 8 laboratories of CSIR, FFDC, SMPB and NMPB demonstrated the technologies and schemes for farmers at the Kisan Mela. Stalls of industries,voluntary organizations and women empowerment schemes were also set up on the Kisan Mela. An advanced economical technique for the manufacture of plant material of geranium, CIMAP's herbal products, Early Mint Technology, etc. were also discussed and exhibited at the Kisan mela.

Scientist-Industry meet on 24.09.2019 at CSIR-CIMAP, Lucknow

Leading aroma industries and scientists meet was organized at CSIR-CIMAP on September 24, 2019 to assess the market potential of the essential oils. In this meet, Mr Yogesh Dubey, President, Essential Oil Association of India (EOAI), Mr. Anurag Katiyar, Vice President, EOAI (Central Zone) and Mr. Shailendra Jain from FAFAI and other representatives from M/s Ajmal Perfumers, Mumbai, M/s Keva Flavours Pvt. Ltd., Mumbai, M/s Ultra International, New Delhi and other 30 leading industry representatives were participated and shared their view on demand and supply of the essential oils in domestic and international market. Industry also appreciated proper implementation of the CSIR-Aroma Mission on the farmers' fields and resulted into reduction in imports of essential oils.

A view of inaugural function

Welcome by acting Director, CSIR-CIMAP

Interaction with the leading aroma industry

A view of participants in concluding session

F. Publication of Extension Literature/Publicity folders/ Brochures

- "Aus Gyanya" published and released on the occasion of Kisan Mela-2019.
- "Aus Gyanya" published and released on the occasion of Kisan Mela-2020.

Relative Economics of Menthol Mint Cultivation with existing Competitive Crop Combinations in Dudhwa Tiger Reserve Area of Uttar Pradesh

Unveiled that 62.50 per cent farmers were having the educational qualification level of primary to postgraduate and remaining of 37.50 per cent farmers were deprived of schooling. More than three fourths 384 of the sample farmers (96.00%) have perceived the agriculture as their main occupation, whereas only (4.00%) of them (16 families) have selected the agriculture as their secondary occupation. The average landholding size of the respondents has been found to be 2.39 acres, which are slightly less than the national average landholding size of a household. The larger area (38.50%) is covered under the combination of paddy-mentha-maize (42.50) followed by paddy-mustard-mentha (32.60%), sugarcane (22.65%) and paddy-wheat-maize (6.25%).The majority of the respondents had the medium level of mass media exposure, extension contact and having a high level of social participation. As the annual rate of returns from investment were affected by adoption cropping pattern, method of production and prices of input and output. It is also observed that some competing crops performed better in terms of total and net returns over the cost of cultivation. It is also observed that the benefit-cost ratio mentha performed better and found noticeably higher than that of other existing competitive crop combinations. Moreover, among the three major cropping patterns, the maximum net return was obtained from Paddy-Mustard-Mentha accounted for ` 69.81K and B-C ratio was 1:1.62, it implies that farmers invest single rupee on deployed resources has been received 1.62 rupees additional as profit, it is also implied that marginal efficiency of recourses used and allocation considered as satisfactory level.

Comparative economic study of Tulsi and Paddy cultivation in Sitapur district of Uttar Pradesh

Observed that tulsi gives higher returns over paddy. However, the input cost of paddy is higher than tulsi crop but the net return of tulsi was more profitable than paddy. The benefit cost ratio has been observed 2.70 and 1.34 of tulsi and paddy respectively. It is suggested from the study that maximum profit is generated through tulsi cultivation followed by paddy crop. This study can set an example of profitability model for entrepreneurship development in other part of country.

Performance evaluation of newly developed variety of menthol mint at farmer's field- A case study of mint cultivation in Central Uttar Pradesh

CIM-Kranti gives more returns (Rs.98491/- ha/year) than the other varieties (Rs.70977/-ha/year) of mint. The input cost of CIM-Kranti is higher than other varieties while the net return of CIM-Kranti has more profitable than other varieties. The benefit cost ratio has been observed 1.45 and 1.74 of other varieties and CIM-Kranti respectively. The new variety "CIM-Kranti" of menthol mint is cold and frost tolerant and has the potential to produce 10-15% more oil i.e. 145-160 kg/ha in summer season as compared to all other popular commercial cultivars of menthol mint. It is suggested from the study that maximum profit is generated through CIM-Kranti cultivation followed by other varieties of mint.

New Extraction Technologies, value addition and utilization of lemongrass (*Cymbopogon flexuosus*)

Study indicate traditional and modern techniques of oil extraction adopted by the farmers and industries. The study focused on yield and quality of lemongrass received through various extraction units.

Computational Biology

Highlights of Computational Biology

The Computational Biology Unit is devoted to the theoretical investigation of biochemical data, biological sequence analysis, OMICS data or Big data analysis using methods/algorithms of Artificial Intelligence/ Machine Learning/Deep Learning/Bioinformatics tools & techniques, Next Generation Sequencing data analysis of Medicinal and Aromatic Plants Genome & Transcriptome, Molecular Modeling & 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, Systems Pharmacology, Agrinformatics, Advanced Remote Sensing Tools and Techniques , Unmanned Aerial Vehicles (UAVs) for Precision Agriculture, Database and Tool development. Faculties of the unit have been actively contributed to the Major National projects namely Aroma Mission, Phytopharmaceutical Mission, Namami Gange, AgriDrone and Indian Biodiversity Information Network. 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 this period, a total of 02 students were awarded Ph. D. under JNU (02) Ph.D. program

During the year 2019-2020, precision agriculture studies using Hyperspectral Proximal Sensing in Medicinal and Aromatic Plants were undertake especially for Mentha (*Mentha arvensis L.*) and Chamomile (*Chamomila recutita*). Under the CSIR Niche Creation project, 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 initiated with focus on motiroing the menthol mint crop. Under the project Indian Bioresource Information Network (IBIN) Geoportal for enhancing bioresource services, institutional linkages and outreach about 148 records of medicinal and aromatic plants which belong to 22 plant families were also digitized. In the research work on the development of bioinformatics pipeline, lncRNApipe bioinformatics pipeline for identification of long non-coding RNAs from medicinal and aromatic plants was also started. A repository (MAPslnc database) was also developed for the lncRNApipe to digitize the long non-coding RNAs from medicinal and aromatic plants.

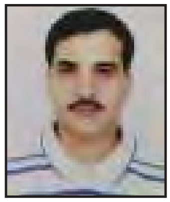
During this period, the Computational Biology Units published 03 publications in high impacted journals such as Journal of Precision Agriculture (IF 3.340), Industrial Crops and Products (IF 4.450). During this period a mobile app (MenthaMitra) for the mentha growers was also launched, which has been downloaded by more than 5000 farmers

Er. Manoj Semwal

Dr Feroz Khan

Er. Bhaskar Shukla

Input: Manoj Semwal मनोज सेमवाल



Precision Agriculture Studies using Hyperspectral Proximal Sensing in Medicinal and Aromatic Plants

Mentha (*Mentha arvensis L.*)

Precision nitrogen fertilization is an urgent requirement not only for enhanced sustainable agricultural productivity but also to improve the soil health. Traditional methods of nitrogen estimation are tedious and in recent years; non-destructive methods based on reflectance characteristics have gained prominence.

The study was able to correlate the relationship between VIs and foliar N concentration using Hyperspectral imagine technique for Mentha crop. It was found that GRVI and NDRE provides more accurate estimation as compared to others indices. The study also demonstrated that HS VIs can play a significant role in the crop monitoring and management practices.

Chamomile *(Chamomilarecutita)*

Traditional methods of nutrient monitoring during the crop growth phase are invasive and time consuming, hence the use of advanced sensors like Hyperspectral Imaging can be an effective tool for non-invasive monitoring of the crop health. In the present study, the effect of different nutrient treatments including microbial culture and micronutrients on chamomile crop were investigated using portable hyperspectral camera (400-1000 nm). Various Hyperspectral Vegetation Indices (VIs) based on normalized differences (NDVI, RDVI, MSR), soil contrast adjustment (SAVI, MSAVI, OSAVI), simple ratio of two discrete bands (SR, GRVI, Red-edge) and three discrete bands (MCARI, TCARI, TVI, SIPI) over multiple nutrient treatments were calculated and were compared to characterize the crop growth status, biophysical variability, vigour, leaf area index (LAI) and pigments like carotenoids & chlorophyll. Results show that Normalized Difference Vegetation Index (NDVI) and Renormalized Difference Vegetation Index (RDVI) are best for discriminating amongst different nutrient management practices. The study illustrates the use of hyperspectralremote sensing as an effective non-invasive tool for nutrient management and crop health assessment.

UAV based high resolution remote sensing for modernized and efficient cultivation practices of commercially important medicinal and aromatic crops

In the present study, crop monitoring using Unmanned Aerial Vehicles (UAV) was undertaken to demonstrate the applicability of vegetation indices derived from UAV imagery to assess Mentha, Chili, Cucurbits and Okra crop vigor at mature stage of crop growth and it was observed that the ratio of EVI/NDVI is a better estimation of crop mapping having R2 = 0.99; followed by SAVI/NDVI having R2 = 0.99 and NDRE/GNDVI having R2 = 0.87 respectively. In comparison, the statistical relationship between GNDVI/NDVI, NDRE/NDVI was found to be insignificant (R2 < 0.028) and in GDVI/NDVI was negative (R2 = -0.358), which confuses the prediction of crop types.

The study therefore, demonstrated that the ratio of NDRE/GNDVI derived from UAV imagery is a reliable predictor of crop vigor and is applicable even in complex smallholder farms due to its sensitivity for individual crops in the complex farming system.

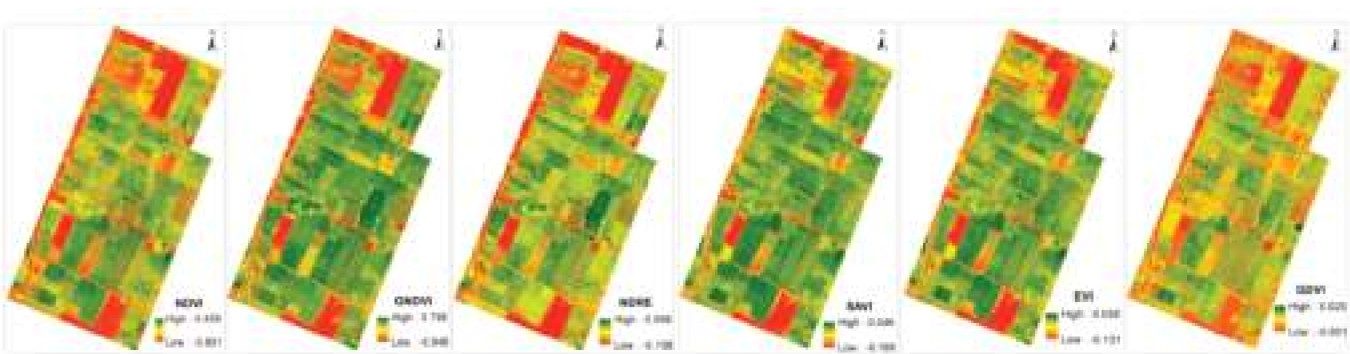


Figure 1: NDVI, GNDVI, NDRE, SAVI, EVI and GDVI maps of the surveyed area

Multi-temporal high resolution Unmanned Aerial Vehicle (UAV) multispectral imaging for menthol mint crop monitoring

In this study, the use of drone technology for menthol mint crop monitoring was undertaken. Drone fitted with multispectral and thermal camera was flown over the study area three times during the cropping season in the months of May and June 2019. The high resolution multispectral images were orthomosaicked and thematic maps of popular vegetation indices viz., Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI) and Normalized Difference Red Edge (NDRE) were generated to develop strategies to monitor the

Figure 2: Unmanned aerial vehicle (UAV) system used

menthol mint crop health status. Results showed that the highest value for NDVI, GNDVI, and NDRE were obtained in thematic maps generated from imagery acquired during crop maturity and GNDVI index was found to be the most suitable indicator for assessing the health of menthol mint crop.

Indian Bioresource Information Network (IBIN) Geoportal Phase III: Enhancing BioResource Services, Institutional Linkages and Outreach

In this study, the development of medicinal and aromatic plants web enabled information system, an independent platform for reliable geo-database containing primary information on the taxonomic and biodiversity status on medicinal and aromatic plants of herbarium holdings at CSIR – CIMAP was

Figure 4: Snapshots showing details of the MAP-WIS homepage

being undertaken. In the medicinal and aromatic plants web information database, about 148 records of medicinal and aromatic plants which belong to 22 plant families were digitised (http://cimap.res.in/ibin.). The database captures the data on Botanical name, Classification, Taxonomy, Geographical Distribution, Plant Description, Chemical Constituent and Structure, Part of the plant recognized and its therapeutic uses, Pharmacology, Morphological attributes and Scientific Literature.

Input: Feroz Khan फिरोज खान

Studied quantitative structure-activity relationship and perform molecular docking on human proteasome inhibitors and developed QSAR machine learning model for anticancer activity targeting NF-êB signalling pathway. Performed 3D QSAR studies on Flavone analogs for anticancer bioactivity targeting Tankyrase inhibition. Also performed molecular docking simulations on flavone analogs for assessing the target binding affinity. Also performed drug likeness studies through Lipinski's Rule and ADMET studies. Developed the anticancer 2D & 3D QSAR machine learning model for 18â-glycyrrhetinic acid derivatives based on triple-negative breast cancer cell line bioactivity. Also performed molecular docking simulations and in-vitro evaluation on selected hits. Identified the medicinal plants as sources of novel anticandidal drugs with information of experimental (*in-vitro*) bioactivity.

