वार्षिक प्रतिवेदन
२०२०-२०२१

Annual Report
2020-2021

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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CSIR-Central Institute of Medicinal and Aromatic Plants
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Cover page
Depicts the medicinal and aromatic plants useful against Covid-19

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From The Director's Desk....

CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), a frontier institute dedicated to basic and applied research and dissemination of technologies related to Medicinal and Aromatic Plants (MAPs) is completing its 62 years since its inception as Central Indian Medicinal Plant Organization (CIMPO) in 1959. The institute has shown remarkable progress during the past one year as always and even amidst the dark phase of the COVID-19 pandemic. It's a moment of extreme pleasure and pride for me to present the second Annual Report 2020-21 of CSIR-CIMAP, during my term as Director of the institute.

As the nodal laboratory of Aroma Mission Phase-II, CSIR-CIMAP has made remarkable progress towards improving the income of farmers, nurturing essential oil-based aroma industry in the country and limiting the migration of youth from rural to urban areas in search of job. This also holds a special value during the COVID-19 pandemic period. In total, 700 ha of land was covered for aromatic plant cultivation including those subjected to frequent weather vagaries or crop damage by wild animals. The cultivation was further supported by the installation of 09 distillation units in areas falling under various aroma clusters. Altogether, 6525 farmers and entrepreneurs were benefitted from 61 awareness and skill development programs conducted by CSIR-CIMAP during this year. In addition, the mission, via its research programs, has identified 01 high oil-yielding Eucalyptus citriodora clone and developed 04 improved agro-processing technologies. Our scientists are working tirelessly to make India self-sufficient and global leader in the production of essential oils like vetiver, palmarosa and lemongrass. Under Namami-Gange Mission, CSIR-CIMAP identified and distributed prominent medicinal and aromatic plants (MAPs) in upper catchment of river Ganga to find possible leaching of phytochemicals in Ganga water. The plantation is helping in the conservation of the natural landscapes around the Ganga river basin and income enhancement and livelihood security of the farmer community in the vicinity. Through many other government programmes and consultancy projects, and our popular annual event, 'Kisan Mela', thousands of farmers and entrepreneurs have been benefitted in similar way.

On the research front, CSIR-CIMAP has conducted many important works related to MAPs and phytomolecules and published 95 articles in peer-reviewed journals during this period. One of our works published in the Journal of Hazardous Material assessed the effect of arsenic in two cultivars (APwC and APMS) of *Andrographis paniculata*. Results indicated that APMS exhibited lower bioconcentration and translocation factors, higher As tolerance index, and higher content of ent-LRDs along with higher expression of related terpene synthase. Another study published in European Journal of Medicinal Chemistry reports the design and synthesis of diarylnaphthyls and their effect against breast cancer, accounting for 90000 deaths in 2018 in India. In another cancer-related study published in Food and Chemical Toxicology, phytomolecules acacetin and pinostrobin were predicted via in silico methods as a promising inhibitor of cancer-associated protein kinases. Gymnemic acid, another important phytomolecule, was shown to get hyperacumulated in cell suspension cultures of Gymnema following elicitation and the study was published in Industrial Crops and Products. In the same journal, we reported the genetic diversity in Indian poppy germplasm using multivariate and SCoT marker analyses. We have also developed a bioinformatics pipeline for identification (lncRNADetector) and a repository (MAPslnc) of medicinal and aromatic plant long non-coding RNAs and reported the same in RNA Biology. In addition, keeping COVID-19-related social distancing in mind, CSIR-CIMAP successfully conducted

a virtual International Conference on "Plant Specialized Metabolism and Metabolic Engineering (PSMME-2020)" during October 2020 to discuss the latest happenings in various aspects of plant secondary metabolism, its engineering, and application which included 35 eminent invited speakers (India and abroad). The conference was inaugurated by honourable Director General-CSIR, Dr. SC Mande. We are continuing our research through three Network MLP projects (of which CIMAP is the nodal lab for genome- editing project, MLP-07) and various other MLPs/FTTs/FTCs/GAP projects.

During 2020-21, technologies for 17 products were licensed or commercialized to various firms and generated Rs. 82 Lakhs as premium and 21 Lakhs as royalty. To name a few, the immune booster CIM-MEG19 was licenced to M/s Meghdoot Gramodyog Sewa Sansthan, Lucknow, U.P. CIM- Evergreen Tea (herbal formulation anti-aging, anti-inflammatory, brain function strengthening and cognitive boosting activities) was licensed to M/s. Vyom India Organics Private Limited, Bareilly, U.P. Our well-known incense sticks preparation technologies for proper utilization and value addition of used flowers were further licensed to few more companies. MOUs were also signed within this period with various companies like M/s. Innovative Concepts, M/s. Hapi Key etc. and Lucknow University.

The reliability of our work could be further substantiated through the trust shown and certification provided by agencies outside CSIR. CSIR-CIMAP opened a CSIR-Technology Window at Shillong, Meghalaya, following approval from DG, CSIR to support Govt of Meghalaya by providing technical know-how and help in cultivation and distribution of local MAPs and establishment of testing laboratories. 'Aarogya Vatika' programme, a joint effort of CSIR-CIMAP and 'Nav Bharat Times' was started to support Lucknow Municipal Corporation's drive towards plantation of authentic MAP varieties in public gardens, government offices etc. The extraction facility of the Chemical Engineering unit of the Phyto-Chemistry Division was certified as a GMP (Good Manufacturing Practices) facility by the State Ayurvedic Department, which is becoming an essential requirement to assure the safety, quality and efficacy of the herbal products.

CSIR-CIMAP also contributed to nationwide efforts to bring the COVID-19 pandemic emergency under control. Volunteers (Scientists and Research Scholars) from CSIR-CIMAP joined to support the COVID-19 facility at CSIR-NBRI, Lucknow, between July-September, 2020. CSIR-CIMAP distributed a significant amount of sanitizers and surface disinfectants to Lucknow Development Authority (LDA; to support community kitchens) and police personnel. A diffuser formulation incorporating 5 essential oils was developed by the institute and was found to be effective against the SAR-CoV2 vector. A hand sanitizing gel and herbal immune booster CIM-Megh19 (as an alternate therapy) to combat COVID-19 was also developed.

Our strength lies in our students. During the period of this report, 23 students completed their PhDs, and 44 students joined through AcSIR and JNU Ph.D. programmes. The institute has a young brigade of scientists and technical staff, and 03 scientists joined CSIR-CIMAP during this period. This energetic group is working hard to fit into the boots of our experienced but superannuated members, of which 02 superannuated this year. I take this opportunity to congratulate Team CSIR-CIMAP and hope that the students, post-docs, project staff, scientists, technical personnel and all other staff members of the CIMAP-family will work in unison to spread the wonderful music of CSIR-CIMAP's scientific orchestra not only within India but worldwide.

CSIR-CIMAP is thankful to the Director General, CSIR, the chairperson and members of the Research Council and Management Council for their valuable suggestions and helps in shaping the R&D and societal activities, and overall management of the Institute. The Institute is thankful to all the well-wishers who have played a role in bringing the institute to its present stature and hope to get their support in the coming years.

(Prabodh Kumar Trivedi)

निदेशक की कलम से.....

सीएसआईआर-केन्द्रीय औषधीय व सगंध पौध संस्थान एक अग्रणी संस्थान है, जो औषधीय व सगंध पौधों से संबंधित बुनियादी तथा व्यवहारिक शोध व उन्नत तकनीकों के प्रसार के प्रति समर्पित है। सन् 1959 में इसकी शुरूआत केन्द्रीय भारतीय औषधीय संयंत्र (सिम्पो) के रूप में हुई थी और आज यह संस्थान अपनी स्थापना के 62 वर्ष पूरे कर रहा है। कोविड 19 महमारी के अंधेरे चरण के बावजूद संस्थान ने सदा की तरह पिछले एक वर्ष में उल्लेखनीय प्रगति की है। संस्थान के निदेशक के रूप में अपने कार्यकाल के दौरान सीएसआईआर-सीमैप की द्वितीय वार्षिक प्रगति रिपोर्ट प्रस्तुत करना मेरे लिए अत्यंत हर्ष एवम् गौरव का क्षण है। अरोमा मिशन के द्वितीय चरण के नोडल प्रयोगशाला के रूप में सीएसआईआर-सीमैप ने किसानों की आय में सुधार लाने, देश में आवश्यक तेल आधारित सुगंध उद्योग को बढ़ावा देने तथा रोजगार की तलाश में ग्रामीण क्षेत्रों के युवाओं का शहरों में होने वाले पलायन को रोकने में उल्लेखनीय प्रगति की है। कोविड-19 महामारी के दौर में भी इसके विशेष मायने हैं। कुल मिलाकर, 700 हेक्टेयर भूमि में सुगंधित पौधों की खेती हो रही थी, जिसमें वह इलाके भी शामिल थे जहाँ बार-बार मौसम की अनियमितता तथा जंगली जानवरों के द्वारा फसल को नुकसान पहुँचता था। खेती में सहयोग देने के लिए 09 आसवन इकाइयों की भी स्थापना उन क्षेत्रों में की गई जहाँ विभिन्न सुगंध समूह बने थे। इस वर्ष सीएसआईआर-सीमैप ने 61 जागरूकता तथा कौशल विकास कार्यक्रमों को संचालित किया जिससे कुल 6225 किसान तथा उद्यमी लाभान्वित हुए। इसके अलावा, मिशन ने अपने शोध कार्यों के माध्यम से अधिक तेल की उपज देने वाले *यूकैलिप्टस सिट्रिओड्रा* के एक क्लोन की भी पहचान की है एवम् 04 उन्नत कृषि-प्रसंस्करण तकनीकों का विकास भी किया है। हमारे वैज्ञानिक भारत को खस, पामारोज़ा तथा नींबू घास जैसे सुगंधित फसलों के उत्पादन में आत्मनिर्भर और वैश्विक नेता बनाने के लिए अथक परिश्रम कर रहे हैं। नमामि गंगे मिशन के अंतर्गत सीएसआईआर- सीमैप ने गंगा के पानी में फाइटोकेमिकल्स के संभावित रिसाव के लिए गंगा नदी के ऊपरी जलग्रहण क्षेत्र में प्रमुख औषधीय व सगंध पौधों के वितरण की पहचान की है। इस वृक्षारोपण कार्यक्रम से गंगा नदी तट के आस-पास के प्राकृतिक परिदृश्य के संरक्षण तथा वहाँ के किसान समुदाय की आय में वृद्धि व आजीविका चलाने में सहायता हो रही है। कई अन्य सरकारी कार्यक्रमों और परामर्श परियोजनाओं के माध्यम से तथा हमारे लोकप्रिय वार्षिक आयोजन 'किसान मेला' से हज़ारों किसान और उद्यमी लाभान्वित हो रहे हैं।

इस अवधि के दौरान, सीएसआईआर-सीमैप ने औषधीय एवम् सगंध पौधों एवम् उनमें मौजूद फाइटोकेमिकल्स से संबंधित कई महत्वपूर्ण शोध किए तथा 95 लेख विभिन्न जर्नल्स में प्रकाशित भी हुए। एक अध्ययन में, कालमेघ के दो जीनोटाइप्स (APwC & APMS) पर आर्सेनिक का प्रभाव देखा गया। जीनोटाइप (APMS) में जैव सांद्रण कारक एवं ट्रांसलोकेशन कारक की मात्रा पाई गई तथा अध्ययन से पता चला कि आर्सेनिक के कारण APCS2 नामक जीन की द्वितीयक अपापचयों के निर्माण में विशेष भूमिका रही। यह शोध जर्नरल ऑफ *हैजार्डस मैटेरियल* में प्रकाशित हुआ। यूरोपियन जर्नल ऑफ मेडिसिनल केमिस्ट्री में प्रकाशित एक शोध में डाईएराइलनैपथाइल के संश्लेषण एवं इसका उपयोग ब्रेस्ट कैंसर (जिससे 2018 में भारत में 90000 लोगों की मौत हुई) के उपचार में दिखाया गया। कर्क रोग से संबंधित एक अन्य शोध पत्र फूड एवं केमिकल टॉक्सिकोलोजी में प्रकाशित हुआ। इस शोध में in-silico प्रक्रिया द्वारा अकेसिटिन एवं पिनोस्ट्रोविन का प्रभाव कर्क रोग से संबंधित 'प्रोटीन काइनेज' के रोकथाम में देखा गया। शोध पत्र जर्नल ऑफ इंडस्ट्रियल क्रॉप्स एण्ड प्रोडक्ट्स में जिमनेमिक एसिड का अत्यधिक संग्रह जिमनिया के सेल कल्चर में देखा गया। इसी जर्नल में प्रकाशित एक अन्य शोध में अफीम के पौधों में अनुवांशिक मापदंडों का मूल्यांकन एवं विविधता की गई। एक अन्य अध्ययन में सुगंधित एवं औषधीय पौधों के Non-coding RNAs के पहचान हेतु (IncRNADetector) एवं डिचयाजिस्टरी हेतु (MAPs-Inc) पाइपलाइन तैयार की गई। इसके अलावा, कोरोना महामारी के कारण सामाजिक दूरी को ध्यान में रखते हुए सीएसआईआर-सीमैप ने अक्टूबर 2020 में "प्लांट स्पेश्लाइज़्ड मेटाबॉलिज्म एवम् मेटाबॉलिक इंजीनियरिंग (PSMME-2020)" विषयक एक वर्चुअल अन्तर्राष्ट्रीय सम्मेलन का भी सफलतापूर्वक आयोजन किया। इस सम्मेलन में प्लांट सेकेण्डरी मेटाबॉलिज़्म तथा इसकी अभियांत्रिकी और प्रयोग जैसे विषयों से

जुड़ी नवीनतम जानकारियों पर चर्चा की गई। सम्मेलन में देश-विदेश के 35 प्रख्यात वक्ताओं को आमंत्रित किया गया था। सम्मेलन का उद्घाटन डॉ. एस.सी. मांडे (माननीय महानिदेशक-सीएसआईआर) के द्वारा किया गया। हम अपने शोध को 03 नेटवर्क एमएलपी परियोजनाओं के द्वारा आगे बढ़ा रहे हैं, जिसमें जिनोम-एडिटिंग परियोजना (एमएलपी-07) में सीमैप नोडल प्रयोगशाला के रूप में कार्यरत है। इसके साथ सीमैप में कई अन्य एमएलपी/एफटीटी/एफटीसी/गैप परियोजनाओं के माध्यम से भी शोध किए जा रहे हैं।

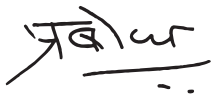
वर्ष 2020-21 में सीमैप द्वारा तैयार 17 तकनीकों का हस्तांतरण भी किया गया। इनसे 82 लाख का अग्रिम मूल्य एवं 21 लाख की रॉयल्टी संस्थान को प्राप्त हुई। इनमें से मुख्य, CIM-MEG19, (रोग प्रतिरोधक क्षमता बढ़ाने वाला) का लाइसेंस M/s मेघदूत ग्रामोद्योग सेवा संस्थान, लखनऊ, उ.प्र. को दिया गया। सिम-एवर्ग्रीन चाय (बुढ़ापारोधी, सूजनरोधी मस्तिष्क के विकास में सहायक तथा संज्ञानात्मक गतिविधियों में वृद्धिकारक) का लाइसेंस M/s व्योम इण्डिया ऑरगेनिक लिमिटेड, बरेली, उ.प्र. को दिया गया। सीमैप द्वारा उपयोग किये गये फूलों से अगरबत्ती बनाने की बहुप्रसिद्ध तकनीक का लाइसेंस कई औद्योगिक इकाईयों को दिया गया। विभिन्न औद्योगिक इकाईयों (M/s Innovative Concepts, M/s Hapi Kay) एवं शिक्षण संस्थान (लखनऊ विश्वविद्यालय) के साथ समझौता ज्ञापन भी इस वर्ष किया गया। संस्थान की विश्वसनीयता को पुनः बाहरी एजेन्सियों द्वारा प्रमाणित किया गया। इस वर्ष मेघालय सरकार को सुगंधित एवं औषधीय पौधों की कृषि क्रियाओं एवं तकनीकी जानकारी देने हेतु एक CSIR-Technology Window शिलाँग में खोली गई। सीएसआईआर-सीमैप ने नव भारत टाईम्स के साथ मिलकर एक संयुक्त प्रोग्राम ''आरोग्य वाटिका'' आरम्भ किया जिसका उद्देश्य लोगों को सुगंधित एवं औषधीय पौधों के बारे में जागरूक करना एवं उच्च गुणवत्ता के संगुंधित एवं औषधीय पौधों का वृक्षारोपण पब्लिक बागान एवम् सरकारी दफ्तर में कराना है। इस वर्ष, संस्थान की रसायनिक अभियांत्रिक यूनिट (फाइटोकेमिकल डिवीजन) को सुगंधित एवं औषधीय पौधों के निष्कर्षण की GMP हेतु उ.प्र. आयुष विभाग द्वारा प्रमाणित किया गया। यह सुविधा औषधीय पौधों की सुरक्षा, गुणवत्ता एवं प्रभाव के लिए अनिवार्य है।

सीएसआईआर-सीमैप ने कोविड-19 महामारी से उत्पन्न आपातकालीन स्थिति को नियंत्रण में लाने के देशव्यापी प्रयासों में भी योगदान दिया। सीएसआईआर-सीमैप से स्वयं सेवकों ने (वैज्ञानिक एवं शोध छात्र/छात्रा) सीएसआईआर-एनबीआरआई में स्थापित कोविड-19 परीक्षा सुविधा को चलाने में भी अपना सहयोग दिया।

सीएसआईआर-सीमैप ने लखनऊ विकास प्राधिकरण (सामुदायिक रसोई हेतु) एवम् पुलिस कर्मचारियों के सुविधा हेतु हैंड सैनिटाइज़र और सरफेस डिसइन्फैक्टेंट बाँटे। हमारे संस्थान ने पाँच सुगंधित तेलों से एक डीकुसर फार्मुलेशन को बनाया एवं यह आर-कोव.-2 के खिलाफ कारगर पाया गया। इसके अतिरिक्त एक 'हैंड सैनिटाइजिंग जेल' एवं 'हर्बल इम्मुन बुस्टर' CIM-MEG19 (वैकल्पिक चिकित्सा के तौर पर) को विकसित किया गया जो कोविड-19 के प्रतिकार में सहायक हो सकती है।

हमारी शक्ति हमारे छात्र/छात्राओं में निहित है। इस रिपोर्ट की अवधि के दौरान 23 छात्र/छात्राओं की पीएचडी पूर्ण हुई तथा 44 छात्र/छात्राओं ने एसीएसआईआर एवं जे.एन.यू. पी.एच.डी. कार्यक्रमों के तहत संस्थान में दाखिला लिया। संस्थान में वैज्ञानिक और तकनीकी कर्मचारियों की युवा ब्रिगेड है तथा 03 नए वैज्ञानिक संस्थान में इस दौरान शामिल हुए। यह ऊर्जावान समूह हमारे अनुभवी एवं सेवानिवृत्त सदस्यों की रिक्त स्थान की पूर्ति करने हेतु कड़ी मेहनत कर रहा है। इनमें 02 वैज्ञानिक इस वर्ष सेवानिवृत्त भी हुए। मैं इस अवसर पर 'टीम सीएसआईआर-सीमैप' को बधाई देता हूँ तथा यह अपेक्षा करता हूँ कि हमारे छात्र/छात्रा, पोस्ट-डॉक विद्यार्थी, परियोजना कर्मचारी, वैज्ञानिक, तकनीकी कर्मी तथा सीमैप परिवार के अन्य सभी कर्मचारी सदस्य CSIR-CIMAP वैज्ञानिक ऑर्केस्ट्रा के अद्भुत संगीत को दुनिया भर में फैलाने के लिए एकजुट होकर काम करेंगे।

सीएसआईआर-सीमैप सीएसआईआर के महानिदेशक, अनुसंधान परिषद एवं प्रबंध परिषद के अध्यक्ष व सभी सदस्यों को उनके बहुमूल्य सुझावों के लिए धन्यवाद देता है, जिनसे संस्थान के समग्र प्रबंधन, अनुसंधान एवम् विकास तथा सामाजिक गतिविधियों को आकार देने में सहायता मिलती है। संस्थान उन सभी शुभचिंतकों का भी आभारी है जिन्होंने संस्थान को उसके वर्तमान स्तर तक पहुँचाने में महत्वपूर्ण भूमिका निभाई है एवं आने वाले वर्षों में भी उनसे सहयोग मिलने की आशा करता है।



(प्रबोध कुमार त्रिवेदी)

Phytochemistry

HIGHLIGHTS

Phytochemistry division of the CSIR-CIMAP has been actively engaged in the various phytochemical aspects of Medicinal and Aromatic Plants (MAPs) such as phytochemical investigation, bioactivity guided isolation of molecules, down-stream processing, supercritical fluid extraction technology, quality assurance, chemical ecology, semi-synthesis of high-value molecules, new chemical processes, target specific designer molecules, etc. The faculties of the division have active collaborations within the institute and with other research organizations. The Phytochemistry division has a sophisticated instrumentation facility (Chemical Central Facility) which caters analytical support not only to internal projects but also to industry, farmers, and academics.

The division has been significantly contributing to the CSIR mission project such as Aroma Mission Phase-I and –II (HCP-007). During this period, several consultancy projects (CNP-357, CNP-391, CNP-384, CNP-419, CNP-438, CNP-427), five Govt. Aided Projects (GAP392, GAP415, GAP432, GAP460, GAP-465) and two CSIR-Network Projects (MLP-09, MLP-10), etc. have also been successfully executed in the division.

In the Aroma Mission projects, the Phytochemistry division extended support for efficient distillation and also developing efficient process technologies for some high-demand aroma molecules.






Scientists of Phytochemistry Divisional Unit

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

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

Phytochemical investigation of some of the important medicinal plants such as *Oroxylum indicum*, *Murraya koenigii*, *Adhatoda vasica, Tinosopra cordifolia, Withania somnifera,* etc. have been performed. Chemical fingerprint of aromatic plants like *Artemisia pallens, Ravenia spectabilis*, *Lavandula angustifolia, Ocimum sanctum, Ocimum basillicum,* and *Trachyspermum ammi, and Apium graveolen,* etc. have been developed.

Four flavonoids and one sterol have been isolated from the stem of *Oroxylum indicum*, vasicine from *Adhatoda vasica,* daucosterol from *Tinosopra cordifolia,* etc. Thymol and scopoletin were efficiently isolated in bulk quantities by downstream processes. Value addition of *Ageratum conyzoides L.*, *Taxus wallichiana*, and some phytomolecules like gallic acid and brevifoliol were undertaken.

Several new processes have been developed for the efficient catalytic conversions of citronellal to (-) menthol, pulegone to menthone and isomenthone. An efficient process for the conversion of phenylpropanoids to vanillin has also been achieved.

The efforts for innovating novel bioactives led to the following observations and achievements; Davana essential-oil and cis-davanone from *Artemisia pallens* have exhibited significant anti-inflammatory activity. *Ravenia spectabilis essential has exhibited significant antibacterial activity against Staphylococcus aureus*, *Staphylococcus epidermidis*, methicillin-resistant *Staphylococcus aureus*, methicillin-resistant *Staphylococcus epidermidis*, *Candida albicans*, and *Candida kefyr*. Value addition of precocene-I to bone-forming activity by conversion to designer trans-stilbenoid moieties has been done. Diarylnaphthyls and gallic acid based indanone derivatives exhibited potent anti-breast cancer activity. A rearranged taxoid, brevifoliol esters showed significant anti-prostate cancer activity. Chlorinated derivatives of *Ocimum sanctum* (CIM-Ayu) have exhibited antimalarial activities.

Under quality control aspects, a validated HPTLC method with a new derivatization reagent for the simultaneous, sensitive, and high-throughput analysis of six bioactive triterpenes i.e. friedelin (**1**), methyl putranjate (**2**), putrone (**3**), roxburghonic acid (**4**), putranjivadione (**5**), and roxburghonol (**6**) in the bark of *Putranjiva roxburghii* with defined traceability and accuracy profile has been developed

During this tenure, Phytochemistry division earned fifteen research publications, three process patents, and one technology for Kalmegh based immune booster [CIM-Megh^{CIMAP}]. The 'CIM-Megh' technology developed by Dr. Karuna Shanker & his team was transferred to the industry. Dr. Ratnasekhar has been awarded the prestigious DBT-Ramalingaswami Fellowship. The Division successfully executed four training programs. There were eight invited talks from the Division at various scientific forums. Recently, the Division developed a GMP grade extraction facility for MAPs.

Er. G. D. Kiran Babu b- th- Mh- fdj.k ckcu

Variability in quantitative and qualitative characteristics of Palmarosa oil produced from three varieties

Studies were conducted to record the variability in essential oil yields and their quality from three varieties of Palmarosa (*Cymbopogon martinii*) *viz*. CIM-Harsh, PRC-1, and Trishna which were harvested from the experimental fields of CRC, Hyderabad. The fresh foliage (containing flowers, leaves, and stems) was hydrodistilled for 3h in Clevenger-type apparatus to recover the oil which was measured, dried over anhydrous sodium sulfate, and then analyzed by GC-FID. In the present experimental condition, the highest Palmarosa oil yield was recorded in PRC-1 (0.61%) followed by Trishna (0.51%) and CIM-Harsh (0.50%). The GC analysis revealed that the highest concentration of geraniol, the principal component of Palmarosa oil, was present in the Trishna variety (76.02%) closely followed by PRC-1 (75.16%), whereas CIM-Harsh possessed lower content (71.53%). Geranyl acetate, the second major constituent, was present in PRC-1 (15.01%) followed by Trishna (12.77%) and CIM-Harsh (10.71%). Geraniol and geranylacetate are extensively used in pharmaceuticals, cosmetics, flavoring, and many other preparations. Geraniol has characteristic sweet rose-like, citrus with fruity, waxy nuances odor and hence widely used as fragrance material in deodorants, domestic household, and cosmetic products. Linalool, the other major chemical constituent of the oil, was recorded highest in Trishna (2.53%) closely followed by PRC-1 (2.3(%) and CIM-Harsh (1.93%). The foregoing studies revealed that Trishna gives better yields and quality of oil in the present experimental conditions.

Table: Comparison of palmarosa varieties for oil yield (%) and chemical composition of major constituents (%) at CRC, Hyderabad

	CIM-Harsh	PRC-1	Trishna
Oil yield	0.50	0.61	0.51
Linalool	1.93	2.39	2.53
Geraniol	71.53	75.16	76.02
Geranyl acetate	10.71	15.01	12.77

Effect of saline water on Palmarosa oil yield and quality during hydrodistillation

Experiments were conducted to evaluate the effect of sodium chloride concentration in the feed water during hydrodistillation of fresh foliage of Palmarosa (*Cymbopogon martinii* cv. Trishna). In general, the Palmarosa oil yields were increased with an increase in the concentration of NaCl when compared to the control (0% NaCl) (Table). The highest oil yield was recorded when the foliage was distilled with 5% NaCl solution followed by 10% and 20% solution. The lowest oil yield was observed in the control i.e. foliage distilled without NaCl. However, the lowest concentration of geraniol, the major component of Palmarosa oil, was detected in the oil distilled with 5% (76.3%) and 10% (76%) NaCl solutions (Fig.). The control sample was found to contain highest content of geraniol (83.5%) followed by 20% NaCl solution (81.7%) and 15% NaCl solution (80.4%). On contrary, higher geranyl acetate content was found in 5% NaCl solution (11.4%) and 10% NaCl solution (10.4%)

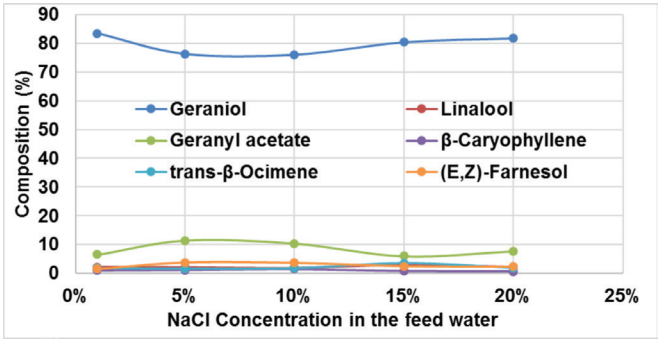


Fig. Variation of major chemical components of fresh Palmarosa foliage distilled with varying NaCl concentration in feed water during hydrodistillation.

Table : Variation of palmarosa oil yield and major chemical components as affected by sodium chloride concentration in the feed water

Concentration of brine solution (% w/w)	Oil yield (%, v/w)	Concentration of major chemical components (%)		
		Linalool	Geraniol	Geranyl acetate
0% Brine solution (Control)	0.55	2.156	83.503	6.505
5% Brine solution	0.80	2.018	76.302	11.408
10% Brine solution	0.67	1.774	75.996	10.385
15% Brine solution	0.57	3.011	80.361	5.993
20% Brine solution	0.63	2.178	81.721	7.720

and lower concentration was detected in 15% NaCl solution (6%), control (6.5%) and 20% NaCl solution (7.7%). Not much variation in linalool content was observed in these experimental samples. The present experiments revealed that the concentration of additive i.e. NaCl in the feed water, during hydrodistillation of Palmarosa foliage, affected the yields and quality of the oil. It may be attributed to the elevation of the boiling point of water by adding NaCl.

Er. G.D. Kiran Babu & his team

Dr. A. S. Negi Mk vjfon flg uxh

Diarylnaphthylpyrrolidine derivative exhibits anti-breast cancer activity *via* microtubule destabilization and DNA-Topoisomerase-II inhibition

Breast cancer is the second leading cause of deaths in women globally. In 2018, it accounted for about 18% of all cancer types in India with 1.8 lakhs registered cases and 90,000 registered deaths. Breast cancer is multifactorial. Due to the heterogeneity of the disease, effective treatment is still a challenge. The treatment of advanced-stage breast cancer is very difficult and restricted due to chemotherapy resistance. Although several effective drugs have been developed, yet development of effective, safe, and affordable anti-breast cancer drug is still a challenge.

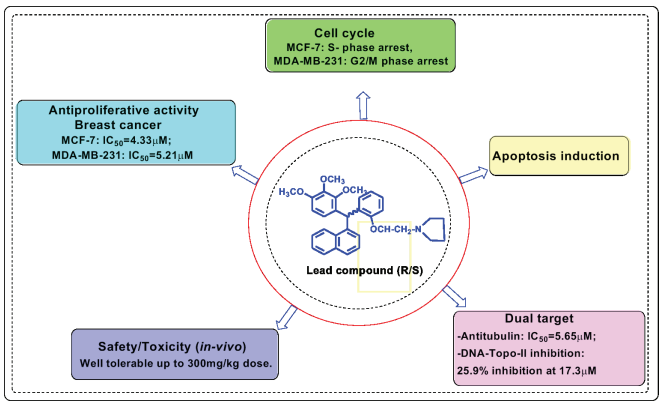


Fig. Antiproliferation effect of diarylnaphthylpyrrolidine derivative against human breast cancer cell lines

The present study dealt with the design and synthesis of diarylnaphthyls as possible anti-breast cancer agents. Among the thirty-three representatives with significant antiproliferative activity, two of the compounds were quite efficacious against human breast cancer cells.

The diarylnaphthylpyrrolidine derivative induced apoptosis in both MCF-7 and MDA-MB-231 cells and exerted S phase and G2/M phase arrest respectively *via* distinct mechanistic pathways (Fig.). It showed moderate microtubule destabilization. Further, it exhibited DNA topoisomerase-II inhibition effect in MCF-7 cells. In safety studies, it was well tolerated and found safe up to 300 mg/kg dose in Swiss albino mice. The dual action antiproliferative effect of diarylnaphthylpyrrolidine derivative is quite interesting and warrants future development. [*Eur. J. Med. Chem.* **2020**, 188, Art. 111986]

Ind-V, a fluorinated benzylidene indanone exhibits anti-breast cancer activity through modulation of microtubule dynamics and antiangiogenic activity

Over the years the unique attributes of fluorine have been well understood which yielded several useful fluorinated motifs. The judicious use of this element in a pharmacophore can improvise the physical, biochemical, pharmacological, and pharmacokinetic properties. Recently, the strong electronegativity, small size, and modest lipophilicity of fluorine necessitated its preferential utility in drug design. Modulation of tubulin-microtubule dynamics is one of the most

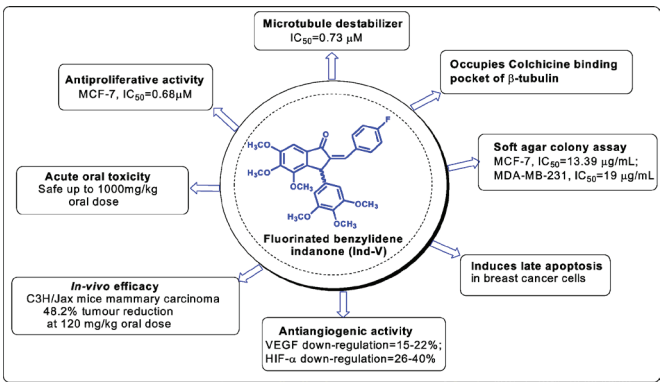


Fig. Anti-breast cancer activity of **Ind-V** against hormone-dependent breast cancer

effective targets for cancer chemotherapeutics. The logically designed and identified lead compound **(Ind-V)**, a fluorinated benzylidene indanone, has been extensively evaluated for cancer pharmacology (Fig.).

Ind-V acted as a microtubule destabilizer by occupying the colchicine binding pocket and induced G2/M phase arrest in MCF-7 cells. Compound **Ind-V** also exerted an antiangiogenic effect in MCF-7 cells by down-regulating Vascular Endothelial Growth Factor (VEGF) and Hypoxia-Inducible Factor-α (HIF-α). In the *in-vivo* C3H/Jax mice mammary carcinoma model, **Ind-V** effectively reduced tumour volumes by 48.2% at a 30 mg/kg oral dose. Further, in acute oral toxicity studies, it was well tolerated and safe up to 1000 mg/kg dose in Swiss albino mice. The fluorinated benzylidene indanone (**Ind-V)**, a new chemical entity (NCE), can further be optimized for better efficacy against breast adenocarcinoma. [*Eur. J. Pharm. Sci.* **2020**, 154, Art. No. 105513]

Brevifoliol ester induces apoptosis in prostate cancer cells by activation of the caspase pathway

Prostate cancer is the fourth most abundant cancer type around the globe. Worldwide, there are approximately 1.41 million cases of prostate cancer in 2020. Presently, flutamide, docetaxel, cabazitaxel, abiraterone, enzalutamide, apalutamide, mitoxantrone, etc. are first-line drugs that are associated with serious side effects.

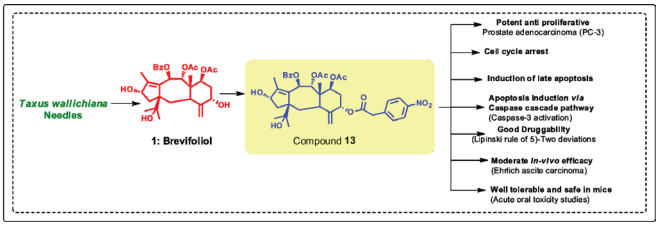


Fig. Anti-prostate cancer activity of brevifoliol derivative 13

The severity of this disease may lead to metastasis, urinary incontinence, and erectile dysfunction. There is still a need for effective, safe, and affordable anti-prostate cancer drugs. Brevifoliol, a rearranged taxoid from *Taxus walllichiana* needles has been derivatized as C5 esters using Steglich esterification reaction.

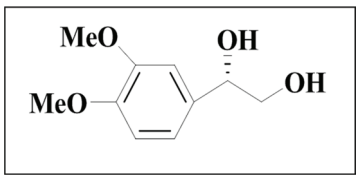
Seventeen diverse analogues were evaluated against a panel of human cancer cell lines by MTT assay. Among these, two of the semi-synthetic analogues *i.e.* **13** and **16** exhibited potent cytotoxicity (IC_{50} = 4.7 μM & 5.0 μM), selectively against PC-3 prostate cancer cell lines. In cell cycle analysis, analogue **13** induced S and G2/M phase arrest and enhanced 26% apoptosis by activating caspase-3 (Fig.). Compound **13** showed moderate efficacy in *in-vivo* Ehrlich ascites carcinoma in Swiss albino mice by reducing 56% tumour volume at 100 mg/kg i.p. dose. Further, compound **13** was found to be safe in Swiss albino mice up to 1000 mg/kg dose in acute oral toxicity. Brevifoliol ester **13** may further be optimized for better efficacy.

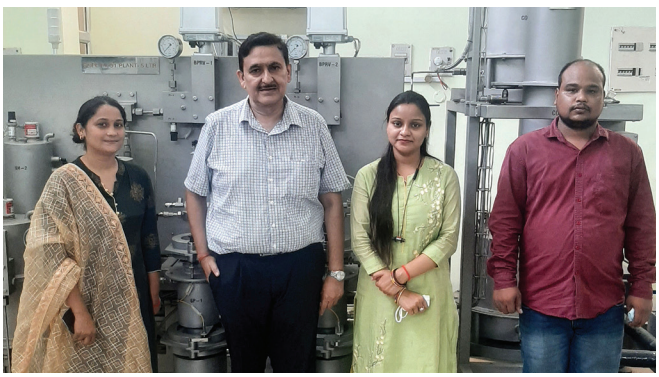
Dr. A. S. Negi & his team

Dr. Sudeep Tandon Mk- lqnhi V.Mu

Extraction and isolation of new Chemical constituent from the stem of *Cuscuta reflexa* Roxb.

Cuscuta reflexa, dodder, amarbel or akashabela is a parasitic weed plant and also an extensive climber. It is a rootless, leafless, perennial homo parasitic twining herb belonging to *Convolvulaceae* family. Phytochemical investigations of *C. reflexa have reported the presence of several classes of compounds*. As a part of our research on isolation of active compounds, we isolated one new compound along with eight known compounds from the stem of *Cuscuta reflexa* Roxb. The structures of these compounds were elucidated by spectroscopic analysis. The chemical investigation led to the isolation of the new compound characterized as 3', 4'-dimethoxy-1-phenyl-1α, 2-ethanediol, along with eight known compounds as tridecanyl palmitate, palmitic acid, n-pentatriacontane, *n*-triacont-21, 27-dien-1-ol, kaempferol, chlorogenic acid, 5, 7-dimethoxyapigenin and quercetin. The antimicrobial potential of 3', 4'-dimethoxy-1-phenyl-1α, 2-ethanediol showed significant antimicrobial properties against bacterial and fungal pathogenic strains. Further work is in progress.





Dr. Sudeep Tandon & his team

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

Extraction and isolation of phytomolecules from *Adhatoda vasica* (L.)

A reproducible and optimized Vasicine separation procedure was developed. The methanol extract of *Adhatoda vasica* L. leaf (50 g) (Family: Acanthaceae) was initially processed for the removal of low polar impurities. Subsequently, the extract was treated with the base at an optimized pH condition followed by its extraction with chloroform which yielded a major alkaloid Vasicine (>95% pure, 610mg).

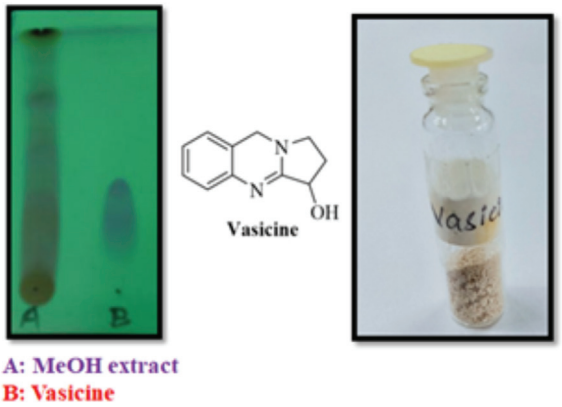
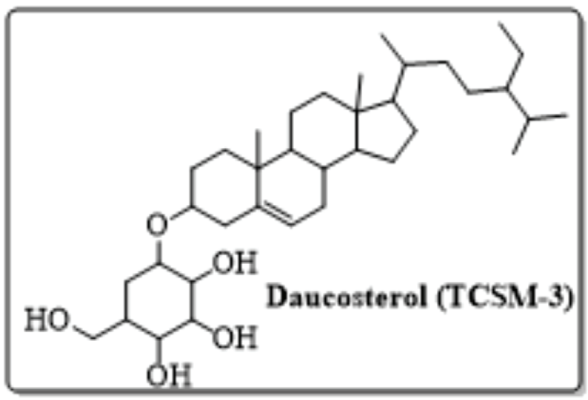


Fig. Vasicine and its Thin-layer chromatogram

Extraction and isolation of phytomolecules from *Tinospora cordifolia* (Willd.) Miers

Column chromatographic separation of methanolic extract (109.0 g) obtained from the stem (1.76 Kg) of *Tinospora cordifolia* (Willd.) Miers (Family: Menispermaceae) yielded a couple of pure compounds. Out of these, one compound was identified as Daucosterol (450 mg).

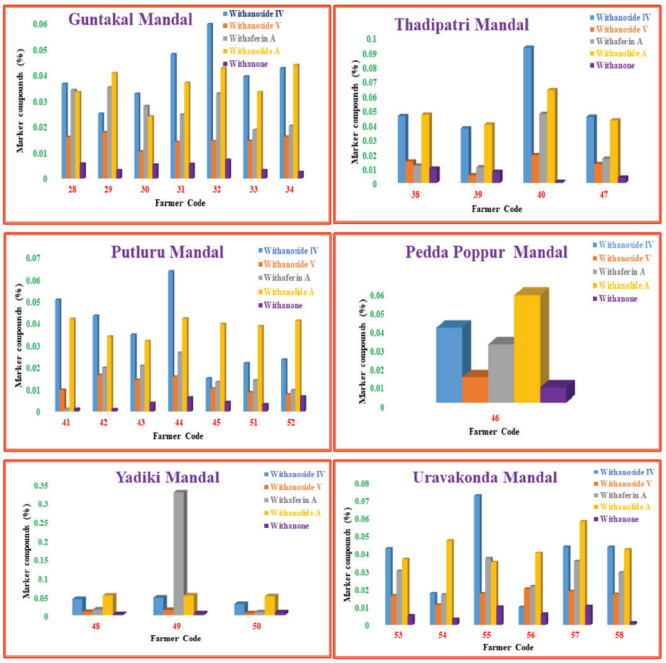


Conducting sample survey for quality analysis of Aswagandha by HPLC method in the farmer fields of Andhra Pradesh

Withania somnifera (L.) Dunal [Family: Solanaceae] commonly known as 'ashwagandha' is one of the most important medicinal plants used in traditional systems of Indian medicine. The efforts CSIR-CIMAP research center (CRC-Hydrabad) at Hyderabad to introduce Ashwagandha variety CIM-Poshita in semi-arid regions of Ananthapur and Kurnool districts gave good results. Further, efforts were have made to increase the income of Ashwagandha farmers by way of mapping the marker compound availability in their produce. Ashwagandha samples (cropping season 2020-21) including leaf, stem, and root were collected from 125 different farmers' fields of both the districts of AP. The collected samples were analyzed for withanolide markers on HPLC. The chemical profiling of 5 marker compounds namely Withanone, Withanolide A, Withaferin A, Withanoside IV, and Withanoside V, of Ashwagandha in the districts of Anantapur and Kurnool, is given below which shows a dynamic variation of marker compounds in various mandals and villages. The samples collected from farmers' fields of all the mandals of Anantapur showed Witnanoside IV as a major compound followed by Withanolide A and Withaferin A except one farmer sample collected in Yadiki mandal which showed Withaferin A as a predominant component in the root samples. The chemical profiling of samples collected from farmers' fields of Alur, Aspiri, Pattikonda, and Holagunda mandals of Kurnool district showed prevalently more Withanoside IV followed by Withanolide A and Withaferin A. However, Withaferin A was predominantly found in the Halharvi mandal. The rest of the mandals showed varying amounts of the marker compounds.

The observed dynamic variation of marker compounds may be due to variations in microclimate conditions.