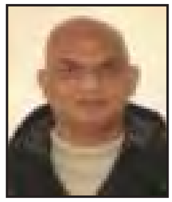
Dr Feroz Khan & his team

Input: Bhaskar Shukla भास्कर शुक्ला

lncRNApipe bioinformatics pipeline-based identification and MAPslnc database-based repository of long non-coding RNAs from medicinal and aromatic plants

Recent studies of experimentally validated long non-coding RNAs (lncRNAs) indicate their critical and diverse biological roles in plants. There is still a lot of scopes to identify uninvestigated lncRNAs (>200nt) in medicinal and aromatic plants (MAPs). High throughput RNA sequencing analyses have generated a huge amount of transcript sequence data. Identification of lncRNAs is a highly computational task and consumes a lot of time and memory. Several tools, techniques and databases are required for this effort. We developed lncRNApipe, a bioinformatics pipeline for identifying novel lncRNAs, especially from MAP species. The identification involved several filters to enhance the accuracy of the results. It has been used to analyze more than 45092 lncRNAs identified computationally in 17 species of MAPs. The unique information of MAP lncRNAs generated through our pipeline has been organized in the MAPslnc database, which would help the MAP research community for further exploration and knowledge generation. The lncRNApipe web server and MAPslnc database have been developed simultaneously in order to facilitate the potential stakeholders towards identification of lncRNAs. [Shukla B*, Sanchita, Srivastava G, Sharma A, Shasany AK, Shukla AK. lncRNApipe bioinformatics pipeline-based identification and MAPslnc database-based repository of long non-coding RNAs from medicinal and aromatic plants. Presented at the 88th Annual Meeting of the Society of Biological Chemists (India) on the theme "Advances at the Interface of Biology and Chemistry" organized by Bhabha Atomic Research Centre (BARC) and Homi Bhabha National Institute (HBNI) in Mumbai during 31st October – 03rd November, 2019. (PP-26, page 129)]

Jigyasa and School connect programme



Input: Alok Kumar Krishna
आलोक कुमार कृष्णा

CSIR-CIMAP organizes - Gyan Vigyan Bal Mela

"Jigyasa" is one of the major intiatives taken up by CSIR at national level as a Scientific Social Responsibility (SSR).Council of Scientific & Industrial Research(CSIR) and Kendriya Vidyalaya Sangathan(KVS) had signed a MOU on Student Scientist-connect Programme, "Jigyasa" on 6th July 2017,to provide a unique platform for brinigng Scientists and Teachers for nurturing young minds. The programme envisage some of the following model of engagements like Laboraotory visit,Popular lecture Series,Summer Vacation programmes, Scientists as teachers, Teachers as Scientists,Teachers workshop, Student Resedential Programme,Visits of Scientists to schools,lab specific activities/onsite experiments etc. The sole objective of this programme is extending the classroom learning and focusing on a well planned research laboratory based learning.

Under this CSIR-KVS Jigyasa Programme, for the year 2019-2020, CSIR-CIMAP organized a four days Programme "Gyan Vigyan Bal Mela" from 15^{th}-18^{th} January,2019. In this Programme, a total nine number of lectures were delivered in a series while four lectures were organized in as special lecture from 15^{th} -18^{th} Jan., 2020 at CIMAP, Lucknow. These are some photograhs taken during this event and some of the details are given as under;

Glimpses of CIMAP Gyan Vigyan Bal Mela 2020

Date : 15-18 January, 2020

Glimpses of CIMAP Gyan Vigyan Bal Mela 2020












CSIR-Aroma Mission

Total Area Covered (ha)	2391
Total Manpower Trained (number)	More than 12000
Total Awareness Programs (number)	More than 235
Varieties Developed since Aroma Mission Inception	12

CSIR Aroma Mission, which started in the year 2017, completed its first phase in March, 2020. The mission endeavored to boost the cultivation as well as value-addition of aromatic crops for making our country not only self-reliant but also as global leader in the production and supply of several essential oils. CSIR Aroma Mission aimed to develop, disseminate and deploy the aroma related S & T developments in CSIR labs to the end users including farmers, industry and society, to enhance income of farmers, quality of their life, business opportunities and rural development.

CSIR – CIMAP, as a nodal laboratory, successfully implemented Aroma Mission covering an area of around 2391 ha with various crops contributing immensely in improving income of farmers and nurturing essential oil-based aroma industry in the country. Aroma Mission, besides enhancing farmers' income (on an average incomes of the farmers enhanced by Rs. 30-70,000/ha/year), could also generate ample rural employment (3 - 4 lakhs man-days). About 93 improved distillation units were installed, which could produce about 400 tons of essential oil for Indian Aroma Industry. This has led to creation of an ecosystem benefitting the growers, industry, and next generation entrepreneurs. With an increase in the income of the farmers considerably, the mission was helpful in limiting the migration of youths from rural to urban areas in search of job opportunities due to falling productivity and profitability in agriculture. More than 900 aroma clusters, spread over 2000 ha were developed in 20 states and provided opportunities to the underprivileged in the aspirational districts of the country. Help and assistance in the mission was also provided to the women self help groups, SC, ST and other vulnerable groups. The mission provided crop alternatives to the farmers, especially tribals, economically weaker sections having small land holdings, to achieve higher incomes even from a small piece of farmland. Aromatic crops tolerant to various stresses or environment extremities were popularized in areas where frequent episodes of weather vagaries happen and the farms are exposed to various biotic and abiotic stresses including damage by wild animals minimizing the use of fertile lands and the conventional food crops being replaced with aroma crops. Several essential oil-based aroma products were developed and many of these technologies were transferred to the industries.

Since availability of quality planting material of aromatic crops is a major limitation for expansion in area under cultivation, productivity and profitability of aromatic crops, a huge amount of planting material of high-yielding varieties of commercially important aromatic crops (most significant being Lemongrass – 37 Lakh slips, Citronella – 20 Lakh slips, Vetiver – 26 Lakh slips, Palmarosa – 330 kg seeds, Menthol Mint – 700 kg suckers, Geranium – 0.12 Lakh slips, *Ocimum* – 40 kg seeds and Patchouli – 0.01 Lakh slips) was generated at the farms of the CSIR-CIMAP which served as nucleus material for the spread/distribution to a large number of interested farmers.

Dr RA Mashelkar interaction with the Aroma Mission beneficiary farmers from various states

One-day Business Meet was organized at CSIR-CIMAP to access the market scenario of the essential oil produced under CSIR Aroma Mission. During this event, about 25 representatives from major essential oil industries were present.

Revival of geranium in Ooty, Tamil Nadu

Popularisation and expansion of Lemongrass and Mints in Naxalite-affected Bastar and tribal area of Jharkhand, Annamalai (TN) Dudhwa, UP.

Many of the drought-tolerant crops like lemongrass and palmarosa were expanded in Vidarbha, Bundelkhand, Odisha, Gujarat and Rajasthan which are frequently affected by insufficient rainfall. Crops like vetiver and palmarosa, which are able to tolerate extended periods of flood and salinity, were introduced in the cyclone- and Tsunami- affected coastal areas of Gujarat and Tamil Nadu. Presently, around 100 ha area is under cultivation of Vetiver in Cuddalore district of Tamil Nadu and 500 ha. Palmarosa in the Kutch area of Gujarat, providing handsome profits to the farmers. Efforts were also made to introduce high-value aroma crops in the North-East region where high-yielding varieties of Citronella were introduced to revive cultivation of this important crop,

Lemongrass Cultivation in Tikarpada Tiger Reserve, Odisha

Palmarosa cultivation in salt affected areas of Kutch, Gujarat

the oil of which is in high demand and is imported in huge amounts. Another significant intervention in North-East was the successful cultivation of vetiver in the Brahmaputra basin, which remains saturated with water for a long period.

To make farmers aware about the benefits of aromatic crops more than 200 one-day awareness programs were organized across the country benefiting about

Expansion of Lemongrass & Palmarosa in rain-fed areas of Vidarbha, Bundelkhand and Odisha.

Distribution of Quality Planting Material to Farmers

Plantations of Vetiver in Majuli, Island Assam

12000 farmers. Also, five advanced (3-5 days) training program were organized for imparting training to the farmers and the entrepreneurs on cultivation and processing of aromatic crops.

Since the conceptualization of the Mission, twelve (12) high-yielding variety of aromatic crops were developed and released for commercial cultivation which may lead to considerable enhancement in the area under cultivation of aromatic grasses.

In order to enlarge the impact of the proposed activities of the Aroma Mission efforts were made to bring other stakeholders and line ministries on board which include aroma industries, MSME, DONER, DBT, state agriculture/ horticulture/ forest departments/ universities and farmer organizations. Efforts are on to involve stakeholders in providing additional resources to install improved primary processing/distillation units in the farmers' field for efficient on-site processing of raw material and to build mechanisms to link aroma industry with farmers for procuring essential oils at fair prices.

It is hoped that this Mission will pave the way for achieving self-sufficiency as well as global leadership in the production of essential oils like vetiver, palmarosa, lemongrass so as to export these oils to other countries. The opportunities of value-addition to these oils would generate opportunities for entrepreneurs to venture into start-ups in the areas of perfumery, high-value aroma molecules and aroma-based products.

Popularizing of EMT a input saving agro-technology in Menthol mint

Commercializing of geranium farming in northern Indian plains

CISR Nutraceutical Mission

CSIR-CIMAP is focusing its effort in development of nutraceutical formulations under following categories

A. Enhancing nutrition

1. Development of a suitable oral formulation for the increased bioavailability of vitamin B12 using standardized extracts of selected medicinal plants.
2. Development of Nutrifoods for breakfast, a low cost/feasible cost to be met by Govt, which is ready to use in schools and acceptable by children.

B. Cognition

1. Alpha linolenic acid (ALA) based Nutraceuticals for cognition and depression management.
2. Development of nutraceutical for neurodegeneration linked cognitive impairments in elderly population.

C. Immunity

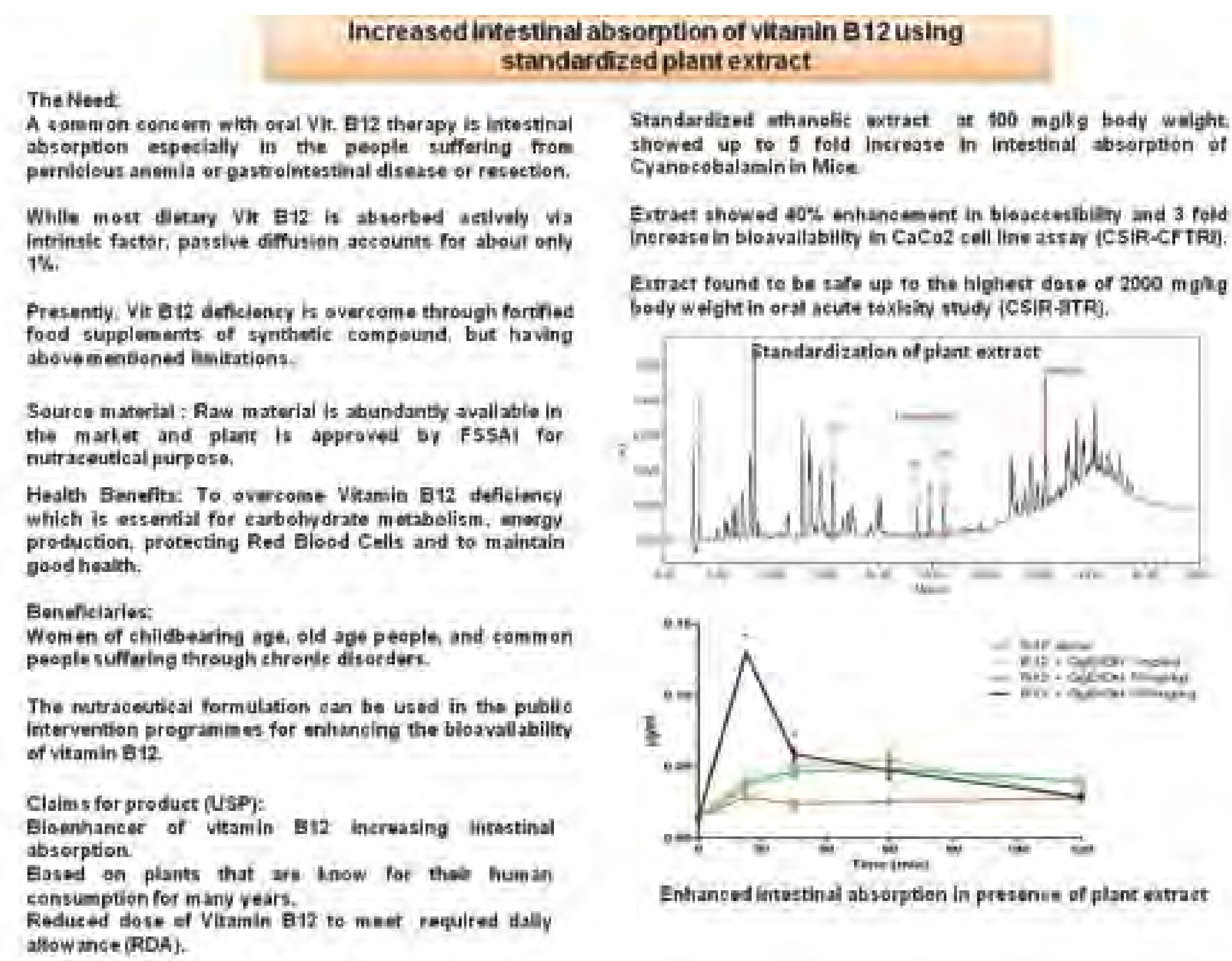
1. Triphala based validated formulation for compromised immunity.

Progress :

Enhancing nutrition

Standardized plant extract for enhanced intestinal absorption of vitamin B12

CSIR-CIMAP has identified a plant (which is frequently used Ayurveda/traditional system of medicine) extracts that have shown potential in enhancing the intestinal absorption of vitamin B12 through *in vitro* (CaCo2 cell line) and *in vivo* (mice model) bioassays. No oral sub-acute toxicity of this plant extract was observed at the highest dose up to 2000mg/kg body wt. in small animal model. This plant extract has been standardized with respect to major chemical markers. The cost effective oral formulation (capsules) has been developed with standardized plant extract, however, further pre-clinical and human studies are required to be done before



the formulation is licensed to the interested industrial partner for its commercial utilization.

Advantages:

1. Releases the Vitamin B12 in controlled manner.
2. It provides pH dependent solubility (soluble in alkaline/intestinal pH) due to which the acidic gastric environment is bypassed and releases in intestinal pH .
3. It reduces the dosing frequency and thereby improves the patient compliance.

Ready-to-eat nutraceutical products with benefits of medicinal plants.