Comparative Studies of Ashwagandha in Ananthapur District



Comparative Studies of Ashwagandha in Kurnool District

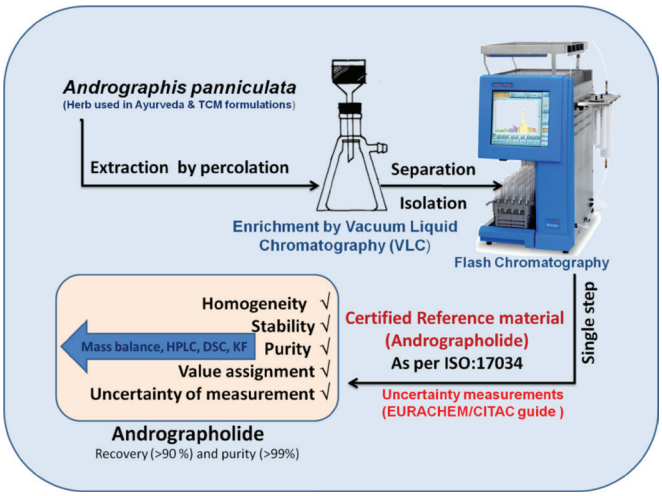
Dr. Karuna Shanker Mk- d : .kk 'kdj

Simplified process of candidate certified reference material development for the analysis of *Andrographis paniculata* (Burm.f.) Nees

Worldwide, there is an inflated demand for analytical and primary reference standards (PRS) of active ingredients and marker chemicals of medicinal plants. As per the recommendation of the World Health Organization (WHO) and regulatory agencies of the USA, Europe, India, and China, the use of reference standards is mandatory to demonstrate the efficacy and consistent quality of botanicals, derived therapeutics, nutraceuticals, and functional food. Andrographolide is a principal compound of *A. paniculata* which attributes to define the quality and efficacy of *A. paniculata* derived medicinal products. For the first time, authentication, sample preparation, homogeneity, storage stability, trueness, and reliability assignment by uncertainty measurement of andrographolide by high-performance liquid chromatography (HPLC) were illustrated. The impurities in the samples due to residual moisture, inorganic and organic were determined by Karl-Fisher titration, thermogravimetric analysis, and differential scanning calorimetry methods, respectively. Following the EURACHEM/CITAC guide of CG-4 statistical procedure, the certified value and corresponding expanded uncertainty of andrographolide, andrographolide CRM was assigned to be 99.33% ± 0.02% (k = 2) with one-year stability ($p < 0.05$). This andrographolide CRM can be used for accurate measurement, quality controls assays, and establish meteorological traceability to meet the technical requirement ISO-17025:2017. [DOI:https://doi.org/10.1016/j.microc]

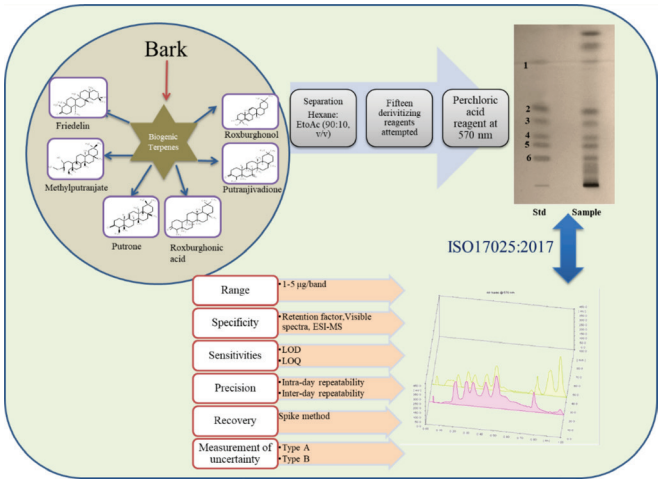
HPTLC method for the simultaneous determination of six bioactive terpenoids in *Putranjiva roxburghii* Wall

High throughput and sensitive determination of triterpenoids are challenged by high-performance liquid chromatographic methods due to their non-chromophoric nature, lipophilic properties, and sequential run. The present study demonstrates the development of a validated high-performance thin-layer chromatography (HPTLC) method for the simultaneous determination of bioactive terpenoids in the bark of



Putranjiva roxburghii with uncertainty measurement to fulfill the technical requirement of ISO 17025:2017.

Optimum separation of friedelin (**1**), methyl putranjate (**2**), putrone (**3**), roxburghonic acid (**4**), putranjivadione (**5**), and roxburghonol (**6**) was achieved on silica gel 60 F_{254} plates using *n*-hexane–ethyl acetate (90:10, *v*/*v*). The sensitive estimation of targeted terpenoids was achieved by screening 15 different post-chromatographic derivatization reagents. The method was validated as per the ICH guidelines. Additionally, an uncertainty measurement for reliable and accurate determination was established following EURACHEM/CITAC guide CG-4 statistical procedure. The expanded uncertainty of terpenoids (**1**–**6**) measurement in *P. Roxburghii* bark was in the range of 0.44–2.17%, which confirmed that at a confidence level of 95%, the unknown true value was within ±5% range of the measured value. The compound methyl putranjate (**2**) showed the minimum uncertainty (0.4424), while putranjivadione (**5**) showed the maximum uncertainty (2.1722). This is the first validated HPTLC method with a new derivatization



reagent providing the simultaneous, sensitive, and high-throughput analysis of six bioactive triterpenes in the bark of *P. roxburghii* with defined traceability and accuracy profile.

Dr. Karuna Shanker & his team

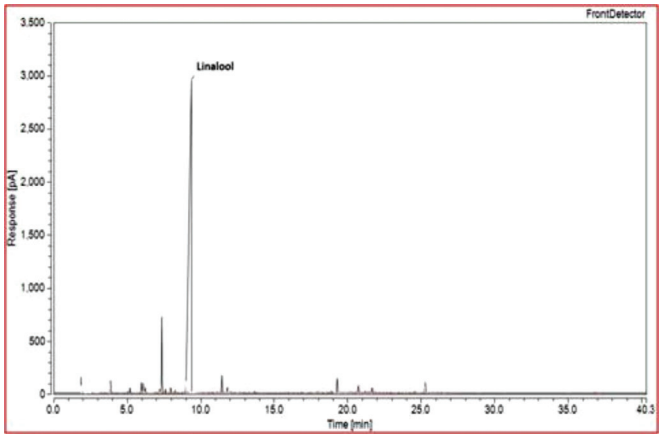
Dr. R.C. Padalia Mk- vkj-lh- iMkfy;k

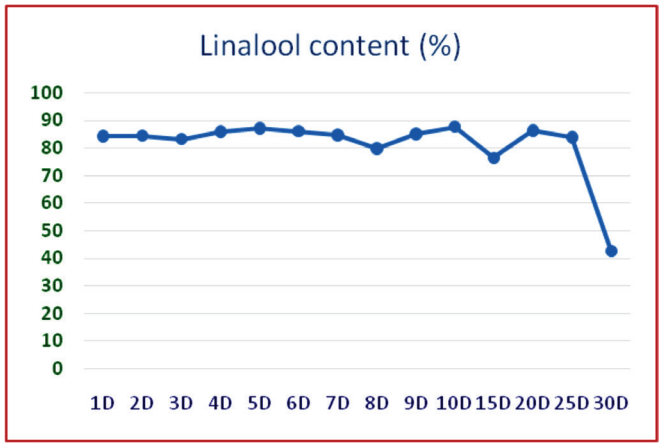
Aroma profile of celery (*Apium graveolens* L.) concerning different growth stages and plant parts

Apium graveolens L., a member of the Apiaceae family, is a popular aromatic herb and spice. The seeds are used for their traded 'celery oil' for food-flavour and medicinal purposes. The characteristics aroma of celery is due to monoterpenes, sesquiterpenoids, and phthalides. The celery crop was cultivated at CRC Pantnagar and CRC Purara and analyzed for its aroma profile during different growth stages. The aerial parts were harvested during four stages viz. vegetative, flowering initiation, full flowering, and seed setting stage. Limonene (72.7-84.7%), sedanenolide (3.4-5.3%), neocnidilide (0.4-6.2%), myrcene (1.2-1.5%), β-selinene (1.1-1.7%), 3-butyl phthalide (1.1-2.3%) were identified as major characteristic constituents during different growth stages and seed setting stage was optimum with maximal oil content (0.4%). The essential oil from the leaf, stem, and umbels of *A. graveolens* was found to be rich in limonene (71.2-82.4%). However, the seed oil (1.4%) constitutes higher content of sedanenolide, butyl phthalide, and neocnidilide. *Z*-Ligustilide and isopropyl hexadecanoate were identified as the marker constituents of its root oil along with phthalides. Celery could be a promising crop for hills for its essential oil rich in limonene and bioactive phthalides as well as for its herb for food-flavour and medicinal purposes.

Optimization of harvesting and post-harvest drying periods for *Ocimum basilicum* var. CIM-Surabhi for production quality essential oil

The crop maturity stages and post-harvest drying periods were optimized for quality essential oil composition of the 'CIM-Surabhi' variety of *Ocimum basilicum* L. The essential oil content was varied from 0.3-0.5% during different maturity stages with maximal in full bloom stage (0.5%) followed by half bloom (0.4%) and seed setting stage (0.3%), whereas linalool content was found higher in half bloom (85.8%), followed by full bloom (85.1%) and seed setting stage (82.5%). Results showed that this variety has the potential for production of 220-230 q.ha^{-1} herb with 110-115 kg.ha^{-1} essential oil rich in linalool. Moreover, results also showed that post-harvest wilting and drying of harvested herb up to 10 days in field conditions has no adverse effect on the quality of essential oil with linalool content (>80%). Therefore, considering the medicinal and aroma values of *O. basilicum* var. CIM-Surabhi offers immense potential for its cultivation at foothill agroclimatic conditions of northern India.



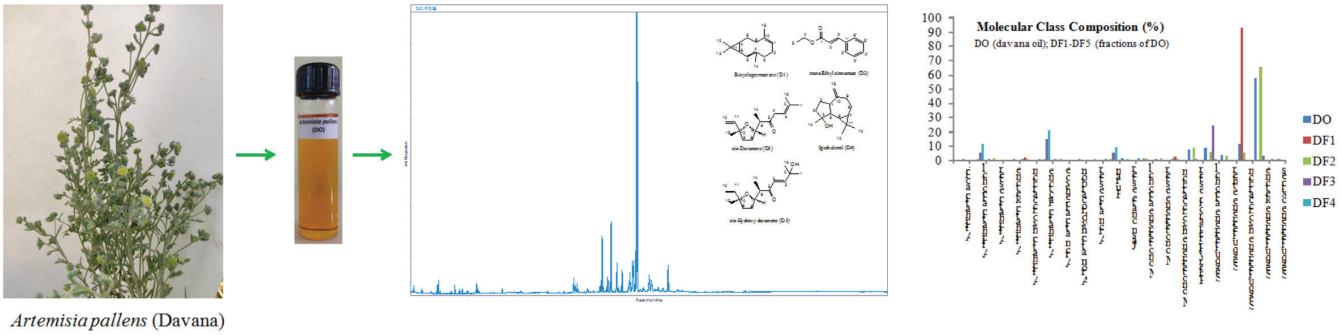


Dr. R.C. Padalia & his team

Ram Swaroop Verma jke Lo : i oek

Chemical composition and anti-inflammatory activity of davana (*Artemisia pallens* Wall. ex DC.) essential oil and *cis*-davanone in primary macrophage cells

Artemisia pallens Wall. ex DC., popularly known as davana, has gained considerable attention because of its unique fragrance, high economic value, and pharmacological properties. The compositional complexity of davana essential-oil has been a challenge for quality control. In this study, the chemical profile of davana essential-oil was developed using polarity-based fractionation and a combination of gas chromatographic, hyphenated chromatographic, and spectroscopic techniques. The analysis led to the identification of ninety-nine compounds. Major components of the essential-oil were *cis*-davanone (53.0%), bicyclogermacrene (6.9%), *trans*-ethyl cinnamate (4.9%), davana ether isomer (3.4%), spathulenol (2.8%), *cis*-hydroxy davanone (2.4%), and *trans*-davanone (2.1%). The study led to identifying several co-eluting novel minor components, which could help determine the authenticity of davana essential-oil. The rigorous column-chromatography led to the isolation of five compounds. Among these, bicyclogermacrene, *trans*-ethyl cinnamate, and spathulenol were isolated and characterized by spectroscopic methods for the first time from davana essential-oil. Davana essential-oil and *cis*-davanone treatment to the LPS, an endotoxin, stimulated primary macrophage cells



Artemisia pallens (Davana)

were able to inhibit the production of pro-inflammatory cytokine.

Chemical composition, antibacterial, and antifungal activity of the leaf essential oil of *Ravenia spectabilis* Engl. (Rutaceae)

This study was planned to investigate the chemical composition and antimicrobial activity of leaf essential oil of *Ravenia spectabilis* Engl. hydrodistillation of fresh leaves of *R. spectabilis* yielded 0.19 ± 0.02% essential oil. The resulting essential oil was analyzed by gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectrometry (GC-MS). Altogether, thirty-one constituents forming 97.6 ± 1.72% of the total oil composition were identified. Major components of the oil were sabinene (60.8 ± 0.36%), α-pinene (5.4 ± 0.30%), myrcene (4.8 ± 0.25%), δ-3-carene (4.7 ± 0.62%), and β-pinene (4.3 ± 0.17%). *In-vitro* antimicrobial potential of the oil was examined against eight human pathogenic bacterial and fungal strains. The essential oil showed significant activity against *Staphylococcus aureus*, *Staphylococcus epidermidis*, methicillin-resistant *Staphylococcus aureus*, methicillin-resistant *Staphylococcus epidermidis*, *Candida albicans*, and *Candida kefyr*. This is the first report on *R. spectabilis* leaf essential oil composition and its antimicrobial activity.

Ram Swaroop Verma & his team

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

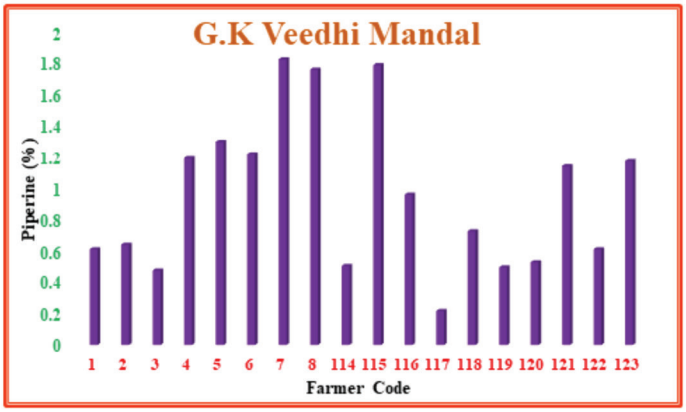
Extraction and isolation of phytomolecules from *Piper longum* L.

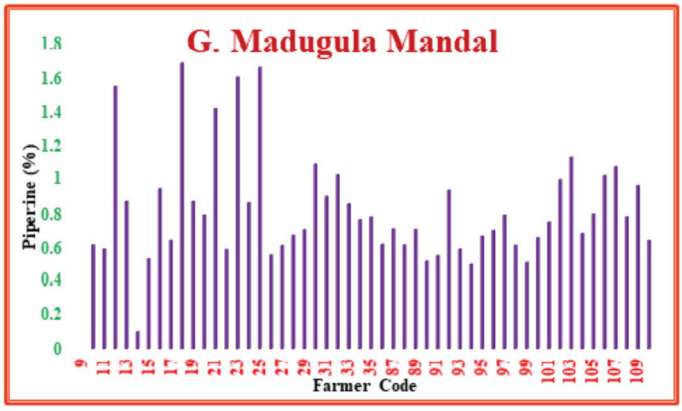
Piper longum L. is commonly known as long pepper, Pippalmodi. It is reported as a good remedy for treating tuberculosis, respiratory tract infections, chronic gut-related pain, and arthritic condition. On fractionation with hexane, hexane soluble and hexane insoluble fractions were obtained from hexane extract of the root. The hexane soluble portion by precipitation and crystallization with hexane yielded piperine as pale yellow colour needles. The hexane insoluble portion by precipitation and crystallization with 20% chloroform in hexane yielded yellow coloured crystalline Piperyline. The isolated compounds were identified with the help of reference standards and spectroscopic studies.

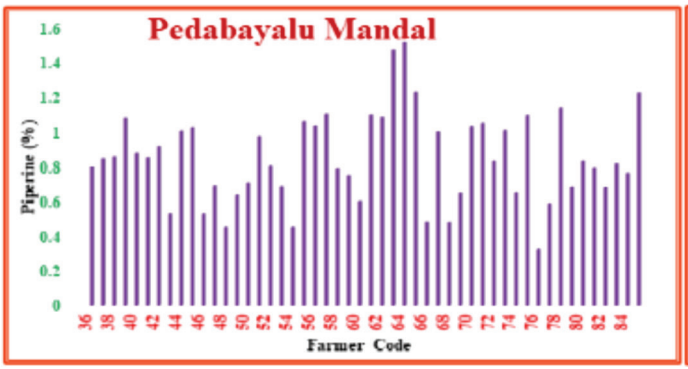
Conducting sample survey for the quality analysis of *Piper longum* by HPLC method in the Farmer's fields of Andhra Pradesh

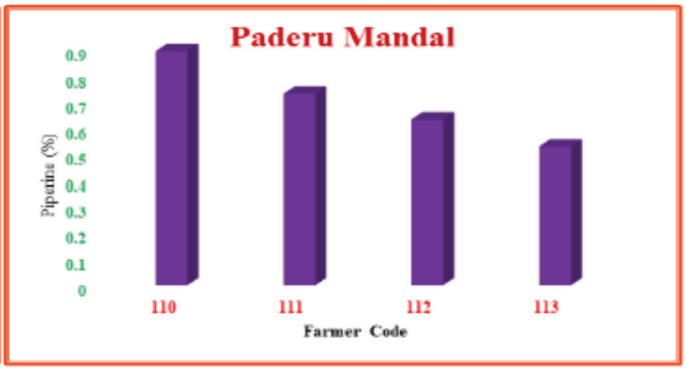
Long Pepper known as *Piper longum* L. is one of the three ingredients in the Ayurvedic formula Trikatu along with ginger and black pepper. It is used for cough, bronchitis, asthma, inflammation, drowsiness, insomnia, epilepsy, stomach disorders, and tuberculosis, etc. In India it is possessing high demand due to its medicinal properties. It is cultivated by tribal farmers for its root as bi/triennial crop in Paderu, G. Madgula, G.K. Veedhi, and Pedabayalu tribal hill areas of Visakhapatnam district of Andhra Pradesh. Under CSIR rural development program and with the funding support from APMAPB, CIMAP-Research Centre, Hyderabad has developed the bestagro-packages for Long pepper and transferred to the tribal farmers by way of conducting awareness camps and training programs. This has benefitted about 4000 tribal farmers of Visakhapatnam. Further, it is thought that the quality analysis of their produce will enhance its marketability at higher pricing. A survey project for quality mapping of long pepper of Visakhapatnam was proposed to APMAPB for one cropping season.

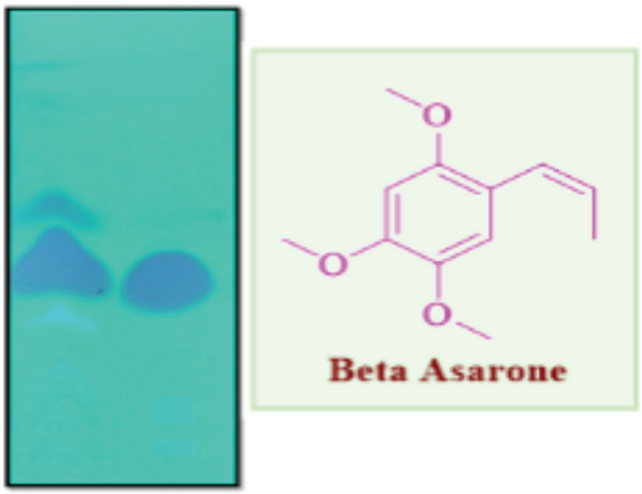
The activity included the surveyand collection of samples of *Piper longum* from the fields of 123 tribal farmers for mapping of marker compound 'Piperine'. A format was designed and all the details of the farmers along with the GPS points of their fields were recorded. The marker compound analysis was carried out by HPLC is given below.











Extraction & isolation of β-Asarone from *Acorus calamus* Linn

A. calamus Linn., commonly known as 'Sweet flag' is used as a 'rejuvenator' of the brain and nervous system and in the treatment of cough, bronchitis, inflammation, depression, etc. Paste of the rhizome is used in rural areas of southern India to improve speech and memory in children. The essential oil obtained by the Clevenger apparatus from the root was subjected to column chromatographic separation using 5% ethyl acetate in hexane. The purification of essential oil yielded a pure yellow color liquid which was identified as β-Asarone with the help of authentic compound and spectroscopic data. The isolated β-Asarone was used as a standard for HPLC analysis of different cultivars of *A. calamus* samples

HPLC analysis of marker Compounds variation in *Cassia angustifolia* (Senna) during different time intervals

C. angustifolia root, leaf, flower, whole plant, pod, and stemsamples were collected at CSIR-CIMAP, Research Centre, Hyderabad for three months at short intervals of every 15 days once. The collected material was analyzed by RP-HPLC. In this study, the variations of chemical markers were observed in the different plant parts which are described below.

- ***Variation of Marker Compounds in Leaf:*** Sennoside B and A were observed more at 105 days aged plant and least was noticed at 45 days aged plant. Similarly, Rutin was recorded as the highest percentage at 60 days and least was notices at 105 days.
- ***Variation of Marker Compounds in Stem:*** Sennoside B and A were observed more at 105 days and least was noticed at 45 days. In stem, the sennoside A and B gradually increased from 45 days to 105 days. The Rutin was observed at 105 days. It was noticed that the pattern was increasing decreasing and increasing.
- ***Variation of Marker Compounds in Root:*** The percentage of the marker compounds in the root was very less compared to leaf and stem in all the stages. The highest yields of all the marker compounds were observed at 90 days and the least was noticed at 45 days.
- ***Variation of Marker Compounds in Whole plant:*** The available percentage of the marker compounds was more in the whole plant next to the leaf. The sennoside B was observed more at 90 days and whereas Sennoside A at 105 days. The pattern of sennoside A was observed increasing whereassennoside B was increased up to 90 days later decreasing pattern was noticed. Similarly, rutin was increased up to 75 days then decreased upto 90 days and again increased upto 105 days and was observed maximum at 105 days.
- ***Variation of Marker Compounds in Flowers:*** The flowers are formed between 75 to 90 days. The flowers consist least percentage of the marker compounds compare to other parts. The sennoside B and A were more at 105 days. Whereas, Rutin was present more at 90 days. The pattern of sennoside A and B was increasing and Rutin as decreasing pattern was observed.
- ***Variation of Marker Compounds in Pods:*** The pods are formed between 75 to 90 days. The pods contain a good percentage of the marker compounds. All the marker compounds i.e. sennoside A, sennoside B, andRutin were observed more during 105 days. Overall, a gradually increasing trend was noticed during the growth period.

Conclusively, marker compounds are accumulated to the maximum in leaf and pods during 90 to 105 days, and hence, this should be the ideal harvesting period.

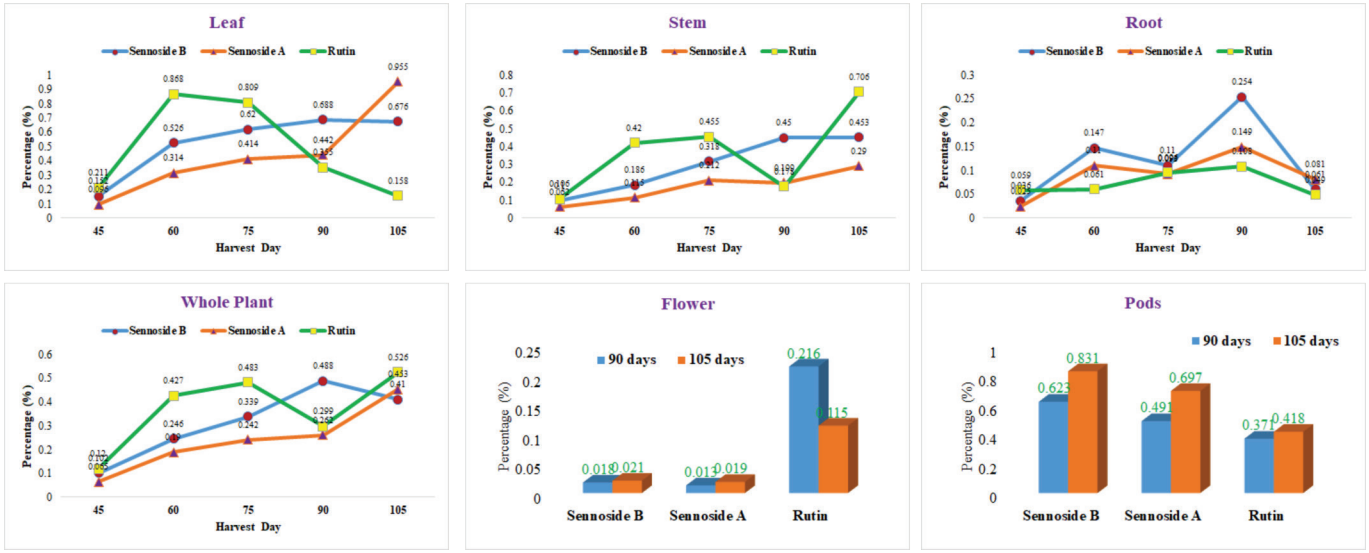


Fig. Variations of marker compounds in different stages and different parts of the plant.

Generally, the remaining parts like root, stem, and flower were discarded and ignored. Our study revealed the presence of maker compounds in these parts and therefore, farmers can conveniently trade them to generate additional income.

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

Development of C^{14} dating based tool for authentication of plant secondary metabolites from petroleum based sources

In India, economically motivated adulteration has been a major concern in flavor and fragrance sector. Fraudulent substitutes derived from other sources or synthetic ingredients (sourced from petroleum) are intentionally added to consumer products in order to reduce the cost of production or increase the apparent value for the overall purpose of economic gain.

I am working on development of radiocarbon carbon dating based technique for authentication of plant based aroma chemicals from petroleum based chemicals.

AMS based C^{14} radiocarbon dating for a total of twenty samples of flavor and fragrance value were performed till the end of March 2021. Based on the C^{14} results, one manuscript is under draft stage for publication.

Cyclodextrin based Gas Chromatography and GC/MS methods for determination of chiral pair constituents in mint essential oils

The genus *Mentha* has been known as culinary source of minty note. Besides, the essential oil derived from different species, it imparts value to several consumer products like confectionary, cosmetics, and pharmaceutical preparations. A simple and sensitive enantioselective gas chromatographic method is described in this study for the quantitative analysis of terpenoid enantiomers in essential oils of two different mint species. The method is based on the separation of enantiomers in different cyclodextrin coated stationary phases. Limonene, menthone, menthol, and menthyl acetate were identified as pure (-)-enantiomers whereas isomenthone, neomenthol, pulegone, and piperitone as pure (+)-enantiomers in menthol mint, and peppermint oils, respectively. The selectivity of each enantiomer was also demonstrated using different substituted cyclodextrin phases. A β-cyclodextrin phase with diethyl substitution provides baseline resolution for all target enantiomers with selectivity ranged from 1.004 to 1.050. Moreover, permethylated or diacetylated-β-cyclodextrin showed no selectivity for (+/-)-menthol enantiomers. The current study may facilitate the origin authentication studies of mint oils. Investigation of enantiomers involved in menthol biosynthesis pathway has so far shown no indication of the presence of both enantiomers in revealed that only (-)-menthol is present in the essential oils of Mentha species. Presence of single enantiomer i.e., (−)-germacrene D in higher plants is also verified on cyclodextrin based analysis (Fig.

1). Furthermore, we reported that diethyl substituted β-cyclodextrin is as the most versatile chiral phase for studies related to origin authentication of essential oils.

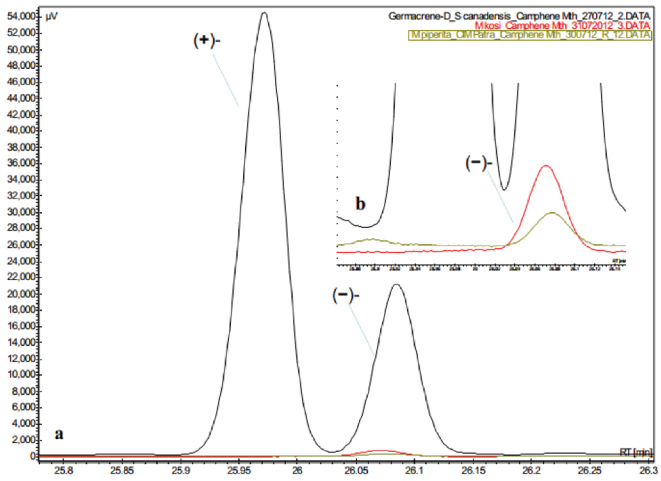


Fig. Resolution of germacrene D enantiomers in mint varieties of CSIR-CIMAP: Solidago oil revealed presence of both enantiomers (**a**), and expanded view showing presence of single isomer in Kosi and CIM-Patra essential oils (**b**) (J Essent Oil Res. 2021)

Investigation of monoterpenoids rich essential oils of two *Ocimum basilicum* L. varieties at different agro-climatic conditions in India

India is an emerging basil essential oil producer in South-east Asia. Two high essential oil yielding hybrids, namely one inter specific hybrid between of *O. basilicum* and *O. kilimandscharicum* Gürke (HYBL-1) and another intraspecific hybrid of *O. basilicum* × *O. basilicum* (OBL-1) of basil were analyzed using GC, enantiomeric GC, NMR, enantio-GC–MS and GC–MS methods. Inter specific hybrid HYBL-1 contained high essential oil-rich in linalool (68.5%), camphor (8%), and 1,8-cineole (4.6%) as characteristic constituents among monoterpenoids, whereas β-caryophyllene (1.9%), germacrene D (1.0%), and epi-α-cadinol (1.9%) were the sesquiterpenoids at the Lucknow (North Indian conditions) and linalool (71.8%), camphor (9.4%) and 1,8-cineole (4.3%) at Hyderabad (South Indian conditions) locations. Intraspecific hybrid (OBL-1) possessed linalool (66.1%), 1,8-cineole (5.4%) and geraniol (8.6%) with sesquiterpenoids in low proportions. Inter specific hybrid HYBL-1 showed superiority over OBL-1 in the multi-location trials conducted at Lucknow and Hyderabad. Average mean performance of inter specific hybrid over locations was: herb yield 44.80 t/ha, oil content 0.63%, oil yield 188.50 kg/ha, linalool content 67.65%, camphor content 8.90% v/s OBL-1 herb yield 21.32 t/ha, oil content 0.53%, oil yield 97.50 kg/ha, linalool content 65.55%, camphor content 0.00%, respectively. The essential oil of these two hybrids subjected to enantiomer differentiation revealed a high enantiomeric excess for (3*R*)-(−)-linalool, whereas (1*R*)-(+)-camphor was recorded exclusively in inter specific hybrid. The extensive NMR experiments were performed to confirm constituents in these hybrids and found that NMR spectroscopy could also be an ideal tool for the differentiation of essential oils from commercial samples declared as natural.

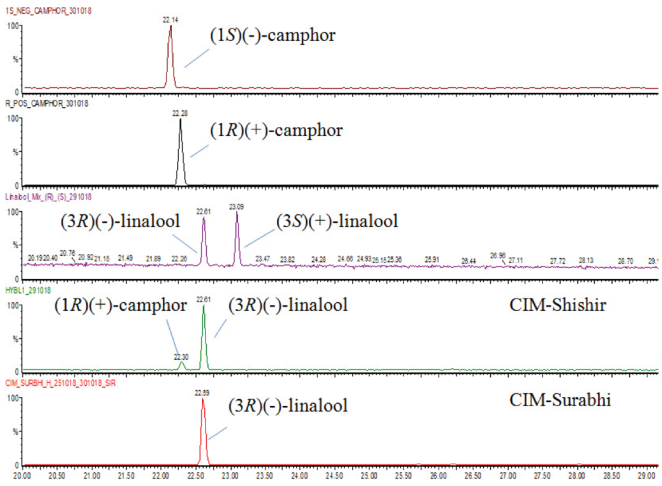


Fig. Enantiomer differentiation of chiral pairs in inter specific hybrid (HYBL-1; CIM-Shishir) and intraspecific hybrid (OBL-1; CIM-Surabhi) (Act Ecologia Sinica. 2020)

Intra-specific chemical diversity across the years/environments among the genotypes of basil (*Ocimum viride* Willd.) essential oil

We studied chemical variations among the seven potential lines of *Ocimum viride* over three consecutive years (Fig 1). The statistical analysis was performed to select the best genotypes. The essential oil obtained by hydro-distillation from the aerial parts of *O. viride* genotypes was subjected to GC, enantiomeric GC, and GC/MS analyses for their chemical characterization. GC-FID analysis revealed maximum proportions of eugenol (37.8-45.8%) along with monoterpenes such as (*Z*)-β-ocimene (9.3-29.5%) (Fig 2). The sesquiterpenoids identified were β-caryophyllene (3.1%-4.6%), α-*trans*-bergamotene (5.5%-7.4%) and germacrene D (5.9%-10.6%). In this study, genotype 129 was recorded as the best genotype in terms of the maximum number of identified constituents. Besides, genotype 131 contained higher monoterpenoids. The thermo-gravimetric analysis revealed the stability

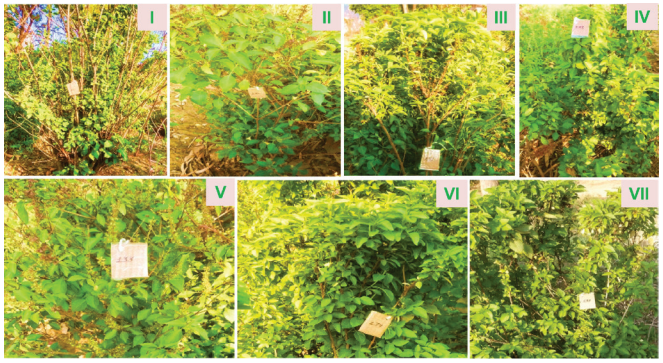


Fig 1. Populations of *Ocimum viride*

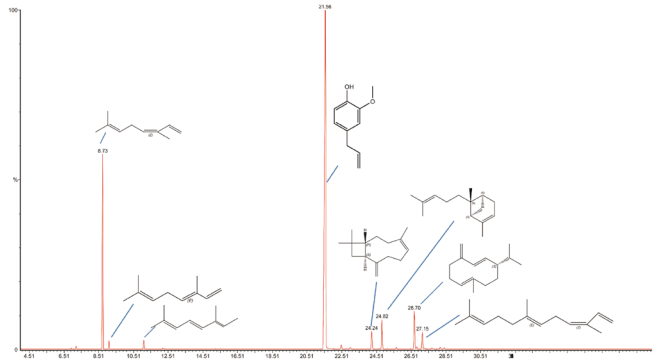


Fig 2. (*Z*)-β-ocimene + eugenol rich unique Ocimum sp (*O. viride*);

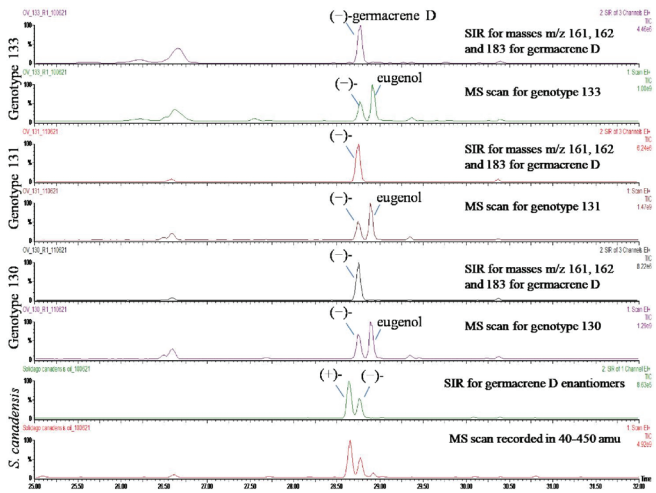


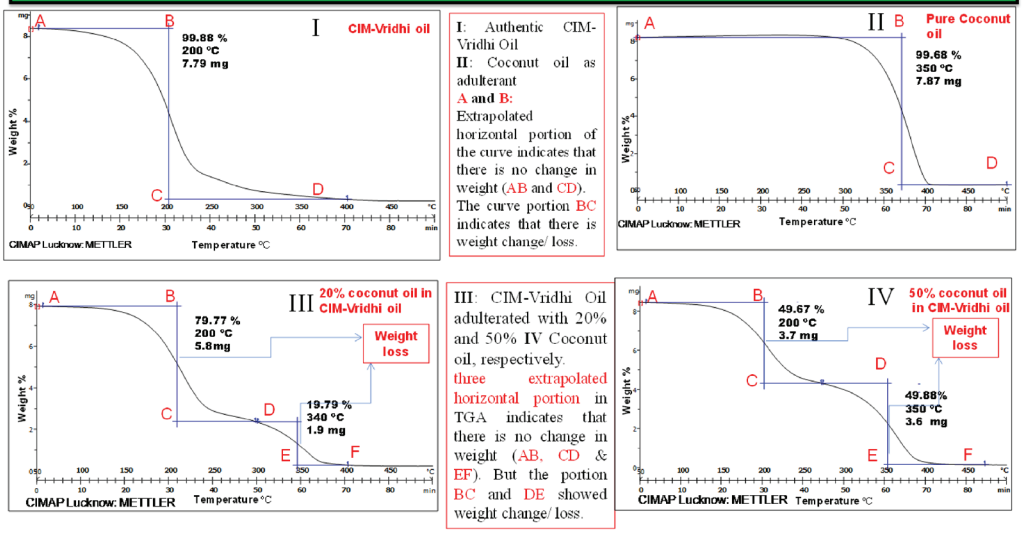
Fig 3. SIR based identification of germacrene D enantiomers in three best genotypes of *O. viride* essential oils

pattern of extracted essential oils and showed the complete degradation at 190°C-200°C. Major chemical constituents such as eugenol were isolated through column chromatography, and structure elucidation was carried out using 1D and 2D NMR experiments. Separation of germacrene D enantiomers (+)- & (−)-form) were achieved using cyclodextrin-based capillary column in each genotype. The (−)-germacrene D was found to be the most predominant enantiomer in all genotypes. Genotype 133 was recorded with the highest enantiomeric excess (≥ 99%) (Fig 3). The statistical analysis revealed the best genotypes based on the correlation between years/ environment x constituents (Y x C) interaction. This analysis helped in estimating better oil yield analysis, chemical diversity, and herb yield analysis on a field experiment basis.

Development of Thermo-gravimetric analysis (TGA) based quality control tool for determination of high boilers in essential oils

- Essential oils and flavor chemicals are not always reaching the consumer in their original composition. They may be adjusted to meet the required quality or specification of a legal standardizing authority.
- Higher boilers like coconut oil, mineral oil, etc pose a big challenge in quality control analysis of high value essential oils.
- In routine gas chromatography analysis, high boilers are not detectable due to the limitation of column operating conditions, maximum oven temperature, and type of detectors used etc. Therefore, the adulterants remained non-detectable in many high value essential oils.
- TGA is a technique in which the mass of a substance is measured as a function of temperature where the substance is subjected to a controlled temperature programme.
- Themo-stability results demonstrate a quick and easy method for determination of devolatilization behaviour of volatile essential oil and its possible adulterants viz., vegetable oil or PEG analogues.
- For authentic essential oil, a single stage decomposition pattern in TGA is observed.
- Two of our commercially important vetiver essential oil of CIM-Vridhi & CIMAP-Khusinolika showed single stage decomposition with complete mass loss/ de-volatization at 200 ºC (Fig. 1 and Fig. 2).

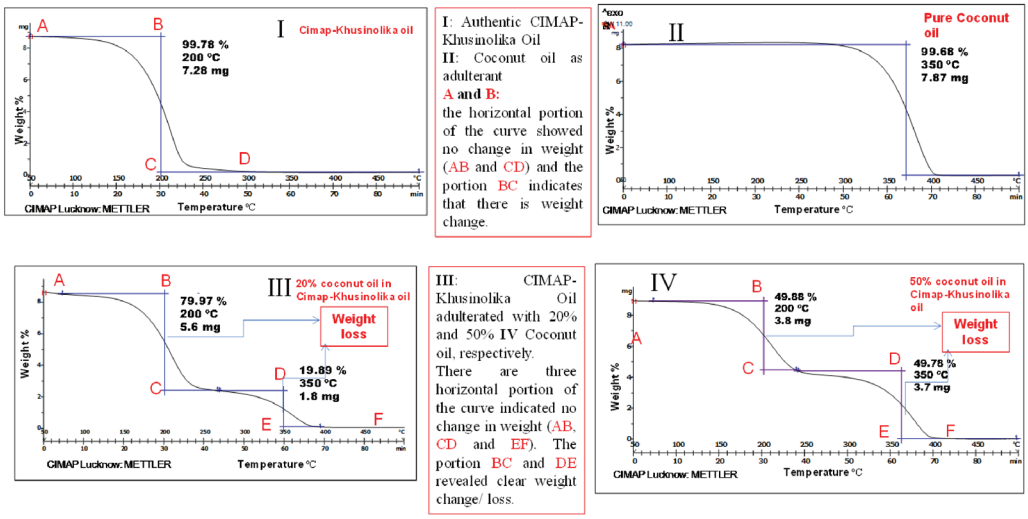
Fig. 1 TGA based detection of adulterants in vetiver essential oil var. CIM-Vridhi



I: Authentic CIM-Vridhi Oil
II: Coconut oil as adulterant
A and B: Extrapolated horizontal portion of the curve indicates that there is no change in weight (AB and CD). The curve portion BC indicates that there is weight change/ loss.

III: CIM-Vridhi Oil adulterated with 20% and 50% IV Coconut oil, respectively. three extrapolated horizontal portion in TGA indicates that there is no change in weight (AB, CD & EF). But the portion BC and DE showed weight change/ loss.

Fig. 2 TGA based detection of adulterants in vetiver essential oil var. CIMAP-Khusinolika



I: Authentic CIMAP-Khusinolika Oil
II: Coconut oil as adulterant
A and B: the horizontal portion of the curve showed no change in weight (AB and CD) and the portion BC indicates that there is weight change.

III: CIMAP-Khusinolika Oil adulterated with 20% and 50% IV Coconut oil, respectively. There are three horizontal portion of the curve indicated no change in weight (AB, CD and EF). The portion BC and DE revealed clear weight change/ loss.

Dr. CS Chanotiya & his team

- We have recorded multiple stage decomposition patterns in adulterated oil samples, where coconut oil was mixed in CIM-Vridhi and CIMAP-Khusinolika on different weight basis (20 to 50%):
- First decomposition observed at 200 ºC whereas
- Second decomposition recorded at 350 ºC in CIM-Vridhi & CIMAP-Khusinolika, respectively.

In conclusion, presence of multiple stages in a TGA revealed presence of adulterants in the vetiver oil.

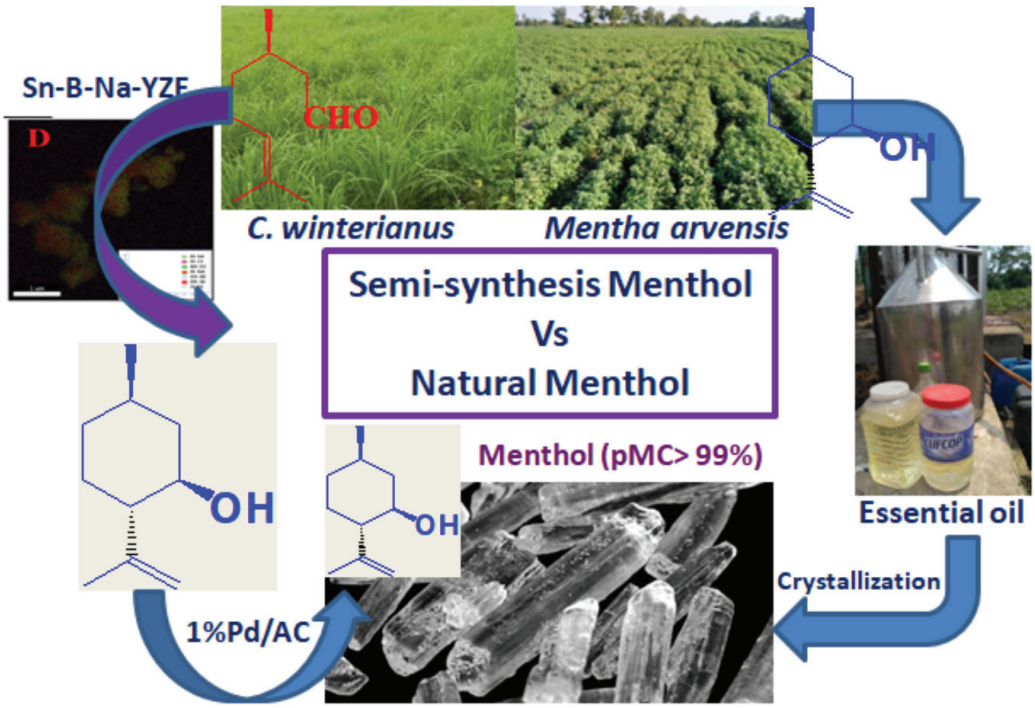
- Similarly, pure coconut oil showed single stage decomposition at higher temp (350 ºC).
- Our results showed that the commercially important essential oils can be distinguished very well by plotting TGA curve, if misbranded or adulterated by addition of non volatile compositions/ fractions.
- Detection of adulterants in essential oils using TGA has been developed for the first time and can be used as a tool in the authentication of high value essential oils.

Dr. PK Rout Mk- ihd jkmr

Value addition of essential oils

Team: Dr. PK Rout & Dr. CS Chanotiya

Menthol is one of the common ingredients used for the flavoring of pharmaceuticals and nutraceutical products with annual consumption of over 10000 Ton. Though *Mentha arvensis* cultivation is largely promoted, it falls far short to meet the Global demand. Nearly 40% of demand is meeting out from synthetic menthol which is mainly derived using petrochemical as primary feedstock. In the present work, a novel catalytic process has been developed for selective semi-synthesis of menthol from citronellal-rich essential oils such as *Cymbopogon winterianus* and *Corymbia citriodora*. In the first step, citronellal is cyclized to isopulegol isomers (~98%) using novel bi-acidic composites Al-B-NaYZE or Sn-B-NaYZE. This carbonyl-ene (Prins) rearrangement was facilitated by Lewis and Bronsted acidic sites of composites to produce isopulegols. Further, isopulegols are selectively reduced to 98% of menthol over 1%Pd/AC at 40 psi H_2 pressure. The reaction mixture was slowly frozen to -40ºC for trouble-free isolation of the crude menthol. Further, biologically active form (-)-menthol was purified from the crude menthol through the esterification process. The isolated (-)-menthol was found 100% biobased on ^{14}C radiocarbon dating in the Accelerator Mass Spectrometry system. The catalytically modified as well as spent essential oils have displayed significant anti-microbial and anti-oxidant activities. Therefore, the work on sustainable semi-synthesis of pharmaceutically important (-)-menthol was found to be as nature identical and can be differentiated from synthetic menthol of petrochemical origin.



Value addition of Castor oil

Team: Dr. PK Rout*, Er AD Nannaware, Dr. CS Chanotiya & Dr. Alok Kalra

(+)-α-Decalactone, an important food flavor with GRAS status is produced from ricinoleic acid through microbial biotransformation. As it is produced through biotransformation, it is classified as natural (labeled as natural flavors, in accordance with the CFR21 Sec. 101.22 and EU Flavor Regulation 1334/2008/EC).