CSIR-CIMAP has developed recipes of manufacturing nutritive breakfast items such as Methionine rich Ragi Bun, Nutritive Mathari, and Millet Crackers.

Methionine rich Ragi Bun: agi is anextremely nutritious millet,that resembles mustard seeds in appearance. Finger millet is especially valuable as it contains the amino acid methionine. The developed bun combines the values from Ragi, wheat, amaranth leaves and jaggery into making anutrition dense and methionine rich bun.

USP

- Methionine rich Ragi based food product
- Sweet flavour incorporated through the use of Jaggery powder
- Maida and sugar free breakfast
- Rich in protein, carbohydrates, calcium, vitamins and minerals especially methionine.
- Tasty and easy to serve

Nutritive Mathri : Beetroot (*Beta vulgaris*) is a root vegetable packed with essential nutrients, fiber, Folate (vitamin B9), manganese, potassium, iron, and vitamin C. The developed nutritive breakfast is a calories & iron dense food product made with oats and beetroot.

USP

- Iron rich Beetroot based food product
- Mineral rich Jaggery incorporated
- Maida free breakfast
- Rich in calories, protein, carbohydrates, calcium, vitamins and minerals.
- Tasty and easy to serve

Millet Cracker: Pearl Millet (Bajara) is one of the oldest known cereals. It has been cultivated since pre-historic times for its goodness, nutrition and health benefits. It packs flavor and is highly nutritious. Millet crackers are highly nutritious crackers prepared with increasing the nutritional values through flax seeds and spices.

USP

- A millet based food product with anti-oxidant property
- Protein rich appetizing food product
- High content of calories, calcium, magnesium and other mineral and vitamins.
- Flax seeds and spices were used to enhanced the nutritional values of Millet Crackers

Cognition

Alpha linolenic acid (ALA) based Nutraceuticals for cognition and depression management.

Samples of ALA based formulation received from CSIR-CFTRI and CSIR-NIIST were studied for their toxicity profile. None of them was toxic to *Caenorhabditis elegans* up to 1000 ppm concentrations. Two samples were found to exhibit significant antioxidant and thermal stress tolerance activity which was performed through *in vitro* and *in vivo* assays.

Development of nutraceutical for neurodegeneration linked cognitive impairments in elderly population.

Plant material for three selected plant species i.e. *Withania somnifera* (root), *Bacopa monnieri* (herbs) and pods of *Mucuna puriens* were collected and further extraction was made. All three extracts were standardized with respect marker chemicals and submitted CSIR-IHBT for evaluating their potential in neurodegeration. In CSIR-CIMAP, toxicity was assessed using *C.elegans* model system wherein no toxicity was observed in all these extracts. These extracts also exhibited good antioxidant activity when tested using *C.elegans* model system.

Immunity

Triphala based validated formulation for compromised immunity

Standardization of herbal formulation is essential to assess the quality, purity, safety and efficacy of the drug. Triphala a combination of three fruits (*Terminalia chebula*, *T. bellerica* and *E. officinalis*) in equal proportions is one of the most traded drugs and one of the most effective simplest formulation for the immune system, gastro-intestinal cleansing and eye disease. The project was aimed to develop a standardized formulation based on scientific evidence complementing the traditional claims.

Initially, the pharmacognosy of the three fruits was undertaken followed by comparative studies on traditional preparation and modern extraction techniques for standardization. Three extracts viz., Ethanol, Hydroethanol and Aqueous were analysed based on five phytochemical markers i.e., Ascorbic acid, Gallic acid, Corilagin, Ellagic acid and Chebulinic acid. All the three extracts were assayed through a series of Cell-mediated and Humoral Immune response studies which indicated that the hydroalcoholic extract performed best followed by the aqueous and ethanol extracts. The phytochemical analysis also indicated an optimum concentration of all the five markers in the hydroalcoholic extract. Challenge studies in infectious disease models of *Salmonella enterica* sub sp. Typhimurium, *Escherichia coli* and *Staphylococcus aureus* resulted in complete survival with respect to control groups and a reduced burden of the pathogen in the primary lymphoid organs. Acute and Sub-acute toxicity studies did not reveal any unacceptable results in terms of liver function, kidney function, lipid metabolism or haematological parameters.

A syrup-based formulation has been developed, which now awaits a clinical trial in the next phase of the project.

CSIR-Phytopharmaceutical Mission

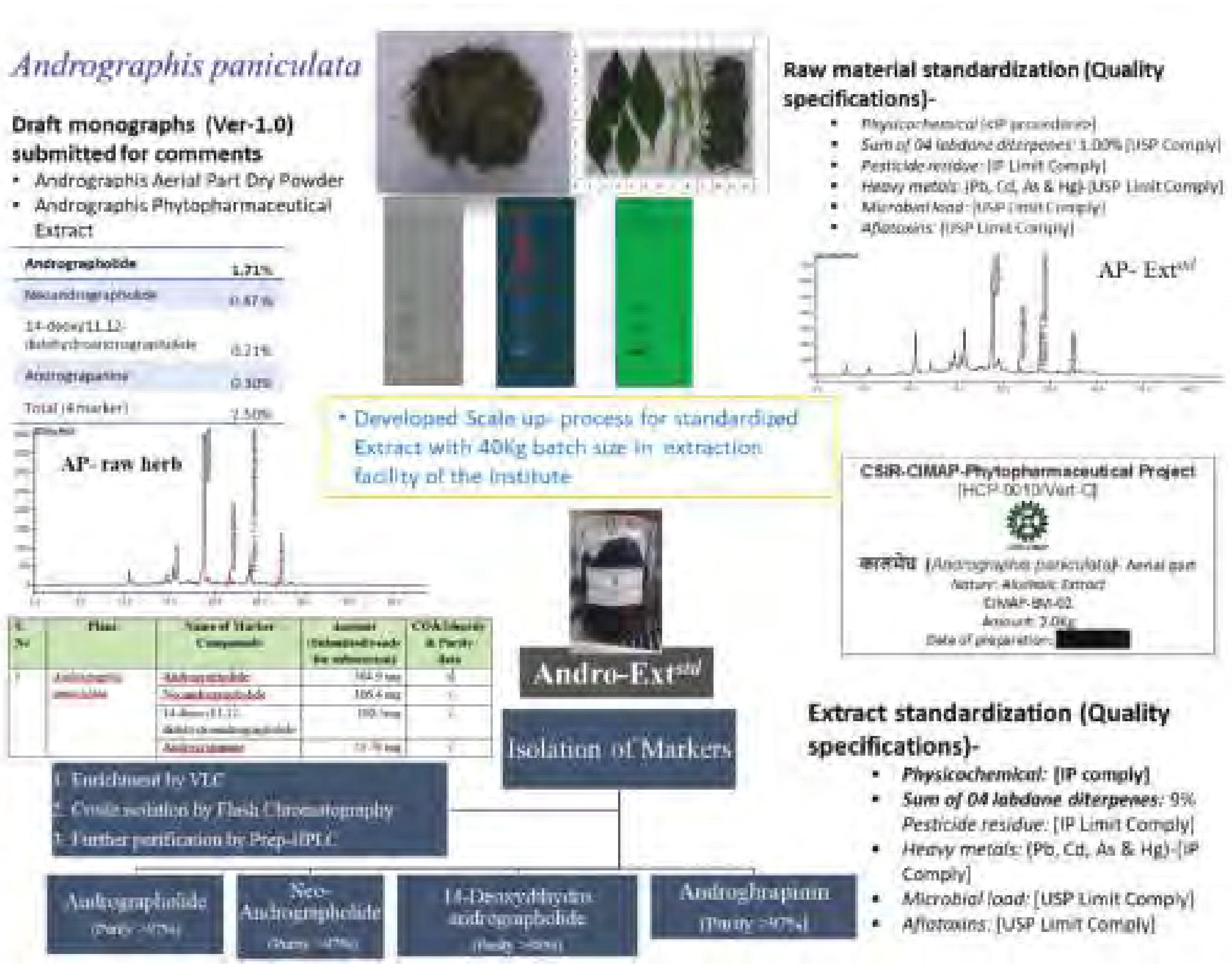
Approx 600 HA of high-value medicinal plants including *Andrographis paniculata, Withania somnifera, Asparagus racemosus Sillybum marianum, Cassia senna, Curcuma longa etc* have been bought under captive cultivation in different states of the country to produce quality raw material to cater demands of domestic and global pharma manufacturing industries and also targeting the upliftment of the societal status of the farmers by enhancing farmers income and employment

Gene bank creation and micro and macro-propagation for mass multiplication of targeted RET medicinal plants species

Protocols for Gene bank creation, micro and macro-propagation for mass multiplication and cultivation of targeted important Rare and endangered and threatened (RET) medicinal plants species *Aristolochia tagala, Coscinium fenestratum, Trichopus zeylanicus, Utleria salicifolia,* and *Decalepis hamiltonii* have been developed to increase in population status of RET medicinal plant species in India.

A new class of drugs is introduced in India as Phytopharmaceutical drugs. In order to meet the requirements of phytopharmaceutical drug a, process was defined to enrich and standardize the extract/ fraction of with defined minimum four phytochemical compounds including minimum one bioactive. Under CSIR-Phytopharmaceutical mission a process was developed to achieve the standardized extract of five medicinal plants viz. *Andrographis paniculata, Phyllanthus amarus, Silybum marianum, Curcuma longa,* and *Gymnema sylvestre*. Batch scale-up process was also optimized for cGMP extract to meet the requirement of global market as per USP quality specifications.

Comprehensive quality-control measures and meticulous monitoring allow us to guarantee that our extracts all attain the same high quality. Wide-range of quality-control practices and meticulous evaluation of control parameters monitoring as well as stability and safety provide the assurance that phytopharmaceutical drugs accomplish the robust high quality. Scientific studies have demonstrated that CSIR-CIMAP's phytopharmaceuticals are effective, safe, well-stable and having consistent defined pharmaceutical quality. Monograph on Phytopharmaceutical of *Andrographis paniculata* has already been submitted for official review and approval by the authorities at Indian Pharmacopeia Commission. Isolation process of 24 PRS (phytochemicals reference substance) was developed. Certificate of analysis along with purity data of following PRS was submitted in the Mission repository.



S. No	Plant	Name of Marker Compounds	COA/Identity & Purity data
1	*Andrographis paniculata*	Andrographolide	√
		Neoandrographolide	√
		14-deoxy11,12-didehydroandrographolide	√
		Andrograpanine	√
2	*Phyllanthus amarus*	Phyllanthin	√
		Hypophyallanthin	√
		Nirtetralin	√
		Niranthin	√
3	*Curcuma longa*	Curcumin	√
		Demethoxycurcumin	√
		Bisdemethoxycurcumin	
		2-Methyl-6p-tolylhept-2-en-4-one	√
4	*Silybum marianum*	Silibinin A Silibinin B	√
		Iso Silibinin A Iso Silibinin B	√
		Silychristin	√
5	*Gymnema sylvestre*	Gymnemagenin	√
6	*Berberis aristata*	Berberine chloride	√
		Palmatine	√
7.	*Glycyrrhiza glabra*	Glabridin	√
		Formononetin	√
		Isoliquiritigenin	√
		Liquiritigenin	√

CSIR-CIMAP also contributed in the drug development part of Phytopharmaceutical Mission Program of CSIR. CSIR-CIMAP worked on "Development of Isoliquiritigenin enriched formulation of *Glycyrrhiza glabra* for diabetes & related complications" and completed pharmacognostic and chemical evaluation of *Glycyrrhiza glabra*. Isoliquiritigenin (ISL) enriched extract of *Glycyrrhiza glabra* was developed and standardized. Four chemical markers (one biomarker) with more than 95% purity were submitted to IIM Jammu. The ISL enriched extract of *G. glabra* was evaluated for anti-diabetic activity in STZ –induced diabetic model in mice and also in db/db mice. The standardized extract was found to be safe in single oral dose toxicity studies and repeat-dose systemic toxicity studies for 28 days.

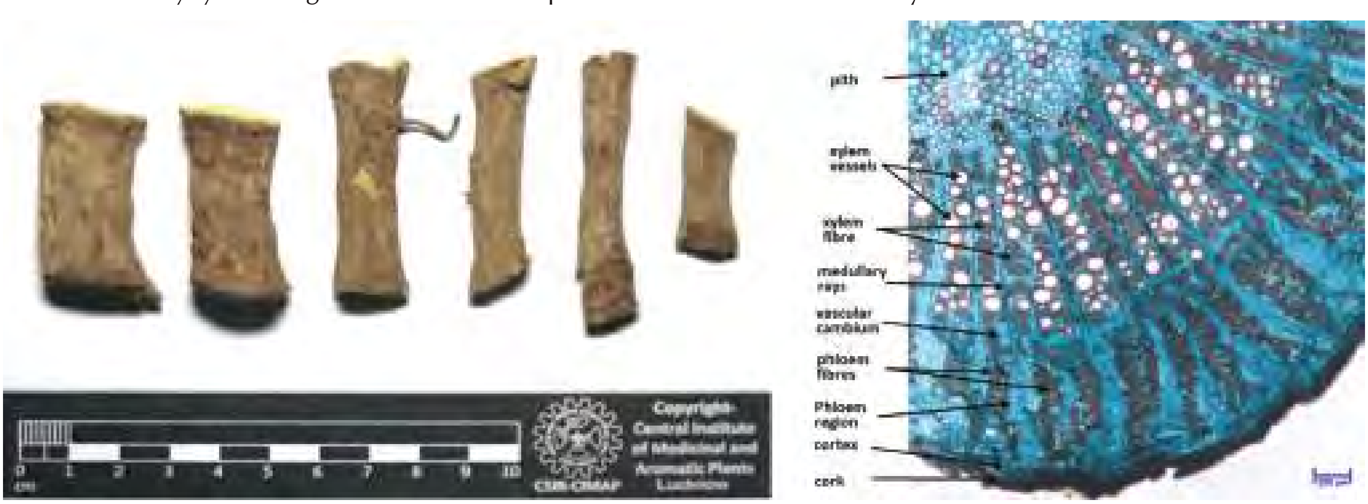


Fig: Pharmacognostic evaluation of *G. glabra*

Highlights of the major activities carried out by the ICT Department

Input: Manoj Semwal & Bhaskar Shukla

The major activities undertaken by the Information and Communication Technologies (ICT) department at CSIR-CIMAP during the Financial year 2019-2020 were

- Maintaining and Upgrading Data Center, Network and Desktop, Audio Visual Services of the institute.
- Regular updates of various information on bilingual website of CSIR-CIMAP along with handling Facebook page, twitter, and uploading short video films on YouTube channel.
- Coordinating all VC calls with HQ, Research Centers and other labs and maintaining VC facility.
- Upgradation of Layer 3 Network Core switch along with its installation and commissioning at CIMAP data Center to improve the performance, scalability and speed of the network.
- Online Portal for Publication of manuscript has been designed so that publication committee would put the summary of the article for one week.
- Regular updates of various activities carried out under this mission program in the Web portal of Aroma Mission(http://aromamission.cimap.res.in).
- Technical support for the implementation of various modules of OneCSIR ERP web portal.
- Procurement and its implementation of Centralized Wireless Access Control System in the institute to make CSIR-CIMAP campus Wi-Fi.

Left to right: Er. Manoj Semwal, Er. Bhaskar Shukla, Sanjay Singh, and Jitendra

Activities of Experimental Farm CSIR-CIMAP, Lucknow.

Inhouse activities

- Facilitating all field scientists and their students for conducting field experiments on variety and agro-technology development.
- Providing support for arranging national events like Kisan Mela, training programs, seminars, and technology up-gradation programs, apart from maintenance of all visiting places in good condition, farm management provides all necessary help in organizing important events.
- The experimental farm provides for the production of quality plant materials different MAPs.
- Management of Manav park, demonstration block, processing units, lawn, garden, and inhouse ornamental Plants

External Services

- Farmers, Students, and the General Public through updated knowledge on MACs cultivation and timely availability of quality seeds and planting material of MACs.
- During 2019-2020, the total sale of quality planting material of MAPs, by-products such as vermicompost, and essential oils from the CIMAP Experimental Form was **10.73 Lakhs.**

Technology Dissemination

The popularization of Geranium cultivation and Early Mint Technology on farmer's field through training and demonstration

Low cost field agro-technology was developed by CSIR-CIMAP Lucknow for the saving of planting material of rose-scented geranium successfully demonstrated on the farmer's fields of Western UP and Central UP. The benefit of geranium farming over menthol mint could also be demonstrated successfully in the fields of above farmers simultaneously.

Twenty training/ group discussions cum demonstration programmes were organized in areas of Western UP and Central UP for the popularization of Early Mint Technology and Geranium. About 758 farmers participated in these programmes and 12 field demonstrations were laid out by the team of CSIR-CIMAP Lucknow.

The summary of the training and demonstration programmes is given below: -

S. No	State/ Location	No. of District covered	No. of Training/ group discussions	No. of Partici-pants	No. of Field demon-strations
1.	Western UP	07	14	573	09
2.	Central UP	03	06	185	03
Total	**02**	**10**	**20**	**758**	**12**

Contributions of CIMAP in Ganga Mission

CSIR-CIMAP, developed (MAPs) Medicinal Aromatic Plants (MAPs) based cropping system for soil and water conservation, wastewater treatment, embankment stabilization, flood control, disaster and pollution mitigation, agro forestry management, and many other environment-friendly applications. Identification and selection of flood prone/wasteland in Ganga basin of Uttar Pradesh Districts. By MAPs based cultivation not only reducing additional load on Agricultural Lands and also generating self employment of Ganga Basin Villagers. For the production and supply of quality planting material develoed nurseries and demonstrated improved MAPs agro-technologies among the growers of Ganga basin. In order to create the awareness and providing upto date infomation agro technologies, processing and trading through training, technical bulletins, e-services among the growers, forest officials

Figure : Awareness camp, training programme and field demonstrations of Early Mint Technology and Geranium plant saving during rainy season and industries and also improving farmers income and livelihood with assured buy-back mechanism.

Area near by Gang River covered by Vetiver (Khus) plantation under NMPB sponsored project "Dissemination of Vetiver (*Chrysopogon zizanioides*) agro-technology in flood prone contaminated area of Ganga river of Uttar Pradesh"

Districts	Total No. of Farmers	Total slips planted in forest fields	Total slips planted in farmers fields (Nos.)	Total area covered (ha)	Expected area to be covered by the multiplied slips (ha)
Kanpur	42	2,50,000	7,14,500	20.00	200.00
Banaras	36	-	5,77,000	11.54	125.00
Total	**78**	2,50,000	**12,91,500**	**31.54**	**325.00**

For capacity building providing hands on training for multiplication, cultivation and processing of MAPs and their technical knowledge to Ganga River farmers of Uttar Pradesh. Under this project CSIR CIMAP has organized three training programmes and one skill development programme on MAPs QPM development, cultivation, processing and value addition among the farmers, entrepreneurs and forest official. And also made several fields visits of the CSIR-CIMAP scientists/ technical's/research scholars for site specific advisory to farmers and forest officials.

CIM-ATAL: Geraniol rich Lemongrass variety (*Cymbopogon flexuosus* (Steud.) Wats.)

Lemongrass is major source of high citral content. However, chemovariants of lemongrass containing geraniol as major constituents, instead of citral, have been developed. CIM-ATAL is a highly vigorous, light green leaves, light brown stem, leaves of semi-erect leave and erect growth nature compare to another varietal. Geraniol content 89.6 and Oil content 2.10%. Herb yield 250-300 q/ha and oil yield 300-325 q/ha. The geraniol rich lemongrass variety can produce more oil and herb yield compared to palmarosa. The new variety gives an herb yield 250-300 q/ha/y and oil yield 300-325 q/ha/y.

Variety: CIM-ATAL

CIM-SUKHDA: High Linalool rich inter-specific hybrid of basil (*Ocimum basilicum x Ocimum africanum*)

Linalool is used in perfumery and cosmetics as well as Linalool dependent industries, a need to develop a better strain of *Ocimum* with high linalool content as well as suitable for South Indian conditions was planned by breeding and selection process was undertaken at CSIR-CIMAP, Research Centre, Bengaluru to develop such a strain of *Ocimum*. CIM-SUKHDA is a highly vigorous, medium-dark green leaves, light green stem. Flower colour is white and long and pinkish nature of inflorescence and morphologically distinct from other *Ocimum* varieties and identifiable by its long and pinkish inflorescence with lightish green colour leaves.

Variety: CIM-SUKHDA

Average Linalool content ranges 74.35-80%, herb yield 262.50 q/ha, and oil yield 104.8 Kg/ha.

CIM-AKSHAY: High yielding thymol rich variety of *Ocimum gratissimum* L. for Southern climatic condition.

The genus *Ocimum* L., belonging to family Lamiaceae, possesses a high level of morphological as well as chemical variability caused by polyploidy and inter- and intra-specific hybridization. The only source of thymol to meet the demand is *Thymus* and *Tachyspermum ammi*. *Ocimum gratissimum* will be an additional source of thymol that will be cultivated throughout the year because of its perennial nature. CIM-AKSHAY is morphologically distinct from other *Ocimum* varieties and identifiable by its broad and bigger leaves with dark green color, Multi-cut, and Perianal nature and per year we can harvest 3-4 harvest with Thymol 4-50%, Herb yield (t/ha) 500-550, and oil yield (kg/ha) 200-220.

Variety: CIM-AKSHAY

CIM – Mohak : Novel aroma bearing an inter-specific spearmint hybrid: CIM Mohak (*Mentha spicata* L.)

Spearmint (*Mentha spicata* L.; Family: Lamiaceae) is commercially cultivated for extraction of essential oil and widely used as a culinary herb, in flavouring, confectionary and pharmaceutical industries for preparations of chewing gums desserts, sweet dishes, herbal teas, etc. having antimicrobial, carminative, diuretic, stomachic, etc. properties. CIM-Mohak essential oil have novel aroma of long lasting for flavour and fragrance than other spearmint varieties due to presence of high carvone and other special note giving constituents. Now-a-days both Indian and foreign traders are showing their keen interests especially preparation of confectionary items having long lasting note and its oil yield is (kg/ha) 80-100 with Carvone (%) 58-61%.

Variety: CIM- Mohak

CIM Utkrisht: A high essential oil yielding strain of Patchouli (*Pogostemon cablin* (Blanco) Benth) with unique aroma

The new variety CIM-Utkrisht of Patchouli has been developed by CSIR-CIMAP through intensive breeding efforts for improved herb and essential oil yield coupled with high patchouli alcohol (110 Lit./ha v/s 56 lit/ha rich patchouli alcohol 43 % v/s 41% in the check). The variety has consistently recorded a higher biomass and oil yield with high patchouli alcohol content in the oil in the field evaluation trials. The potential dry leaves yield of this new variety is 63 q/ha and oil yield is 110 Lit/ha. This variety is morphologically distinct from other patchouli varieties and clearly identifiable

Variety: CIM-Utkrisht

by its broad, big, dark green to light purple leaves with curcumine is a unique feature/aroma in the essential oil of this variety.

CIM- SUVAAS

A novel and new source of chavibetol in the essential oil of Inter-specific hybrid of *O. basilicum and O. kilimandscharicum*. CSIR-CIMAP developed a number of varieties but none of them having chavibetol rich essential oil and production of essential oil yield is not able to fulfill high demand of chavibetol rich essential oil. Therefore, production of a variety CIM-Suvaas with high essential oil having high chavibetol content with multi- cutting without effects of environment/ temperature would be helpful to overcome low essential oil. CIM-SUVAAS with high herbage 500-600 ql /ha and essential oil yielding 150-200 kg/ha variety with 16-25% Chavibetol content with multi- cutting without effects of environment/temperature would be helpful to overcome low essential oil.

Variety: CIM- SUVAAS

CIM-Sushil: A high vindoline yielding variety of *Catharanthus roseus*

Periwinkle (*Catharanthus roseus* (L) G. Don) has become one of the very extensively investigated medicinal plants after the discovery of two powerful anticancer alkaloids, vinblastine and vincristine. Therefore, new variety CIM-Sushil was developed by CSIR-CIMAP. CIM-Sushil has a dwarf character, spreading/bushy growth habit, wide canopy and small dark green leaves. It has ~0.2% vindoline content and ~5% total alkaloid content in its leaves (on % dry weight basis). It provides an estimated vindoline yield potential of ~4.8 kg/ha and an estimated total alkaloid yield potential of ~120.9 kg/ha. The estimated dry leaf yield potential is ~2418.3 kg/ha, which is achieved within a short span of ~180 days. The study was financial supported by a grant (EMR/2016/002026) from the Science and Engineering Research Board (SERB), India.

Variety: CIM-Sushil

Herbal Products Released

PsoriaCIM Cream

"Non-steroidal aromatic plant based cream formulation for psoriasis like skin inflammation"

Most of the available anti psoriatic products contain topical corticosteroids, keratolytic agents, Vit D and A derivatives, anthralin and many more but their regular use can result in development of skin irritation, brown stains, dry skin, rashes, dermatitis, skin damages.

In the present formulation, we are using novel combination of two phytomolecules with significant activity against psoriasis. The present lead is a non-steroidal drug with plant origin and is effective topically. (**Indian Patent Filed; Patent application number: 201711031817**)

Key Benefits:

- Non-steroidal aromatic plant lead based formulation
- 100% Natural Bio-actives,
- Skin Friendly, Non-Irritant,
- Significantly effective in mitigating psoriasis like skin inflammatory conditions

Team members:

Dr. N. P. Yadav* (Principal Investigator), Vineet Kumar Rai, Priyam Sinha, Dr. D. U. Bawankule, Dr. D. Chanda, Er. Sudeep Tandon, Ms. Anju Yadav, Dr. C. S. Chanotiya, Dr. Puja Khare, Dr. Feroz Khan, Dr. A. Pal, Dr. Alok Kalra

MENTHOFRESH- *Herbal Oral Cleanser*

Menthofresh is scientifically developed plant based formulation having unique combination of essential oils with good antimicrobial property. It deodorizes the mouth for a longer period leaving it fresh and clean.

Unique features of the product:

- A herbal oral cleanser
- Chemical & alcohol free formulation
- Free from artificial sweeteners
- Kills harmful bacteria naturally and provided fresh breath

CIMKESH hair oil

Hairs play a vital role in the personality of human. The fading (pigmentation problem), dandruff, alopecia (loss of hair), split ends, grey hairs are some of the major problems associated with hairs. Keeping these points in consideration, CSIR-CIMAP has scientifically developed a hair care formulation in the form of hair oil that is enriched with unique combination of traditional herbs and essential oils which helps in preventing dandruff, nourishes and strengthens the hairs and controls hair fall.

UNIQUE FEATURES OF THE PRODUCT:

- Traditionally knowledge based hair oil developed with unique combination of herbs for healthy hairs

- Scientifically validated anti-dandruff hair oil
- Free from light liquid paraffin
- Enriched with combination of essential oils for anti-fungal activity
- Naturally nourish & strengthen the hair and helps in hair growth
- Non-sticky in nature with pleasant natural aroma
- Formulation is bio-degradable, non-irritant, safe to use without any adverse effects

TEAM MEMBERS:

Sudha Agarwal, Dinesh Kumar, Priyanka Singh, M.P. Darokar, C.S.Chanotiya, Karuna Shankar, Anirban Pal, Puja Khare, Anju Kumari Yadav, Sajendra Kumar Verma, Kshama Srivastava, Saudan Singh, Sudeep Tandon and Alok Kalra

Product Name: CIM-मृदाशक्ति

The CSIR-CIMAP developed an eco-friendly and cheap technology for production of a natural soil enhancer (CIM-मृदाशक्ति) fromagri-waste using existing distillation units.CIM-मृदाशक्ति also improves groundwater quality by increasing soil retention of nutrients and agrochemicals and made it available for crops. More nutrients remain in the soil instead of leaching into groundwater and causing pollution. The use of CIM-मृदाशक्ति provides an alternative to stubble burning. The loss due to the burning of distilled waste is very high in terms of nutrition, environment, health, and economic returns.