The present process comprised of two steps;

(a) An economical process for the enrichment of ricinoleic acid (94%, approx) from castor oil through the solvent-solvent partition. This process has been scaled up to 3 litre capacity using a continuous partition pulse column.

(b) This enriched ricinoleic acid is bio-transformed into food flavor important (+)-α-decalactone using a newly isolated strain. More than 60% of (+)-α-decalactone is obtained from ricinoleic acid in 70-80 h of inoculation. Chiral-GC-FID analysis revealed that it possessed 99% enantiomeric purity. The obtained (+)-α-decalactone is 100% biobased as per the Accelerated Mass Spectrometry analysis.

Dr. PK Rout & his team

Dr. Atul Gupta Mk- vr;y xIrk

Synthesis and biological evaluation of substituted amide derivatives of C4-ageratochromene dimer analog

Team: Atul Gupta*, Prema G Vasudev, Divya Singh, Suaib Luqman, Feroz Khan

Substituted amide derivatives of C4-ageratochromene dimer analog (19) were synthesized through structural modification of precocene-I (4a), isolated from the essential oil of *Ageratum conyzoides L.*(Fig. 1). The target compounds (18-20, 23I-VI, 24I-VI, and 25I-VI) were evaluated for their bone-forming effect using osteoblast differentiation assay. Seven compounds (23I, 23II, 23IV, 23VI, 24III, 24VI, and 25VI) presented good activity within 1 pM-1nM concentration. At 1 pM concentration, the most active compound i.e. 23II showed effective mineralization of osteoblast cells along with expression of osteogenic marker genes viz RUNX 2, BMP-2, and type 1 collagen without any toxicity towards osteoblast cells (Fig. 2). Single crystal X-ray analyses of 19 and 20 revealed that the core nucleus of these molecules bear phenyl rings in a *Trans*-stilbenoid system and had a good structural correlation with 17β-estradiol (1) and diethylstilbestrol (DES, 3). *In silico* study, about 23II showed its structural complementarities with the LBD of estrogen receptor (ER) which indicated possible ER-mediated activity of compounds.

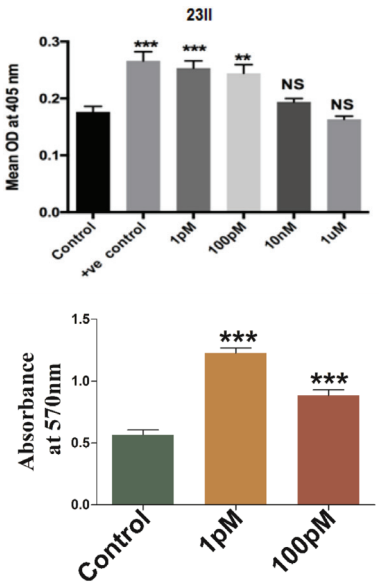


Fig. Effect of 23II on alkaline phosphatase (ALP) activity and mineralization of osteoblast cells

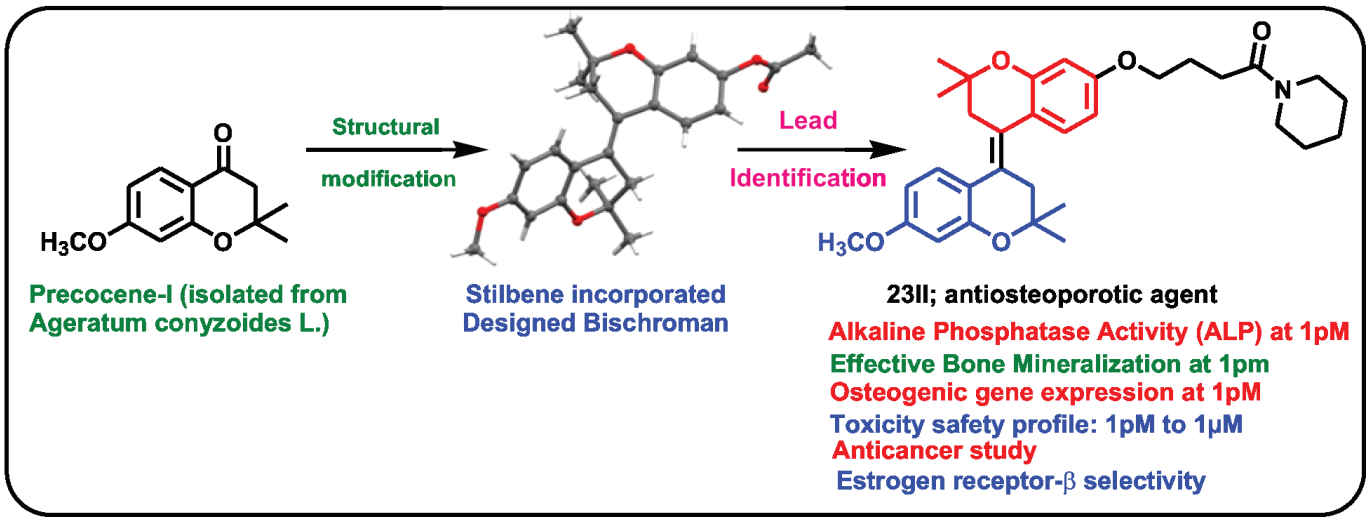


Fig. Structural modification of Precocene-I and identification of the lead compound.

Dr. Atul Gupta & his team

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

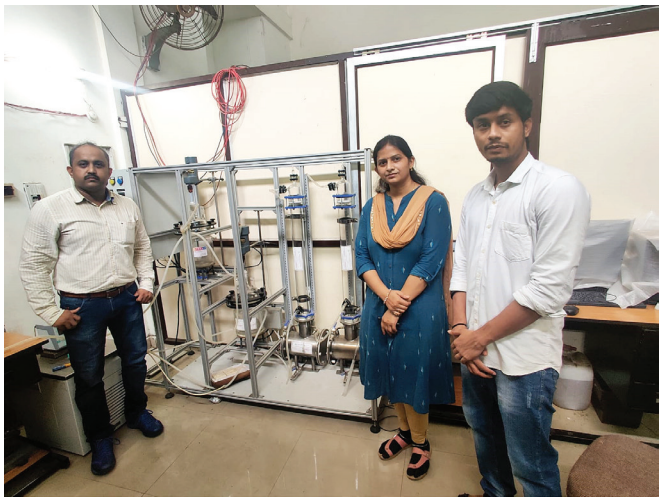
Environmental friendly decentralized solar distillation unit

A decentralized solar aroma distillation unit prototype design of 20 Kg capacity has been developed for highly regions farmers for isolating the valuable volatile fractions from aromatic and medicinal plants. This new design decentralized solar distillation unit is environmentally safe, easy to take to the farmers' field, and is facilitated the aromatic crops growing farmers with higher oil yield. The process optimization study of this prototype has been completed in 20 Kg capacity. Using this new design distillation unit, farmers' dependency on wood will be reduced and will also allow the farmers to have the complete visibility of essential oil obtained from aromatic plants during operation. This technology will help to introduce the agricultural industry to the various uses of solar energy in a very simple and effective way. This solar distillation technology will also curtail the farmer's dependency on fossil resources causing various environmental pollutions. This decentralized solar aroma unit will help in assisting Indian farmers and also end beneficiaries to develop sustainable agribusinesses.

Fig. A prototype of pulse partition column system used for extraction and purification of ricinoleic acid from castor oil.

Designing of partition column for value addition of *castor* oil

A pulse partition column system was designed and developed for the liquid-liquid fractionation and enrichment of ricinoleic acid from castor oil. Using this pulse particle column, an enrichment of ricinoleic acid from castor oil was achieved up to 94% approx.



Er. Ashween D Nannaware & his team

Dr. Hariom Gupta Mk- gjhvke xIrk

Preparation of plant-mediated metal-based nanostructures

Plant-mediated preparation of metal-based nanostructure is one of the eco-friendly methods for the preparation of nanostructures. These nanostructures possess a specific surface activity because of the participation of plant molecules in the crystalline nucleation process. Plant molecules cause to change in the nanostructure morphology and crystalline structure resulting in specific characteristics. In the present study, a series of plant-mediated nanostructures were prepared and characterized using different tools such as XRD, FT-IR, SEM, EDAX, TGA, etc. The initial observations related to these nanostructures are shown in the following figure. Further studies on these newly prepared plant-mediated metal-based nanostructures are in progress.

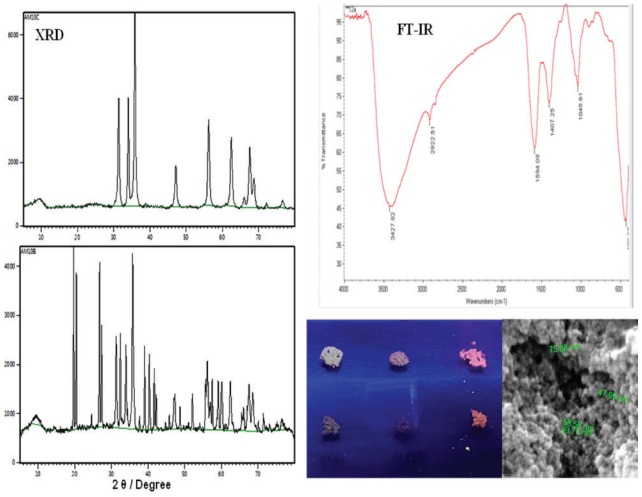


Fig. Demonstrating the X-ray diffraction pattern, FT-IR, SEM image of prepared nanostructures.

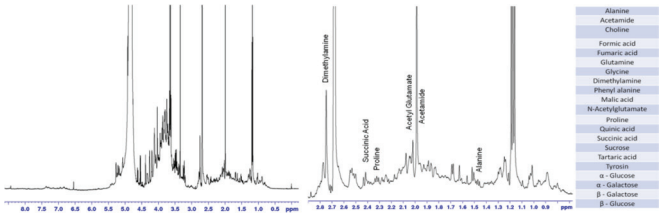


Fig. ^{1}H NMR spectra of water fractionate of roots of *withania somnifera* representing the characteristic peaks of identified molecules.

NMR investigation of solvent fractionates of *Withania Somnifera* (L.) Dunal

NMR-based investigation for four different solvents fractionate of *withania somnifera* roots was performed. One dimensional ^{1}H, ^{13}C, DEPTs, and 2D NMR spectra were acquired and optimize for their concern acquisition parameters. Obtained NMR spectral peaks were found overlapping due to a mixture of various metabolites in the sample. However, characteristic NMR peaks correspond to adequate numbers of primary and secondary metabolites were identified. Obtained NMR spectra of water fractionate and their identified molecules are illustrated in the following figure.

Dr. Hariom Gupta & his team

Dr. Kapil Dev dfiy no

Phytochemical investigation of stem bark *of Oroxylum indicum* (L.) Benth. ex Kurz

Oroxylum indicum (L.) Kurz belongs to the family Bignoniaceae. It is a medium-sized tree that grows in tropical and subtropical regions of Asia. It is called as "Shyonak" or "Trumpet" tree in India. Traditionally, the plant is used in the treatment of various diseases such as anti-microbial, anticancer, anti-inflammatory and anti-arthritis, etc. It is a very important ingredient of several Ayurvedic formulations, especially Dashmool.

As a part of our drug discovery program, the stem bark of the *O. indicum* was collected from Biswanath district, Assam, India. The powdered plant material (dried under shade) was extracted with alcohol to get the alcoholic extract. The alcoholic extract was further fractionated with chloroform, *n*-butanol, and water to yield corresponding fractions. The purification of the fractions was carried out on silica gel column chromatography which yielded five compounds (**1-5**, Fig. 1). The structure of the purified compounds was established by using 1D and 2D-NMR spectral data. The isolated compounds belong to flavonoid and steroid classes. The molecules were characterized as oroxylin A (**1**), chrysin (**2**), baicalein (**3**), hispudilin (**4**), spinasterol (**5**). Further, work is in progress.

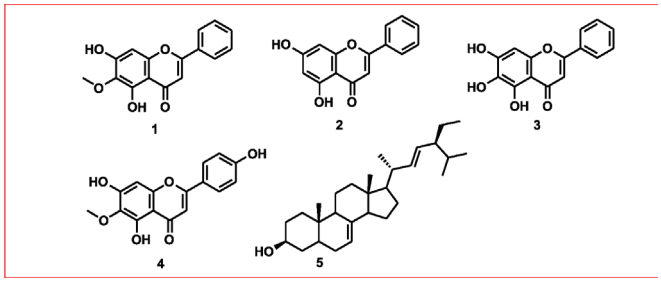


Fig. Chemical structures of the isolated compounds

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

Functional investigation of volatile compounds in floral scent of *Cananga odorata* (Lam.) Hook.f. & Thomson

The major objective of our lab is to develop methodologies for the separation of economically valuable and biologically important natural fragrant enantiomeric compounds and their quality control. The floral volatile chemicals are ecologically important and are scarcely studied for their function in attracting pollinators and deterring florivores. Structural and molecular differences of the volatile compounds present in the floral volatiles are responsible for their diverse functions. Floral volatiles constitute terpenoids and phenylpropanoid-type compounds. Terpenoids are one of the important groups of plant secondary metabolites and are present as major compounds in floral volatiles.In nature, several terpenoids exist as enantiomers and exhibit differential activity in biological systems. In the present study, we studiedthe chemistry of floral volatiles of *Cananga odorata*, a native Indian tree, to explore their ecological functions. The gas chromatography (GC) and gas chromatography-mass spectrometric (GC-MS) analysis of the floral scent revealed that benzyl acetate, linalool, β-caryophyllene, α-humulene, germacrene D, etc. are the important compounds of floral volatiles of *Cananga odorata*. Further, enantiomeric characterization of linalool enantiomers showed that (*R*)-(-)-linalool is a major enantiomer in the floral scent. It is also interesting to identify the function of linalool enantiomers in the floral volatiles of *C. odorata*. Isolation of the chemical compounds and enantiomeric characterization of other mono- and sesqui-terpenoids in the floral scent are under progress. The ecological function of the individual compounds in the floral scent will be evaluated.

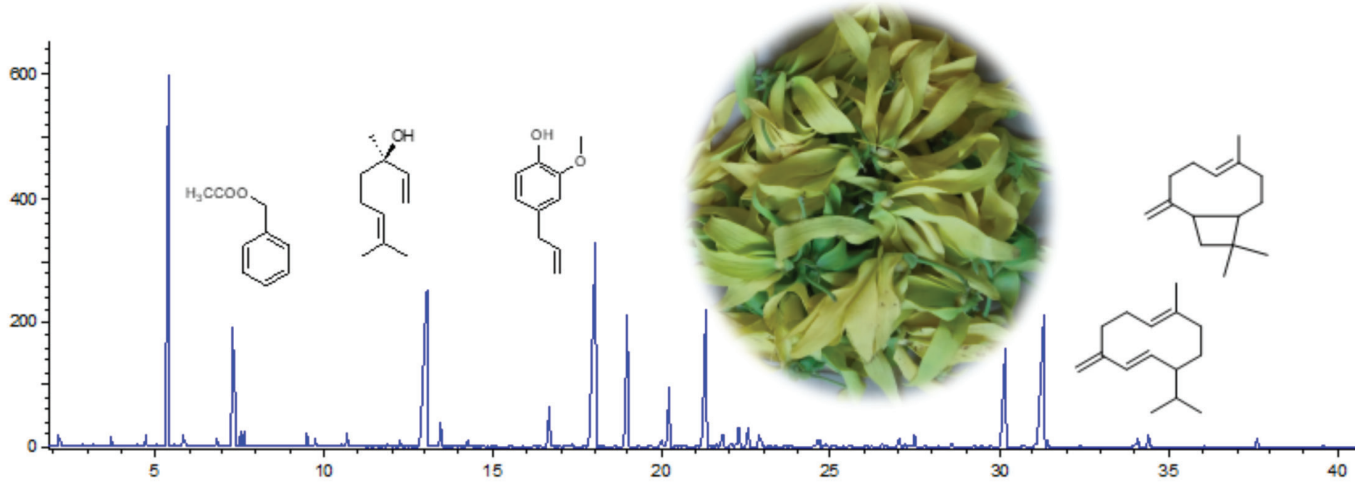


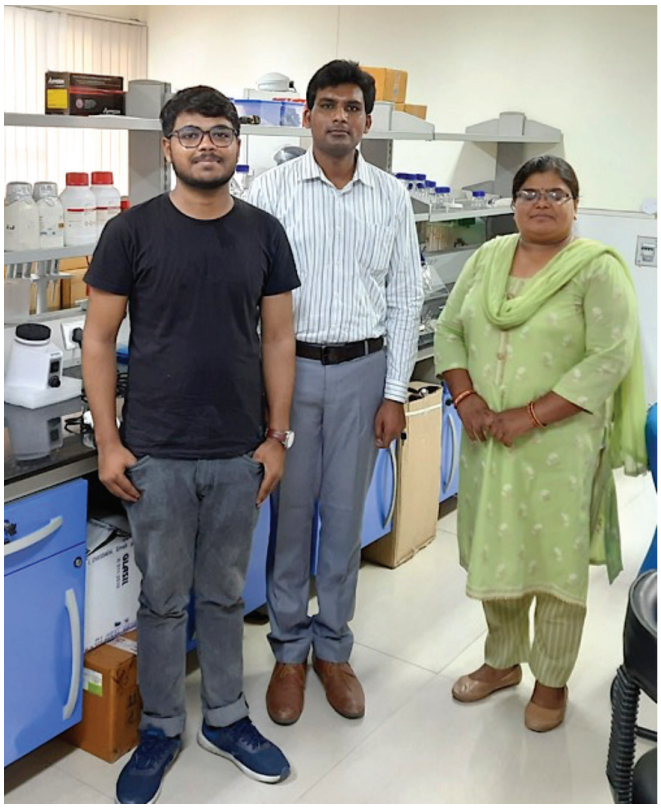
Fig. Chemical composition of the floral scent of *Cananga odorata*

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

A two-tiered system of analysis of aroma for fingerprinting of rice

A unique two-tiered analytical system comprised of rapid on-site screening of samples using handheld portable Near-infrared (NIR) and laboratory confirmatory technique using a Headspace gas chromatography-mass spectrometry (HS-GC-MS) strategy for untargeted analysis was developed. Chemometric models built using NIR data correctly predicted nearly 100% of Pusa 1121 and Taraori, two high-value types of Basmati, from potential adulterants. Furthermore, the profile fingerprints of rice volatile organic compounds (VOC) showed very good classification (R2 >0.9, Q2 > 0.9, Accuracy > 0.99) for these high-quality India Basmati varieties from potential adulterant varieties with aldehydes identified as key VOC marker compounds. Using a two-tiered system of a rapid method for on-site screening of many samples alongside a laboratory-based confirmatory method can classify Basmati rice varieties, protecting the supply chain from fraud.

Fig. Schematic of the published graphical abstract for rice fingerprinting



Dr. Ratnasekhar CH & his team

Bio-prospection and Product Development

Highlights

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

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

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

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

Malaria remains one of the major health concerns due to resistance in Plasmodium species towards existing drugs warranting an urgent need of new antimalarials. The anti-plasmodial activity of extracts fractions or

Scientist of Bio-prospection and Product Development Divisional Unit

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

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

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

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

Area of Research

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

Major scientific outputs/technologies

1. Identification of phyto-extracts/fractions/molecules those are active against harmful microbes/ pathogens and cancer cells.
2. Validation of phytochemically characterized 'Triphala' formulation through typhoid rodent model about its role in stimulating the humoral immunity.
3. Established anti-psoriatic effect of Lavender essential oil and its major components linalool and linalyl acetate in imiquimod-induced mice model.
4. Synergistic activity of 4-Chloroeugenol with artesunate against malarial parasites by increasing the reactive oxygen and nitrogen species besides affecting the macromolecules in terms of DNA damage, protein carbonylation and lipid peroxidation.
5. Potent anti-malarial activity of 4-Chlorothymol and also found it to perturb the redox balance by modulating the glutathione transferase and glutathione reductase, increasing the mean survival time in rodent models of *P. berghei* and *P. yoelii nigeriensis*.
6. Nanophyto-vesicles of Rosmarinic acid (RA) having many important biological activities were prepared, optimized, characterized for improved anti-inflammatory activity in mice.
7. Activation of caspase-3 (a promising target for cancer) by terpenoids and flavonoids in different types of cancer cells.
8. Potential of acacetin (a flavone) in cancer, inflammation, infections and other metabolic disorders.
9. Reported standardized extract of *C. galanga* and novel flurobenzimidazole as anti-hypertensive and vasorelaxant agent.
10. Preclinical pharmacokinetic data generated for standardized extract and formulation of *Andrographis paniculata* as a neutraceutical formulation.
11. Tangeretin (an O-polymethoxylated flavone) present in the peel of oranges, grapefruits, mandarins and tangerines act as a modulator of cancer targets/pathways.
12. Green synthesis of gold nanoparticles from *Lawsonia inermis* and their catalytic activities following the Langmuir-Hinshelwood mechanism.

13. Cardiovascular safety data of essential oil-based product CIM-RespCool and NPY1.
14. Pre-clinical validation of Medicinal and Aromatic Plants (MAPs) derived leads with special emphasis of Immuno-Pharmacology.
15. Pre-clinical Validation of a new Kalmegh based immune booster product **CIM-Megh**.
16. Pre-clinical development of **CIM-RespCool**, a scientific knowledge based essential oil formulation for management of respiratory distress caused by environmental contaminants including viruses.
17. Bulk production and supply of an immune enhancer herbal formulation **CIM- Paushak** for supporting the management of COVID -19 patients.
18. Assessed anti-diabetic potential of different standardized extracts of *G. glabra* and other plant drugs.
19. Translation of research in to products for general healthcare utilizing medicinal and aromatic plants (MAPs) based research leads
20. Transfer of technologies for their commercial utilization promoting new entrepreneurships and start-ups.
21. Successfully organized 5-days online training program on *Herbal Drug Development Technologies* under **CSIR-Skill Initiative Program**.
22. Successfully organized the 5-days training module on *Pre-Clinical Development of Medicinal and Aromatic Plant-based Leads* through online and offline mode under **CSIR-Skill Initiative Program**.
23. Pre-clinical validation of essential oils derived from Aromatic plants against skin inflammation
24. Pharmacological validation of *Citrus limetta* peels (a plant-derived waste) against arthritis using in-vitro and in-vivo bioassays

Linkage with Industry

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

Research Facilities:

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

Instruments:

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

Instruments for Product formulation:

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

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

Anticandidal activity of *Cymbopogon jwarancusa* (Jones) Schult. essential oil.

Cymbopogon jwarancusa (Jones) Schult. is widely distributed from north to eastern India and occurs mostly in the Himalayan region and considered an important source of essential oil for a variety of application. Many tribal communities use it as flavouring agent for local cuisines. In traditional medicine it is used as a blood purifier, and in treatment of rheumatism, cough, fever and cholera. Roots and stem of *C. jwarancusa* were found to be useful in antidotal treatments of snake bite and scorpion sting. The essential oil of *C. jwarancusa* was found to be dominated by monoterpenes, viz. piperitone, δ-2-carene, α-phellandrene, citronellal, geranial, neral, p-menthenols, etc. with sesquiterpenoids, viz. elemol, α-eudesmol, agarospirol as the major constituents.