Team: Dr Puja Khare; Vineet Yadav; Shilpi Jain; Nidhi Nigam; Disha Mishra; Raghavendra Pratap Singh; Mohd. Ahsan; Paurabi Das; Versha Pandey; Asha Singh; Ranu Yadav; Harshita; Anupama; Er S Tandon; Dr Saudan Singh; Dr Karuna Shanker; Dr Anil Kumar Singh; Dr Ashutosh Kumar Shukla; Dr Ram Surash Sharma; Dr Sanjay Yadav

Technologies transferred for commercialization

Name of the technology/ product	Name of the company to whom technology is transferred	Year of tech. transfer
Technology transfer of following products- • Acne preventive face wash • Relaxomap (Anti-inflammatory pain relieving oil) • Painjaa (Anti-inflammatory pain relieving gel) • Painchhoo (Pain balm) • Flomop (Floor disinfectant)	M/s Nandan Impex Pvt. Ltd, Mumbai	2019-20

Details of the products manufactured in CSIR-CIMAP Pilot plant facility (TBIC) for market seeding to support start-ups/ entrepreneurs

S.No	Date	Name of the company	Name of the product
1.	7/3/2019	M/S Sparkhil Trader & General Order Supplier	• Relaxomap
2.	11/3/2019	M/S Ritu Sales &Activation	• Lipbalm
3.	6/4/2019	M/S Kings Herbal Research Lab	• Relaxomap
4.	22/2/2020	M/S HAPI KEY	• Geranium Active • Herby Soft

Skill Training Programme on "Cultivation and Processing of Economically Important Medicinal & Aromatic Crops'

To enhance practical knowledge and improving the farmers ecomonimical efficiency, CSIR-CIMAP,Lucknow organizes various Skill Training programmes every year.These programmes mainly provide skill training to the farmers.Every year a huge number of farmers attened this skill training programme

from almost every part of india to train on improved cultivation techniques, varieties of economically important medicinal and aromatic crops like basil, satawar, ashwagandha, isabgoal, senna, geranium, mints, lemongrass, palmarosa, vetiver, patchouli, chamomile, etc.

The Skill Training programmes deals with, to demonstrate the improved distillation and primary processing technologies and various methods, nursery raising techniques, proper storage and its utilization of medicinal and aromatic plants in various industries, etc.

The Course Content having mainly focus on Activities of CSIR-CIMAP and Medicinal and aromatic plants suitable for Eastern, Central and Western part of country with Improved cultivation techniques of economically

Awareness & Training Programs

important medicinal and aromatic plants with their economics. Some of the key higlights in this training programmes are nursery raising techniques of important medicinal and aromatic plants, post-harvest processing techniques and various methods of distillation of herbal plants, Crop rotation & intercropping, proper storage of essential oils and medicinal herbs, Financial management by experts from Government Agencies/ Officials, Marketing aspects of essential oils and medicinal herbs and global states.

This skill cum-technology up-gradation training programme would be useful for existing and new Farmers, entrepreneurs, distillers, exporters/importers, perfumers, corporate houses for Farming/contract farming, processing, value addition etc.

Under this programme for the year 2019, CSIR-CIMAP,Lucknow organized some skill training programmes are listed below.

S. No.	Date	No. of Participants	No. of Days/ Place	Institutional Training Programme
1	25-27 July, 2019	108	3 Days CSIR-CIMAP Lucknow	CSIR-CIMAP skilled —cum- Technology Upgradation Programme in Cultivation and Processing of Economically Important Medicinal and Aromatic Crops
2	18-20 September, 2019	88	3 Days CSIR-CIMAP Lucknow	CSIR-CIMAP skilled —cum- Technology Upgradation Programme in Cultivation and Processing of Economically Important Medicinal and Aromatic Crops

3	18-24 November, 2019*	23	7 Days CSIR-CIMAP Lucknow	Seven Days Short Term Training Programme on "Cultivation, Processing and Quality Control of Commercially Important Medicinal &Aromatic Plants (MAPs)"
4	10-12 December, 2019	106 + 10	3 Days CSIR-CIMAP Lucknow	CSIR-CIMAP skilled —cum- Technology Upgradation Programme in Cultivation and Processing of Economically Important Medicinal and Aromatic Crops

A training manual on "quality control and quality assurance of medicinal & aromatic plants processing and value addition was also released. The following chapters were covered in this manual.

S. No.	Title of Chapters	Authors
1.	Standardization of medicinal & aromatic Plants and botanical raw drugs for herbal industries.	Dr. Narendra Kumar & Dipayan Ghosh
2.	Plant raw drug standardization : Significance and challenges in quality assurance	Dr. Karuna Shankar and Priyanka Maurya, Namita Gupta
3.	Quality Analysis of Medicinal Herbs: Detection and quantification of Contaminants in raw material and finish product	Dr Puja Khare
4.	High quality seed/planting material production and seed quality testing.	Dr Birendra Kumar
5.	Agriculture diversification for sustainable development : Utilization of water & land resources	Dr. Alok Kumar Krishna
6.	Analytical Methods for Determination of Quality of Commercially Important Essential Oils	Dr. Chandan S Chanotiya
7.	Distillation, Purification and Storage of Essential Oils	Er. Sudeep Tandon
8.	Research Based Herbal Formulations for Startups and Entrepreneurship development – (A unique platform for start-ups)	Dr. Dinesh Kumar

The details of menthol-mint suckers distributed to different farmers of Udhamsingh Nagar and Nainital

District	Place	Nos. of framers	Total nos. of farmers
Udhams-ingh Nagar	Nagadpuri (Bajpur)	30	155
	Patrampur (Jaspur)	30	
	Haripura Harsan (Bajpur)	50	
	Bheekampuri (Bajpur)	40	
	Pantnagar/Rudrapur (U.S. Nagar)	05	
Nainital	Chhoi (Ram Nagar)	30	90
	Dhela, (Ram Nagar)	10	
	Bailpokhra (Kaladhungi)	50	
		Total	**245**

The above farmers belonging to areas showed their keen interest for the cultivation of Menthol-mint variety CIM-Kranti to enhance their income in a sustainable manner as well as to increase farm productivity through agriculture intensification because they are able to take menthol-mint as an additional crop in summer. Approximately a total of 250 acres of land (150 acres and 100-acre area in Udhamsingh Nagar and Nainital district respectively) to be covered by Menthol-mint variety CIM-Kranti during summer 2020.

Glimpses of Quality Planting Material Distribution to the Selected Farmers

Distribution of menthol-mint sucker to the beneficiary farmers of Nainital & U.S. Nagar Districts of Uttarakhand

Kisan Mela 31st January 2019

Kisan Mela 31st January 2019

Kisan Mela 31st January 2019

Kisan Mela 31st January 2019

National Conference on Mints- Prospects, Challenges and Threats held on 24-26 February 2019

National Conference on Mints- Prospects, Challenges and Threats held on 24-26 February 2019

National Conference on Mints- Prospects, Challenges and Threats held on 24-26 February 2019

National Conference on Mints- Prospects, Challenges and Threats held on 24-26 February 2019

Annual day celebration in presence of previous directors on 26th March 2019

Release of the glimpses 60 years on 26th March 2019

Release of Mentho-fresh mouth wash on 26th March 2019

Inaugural ceremony of CIMAP sports meet 2019 on April 9th 2019

Felicitation sanitization staff on the occassion of Swatchata Pakhwada on 10th june 2019

International Yoga day celebration on 21st June 2019

Dr. NP Yadav received ICMR Prize for Biomedical Scientist

Visit of a delegation from National Research Institute of Chinese Medicine (NRICM), Taipei, Taiwan. Prof. Fang Rong Chang, Director, NRICM along with his delegation had a meeting with Dr Abdul Samad, Director, CSIR-CIMAP.

Visit of Taiwanee delegates on July 5th 2019

Visit of French delegation to Interact on research cooperation with the attache of university cooperation/French Embassy in India, Mme. Emilia Cartier on July 8th 2019

Visit of French delegation to Interact on research cooperation with the attache of university cooperation/French Embassy in India, Mme. Emilia Cartier on July 8th 2019

Training program on medicinal and aromatic plants 09-11 July 2019

A tri-partite MoU has been signed between CSIR-CIMAP, BAIF Foundation Pune, and Nishant Aroma, Mumbai on 8th August 2019 at BAIF Foundation, Warje Pune.

Independence day Celebration 15th August 2019

MOU signed with the Integral University on 11th September, 2019

CSIR-Aroma Mission Scientists aroma industry interaction on 24th Sept 2019

CSIR-Aroma Mission Scientists aroma industry interaction on 24th Sept 2019

CSIR-Aroma Mission Scientists aroma industry interaction on 24th Sept 2019

Releasing of newly developed varieities of 'CIM-Utkrisht' & 'CIM-Sushil' on 77th CSIR foundation day developed by the team led by Dr VR Singh, Dr AK Gupta and Dr Ashutosh Shukla

CSIR foundation day celebration 26th September 2019 with Prof. Mukhopadhyay as a chief guest

Seven days Bioinformaties skill development workshop on Machine Learning Application in biological Data Analysis: Linear Regression & k-Means clustering October 15-21 2019

Lecture on MAPs" on 22nd October, 2019, in Joint Forum for Traditional Medicine under the New Southbound Policy at National Research Institute of Chinese Medicine at Taipei

A National Workshop on using IBIN Database for Research and Education in Ecology and Conservation inugurated by Prof. Alok Dhawan on 7–8 Nov 2019

A National Workshop on using IBIN Database for Research and Education in Ecology and Conservation inugurated by Prof. Alok Dhawan on 7–8 Nov 2019

Constitution day oath taking ceremony on 26th Nov 2019

Kisan Mela 31st Janaury 2020

Kisan Mela 31st Janaury 2020

Skill upgrading advance training program on agro-processing and value addition technologies for MAPs February 7-14th 2020

Skill upgrading advance training program on agro-processing and value addition technologies for MAPs February 7-14th 2020

A warm welcome to Dr. P.K. Trivedi to lead CIMAP by Dr. A. Samad, acting Director, CIMAP on 14th February 2020

Dr Prabodh K. Trivedi took over the charge of Director, CSIR CIMAP on 14th February 2020

One day awareness program on cultivation, processing and marketing of Aromatic crops held today on farmer's field at Varne, Satara, Maharashtra under CSIR- Aroma Mission on 18th February 2020

Exposure cum awareness visit of 157 Civil Judges (Junior Division) about MAPs cultivation, processing and value addition technologies on 18th February 2020

Exposure cum awareness visit of 157 Civil Judges (Junior Division) about MAPs cultivation, processing and value addition technologies on 18th February 2020

A meeting to look into the possible collaboration between SYMRISE and CSIR-CIMAP on 19th February 2020

National Science day celebration 28th February 2020

Hankool - an essential oil based hand sanitizer patented product from CSIR CIMAP was distributed by Dr. Prabodh K. Trivedi, Director on 19th March 2020

Visit of Iranian students at CSIR CIMAP

Ist prize in Flower Show organized by Nagar Nigam, Lucknow from 29th February to 1st March 2020

Training on Practical Aspects of Liquid Chromatography from 29th February to 6th March, 2020

Sponsored Projects

SN	Funding Agency	Project No.	Project title	PI	Start date	Total cost (Rs.)	End date
1	DBT, New Delhi	GAP-420	Assessment of distribution, genetic diversity and population status for conservation of recently described tree species (*Eugenia agasthiyamalayana*, *Calophyllum pascalianum* and *Garcinia gamblei*) from Agasthyamalai Bisphere Reserve (ABR),Western Ghats, India	Dr. V Sundaresan	04.01.2019	38,09,800	03.01.2022
2	Government of India Ministry of Finance Department of Revenue, New Delhi	GAP-421	Improvement of latex-less and alkaloid variety of *Papaversomnifera* L. towards development of phenotypically distinct variety for commercial exploitation as nutritive seed crop	Dr. Ved Ram Singh	18.01.2019	2,38,00,000	17.01.2024
3	DBT, New Delhi	GAP-452	Scientific validation of ethno-medicinal plants for enteric infections, development of a formulation along with in-situ/ex-situ conservation of incorporated plants	Dr. Anirban Pal	12.02.2019	25,98,200	11.02.2022
4	DST, New Delhi	GAP-423	Agrobacterium rhizogenes mediated hairy root cultures of *Bergenia* spp.: A potential source for kidney stone remedy	Farah Deeba	21.02.2019	29,95,000	20.02.2022
5	DST-SERB, New Delhi	GAP-424	Metabolic engineering in a carotenoid over-producing bacterium for development of an efficient platform strain for zerumbone production	Dr. Mukti Nath Mishra	14.03.2019	28,83,859	13.03.2022
6	DBT, New Delhi	GAP-425	Application of menthol mint and vetiver technology through introduction of sugarcane-mint intercropping and bio-resources waste utilization for rurul development and women empowerment in Purvanchal region of Uttar Pradesh	Dr. Alok Kumar Krishna	19.03.2019	34,77,780	18.03.2022
7	NMPB, New Delhi	GAP-422	Establishment of nursery for production and supply of quality planting material	Dr. Jananasha AC	20.03.2019	18,92,000	19.03.2022

8	DBT, New Delhi	GAP-426	Molecular and biochemical studies on indigenous medicinal plants from the North East India including *Urginea indica* (Bon Pollundu) and *Dactyloscapnos scandens* for the development of potential Anti-diabetic formulations	Dr. Sumit Ghosh	22.03.2019	25,71,200	21.03.2022
9	Meghalaya Basin Development Authority (MBDA) HQR, Shillong	CNP-427	Providing technical services for setting up of distillation facilities for Meghalaya Basin Development Authority (MBDA) to support Aroma Mission	Er. Sudeep Tandon	23.04.2019	25,14,460	22.04.2020
10	Jharkhand State Livelihood Promotion Society, Jharkahnd (JSLPS)	SSP-428	Training programme on cultivation, processing and marketing of economically important aromatic and medicinal crops suitable for Jharkhand state	Dr. Ram Suresh Sharma	15.05.2019	6,62,500	14.05.2020
11	ACi Asheesh Concentrates International, Mumbai	GAP-430	Identification and selection of THC, CBD, cannabinoid terpene and THCa rich strain/line/genotype of *Cannabis* spp.	Dr. Birendra Kumar	03.06.2019	98,20,800	02.06.2021
12	Telangana State Medicinal Plant Board, Hyderabad	GAP-431	Development of small nursery for supply of quality seed of Ashwagandha (Poshita) in Telangana state	Dr. J Kotesh Kumar	05.07.2019	6,25,000	04.07.2020
13	ICMR-DHR, New Delhi	GAP-432	Development of cancer chemotherapeutics through microtubule dynamics modulators	Dr. Arvind Singh Negi	09.07.2019	24,37,500	08.07.2022
14	DBT, New Delhi	GAP-441	Identification and characterization of active molecules derived from selected edible medicinal plant of Arunachal Pradesh against rotavirus and clinical isolated of drug resistant E. coli and S. aureus.	Dr. MP Darokar	06.08.2019	28,00,192	05.08.2022
15	Rashtriya Krishi Vikas Yojana(RKVY) Government of Odisha Agriculture & Farmers' Empowerment Department	SSP-433	Farm based S&T interventions for socio-economics development in the aspirational district of Nabarangpur, Odisha	Dr. Ajit Kumar Shasany	12.09.2019	48,96,000	11.09.2020

16	DBT, New Delhi	GAP-453	Standardization of Indigenous probiotic based formulation for immunity, Glucose and Lipid metabolism	Dr. Anirban Pal	17.09.2019	27,00,240	16.09.2022
17	Conservator of Forest (Project) Uttar Pradesh, Lucknow	SSP-434	Promotion of cultivation of medicinal plants on Ganga basin in UP.	Dr. Rajesh Kumar Verma	30.09.2019	22,24,000	29.09.2020
18	DBT, New Delhi	GAP-435	Exploring the efficacy of nutrient rich biochar based fertilizer on tea (*Camellia sinensis* L.) and Indian ginseng (*Withania somnifera* L.): A biotechnological intervention	Dr. Puja Khare	01.10.2019	2800240	30.09.2022
19	Biotechnology Industry Research Assistance Council,New Delhi	GAP-439	Production of alpha-farnesene, a natural sesquiterpene, from Yeast expression system	Dr. Venkata Rao, D.K.	10.10.2019	23,80,000	09.04.2021
20	The National Academy Sciences, India (NASI), Allahabad,UP	GAP-436	Enabling tribal farmers of NER (Assam, Meghalaya, Nagaland and Manipur) for enhancement of agriculture income through organization of awareness programme on cultivation and processing of suitable aromatic crops	Dr. RK Srivastava	14.10.2019	6,12,000	13.10.2020
21	DST-INSPIRE Faculty Award, New Delhi	GAP-437	Exploration of role and regulation of putative genes involved in multidrug efflux pimp mediated intrinsic drug resistance in *Mycobacterium*	Dr. Mukti Nath Mishra	15.10.2019	17,23,208	14.10.2021
22	Vindhyachal Agrofarms Pvt. Ltd. Mirzapur	CNP-438	Providing technical guidance for planning and setting up of the processing facilities for the distillation of aromatic crops of the client	Er. Sudeep Tandon	08.11.2019	3,35,710	07.11.2021
23	Government of Nagaland, Kohima	GAP-440	Survey and analysis of area for preparation of Detail Project Report (DPR) for establishment of Centre for Excellence of Medicinal & Aromatic Plants in Nagaland	Dr. RK Srivastava	06.12.2019	5,00,000	05.12.2020
24	DST, New Delhi	GAP-442	High throughput imaging system in Mentha arvensis for management of diseases, nutrient, water and harvesting using machine learning algorithms	Dr. Nupoor Prasad	16.12.2019	28,67,400	15.12.2022

25	United Nations Development Programme (UNDP), New Delhi	GAP-443	Promotion of aromatic crops value chain for conservation based and sustainable livelihood practices in selected districts of Kerala	Dr. ND Yogendra	31.12.2019	41,88,000	30.12.2021
26	A.P. Medicinal & Aromatic Plants Board, Hyderabad	GAP-444	Conducting sample survey for quality analysis of Aswagandha and Long Pepper by HPLC method in the farmer fields of Andhra Pradesh for the cropping period 2017-18	Dr. J Kotesh Kumar	14.01.2020	5,00,000	13.01.2021
27	Krishi Vigyan Kendra, Korea (C.G.)	CNP-446	Providing consultancy for designing, fabrication and setting up of Mild Steel directly fired type field Distillation unit of 500 kg capacity for essential oils based on CSIR-CIMAP knowhow & design	Er. Sudeep Tandon	29.01.2020	4,90,860	28.01.2021
28	M/s Big Brother Nutra Care Pvt. Ltd. Meerut	CNP-445	Development of Tobacco and Nicotine free chewable anti-oxidant granules with anti-microbial effect for oral health	Dr. Karuna Shanker	07.02.2020	23,60,000	06.02.2021
29	DST-SERB, New Delhi	GAP-447	Investigating key roles of cytochrome P450 monooxygenases in triterpene saponin biosynthesis in the medicinal tree arjuna (Terminalia arjuna) for sustainable production of cardioprotective phyochemicals	Dr. Sumit Ghosh	14.02.2020	51,35,637	13.02.2023
30	DST-WOS B, New Delhi	GAP-448	Promotion of *Moringa* based farming system and development of value added products for livelihood security rural employment	Ms. Kamini Singh	29.02.2020	21,84,560	28.02.2023
31	SS Solution India Pvt. Ltd. Lucknow	CNP-449	Providing consultancy and technical guidance for designing and development of mobile solar aroma distillation technology	Er. Ashween D. Nannaware	03.03.2020	9,26,300	02.09.2021

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

Dr Alok Kalra

Former acting Director, CSIR-CIMAP

ALOK KALRA earned his Ph.D. in Plant Pathology from Haryana Agriculture University, Hisar in the year 1986. Subsequently, he joined CSIR-Central Institute of Medicinal and Aromatic Plants, Bangaluru (India) as a Scientist in the year 1986 and superannuated as Chief Scientist and Acting Director in 2019. Dr. Kalra made systematic efforts in developing the efficient strains of *Trichoderma*. Amongst others, *T. Harzianum* was useful as a bio-fungicide, growth promoter, and nematode inhibitor. Another species namely *T. Citrinoviride* was efficient for the production of higher amounts of Exo- and Endo- glucanase, and ß glucosidase. He identified the distillation wastes of Medicinal and Aromatic Plants (MAPs) as a cheap substrate for higher cellulase production and mass multiplication of *Trichoderma* for developing quality vermicompost. Further, his research work was focused on understanding the complementary relationship among plant growth-promoting traits within a community that plays significant roles in delivering microbial services to the plant. He conclusively established the role endophytes in enhancing the tolerance of plants to multiple stresses and modulating the biosynthetic pathways and improving secondary metabolites content in medicinal plants. Dr. Kalra played a key role as Principal Investigator of the CSIR-Aroma Mission project, a Mission project of national importance, from its inception to execution. Under his guidance, the CSIR-CIMAP scored many successes related to the different objectives of the CSIR-Aroma Mission project.

Dr. Kalra is a Fellow of reputed academies of India which include the National Academy of Agricultural Sciences (NAAS) and the National Academy of Sciences, India (FNASc). He has been the recipient of many prestigious awards including the Essential Oil Association of India (EOAI) Award-2005, The Federation of Indian Chambers of Commerce & Industry (FICCI) Award-2005, CSIR-Award for Rural Development-2009, CSIR Technology Award-2000 and 2012. He has represented India as Country Representative in Multi-country Study Mission on Business Potential for Agricultural Biotechnology Products held in the Republic of China in 2005 and 2010 respectively, Dr. Kalra contributed 20 varieties, published more than 100 papers, and 16 patents to his credit.

Staff Members (As on 31 March 2020)

Dr.Prabodh Kumar Trivedi
Director

Chief Scientist
Dr. Abdul Samad
Shri PV Ajaya Kumar
Dr. AK Shasany
Dr. Saudan Singh

Senior Principal Scientist
Dr. Alok Kumar Krishna
Dr. Ved Ram Singh
Dr. MP Darokar
Er. G. D. Kiranbabu
Dr. Arvind Singh Negi
Er. Sudeep Tandon
Dr. Birendra Kumar
Dr. AK Gupta
Dr. Laiq-Ur-Rahman
Dr. Dharmendra Saikia
Dr. Rakesh Pandey
Dr. Vikrant Gupta
Dr. Anirban Pal
Dr. Dinesh A. Nagegowda
Dr. J Kotesh Kumar

Principal Scientist
Dr. (Mrs) Sunita Singh Dhawan
Dr. Dayanandan Mani
Dr. Karuna Shanker
Dr. Rajesh Kumar Verma
Dr. Sanjay Kumar
Er. Manoj Semwal
Dr. Dnyaneshwar Umrao Bawankule
Dr. Feroz Khan
Dr. Sumit Ghosh
Dr. Ashutosh Kumar Shukla
Dr. Narayan Prasad Yadav
Dr. Suaib Luqman
Dr. Rajendra Chandra Padalia
Mr. KVN. Satya Srinivas
Dr. (Mrs) Prema G. Vasudev
Dr. V. Sunderesan
Mr. Ram Swaroop Verma
Dr. (Smt) Puja Khare
Dr. Chandan Singh Chanotiya
Dr. Debabrata Chanda
Dr. Prasanta Kumar Rout

Sr. Scientist
Dr. Rakesh K. Shukla
Dr. Venkata Rao D.K.
Dr.(Mrs) Abha Meena
Dr. Atul Gupta
Dr. (Ms.) Tripta Jhang
Dr. Pradipto Mukhopadhyay
Dr. Kishore Babu Bandamaravuri
Dr. Ramesh Kumar Srivastava
Dr. Mukti Nath Mishra
Dr. Rakesh Kumar Upadhyay
Er. Ashween D. Nannaware
Er. Bhaskar Shukla
Dr. Ram Suresh Sharma

Scientist
Dr. Hari Om Gupta
Dr. Rakesh Kumar
Dr. Yogendra N.D.
Dr. Narendra Kumar
Dr. Jnanesha A.C
Dr. Channayya Hiremath
Dr. Venkatesha K.T.
Dr Akanksha Singh
Dr Dipender Kumar
Dr Gunjan Tiwari
Dr Kapil Dev
Dr Priyanka Suryavanshi
Dr Bhise Rushikesh Nanasaheb
Dr Santosh Kumar Chandappa Kedar
Dr B Shivanna
Dr V S Pragadheesh

Group-III

Medical Officer

Dr VK Agarwal

Sr. Superintending Engineer

Shri A M Khan

Principal Technical Officer

ShriPrem Singh
Dr DK Rajput
Dr. Sukhmal Chand

Sr. Technical Officer (3)

Shri K Bhaskaran
Dr Ateeque Ahmad

Sr. Technical Officer (2)

Mrs. Sudha Agarwal
Dr. Neerja Tiwari

Sr. Technical Officer (1)

Smt. Anju Kumari Yadav
Shri Shiv Prakash
Dr. (Mrs.) Manju Singh
Dr. Rajendra Prasad Patel
Dr. Rakshpal Singh
Dr. Anil Kumar Singh
Shri Ram Pravesh
Dr. Amit Chauhan
Dr. Anil Kumar Maurya
Shri A.K. Tiwari

Technical Officer (Gr. III (3))

Mr. Amit Mohan
Smt Namita Gupta
Shri Sanjay Singh
Shri A. Niranjan Kumar
Mrs. Anju Kesarwani
Shri Balakishan Bhukya

Technical Assistant

Shri Amit Kumar Tiwari
Shri Manoj Kumar Yadav
Shri Ashish Kumar
Sh. Prawal Pratap Singh Verma
Shri Ashish Kumar Shukla
Shri Manish Arya
Shri Sanjeet Kumar Verma
Shri Deepak Kumar Verma
Miss Pooja Singh
Shri Sonveer Singh
Shri Abhishek Kushwaha
Shri Rohit Kumar
Shri Ranjith Kumar Sunkari
Shri Abhishek Singh
Dr(Mrs) Sujata Singh Yadav
Shri Gyanesh Pandey
Shri Mohd Danish

Group-II

Sr. Technician (3)

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

Sr. Technician (2)

Shri Shyam Behari
Shri Ram Chandra
Shri SK Pandey
Shri Gopal Ram
Shri E Bhaskar
Shri PN Gautam
Shri Joseph M Massey
Shri Ram Lakhan
Shri PK Tiwari
Shri Vinod Kumar

Sr. Technician (1)

Shri Dharam Pal Singh
Shri V.K. Shukla
Shri Pankaj Kumar Shukla

Technician (2)

Shri Kundan Narayan Wasnik
Shri Yalla VVS Swamy

Shri Basant Kumar Dubey
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

Group-I

Lab Assistant

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

Lab Attendant (2)

Shri TP Suresh

Administrative Staff

Group-A

Controller of Administration

Shri Bhaskar Jyoti Deuri

Store & Purchase Officer

Shri B.L. Meena
Shri Ram Badal

Administrative Officer

Smt. B. Mallikamba

Finance & Account Officer

Shri Bhaskar Kumar Ravi
Shri H. Chongloi

Group-B (Gazetted)

Sec. Officer [Gen.]

Shri Hare RamKushwaha

Sec. Officer[F&A]

Shri R K Sonkar

Sec. Officer [S&P]

Shri Vikash Chand Mishra

Sec. Officer [Gen.]