The antifungal activity of the essential oil of *C. jwarancusa* was determined using disc diffusion and micro dilution broth assays. The essential oil exhibited significant anticandidal activity against a wide range of candida spp. e.g. *Candida kefyr*, *Candida albicans*, *Candida tropicalis, C. albican* clinical isolate and *Candida krusei*. They were found to be very susceptible to essential oil of *C. jwarancusa*. MIC of the oil was also determined using 2-fold broth dilution assays and MFC values were also worked out. Ketoconazole was used as a standard for antifungal assay.

Table. Anticandidal activity by *Cymbopogon jwarancusa* essential oil against Candida spp.

S. No.	Strains	ZOI (in mm)	MIC (mg/ml)	MFC (mg/ml)
1	*Candida albicans* (ATCC 14053)	30	0.47	0.94
2	*Candida kefyr* (ATCC 204093)	23	0.05	0.47
3	*Candida krusei* (ATCC 14243)	17	0.23	0.94
5	*Candida tropicalis* (ATCC 201380)	18	0.11	0.94
6	*Candida albicans* (clinical isolate)	31	0.05	0.47

ZOI: Zone of inhibition. **MIC**: Minimum inhibitory concentration. **MFC**: Minimum fungicidal concentration

Fig. Determination of antifungal activity Disc Diffusion Assay

Dr. D. Saikia & his team

Dr. Anirban Pal Mk- vfuicu iky

Host pathogen interaction studies through prospecting medicinal and aromatic plants for immunity and anti-malarial activity

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

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

Dr. Anirban Pal & his team

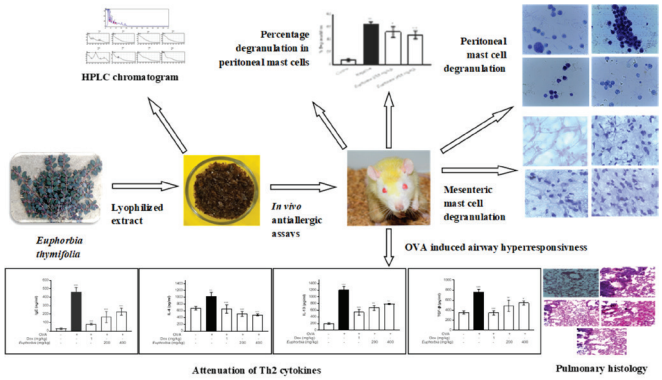
Dr. Dayanandan Mani Mk- n;kunu ef.k

Effect of *Euphorbia thymifolia* extract on mast cell degranulation and allergic inflammation through Th1 and Th2 response

Allergies are a result of a misled immune response that combats with different macroparasites and environmental conditions. Allergic diseases like systemic anaphylaxis, bronchospasm, asthma and rhinitis are highly prevalent and are major health problem affecting all age groups. *Euphorbia thymifolia*, commonly known as "*laghu dudhika*" is a weed widely distributed in India and traditionally used in diarrhoea and dysentery, as a demulcent, laxative; and also in chronic cough and bronchial asthma. The present study was conducted to evaluate the protective role of *E. thymifolia* on mast cell-mediated allergic responses and investigate its underlying mechanisms in the mouse model.

Findings

- The aqueous extract of *E. thymifolia* at the dose of 200 mg/kg and 400 mg/kg body weight, tested on *in vivo* anti-allergic assays.
- *E. thymifolia* dose-dependently reduced compound 48/80 induced anaphylaxis in mice, mast cell degranulation and prevented the mast cells from undergoing morphological changes.

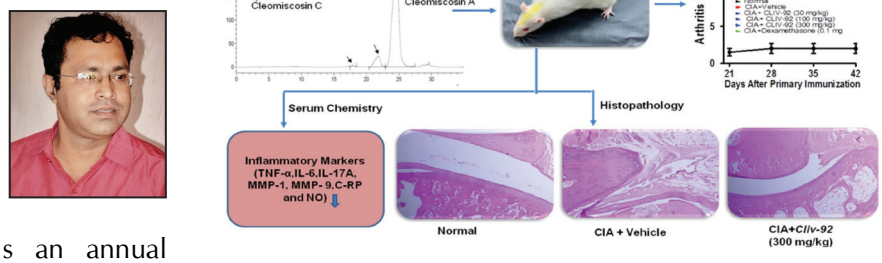


- *E. thymifolia* suppressed important features of allergy possibly through stabilizing the peritoneal and mesenteric mast cells of mice.
- Pre-treatment with *E. thymifolia* inhibited the level of proinflammatory cytokines IL-4, IL-13, TGF-β and IgE in OVA-induced lung inflammation.
- Modulation of Th2 cytokines in airway hyper responsiveness.
- Safety study of *Euphorbia* extract was monitored in mice treated with a single oral dose at 2000 mg/kg body weight. The body weights, organ weights, biochemical and hematological examinations in mice were statistically indistinguishable after one week of treatment, and no biologically meaningful differences were reported.
- Therefore, this study reveals that *E. thymifolia* has the potential to treat allergic conditions and thus, could evolve in developing anti-allergic therapeutic in future.

Dr. Dayanandan Mani & his team

Dr. DU Bawankule Mk- Mh-;- ckoudy

Coumarinolignoids from *Cleome viscosa* Seeds Mitigates Arthritis and Related Complications in Small Animal Models



Cleome viscosa L. (Capparidaceae) is an annual weed use in the Indian System of Medicine, for the treatment of helminth infection, fever, liver diseases, bronchitis, inflammation and fever but it lacks proper pharmacological validation against arthritis inflammation. A Systematic investigation on the seeds of *Cleome viscosa* has resulted in the isolation coumarinolignoids, a lignan (C6C3 unit) which is linked with a coumarin moiety through a dioxane bridge. Isolated coumarinolignoids was coded as *CLIV-92* to perform the pharmacological study against arthritis and associated complications in small animal model. Experimental animals were orally treated with *CLIV-92* as per the standard protocol against arthritis, inflammation, pain and fever in laboratory animals. Oral administration of *CLIV-92* significantly decreases the arthritis index, arthritis score, biochemical parameters like TNF-α, IL-6, IL-17A, MMP-1, MMP-9, Nitric oxide, C-RP production in CIA rat's serum, and also reduced the NFκB-p65 expression as an evidence of immunohistochemistry in knee joint tissue of CIA rats in dose dependent manner. Further individual experiments related to arthritis associated complications in experimental animals demonstrated the anti-inflammatory, analgesic and anti-pyretic potential of *CLIV-92* in a dose-dependent manner. These results suggest the *CLIV-92* may be a suitable therapeutic candidate for further investigation towards the management of arthritis and inflammation associated complications.

Dr. DU Bawankule & his team

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

Anti-psoriatic potential of essential oil and its major components

Essential oils (EO) have been widely used in aromatherapy as traditional medicine. This study was conducted to investigate anti-psoriatic activity of Lavender oil (LO) and its major components linalool (L) and linalyl acetate (LA) using *in-vitro* anti-inflammatory model and IMQ induced psoriasis model in BALB/c mice. Topical application of LO in mice showed 73.67% recovery in PASI scores towards normal and up to 87% recovery in increased level of Th-17 cell specific cytokines when compared to the disease control (DC) mice. L and LA were identified as the major components of LO after GC analysis. Topical application in BALB/c mice, L and LA showed 64% and 47.61% recovery in PASI scoring. Both, L and LA showed significant recovery in Th1 specific TNF-α and IL1β however, only L showed significant recovery of Th17 cytokines towards normal. In contrast to LA (which restored granulosis), L restored epidermal hyperplasia and parakeratosis toward normal. L reduced the expression of NF-κβ, ccr6 and IL-17 however, LA reduced the expression of NF-κβ only. The results of the present study reveal the significant anti-psoriatic activity of LO against IMQ induced psoriasis model in mice (***Journal of Ethnopharmacology*** 261, 2020, 113127).

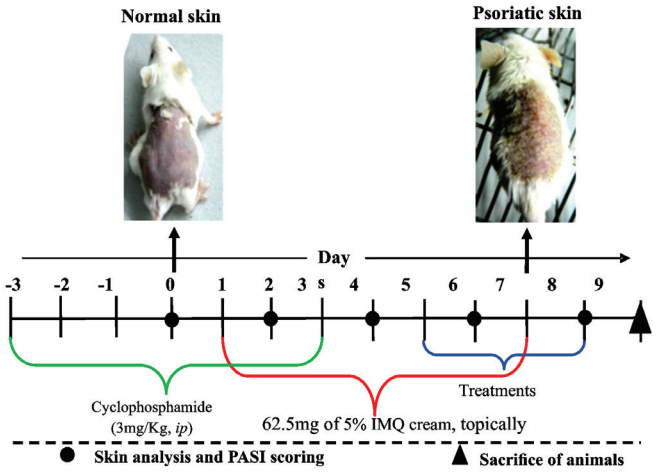


Fig. Imiquimod induced psoriasis model in mice

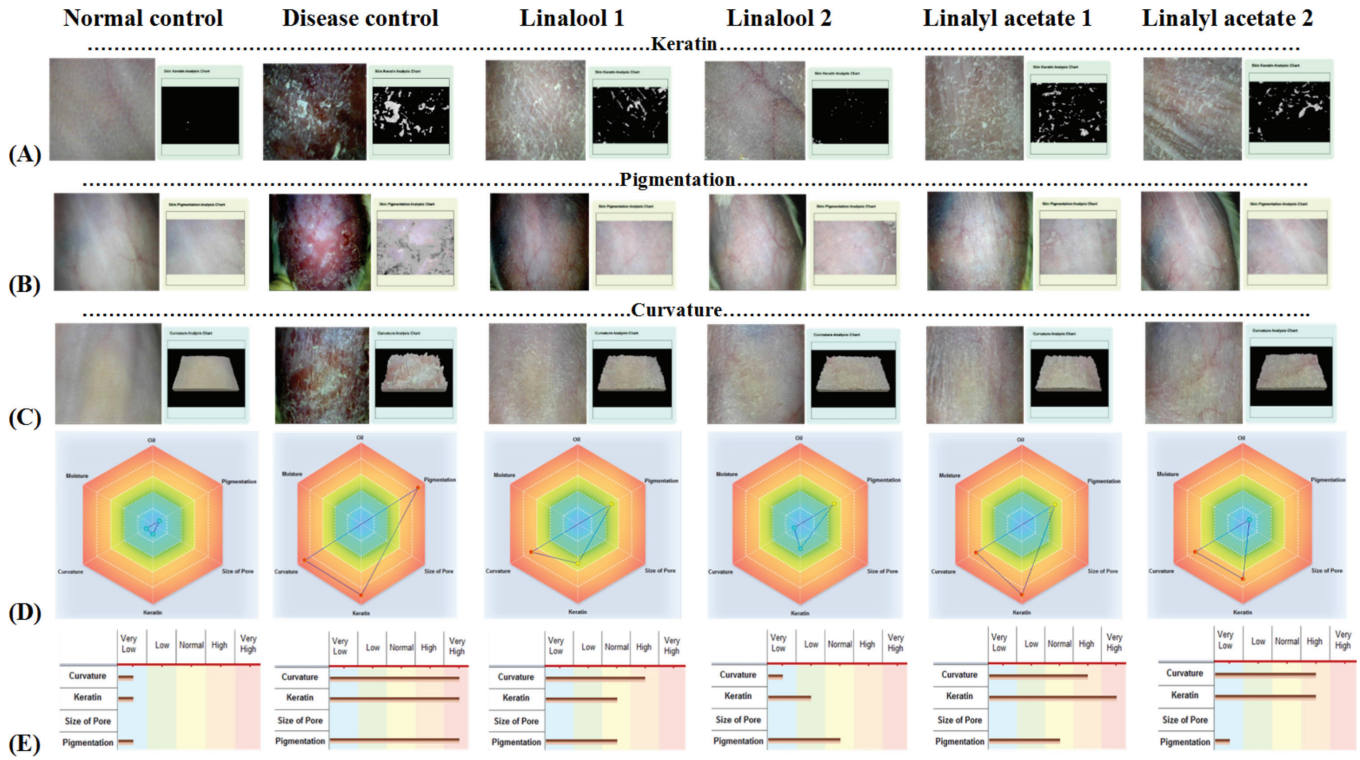


Fig. Vertical columns present the different treatment groups and horizontal rows denote (A) Keratin analysis chart, (B) Pigmentation analysis chart, (C) Curvature analysis chart, (D) Radar graph and (E) Bar graphs of the psoriatic as well as animals treated with linalool and linalyl acetate.

Rosmarinic Acid loaded phytovesicles for anti-inflammatory activity

Rosmarinic acid (RA) is one of the polyphenolic compounds having numerous biological activities *i.e.* anti-inflammatory and antioxidant. The present study was aimed to formulate phytovesicles of RA to abate its low solubility and instability simultaneously. Phytovesicles were prepared by refluxing and thin-film hydration method using soya lecithin and cholesterol. The optimization of phytovesicles using a central composite design study confirmed that the values of phospholipids to drug ratio and refluxing time significantly influenced the dependent variables. Surface and internal morphology were studied using scanning electron microscopy and transmission electron microscopy, respectively. Both studies confirmed the formation of phytovesicles with a smooth surface. Moreover, the equivalent dose of optimized phytovesicles showed significant modulation in percent inhibition in inflammation concerning toxin control for Tumor necrosis factor, Interleukin-1 β, Interleukin-6 against the anti-inflammatory activity. The results indicate that the phytovesicles might be an excellent formulation for anti-inflammatory activity (***Journal of Drug Delivery Science and Technology***, 2020, 59: 101888).

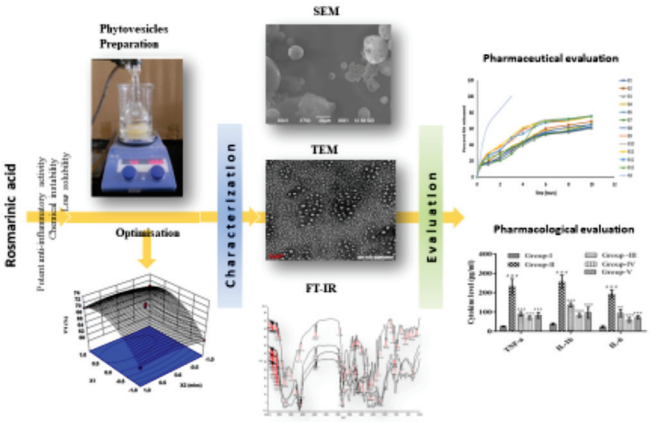


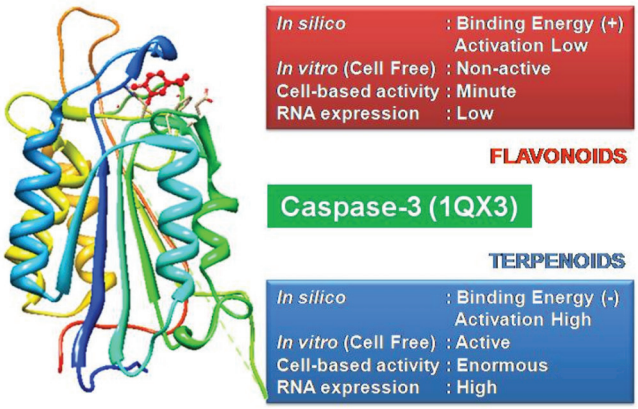
Fig. Preparation and evaluation of Rosmarinic acid loaded phytovesicles

Dr. NP Yadav & his team

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

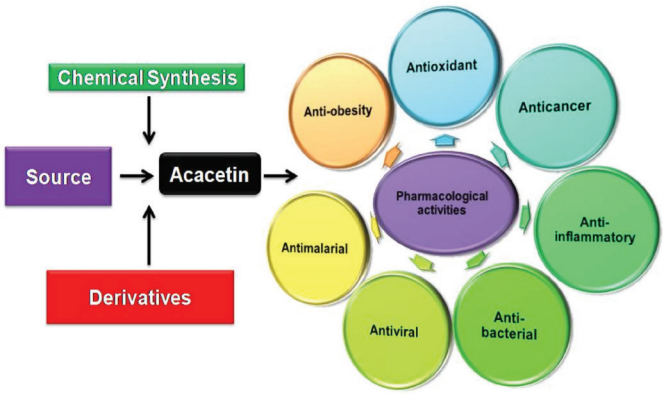
Caspase-3 as a promising target for the discovery of anticancer phytochemicals

Caspase-3, one of the key enzymes responsible for apoptosis, is a promising target for the discovery of phytochemicals as anticancer agents. In our experimental (*in silico*, *in vitro*, cell based, real-time expression) analysis, it was observed that terpenes had an enduring activation of caspase-3 while flavonoids in some way affect the enzyme activity (***Current Topics in Medicinal Chemistry*** 2020; 20: 1876-1887).



Pharmacological activity and therapeutic potential of acacetin

Acacetin (a di-hydroxy and mono-methoxy flavones) is present in Black locust, Damiana, and Silver birch. We highlighted the therapeutic potential of acacetin, with comprehensive information on the biological sources, chemistry, and pharmacological properties together with possible mode of action, safety aspects, patent information, commercialized products and future research opportunities (***Food and Chemical Toxicology*** 2020; 145: 111708).

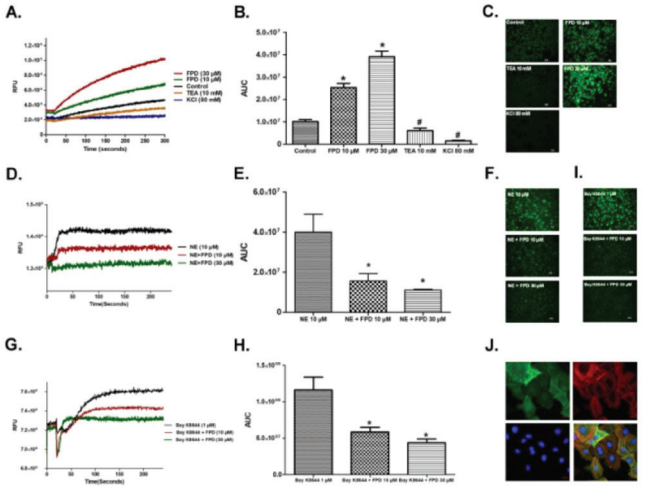


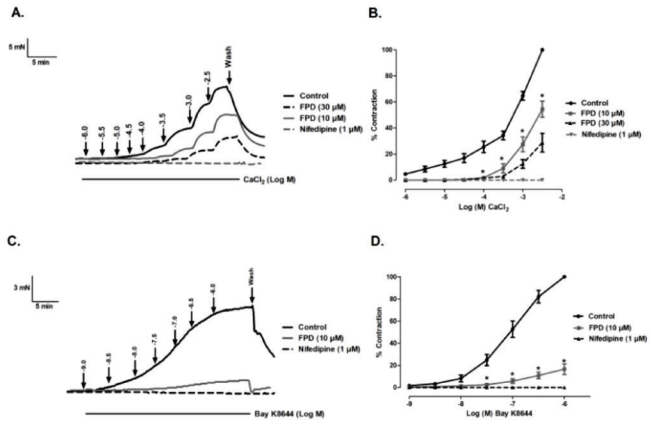
Dr. Suaib Luqman & his team

Dr. Debabrata Chanda Mk- nccr pnk

Antihypertensive effect of a novel angiotensin II receptor blocker fluorophenyl benzimidazole: contribution of cGMP, voltage-dependent calcium channels and BKCa channels to vasorelaxant mechanisms

Contributions of K^+ channels and Ca^{2+} channel functions modulations in the antihypertensive activity of benzimidazoles are not well explored. The present study reports novel fluorophenyl benzimidazole (FPD) as antihypertensive agent and modulations of ion channel functions as main mechanisms of action using *ex-vivo*, *in-vitro* and *in-vivo* studies in rats. Screening of molecules and mechanisms of vasorelaxation of the lead molecule (FPD) was carried out in *ex-vivo* model in mesenteric artery. Validation of K^+ and Ca^{2+} channel





function modulation by FPD was done *in-vitro* in rat aortic smooth muscle cells and with *in-silico* docking studies with target proteins. *In-vivo* antihypertensive activity was executed in SHR and L-NAME models while safety evaluation of FPD was carried out in Swiss albino mice. All the molecules studied produced vasorelaxation and the most potent molecule, FPD relaxes mesenteric arteries in a concentration dependent manner by activating BK_{Ca} channel and inhibiting voltage dependent calcium channel (VDCC). FPD enhanced efflux of K^+ and inhibited Ca^{2+} concentration in aortic smooth muscle cells. *In-silico* docking of FPD with the selected target proteins is in corroboration with *ex-vivo* and *in-vitro* observations showing high binding affinity. FPD significantly decreased blood pressure in both *in-vivo* models, restored expression of genes like Cacna1, camk2d2, TRPC 6, sGCβ1 and Prkg1 in arterial tissues and was well tolerated in acute and sub-acute oral toxicity. The study reports antihypertensive activity of novel fluorobenzimidazole with cGMP associated BK_{Ca} channel and VDCC as putative targets in rats (***Front. Pharmacol***., 30 March 2021, doi.org/10.3389/fphar.2021.611109)

Dr. Debabrata Chanda & his team

Dr. Abha Meena Mk- vkHkk eh.kk

Green synthesis of gold nanoparticles from *Lawsonia inermis* and its catalytic activities following the Langmuir-Hinshelwood mechanism

This study aims to develop instant, facile, efficient, low-cost, eco-friendly green synthesis method for synthesising stable gold nanoparticles using the leaf extract of *Lawsonia inermis*. The phytochemicals in the leaf extract act as a reducing agent in the formation of gold nanoparticles within 45 min. The characterisation of the gold nanoparticles was performed using physicochemical techniques. Besides, the impact

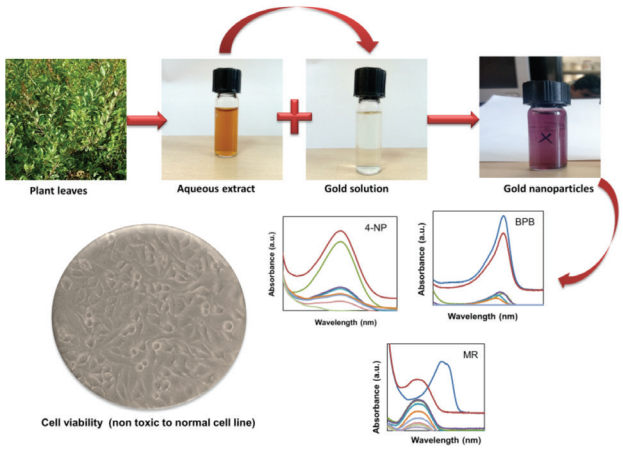


Fig. Graphical view of the synthesis of gold nanoparticles using *L. inermis* (leaf aqueous extract) and its catalytic activity along with non-toxic effect on L-132 cell line.

of different parameters like salt, pH, temperature, and storage on the stability of the gold nanoparticles has been studied. Among the three synthesised gold nanoparticles samples (X, Y, and Z), X sample showed the highest stability. The gold nanoparticles were spherical with an average size of ~20 nm. The most stable gold nanoparticles exhibited excellent catalytic activity in the degradation of anthropogenic aromatic pollutants like 4-nitrophenol, and dyes like bromophenol blue and methyl red. Moreover, the gold nanoparticles did not show cytotoxic effect in normal human epithelial lung cell lines (***Colloids and Surfaces A: Physicochemical and Engineering Aspects***. 606. 125447. 2020).