Shri Sanjay Kumar Ram
Shri Vivek Bajpayee

Sec. Officer [F&A]

Shri Shailendra Pratap Singh

Private Secretary

Smt Kanchan Lata Thomas

Group-B (Non-Gazetted)

Asstt.Section Officer(Gen)

Smt Sufia Kirmani
Shri Muneshwar Prasad
Shri Sant Lal
Shri P Srinivas
Shri Kaushal Kishore
Shri Siddharth Shukla
Shri Ravi Prakash
Shri KG Thomas
Ms. Sanyogita Sainger
Shri PK Chaturvedi
Shri Manoj Swaroop Shukla
Mrs. Sheela Yadav

Asstt.Section Officer(F&A)

Shri Harish Chandra
Shri Shiv Kumar
Shri AL Sahoo
Shri Ayush Singhal
Smt KC Nagarathnamma

Asstt.Section Officer (S&P)

Shri Pankaj Kumar
Shri Shamiullah Khan
Shri Anees Ahmad
Shri Ajeet Verma

Senior Stenographer

Miss Gaitry Sharda
Smt P Sabitha
Shri Srikar Ji Sinha
Ms. Suchita Gupta

Isolated Posts (Group-B)

Shri Yograj Singh
Shri Rohit Khanna
Smt Sangeeta Tanwar

Group-C Posts

Sr. Secretariat Asstt(Gen)

Shri Vijay Kumar Bhartey
Mrs. Preeti Gangwar

Sr. Secretariat Asstt(F&A)

Shri Pradeep Kumar

Jr. Secretariat Asstt(Gen)

Shri R Algarswamy
Shri. Ravi Prakash Mishra
Ms. Pratibha Maurya

Jr. Secretariat Asstt(F&A)

Ms. Sonali Kumari Yadav

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 Tula Singh
Shri Ashok Kr. Pathak
Shri Kishan Lal
Shri P Bhikshapathi
Smt Nirmala Verma
Smt Tara Devi
Smt. Nargis Sufia Ansari
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 Abdul Nadir Khan
Shri Arvind Kumar
Smt. Raj Mati
Shri Harpal Valmiki
Shri Kripa Ram
Shri Mohd. Shameem
Shri Mohd. Mohsin
Smt. Pushpa

New Staff Members

CIMAP Welcomes New Staff Members

S.No	Name	Designation	Date of Joining	Posting
1.	Ms. Sonali Kumari Yadav	JSA(F&A)	29.01.2019	CSIR-CIMAP, Lucknow
2.	Shri Shashank Shivhare	JSA(F&A)	29.01.2019	Resigned
3.	Shri Rajesh Kumar Sonakar	SO(F&A)	26.04.2019	CSIR-CIMAP, Lucknow
4.	Smt.Pushpa	MTS(Gr D)	17.07.2019	CSIR-CIMAP, Lucknow
5.	Dr Akanksha Singh	Scientist	25.10.2019	CSIR-CIMAP, Lucknow
6.	Shri Santosh Prasad Saroj	Technician	04.11.2019	CSIR-CIMAP, Lucknow
7.	Shri Junaid	Technician	05.11.2019	CSIR-CIMAP, Lucknow
8.	Shri Vivek Bajpayee	SO(Gen)	06.11.2019	CSIR-CIMAP, Lucknow
9.	Shri Manish Kumar Maurya	Technician	08.11.2019	CSIR-CIMAP, Lucknow
10.	Shri Pushpendra Katiyar	Technical Assistant	08.11.2019	Resigned
11.	Shri Sujit Singh Chauhan	Technician	11.11.2019	CSIR-CIMAP, RC Hyderabad
12.	Shri Abhishek Kushwaha	Technical Assistant	11.11.2019	CSIR-CIMAP, Lucknow
13.	Shri Sonu Kumar	Technician	13.11.2019	CSIR-CIMAPRC Bengaluru
14.	Dr Dipender Kumar	Scientist	14.11.2019	CSIR-CIMAPRC Pantnagar
15.	Shri Rohit Kumar	Technical Assistant	15.11.2019	CSIR-CIMAP, Lucknow
16.	Dr Gunjan Tiwari	Scientist	27.11.2019	CSIR-CIMAP, Lucknow
17.	Dr Kapil Dev	Scientist	27.11.2019	CSIR-CIMAP, Lucknow
18.	Dr Priyanka Suryavanshi	Scientist	03.12.2019	CSIR-CIMAP, Lucknow
19.	Dr Bhise Rushikesh Nanasaheb	Scientist	03.12.2019	CSIR-CIMAP, Lucknow
20.	Dr Santosh Kumar Chandappa Kedar	Scientist	05.12.2019	CSIR-CIMAP, Lucknow
21.	Shri Ranjith Kumar Sunkari	Technical Assistant	12.12.2019	CSIR-CIMAP, Lucknow
22.	Shri Abhishek Singh	Technical Assistant	20.12.2019	CSIR-CIMAP, Lucknow
23.	Ms Sujata Singh Yadav	Technical Assistant	26.12.2019	CSIR-CIMAP, Lucknow
24.	Dr B Shivanna	Scientist	30.12.2019	CSIR-CIMAP, Lucknow
25.	Dr V S Pragadheesh	Scientist	08.01.2020	CSIR-CIMAP, RC Bengaluru
26.	Shri Sateesh Kumar	Technician	13.01.2020	CSIR-CIMAP, Lucknow
27.	Shri Gyanesh Pandey	Technical Assistant	13.01.2020	CSIR-CIMAP, Lucknow
28.	Shri Danish	Technical Assistant	03.03.2020	CSIR-CIMAP, Lucknow

Staff Superannuated

S.No.	Name	Designation	Date of Retirement
1.	Shri Govind Ram	Senior Technical Officer	31.01.2019
2.	Dr Dasha Ram	Principal Technical Officer	31.01.2019
3.	Smt. Pushpa Semwal	Lab Attendant(2)	31.01.2019
4.	Shri Manmohan	Lab Attendant	29.02.2019
5.	Smt Farzana Hafeez	Assistant(F&A) II(MACP)	31.03.2019
6.	Dr Alok Kalra	Chief Scientist	30.04.2019
7.	Shri Santosh Kumar	Group D (NT)	30.04.2019
8.	Shri Kanhaiya Lal	Assistant Section Officer (F&A)	30.06.2019
9.	Shri Mahesh Prasad	Lab Assistant	30.06.2019
10.	Shri Parvez Nazir	Assistant Section Officer (G)	31.07.2019
11.	Shri Abdul Mabood	Lab Assistant	31.07.2019
12.	Shri Vijay Kumar Singh	Lab Assistant	30.11.2019
13.	Dr Dinesh Kumar	Principal Technical Officer	31.12.2019
14.	Shri Mohd Navi	Lab Assistant	31.12.2019

Publications (2019- 2020)

1. Akhoon BA, Gandhi N, Pandey R. 2019. Computational insights into the active structure of SGK1 and its implication for ligand design. *Biochimie*165: 57-66. (IF:3.18).
2. Akhoon BA, Gupta SK, Tiwari S, Rathor L, Pant A, Singh N, Gupta SK, Dandekar T, Pandey R. 2019. C.elegans protein interaction network analysis probes RNAi validated prolongevity effect of nhr-6, a human homolog of tumor suppressor Nr4a1.*Scientific Reports* 9:15711 | https://doi.org/10.1038/s41598-019-51649-0. (IF: 3.99)
3. Alam S, Khan F. 2019. 3D-QSAR, Docking, ADME/Tox studies on Flavone analogs reveal anticancer activity through Tankyrase inhibition. *Scientific Reports*, 9(1):5414. (IF: 3.99)
4. Chaturvedi T, Singh S, Nishad I, Kumar A, Tiwari N, Tandon S, Saikia D, Verma RS. 2019. Chemical composition and antimicrobial activity of the essential oil of senescent leaves of guava (*Psidium guajava* L.). *Natural Product Research*, DOI: 10.1080/14786419.2019.1648462 (IF: 2.158)
5. Chauhana A, Venkatesha KT, Padalia RC, Singh VR, Verma RS, Chanotiya CS. 2019. Essential oil composition of leaves and inflorescences of *Elsholtziadensa*Benth. from western Himalaya. *Journal of Essential Oil Research*, 31(3), 217-222 (IF:1.148).
6. Dhawan SS, Lal RK,Gupta P,Chanotiya CS, Kalra A, Mishra A, Singh SK, Yadav A, Srivastava S, Singh S, Singh VR, Tandon S, Singh R, Verma RK, Singh S, Maurya R. 2019. Registration of a new variety of basil- CIM Shishir: A multicut, lodging resistant, cold tolerant, high essential oil yielding, linalool rich inter specific hybrid of Ocimum, *Journal of Medicinal and Aromatic Plant Sciences* 86-91.
7. Gautam KK, Sharma P, Sinha S, Pandey A, Samad A. 2019. First Report of Sugarcane Grassy Shoot Phytoplasma (16SrXI) Associated with Little Leaf Diseas of *Chrysopogonzizanioides* from India. *Plant Dis*. 103:2468 (IF: 3.02)
8. Gupta R, Singh A, Srivastava M, Shankar K, Pandey R. 2019. Plant-microbe interactions endorse growth by uplifting microbial community structure of *Bacopa monnieri* rhizosphere under nematode stress. *Microbiological Research* 218: 87-96 (IF: 3.97).
9. Hussain Y, Luqman S, Meena A 2020. Research progress in improving shortcomings of the anticancer drug (s) considering flavonoid (s) synergy with novel approaches. *Currents Topics in Medicinal Chemistrydoi.org/10.2174/1568026620666200502005411*(IF: 3.26).
10. Imran AM, Prakash R,John AA, Wani Z, Yadav D, Bawankule DU, Luqman S, Khan F, Singh D, Gupta A. 2020.Induced osteoblast differentiation by amide derivatives of stilbene: The possible osteogenic agents.*Bioorganic & Medicinal Chemistry Letters*, 30, 11, 127138. (IF: 2.57)
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Books and Book Chapters

Books:

1. Pandey R, Mishra AK, Singh HB, Kalra A, and Singh D. 2019. Diseases of Medicinal and Aromatic Plants and Its Management" Published by Today & Tomorrow Press, New Delhi: ISBN: 9788170196334, 366pp.

Book Chapters:

1. Ashish K, and Jnanesha AC. 2019. Agro-technologies in Economically Important Aromatic Plants in India. In. *Medicinal, Aromatic & Spice Plants*. Eds. Akhil Baruah. Eastern Book House Publication, Guwahati, India, Vol. 01; pp. 348-366. ISBN: 978-93-88881-02-9.
2. Ashish K, and Jnanesha AC. 2019. Milk thistle [*Silybum marianum* (L.) Gaertn]. In. *Medicinal plants in India: Importance and cultivation*. Eds: Gosh SN, Jaya Publishing house, Delhi, pp.388-414, ISBN: 9789388668095.
3. Ashish K, Singh MK and Jnanesha AC. 2019. Utilization of Flyash for Cultivation of Medicinal and Aromatic crops. In. *Innovation in Agriculture, Environment and Health, Research for Ecological Restoration*. Eds. Hemlata Pant, Ambreesh Singh Yadav, Manoj Kumar Singh, Jyoti Verma, Vivek Kumar Srivastava and Ashish Kumar. Society of biological sciences and rural development, Allahabad, India; pp. 102-109. ISBN: 9788192353555.
4. Chaturvedi S, and Pandey R. 2019. Mycorrhiza - A beneficial approach for disease management in medicinal and aromatic plants In: *Diseases of Medicinal and Aromatic Plants and Their Management*. Eds: Rakesh Pandey, A.K. Misra, H.B. Singh, Alok Kalra and Dinesh Singh; Published by Today & Tomorrow Press, New Delhi, pp.249-272. ISBN: 9788170196334
5. Jnanesha AC, and Ashish K. 2019. Agro-technology and Bio-prospecting in Important Medicinal Plants. In. *Medicinal, Aromatic & Spice Plants*. Eds. Akhil Baruah. Eastern Book House Publication, Guwahati, India, Vol. 01; pp. 327-347. ISBN: 978-93-88881-02-9.
6. Pandey, R., Singh, A. Trivedi,S, Smita, S S, Pandey, T, Shukla, A and Tandon S. 2019. Diseases of mints and their management. In: *Diseases of Medicinal and Aromatic Plants and Their Management* Eds: Rakesh Pandey, A.K. Misra, H.B. Singh, Alok Kalra and Dinesh Singh;, Published by Today & Tomorrow Press, New Delhi, pp273-303, ISBN: 9788170196334
7. Singh A, Chaubey R, Singh S, and Pandey R. 2019. Diseases of ashwagandha, henbanes, patchouli, coleus and their management In: *Diseases of Medicinal and Aromatic Plants and Their Management,* Eds: Rakesh Pandey, A.K. Misra, H.B. Singh, Alok Kalra and Dinesh Singh Published by Today & Tomorrow Press, New Delhi, pp: 199-247. ISBN: 9788170196334.
8. Singh A, Gupta R, Chaturvedi S, and Pandey R. 2020. Harnessing the soil microbial wealth for enhancement of plant secondary metabolites in medicinal and aromatic plants; In: *New and Future Development in Microbial Biotechnology and Bioengineering; Microbes in soil, Crop and Environmental Sustainability*. Eds. J.Singh, Elsevier, pp:179-186 DOI: https://doi.org/ 10.1016/ B978-0-12-818258-1.00011-X.
9. Singh SK. Dhawan SS. 2019. *Mucunapruriens* (L.) DC: Ensuring Sustainability and Societal Enabling Through Agricultural Practices Plants of commercial values. In: *Plants of Commercial Values*, Eds. Singh B, New india Publishing Agency, New Delhi, India, pp 265-272. ISBN: 9789387973503.
10. Yadav K, Singh MR, Rai VK, Srivastava N, Yadav NP. (2020). Commercial aspects and market potential of novel delivery systems for bioactives and biological agents. In: *Advances and Avenues in the Development of Novel Carriers for Bioactives and Biological Agents*, Eds: Singh MR, Singh D, Kanwar JR, Chauhan NS Academic Press, pp.595-620, ISBN: 9780128196663.