Acacetin and pinostrobin as a promising inhibitor of cancer-associated protein kinases

Present study aims to find inhibitory prospects of selected flavonoids for cancer-chemoprevention/ treatment. The molecular docking interaction analysis was done by exploring binding potential of flavonoids with kinases (PI3K, Akt, mTOR, EGFR, MAPK, MKK4, FYN, ZAP, BRAF, JAK- STAT1, STAT3, STAT4, STAT5, and VEGF) involved in various carcinogenesis phases. Among flavonoids acacetin showed highest binding-energy against JAK-2 following FYN > VEGF > PI3K > MKK4 > MAPK > BRAF > STAT5 > STAT1 > STAT4 whereas pinostrobin depicts higher binding-energy with JAK-2 followed by BRAF > MKK4 > VEGF > PI3K > MAPK > STAT1 > STAT4 > STAT5. Further, molecular-dynamic simulation revealed that pinostrobin interacted with JAK-2 protein with binding-energy of -25.068 ± 1.08 kJ/mol whereas acacetin interacted with both JAK-2 and Fyn with binding-energies of -23.466 ± 0.9508 kJ/mol and-8.935±1.3108 kJ/mol respectively. High binding-energy, low inhibition-constant, and drug-likeness of acacetin and pinostrobin provide a clue for their usage as a JAK-2 inhibitor which could be useful for molecular/cell- target based *in-vitro* and *in-vivo* investigations (***Food and Chemical Toxicology***. 151. 112091**.** 2021)

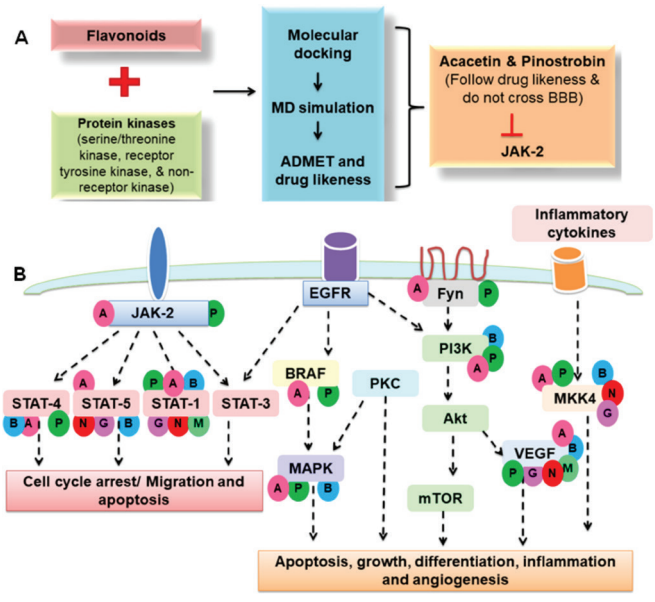


Fig. A. Research methodology. B. Molecular interaction of tested flavonoids against the selected protein kinases A: Acacetin; B: Baicalin, G: Gosyypin; M: Myricitrin, N: Narirutin, P: Pinostrobin.

Prospects of tangeretin as a modulator of cancer targets/pathways

To date, cancer is the second leading cause of death worldwide after cardiac arrests. A large number of synthetic drugs are available for the treatment of different types of cancer; however, a major problem associated with these drugs is its toxicity towards normal cells. To overcome these problems, researchers focus on plants derived natural products because of its lower toxicity towards normal cells. Tangeretin is a polymethoxylated flavone found extensively in citrus fruits and has shown potent anti-cancer activity in different types of cancer. Hence, this review examines the anti-cancer activity of tangeretin via different molecular target/ pathways. Tangeretin induced apoptosis via both intrinsic and extrinsic pathway and arrest cell cycle. It also suppresses cell proliferation by modulating PI3K/ AKT/mTOR, Notch and MAPK signalling pathway. Besides, it induces autophagic cell death, suppresses migration, invasion and angiogenesis. Further, the role of tangeretin in multidrug resistance and combination therapy, different biological sources of tangeretin, its derivatives and Pharmacokinetics profile and toxicity studies are also discussed. Towards the end, the challenges associated with tangeretin usages as potential anti-cancer phytochemicals are also mentioned, which concludes that tangeretin, like a pandora's box, needs to carry out more research to improve the usefulness of tangeretin for better human health. (***Pharmacological Research***. 161. 1052020. 2020).

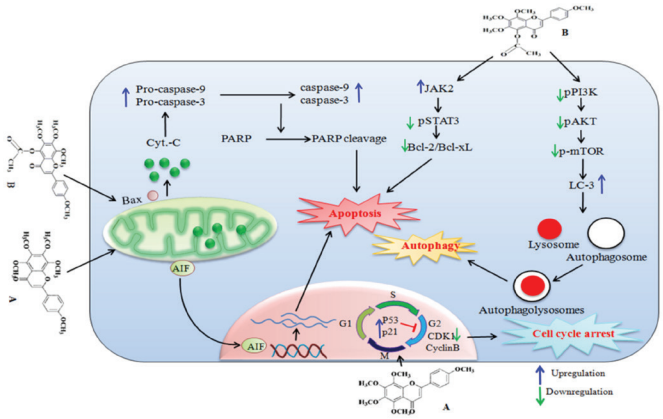


Fig. Anti-cancer mechanism of tangeretin derivatives. **A-**Tangeretin derivative 5-Demethyltangeretin (5DT) induces apoptosis via PARP cleavage and DNA fragmentation. It also downregulate the CDK1/cyclinB and arrest G2 phase of cell cycle. **B-** Another tangeretin derivative 5-acetyloxy-6,7,8,4'-tetramethoxyflavone (5-AcTMF) induced the release of cytochrome-c from mitochondria and increase caspase levels which cleave the PARP and induce apoptosis. It also induce apoptosis via activating JAK2 which downregulate the phosphorylation of STAT3 and Bcl-2/Bcl-xL protein level. It also up-regulate LC-3 expression by inactivating PI3k/AKT/m-TOR pathway and induce autophagy.

Dr. Abha Meena & her team

Plant Biotechnology

HIGHLIGHTS

The Plant Biotechnology Division (DU) of CSIR-CIMAP is working in the areas of genomics, molecular biology, biochemistry, synthetic biology, *in silico* biology and tissue culture with respect to Medicinal and Aromatic Plants (MAPs). Most of the divisional activities are basic research and aimed for the improvement of MAPs for improved quality and traits in terms of secondary metabolites. Active collaborations from faculty of other disciplines of CSIR-CIMAP are also integrated into the research programmes for generating high-quality data and output of international standards. The major focus plants during the year *Withania somnifera*, *Andrographis paniculata, Bacopa monnieri, Catharanthus roseus*, *Mucuna pruriens, Gymnema sylvestre*, *Ocimum* species, *Artemesia annua*, Geranium, *Cannabis*, *Coleus* and few others. Most of the faculty of the division are actively involved in the R&D projects funded by CSIR or external Government agencies. A major Focussed Basic Research (FBR-Network) project, "Genome Editing for Crop Improvement (GE-Crop; MLP0007)" has been recently sanctioned by CSIR, in which CSIR-CIMAP is the Nodal laboratory with seven other participating laboratories, and scientists from this DU are leading this important programme. The scientists of this division are also involved in other FBR-Network projects (MLP0048 and MLP0049), where CSIR-CIMAP is one of the participating laboratory, and Aroma Mission (Phase-II implementation). In

Scientis of Plant Biotechnology Divisional Unit

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

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

addition to these, four other FBR projects (MLP0002, MLP0003, MLP0005 and MLP0006) from CSIR and two GAP projects from external funding agencies have been sanctioned to scientists of this division during this period. In the Genome Editing Network project (GE-Crop), five medicinal and aromatic plants viz. *W. somnifera*, *A. annua*, *Ocimum* spp., *Cannabis*, *Coleus* and in addition to tomato and other model plants are being targeted for the improvement of metabolites and physiological characters through the CRISPR/Cas9 approach.

A Geraniol-10-hydroxylase from *B. monnieri* has been identified and characterized and its regulation through methyl jasmonate responsive BmMYB35 transcription factor was established. The miRNA from *B. monnieri* (Bm-miR172c-5p) was identified and found to regulate F5H-1 gene, which is involved in lignin biosynthesis and secondary xylem thickness. In addition, *in silico* approach identified and predicted 123 miRNAs in *Azadirachta indica* sequences that are available in public databases. In vindoline-rich *Catharanthus roseus* genotype (CIMAP866), which was previously developed in CSIR-CIMAP, phenotypic, genetic and expression profiling was carried out and vindoline content was found to be a direct function of *dat* expression and laticifer number. Work is also being carried out for developing distinct, high-yielding, early-maturing, stress-tolerant genotypes/chemotypes of *Ocimum*, Menthol mint, *M. pruriens, G. sylvestre* by applying various breeding techniques coupled with molecular analysis.

Scientists from this DU also participated in DNA barcoding of *Achyranthes* species. A robust Virus-Induced Gene Silencing (VIGS) protocol for kalmegh (*Andrographis paniculata*) was developed for further functional characterization of important genes. Transgenic Geranium expressing bacterial ACC deaminase gene was developed, which showed 40% more biomass over the wild-type plants. In the Gymnema cell suspension cultures, a significant increase in deacylgymnemic acid and gymnemic acid was observed upon treatment with 20 μM SNP. In *Withania somnifera*, previously large-scale transcriptome sequencing was done to identify gene(s) involved in root morphotypes. Further work is in progress towards the characterization of a few of the genes involved in root development. In addition, radial patterning of withanolides are also being analysed. Cold tolerance-related gene homologs (such as *ICE1*, *CBF3*, *LTP3*, *HY5*, *MYB15*, and *GRP7)* from *O. tenuiflorum* were identified based on the information available from Arabidopsis, and are being characterized. Apart from the medicinal and aromatic plants, a terpene synthase gene (bulnesol/elemol synthase; StBUS/ELS) from potato was functionally characterized which was found to confer tolerance against few plant bacterial and fungal pathogens, and could be utilized to improve biotic stress tolerance in MAPs. In addition to the high-quality basic research, few scientists are also involved in the release and commercialization of the previously developed MAP varieties for the benefit of farmers and industry. The division is constantly trying to develop competence in modern areas/technologies such as genome editing and pathway engineering for improving the quality of raw herbs for enhanced industrial acceptability.

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

Pathway Elucidation and Engineering of the Secondary Plant Products

Plants have developed very efficient approaches to magnetize pollinators or seed-dispersing animals and their defence against herbivores, micro-organisms and other plants. In natural growth conditions, one of the major strategies adopted by plants for these purpose is based on the production of secondary metabolites. Some of these secondary plant products are known to be beneficial for human health. Accumulation of these products in plants also fluctuates depending upon cellular, climatic and developmental conditions that limit their proper industrial utilization and drug development. There is an urgent need to scale up biosynthesis of these secondary plant products in homologous system or develops strategies for the synthesis of these molecules in heterologous systems through pathway engineering.

My group has been working on plants synthesizing various bio-medically important phytoceuticals. We have characterized various regulatory factors from tobacco and tomato plants and using these to engineer plants for enhanced biosynthesis of flavonoids. Among the regulatory factors identified to date, ELONGATED HYPOCOTYL 5 (HY5), a bZIP family transcription factor is the most investigated and known as the center of transcriptional network hub. However, HY5 has not been characterized from plants known to synthesize important secondary metabolites. Based on homology search and phylogenetic analysis, our group identified HY5 from *Nicotiana tobaccum,* and characterized for its role in secondary plant product biosynthesis and stress response through developing overexpressing lines (NtHY5OX) and CRISPR/Cas9-based knockout mutant (NtHy5^{CR}) plants. NtHY5 was able to complement the *Arabidopsis thaliana hy5* mutant at molecular, morphological and biochemical levels. Overexpression of *NtHY5* in tobacco led to the up-regulation of the phenylpropanoid pathway genes and enhanced the flavonoid content, whereas mutant plants had the opposite effect. In addition, overexpression and mutant plants showed opposite phenotypes **(Figure 1)**. Electrophoretic Mobility Shift Assay (EMSA) suggested that NtHY5 interacts with the promoter of *NtMYB12,* a transcription factor known to regulate flavonoid biosynthesis. In addition, *NtHY5* enhanced the abiotic stress tolerance as evident by the salt tolerance ability of HY5 overexpressing lines by diminishing the ROS accumulation after salt treatment. These data provide credible evidence about the potential role of NtHY5 in light-mediated flavonoid biosynthesis, plant growth and abiotic stress tolerance in tobacco. The

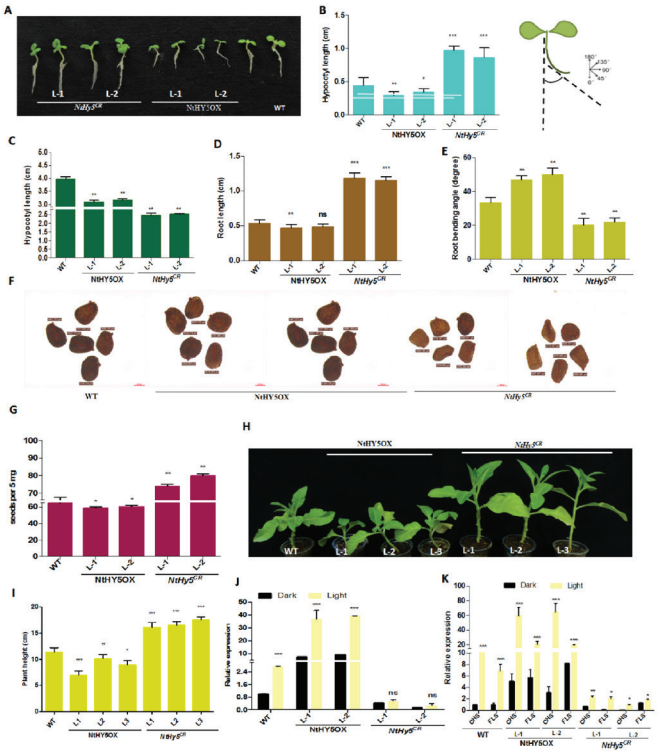


Figure 1. NtHY5OX and CRISPR–Cas9-derived knockout mutants show altered phenotypes and gene expression. **(A)** Representative image of 10-d-old light grown WT, NtHY5OX and *NtHY5^{CR}* seedlings grown on half-strength MS medium. Scale bars, 1 cm. **(B)** Measurement of root bending angle of 10-d-old light grown WT, NtHY5OX and *NtHY5^{CR}* seedlings. **(C), (D)** Hypocotyl length of 10-d-old light and dark grown WT, NtHY5OX and *NtHY5^{CR}* seedlings. **(E)** Root length of 10-d-old light grown WT, NtHY5OX and *NtHY5^{CR}* seedlings. **(F)** Quantitative analysis of seed size of WT, NtHY5OX and NtHY5^{CR} plants. **(G)** Quantitative estimation of Number of seeds per 5 mg of WT, NtHY5OX and *NtHY5^{CR}* plants. **(H), (I)** Relative expression of NtHY5 and phenylpropanoid pathway genes (*NtCHS, NtCHI, NtFLS* and *NtDFR*) in 10-d-old light grown seedlings transferred to dark for 3h. **(J)** Representative image of 40-day-old WT, NtHY5OX and *NtHY5^{CR}* plants showing plant heights. **(K)** Data presenting difference in height of 40-day-old WT, NtHY5OX and *NtHY5^{CR}* plants. Tubulin was used as the endogenous control to normalize the relative expression levels. The statistical analysis was performed using two tailed Student's t-tests. The data are plotted as means ± SD (n = 3). For measurement of root bending angle, root length, hypocotyls length and seed size (n = 10-12). The error bar represents standard deviations. The asterisks indicate significant difference, *P < 0.1; **P < 0.01; 0.001.

photomorphogenic mutant, *Nthy5*, developed in this study, will help in elucidating the role of the HY5 in different biological processes in tobacco.

miRNAs and Associated Factors

MicroRNAs (miRNAs), small non-coding RNAs, are processed product of primary miRNAs (pri-miRNAs) and regulate target gene expression. As miRNAs are small in size, mutants of all miRNAs are not available and their functional characterization has not been studied in detail. Recently, through overexpression and target mimic lines, we functionally characterized Arabidopsis (*Arabidopsis thaliana*) miR858a and established the potential role of miR858a in flavonoid biosynthesis and plant growth and development. To establish role of miRNAs and associated factors, we used CRISPR-based approach and edited pre-miR858, mature miR858 as well as miRNA-encoded peptide (miPEP858a). miPEP-edited plants showed altered metabolite content and phenotypes similar to that of pre-miRNA- and mature miR858-edited plants **(Figure 2)**. miPEP858a-edited and miPEP858a overexpressing lines showed altered plant development and accumulated modulated levels of flavonoids due to change in the expression of regulatory and structural genes associated with phenylpropanoid pathway and auxin signaling. In addition to miR858a, our group is characterizing other miRNAs (miR408, miR775, miR397, miR15, miR172) through overexpression and developing their knock-out mutants using CRISPR-based approach.

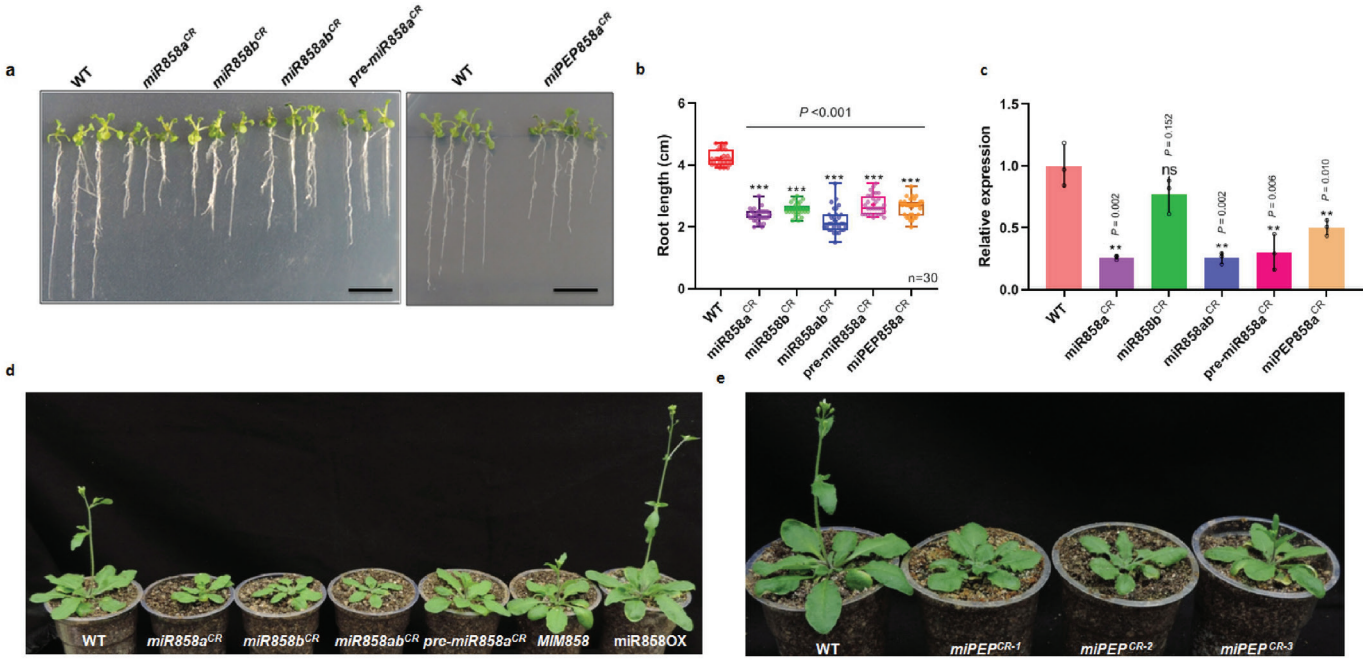


Figure 2. CRISPR/Cas9 derived knockout mutants show altered phenotype and gene expression. (a) Representative image of 10-day old WT, CRISPR/Cas9 edited *miR858a*^{CR}, *miR858b*^{CR}, *miR858ab*^{CR}, *pre-miR858a*^{CR}, *miPEP858a*^{CR} seedlings grown on ½ strength Murashige and Skoog (MS) medium, (Scale bars, 1 cm). **(b)** Root length of 10-day old WT, *miR858a*^{CR}, *miR858b*^{CR}, *miR858ab*^{CR}, *pre-miR858a*^{CR}, *miPEP858a*^{CR} seedlings grown on ½ strength Murashige and Skoog (MS) medium, n = 30 independent seedlings (small open circles). Data are plotted as means ± SD. Error bars represent standard deviation. The experiment was repeated three times independently with similar results. **(c)** Quantification of pre-miR858a in 30-day old rosette of WT, *miR858a*^{CR}, *miR858b*^{CR}, *miR858ab*^{CR}, *pre-miR858a*^{CR}, *miPEP858a*^{CR} plants (small open circles represent individual values). This experiment was repeated three times independently with similar results. **(d)** Representative image of 30-day old WT, *miR858a*^{CR}, *miR858b*^{CR}, *miR858ab*^{CR}, *pre-miR858a*^{CR}, MIM858 and miR858OX plants **(e)** Representative image of 30-day old WT and *miPEP858a* edited plants**.** These experiments were repeated three times independently with similar results (g and h). Statistical analysis was performed using two-tailed Student's t-tests. Data are plotted as means ± SD. Error bars represent standard deviation Asterisks indicate a significant difference, *P < 0.1, **P < 0.01, ***P < 0.001, ns represents no significant difference).

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

Enhanced gymnemic acids production in cell suspension cultures of *Gymnema sylvestre* (Retz.) R.Br. ex Sm. through elicitation.

Gymnemic Acids (GAs) belongs to the class of triterpenoid saponins present majorly in the leaves of *Gymnema sylvestre*. These bioactive compounds are responsible for hypoglycemic activity. Therefore, it is expansively used in Ayurveda treatment for diabetes. This study is aimed to develop an effective method for suspension culture and to investigate the effect of sodium nitroprusside (SNP), salicylic acid (SA) and methyl jasmonate (MeJA) on the enhancement of deacylgymnemic acid, gymnemagenin, gymnemic acid IV and gymnemic acid XVII in *G. sylvestre*cell suspension culture. To induce callus, *in vitro*-derived leaf explants were cultivated on Murashige and Skoog's (MS) medium supplemented with different concentrations of 2,4-dichlorophenoxyacetic acid (2,4-D) or α-naphthalene-acetic acid (NAA) either alone or in combination with 6-benzylaminopurine (BAP) or kinetin (Kin) at 1.0 to 5.0 mg/L. Highest callus initiation frequency (95.30 ± 1.40%) and better friable callus observed on MS medium supplemented with 3.0 mg / L (2, 4-D) + 1.0 mg / L (Kin). Optimized callus induction medium was used to develop cell suspension culture, growth kinetic study, elicitors treatment and the production of major bioactive compounds. At 40 days, highest fresh cell suspension culture biomass was 339.08 g/L FW. Biomass production, 366.68 g/L FW and 30.30 g/L DW were the highest in the treatment of 20 μMSNP among the tested elicitors. The highest accumulation of deacylgymnemic acid (2936.90μg/g DW, 96h treatment) and gymnemic acid XVII (2414.20 μg/g DW, 48h treatment) were obtained in 20 μM SNP treatments which were 6.1 and 5.2-fold higher than the control. Furthermore, the highest values of gymnemagenin (1179.77 μg/g DW at 50 μM treatment) and gymnemic acid IV (731.04 μg/g DW at 10 μM treatment) were obtained in SA treatment which was 4.12 and 5.11-fold greater than the control was studied through our newly developed HPLC method. The findings of the present study showed that the SNP could be a good strategy for large-scale industrial production of triterpenoid saponins in *G. sylvestre* cell suspension cultures.