Patents

Patents Granted

Title	Inventors	Country	Patent number/ grant date
An environment friendly process for isolation of lipids, cellylose, hemicellulose and lignin from the agricultural residues (Biomasses) • The present invention relates to an eco-friendly, efficient and economical process for the isolation of biopolymers such as lipids, cellulose, hemicellulose and lignin from agricultural residues. The present invention further relates to the preparation of new solvent systems such as imidazole-tosylic acid, imidazole-formic acid, imidazole-acetic acid, etc for isolation of lignin and aqueous solution of imidazole-alkali for isolation of hemicellulose.	PK Rout AD Nannaware Om Prakash Ram Rajasekharan	USA	US 10287527 14.5.2019
A process for chemical conversion of isolated cellulose from aromatic spent biomass to hydroxyl methyl furfural. • The invention relates to the development of green process for the preparation of hydroxymethyl furfural (HMF) from cellulose isolated from spent aromatic biomass. HMF is a key intermediate substance useful as substitute of petro chemicals. As cellulose is the major constituent (40-50%) of the spent aromatic biomass (hemicellulose, 25-30% and lignin 15-20%) it is being used for synthesis of HMF. The synthesis of HMF from isolated cellulose is an economical process and is completely environment-friendly which describes the development of sustainable, integrated and holistic strategy for utilizing the waste aromatic biomass to produce various valuable bio-chemicals.	P K Rout A D Nannaware Ram Rajasekharan	India	India 326942 6.12.2019
2-benzyl-indanone compounds as anticancer agent and a process for preparation thereof. • The anticancer activity of gallic acid derivative has been invented, in order to obtain new potent and cost effective molecule using *in vitro* cytotoxicity assay. The compound also exhibited tubulin polymerisation inhibition. 2-(3′,4′-methylenedioxybenzyl)-3-(3″,4″,5″-trimethoxyphenyl)-indanone-1 (**1**), possessing molecular formulae as $C_{29}H_{30}O_9$ was synthesized from gallic acid, exhibits potent *in-vivo* anticancer activity. Compound **1** was evaluated for acute oral activity in Swiss albino mice and it was found to be well tolerated by the experimental animals up to 300mg/kg body weight.	AS Negi Aastha Singh Suaib Luqman Debabrata Chanda Dilip Manikrao Mondhe Ajit Kr. Saxena Kaneez Fatima Arjun Singh	Europe, Great Britain, France	Europe, Great Britain, France 3322687 26.2.2020

Awards & Recognitions

S. No	Name of Award	Name of Awardee	Year	Agency	Work	Any other
1	Raman Research Fellowship awarded by CSIR for the year 2019-'20 to conduct research at Biomolecular Technology Group, School Allied Health Sciences, Health & Life Sciences, De Montfort University, The Gateway, Leicester, LE1 9BH, United Kingdom.	Dr Velusamy Sundaresan		CSIR, New Delhi	An ethno-genomics-based strategy towards generation of authentic Biological Reference Library with DNA barcode sequences to underpin authentication of Ocimum species	
2	Dr. P.D. Sethi Memorial National Award	Dr. Karuna Shanker	2020	Anchrom Enterprises India Pvt. Ltd behalf of Dr. P.D. Sethi Memorial National Award Committee 2018	Simultaneous quantification of six polymethoxyflavones in *Gardenia lucida* Roxb. using high-performance thin-layer chromatography" authored by Priyanka Maurya, Madhumita Srivastava, and Karuna Shanker*	Cash prize : 15000/-
3	Newton-Bhabha Fellowship	Ms. Sonali Mishra Student of Dr. Karuna Shnaker, Ms Arpita Tripathi, student of Dr. A. Kalra	2019	Department of Science and Technology, Govt. of India and British Council, UK		
4	Nominated as a subject expert member of Unani Pharmacopeia Committee of Central Council for Research in Unani Medicine (CCRUM)	Dr. Karuna Shanker	2019	Ministry of AYUSH, Govt of India.		

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Smt. Sudha Agarwal
Senior Technical Officer (2), CSIR-CIMAP, Lucknow

Control of Finance & Account /
Finance & Account Officer

Member Secretary

Controller of Administration /
Administrative Officer

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The summary of the cases during 1st Jan 2019 - 31st March 2020 is:

From 01st Jan 2019 - 31st Mar 2020					
Application Received	**Rejected**	**Information provided**	**1st Appeal**	**Decision where 1st appeal replied**	**Referred to CIC, New Delhi**
110including Transfer cases	NIL	110	04	04	NIL

Input: Bhaskar Shukla/D.Saikia

Budget at Glance (As on 31 March 2020)

	Allocation (₹ in lakhs)	Expenditure (₹ in lakhs)
Pay and Allowance	3077.983	3077.983
Contingency	397.332	397.332
HRD	0	0
Lab Maintenance	356.31	356.31
Staff Qtr. Maintenance	48.845	48.845
Chemicals / Consumables	465.824	465.824
Works and Services	113.93	113.93
Apparatus and Equipment	445.963	445.963
Office Equipment	0	0
Furniture and Fitting	4	4
Library (Books& Journal) P50	110.982	110.982
Staff Qtrs. (Construction)	41.787	41.787
CSIR Network Projects	1174.526	1174.526
Total	6837.482	6837.482
Pension	1935.653	1935.653
External Budgetary Resources		
Lab Reserve Fund (LRF)		6.052
External Cash Flow (ECF)		946.751

Input: Finance & Accounts

PhD Awarded

List of the PhD Degree Awarded

S. No.	Name of the students	Thesis Title	Supervisor / Co-supervisor	Date of Viva	University/ Institute
1	Laxmi Rathore	Evaluation of antiaging and stress modulating activities of Boeravinone B from *Boerhaavia diffusa* L. in *Caenorhabditis elegans*	Dr. RakeshPandey	7th January 2019	AcSIR
2	Mridula Singh	Gene prospecting in *Papaver somniferum* using contrasting genotypes	Dr. Ashutosh Kumar Shukla	18th February 2019	AcSIR
3	Nida Qamar	Understanding monoterpenes channeling in Mentha species Understanding monoterpenes channeling in Mentha species	Dr. Ajit Kumar Shasany	24th January 2019	AcSIR
4	Vineet Yadav	Evaluation of synergistic effect of distilled waste derived biochar on carbon storage, soil fertility and MAPs productivity	Dr. (Mrs.) Puja Khare	18th February 2019	AcSIR
5	Swati Srivastava	Computational analysis of miRNAs and their role in secondary metabolite biosynthesis of MAPs	Dr. Ashok Sharma	21st February 2019	AcSIR
6	Atul Kumar Srivastava	Investigation of *curvularia* spp. infecting economically important medicinal and aromatic plants: Secondary metabolite profiling and their management	Dr. Abdul Samad	22nd February 2019	AcSIR
7	Khushboo Khan	Carbon sequestration and agro-economic potentials of aromatic crops based cropping systems	Dr. Rajesh Kumar Verma	7th March 2019	AcSIR
8	Pooja Singh	Genetic transformation of *Pelargonium graveolens* with bacterial *acc deaminase* gene for biotic and abiotic resistance	Dr. Laiq ur Rahman	11th March, 2019	AcSIR
9	Gaurav Srivastava	*In silico* Molecular Insight into the Structural and Functional Aspects of Drug Resistance Mechanisms in *Mycobacterium tuberculosis*	Dr. M P Darokar/ Dr. Ashok Sharma	13th March 2019	AcSIR

10	Neha Verma	Genetic Transformation Studies for Terpenoid Indole Alkaloids Pathway Engineering in *Catharanthus roseus* (L.) G. Don	Dr. Laiq ur Rahman/ Dr. A.K Mathur	14th March 2019	JNU
11	Sana Khan	Metabolic Engineering of Phenylpropanoid Pathway in Ocimum Species for Vanillin Production	Dr. Laiq ur Rahman	1st April 2019	AcSIR
12	Garima Singh	Molecular Interaction Study of Heavy Metals Chelator Metallothionein Type 2 with Cadmium in Medicinal and Aromatic Plants	Dr. Ajit Kumar Shasany / Dr. Ashok Sharma	2nd April 2019	AcSIR
13	Shiwani	Understanding of Aroma in *Ocimum* Species : Insights from Molecular, Phytochemical and Structural Studies	Dr. (Mrs.)Neelam Singh Sangwan	9th April 2019	AcSIR
14	Anant Kumar	Pharmacological Intervention of Selected Medicinal and Aromatic Plants-Derived Waste With Special Emphasis on Inflammatory Response in Malaria, Liver and Skin Disorder	Dr. D U Bawankule	3rd May 2019	AcSIR
15	Shilpi Jain	Biochar amendments to soils from acidic mine sites: Effects on soil properties and plant growth	Dr. Puja Khare	17th May 2019	JNU
16	Renu Yadav	Genetics of quantitative and qualitative traits including tropane alkaloids in Black henbane quantitative and qualitative traits including tropane alkaloids in Black henbane *(Hyoscyamus niger* L.)	Dr. V R Singh/ Dr. R.K. Lal	30th May 2019	JNU
17	Muktesh Chandra	Transcriptome Profiling and Expression Analysis of Secondary Metabolism and Associated Pathway Genes in Ocimum Species	Dr. (Mrs.)Neelam Singh Sangwan	3rd June 2019	AcSIR
18	Seema Meena	Understanding the biosynthesis of specialized metabolites in Lemongrass, Basil and Curry leaf	Dr. Dinesh Nagegowda	28th June 2019	JNU

19	Dinesh Kumar Patel	Prospecting Plant Bio-actives for The Management of Emerging *Plasmodium-Salmonella* Co-infection	Dr. Anirban Pal	17th July 2019	JNU
20	Mangal Singh	Studies on soil microbial diversity influencing ecosystem functioning and plant growth of Ocimum	Dr. Alok Kalra	26th July 2019	JNU
21	Varun Diwedi	Identification and characterization of pathogen responsive terpene synthases in *Solanumtuberosum*	Dr. Dinesh Nagegowda	16th August 2019	JNU
22	Disha Mishra	Synthesis of bio nanocomposites from plant cellulose: For controlled release of therapeutic molecules	Dr. Puja Khare	22nd August 2019	JNU
23	Swati Upadhyay	Identification, Isolation and Characterization of Root Specific Transcript of Asparagus racemosus	Dr. Rakesh Kumar Shukla	26th August 2019	JNU
24	Sonam Khare	Prospecting Rosa damascena, Phyllanthus emblica and Moringa oleifera for antimalarial activity with emphasis on combination therapy	Dr. Anirban Pal	2nd September 2019	JNU
25	Yashdeep Srivastava	Transcriptome Based Search For Role of Novel Transcription Factors and Terpene Synthesis Gene in *Withania somnifera*	Dr. (Mrs.)Neelam Singh Sangwan	2nd September-2019	JNU
26	Vineet Kumar Rai	Development of novel drug delivery system based herbal formulation for the treatment of psoriasis: optimization, characterization and evaluation	Dr. N.P. Yadav	9th September 2019	JNU
27	Nidhi Nigam	Effect of recalcitrance carbon amendments on systemic reduction of Pb and Cd in selected medicinal plants	Dr. Puja Khare	9th September 2019	JNU

28	Atul Tyagi	Computational biology approach for identification and designing of bioactive antimicrobial peptides from plants	Dr. Ajit Kumar Shasany/ Dr. Ashok Sharma	11th September 2019	JNU
29	Priyanka Maurya	*Chemical Investigation of Some Medicinal Plants of Family Rubiaceae*	Dr. Karuna Shanker/ Dr. M M Gupta	30th October 2019	AcSIR
30	Amit Chand Gupta	Therapeutic Mechanisms of Plant-derived Naphthoquinone on Activated Innate Immunity in Inflammation linked Diseases: *In- Vitro* and *In- Vivo* Study	Dr. D U Bawankule	28th November 2019	JNU
31	Shalini Trivedi	Studies of phytomolecules from *Gardenia lucida* (Roxb.) for their anti-aging and anti-Alzheimer's activities in *Caenorhabditis elegans*	Dr. Rakesh Pandey	19th December 2019	JNU
32	Ajay Kumar	Exploration of efficacy enhancing biomolecule (s) for drug load reduction	Dr. Dharmendra Saikia	23rd December 2019	JNU
33	Aparna Shukla	Molecular Modelling Studies on Plants Molecules and Their Derivatives for Immunomodulatory and Anti-cancer Activity	Dr. Feroz Khan	24th December 2019	JNU
34	Yogesh Kumar	Studies on Proteome wide Identification of Plants Terpene Synthase Motifs using Weight Matrix Method and Database Development	Dr. Feroz Khan	26th December-2019	JNU
35	Nidhi Mishra	Development and evaluation of novel drug delivery system of important phytomolecules for liver targeting	Dr. N.P. Yadav	7th January 2020	JNU
36	Kuldeep Singh Yadav	Development of liver targeted nanoparticles using formulation by design: characterization and evaluation	Dr. N.P. Yadav	17th January 2020	JNU
37	Tania Ray	Enhancing Disease Resistance and Yield of Secondary Metabolites of *Papaver somniferum* through Endophytic Microbes	Dr. Alok Kalra	21st January 2020	JNU

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

Glimpses from the CIMAP History

Central Institute of Medicinal and Aromatic Plants, popularly known as CIMAP, is a frontier plant research laboratory of Council of Scientific and Industrial Research (CSIR). Established originally as Central Indian Medicinal Plants Organization (CIMPO) in 1959, CIMAP is steering multidisciplinary high quality research in biological and chemical sciences and extending technologies and services to the farmers and entrepreneurs of medicinal and aromatic plants (MAPs) with its research headquarter at Lucknow and Research Centers at Bangalore, Hyderabad, Pantnagar and Purara. CIMAP Research Centers are aptly situated in different agro-climatic zones of the country to facilitate multi-location field trials and research. A little more than 50 years since its inception, today, CIMAP has extended its wings overseas with scientific collaboration agreements with Malaysia. CSIR-CIMAP has signed two agreements to promote bilateral cooperation between India and Malaysia in research, development and commercialization of MAP related technologies. CIMAP's contribution to the Indian economy through its MAPs research is well known. Mint varieties released and agro-packages developed and popularized by CIMAP has made India the global leader in mints and related industrial products. CIMAP has released several varieties of the MAPs, their complete agro-technology and post harvest packages which have revolutionized MAPs cultivation and business scenario of the country. Recognizing the urgent need for stimulating research on medicinal plants in the country and for coordinating and consolidating some work already done by organizations like the Indian council of Agricultural Research, Indian Council of Medical Research, Tropical School of Medicine of Culcutta and various States Governments and Individual workers, the Council Scientific and Industrial Research approved in 1957 the establishment of the Central Indian Medicinal Plants Organization (CIMPO) with the following objectives. 'To co-ordinate and channelize along fruitful directions the present activities in the field of medicinal plants carried out by the various agencies, State Governments etc., to develop the already existing medicinal plants resources of India, to bring under cultivation some of the important medicinal plants in great demand and also to introduce the cultivation into the country of exotic medicinal plants of high yielding active principal content' It was further decide that as the work on all aspects of cultivation of aromatics plants was identical with all the cultivation of medicinal plants, the aromatic plants should also be covered within the scope of CIMPO. The Essential Oils Research Committee functioning under the Council of Scientific & Industrial Research was then dissolve and its activities taken over by CIMPO. The Organization started functioning with effect from 26 March 1959 with the appointment of late Shri P.M. Nabar its first Officer Incharge.

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

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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