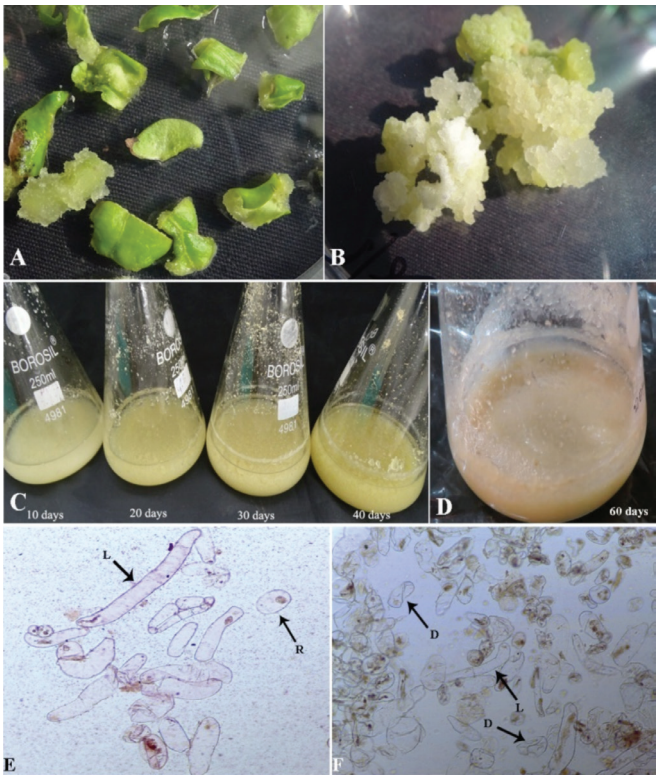


Fig. Callus induction and cell suspension of *G. sylvestre*. (A) Callus induction from *in vitro* derived leaf segment on MS medium supplemented with 3.0 mg/L (2, 4-D) + 1.0 mg/L (Kin). **(B)** Proliferation of callus. **(C)** Different growth (stage) of cell suspension culture. **(D)** Death phase at 60 days old cell suspension culture. **(E)** Microscopic view of cell of cell aggregates showing round (R) and elongated (cells (10x). **(F)** Photomicrograph of cell suspension culture showing viable/ live (L) and non-viable/dead (D) cells (10x). MS, Murashige and Skoog; 2,4-D, 2,4-dichlorophenoxy acetic acid; Kin, Kinetin.

Dr. LU Rahman & his team

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

Functional characterization of defense responsive terpene synthases

Terpene synthases (TPSs) produce a variety of terpenoids that play numerousfunctional roles in primary and secondary metabolism, as well as in ecological interactions. Our lab has reported the functional characterization of an inducible and novel potato TPS gene encoding bulnesol/elemol synthase (StBUS/ELS). The expression of StBUS/ELS in potato leaves was significantly induced in response to both bacterial (*Pseudomonas syringae*) and fungal (*Alternaria solani*) infection as well as methyl jasmonate treatment, indicating its role in defense. The leaves exhibited the highest StBUS/ELS expression followed by the stem with least and similar expression in tuber, sprout and root. Recombinant StBUS/ELS catalyzed the formation of different sesquiterpenes by utilizing farnesyl diphosphate as substrate, and themonoterpene geraniol from geranyl diphosphate. Among the sesquiterpenes formed by StBUS/ELS, elemol was the predominant product followed by α-bulnesene, bulnesol and β-elemene. Further, gas chromatography–mass spectrometry (GC–MS) analysis of StBUS/ELS assay products at different injection temperatures revealed elemol and bulnesol as the major products at 275 and 200/150 ºC, respectively, without much change in the levels of minor products (Fig.). This indicated thermal rearrangement of bulnesol into elemol at higher temperatures. Transient overexpression of StBUS/ELS in potato leaves conferred tolerance against the growth of bacteria *P. syringae* and *Ralstonia solanacearum*, and the fungus *A. solani* (Fig.). Further, expression analysis of pathogenesis-related (PR) genes in StBUS/ELS overexpressing leaves showed no significant change in comparison to control, indicating a direct involvement of StBUS/ELS enzymatic products against pathogens. Overall, our study showed that StBUS/ELS is a pathogen-inducible TPS encoding bulnesol/elemol synthase and provides a direct role in defense against biotic stress in potato (Dwivedi et al., 2020).

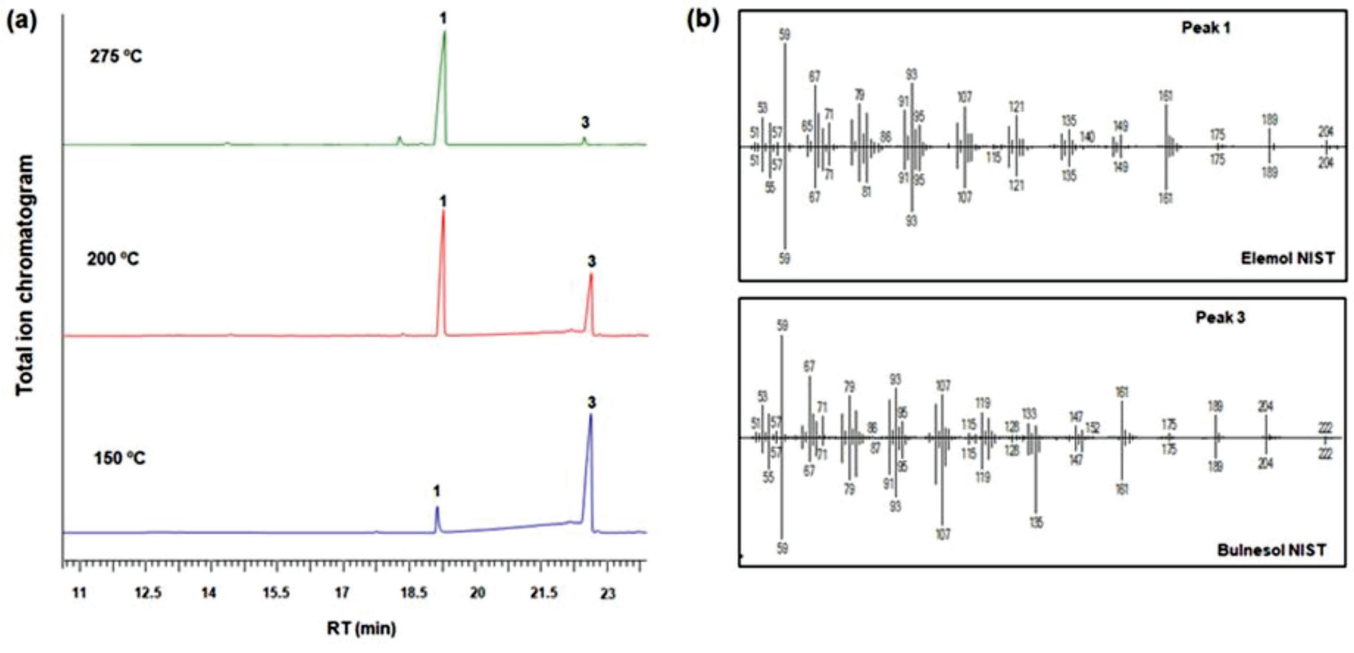


Fig. GC–MS of StBUS/ELS enzyme reaction product with inject temperature set to 150, 200 and 275 ºC. (a) Top chromatogram represents reaction product injected at 275 ºC, while middle and lower chromatogram represents StBUS/ELS reaction product injected at 200 and 150C. Major compounds identified: 1, elemol; 3, bulnesol. **(b)** Comparison of StBUS/ELS reaction product injected at 200C peak 1 (elemol) and peak 3 (bulnesol) mass spectrum with NIST library. RT represents retention time.

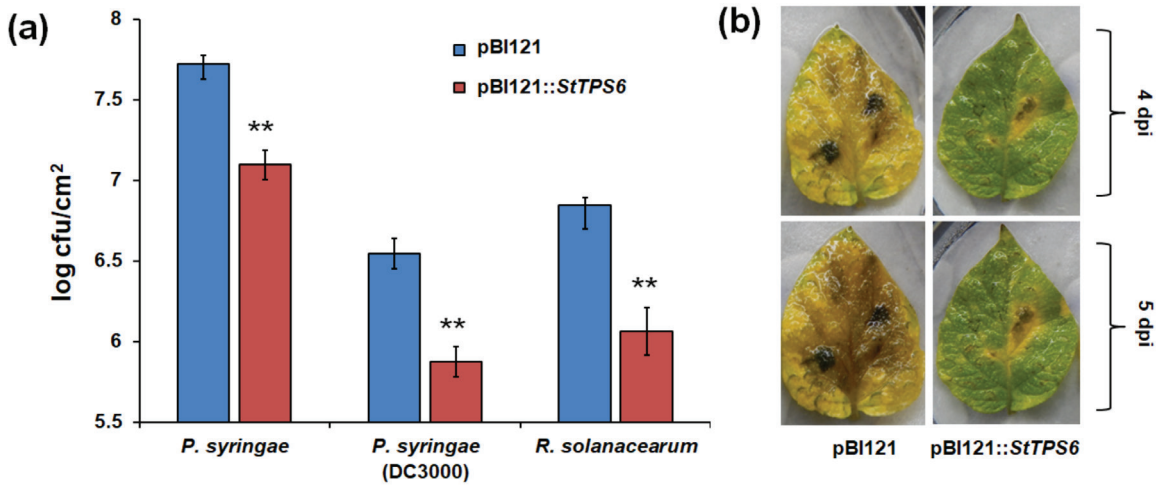
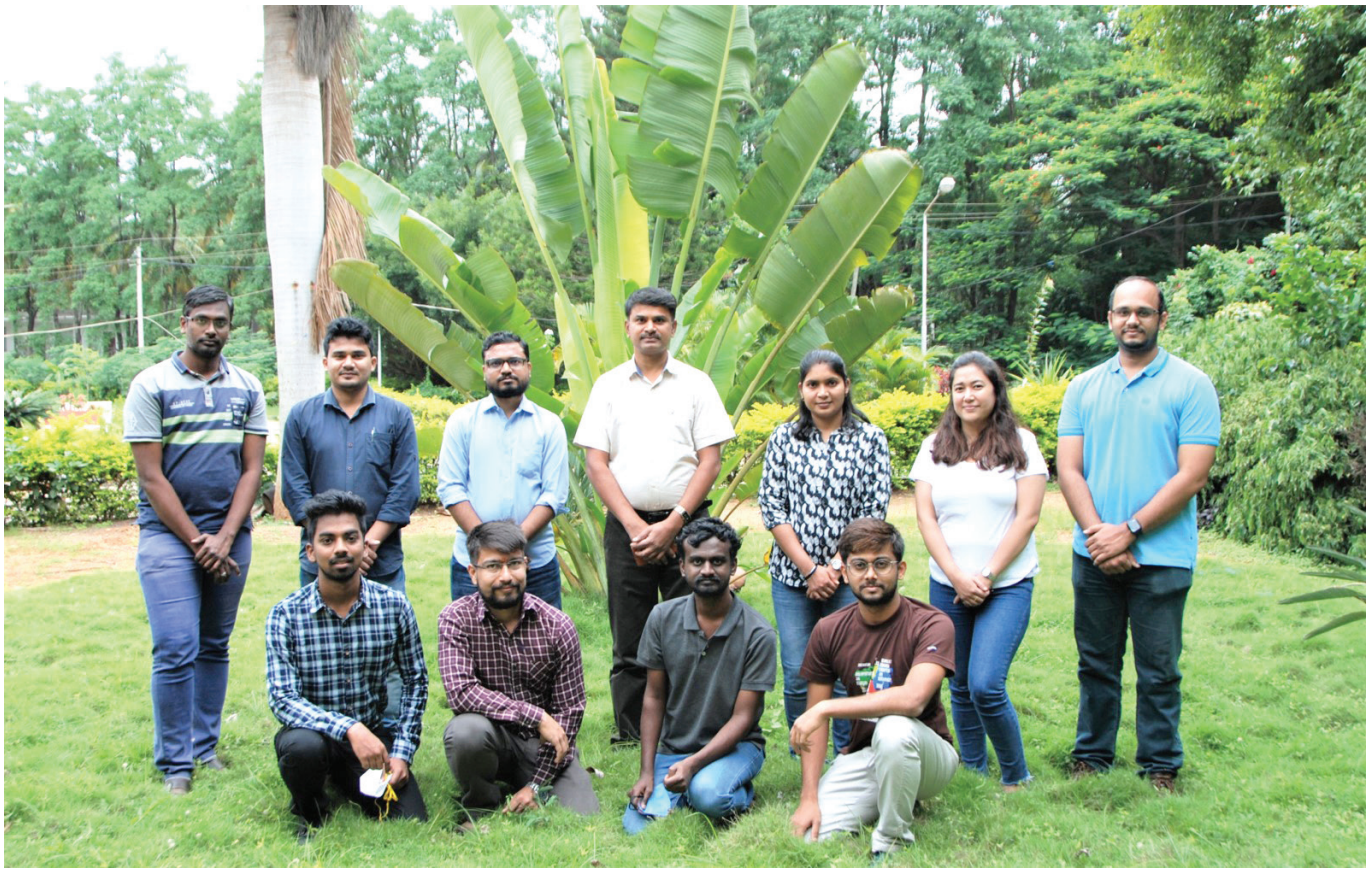


Fig. Effect of transient overexpression of StBUS/ELS on biotic stress and defense gene expression in potato leaves. (a) Bacterial growth assay with *Pseudomonas syringae*, *P. syringae* (DC3000) and *Ralstonia solanacearum* strains. After 2 days of agroinfiltration, potato leaves were infiltrated with bacterial strains. CFU was calculated at 3 dpi of bacterial infiltration by plating serial dilutions of leaf disc extracts. **(b)** Phenotype of *Alternaria solani* inoculation on detached leaves on fourth and fifth day after treatment. Infection assay was carried out using fully expanded transiently infiltrated leaves at 2 dpi.



Dr. Dinesh A Nagegowda & his team

Dr. Vikrant Gupta Mk- foØkr xIrk

Genome-wide identification and analyses of *Azadirachta indica* MicroRNAs

MicroRNAs (miRNAs) are small non-coding RNAs of ~19-24 nucleotides (nt) in length and considered as potent regulators of gene expression at transcriptional and post-transcriptional levels. Numerous miRNAs have been identified and studied in plants with known genomic or small RNA resources. Despite the availability of genomic and transcriptomic resources, the miRNAs have not been reported in the medicinal tree *Azadirachta indica* (Neem). For the first time in this investigation, extensive identification of miRNAs and their possible targets in *A. indica* were reported. A comprehensive *in silico* search of miRNAs in the *A. indica* genome was carried out. Overall, 123 miRNAs were identified and predicted which were classified into 63 families. Their tertiary stem-loop hairpin structures were predicted. The size of the *A. indica* (ain)-miRNAs ranged between 19 to 23 nt in length, and their corresponding ain-miRNA precursor sequences MFEI value averaged as -1.147 kcal/mol. The target genes of ain-miRNAs were predicted in *A. indica* as well as *Arabidopsis thaliana* plant. The gene ontology (GO) annotation revealed the involvement of ain-miRNA targets in developmental processes, transport, stress and metabolic processes including secondary metabolism. Stem-loop qRT-PCR was carried out for 25 randomly selected ain-miRNAs and differential expression patterns were observed in different *A. indica* tissues. Expression of miRNAs and its targets shows negative correlation and modulation in a dependent manner. The findings of this study besides giving firsthand information about *A. indica* miRNAs and their targets, also contributes towards the better understanding of miRNA-mediated gene regulatory processes in plants.

Molecular investigations on cold tolerance-related gene homolog(s) from *Ocimum* Species

Ocimum belongs to the family Lamiaceae and is one

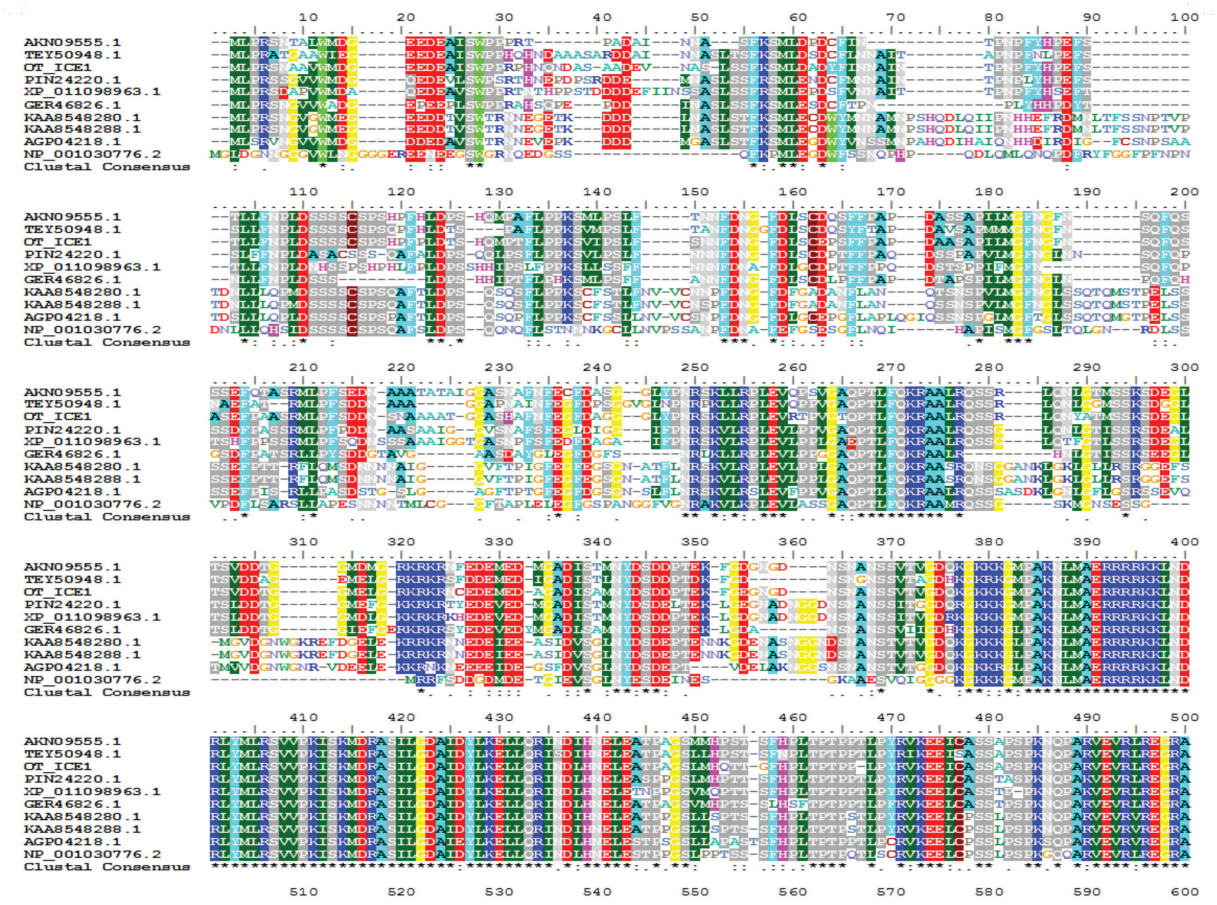


Fig. A snapshot of amino acid alignment of *OtICE1* and related proteins in other taxa, identified from NCBI GenBank

of the best known genera for its medicinal properties and economically important aromatic oils. Some of the Ocimum species are used as constituents in Ayurvedic and indigenous medicines while few others are used in flavor. *Ocimum sanctum* (*O. tenuiflorum*) is economically important due to its property as an immunity booster and considered as holy basil in Indian culture. *Ocimum* species, especially *O. sanctum* and *O. basilicum* are grown in a large scale in India due to their economic value. *O. sanctum* is sensitive to cold and shows chilling injury, which limits its total growth per area and dramatically reduce its oil yield, leading to economic losses for farmers. It would be imperative to apply molecular approaches to identify the genes that could confer chilling tolerance to *Ocimum* species. Molecular approaches have identified key regulators and genetic pathways of abiotic stress tolerance including chilling, and advanced system biology approaches have been successful in shedding light on complex biological processes.

To study the molecular aspects of the chilling response, attempts have been made to identify the genetic components that are expected to impart cold-tolerance in *Ocimum* species. For the identification of cold tolerance-related gene homolog(s) from *O. tenuiflorum*, the cold tolerance-related genes such as *ICE1*, *CBF3*, *LTP3*, *HY5*, *MYB15*, and *GRP7* which are characterized and reported in model Arabidopsis, were used to perform homology-based search in the *Ocimum* transcriptome dataset(s). Several putative candidate sequences which are similar to the above selected genes(s) could be identified, and primers were designed for their amplification and subsequent cloning. *ICE1* (*INDUCER OF CBF EXPRESSION 1*), an MYC-like bHLH transcriptional activator, is an upstream transcription factor that regulates the transcription of CBF genes during cold in Arabidopsis. From *O. tenuiflorum*, we could successfully PCR-amplify the putative ICE1 homolog, and cloned it in general cloning vector. The secondary PCR (by using nested primers) resulted in an amplification product of approximately 1558 bp, which was further ligated in pGEM-T Easy vector. Further investigations for its functional characterization would be carried out in model systems.

Dr. Vikrant Gupta & his team

Dr. Sunita Singh Dhawan Mk- luhrk flg /kou

Assessing and integrating the transcriptome analysis with plant development, trichomes and secondary metabolites yield potential in *Mentha arvensis*

In continuation to our earlier studies 2018, 2020, the site of monoterpenes biosynthesis in mint has been specifically localized to the secretory cells of the glandular trichomes located upon the aerial surfaces. The number and size of trichomes are playing a major role in essential oil biosynthesis. GC based metabolite profiling was used for *M. arvensis* to study the developmental processes in 10 different genotypes and correlated with gene expressions along with biosynthetic pathway as well as trichome development related genes. Simultaneously, RNA sequence based transcriptome analysis was performed for an insight in the transcription factor involved and differential gene analysis, which are responsible for biosynthesis of essential oil as well as trichome development. (Plant Physiology and Biochemistry 10.1016/j. plaphy.2021.03.009).

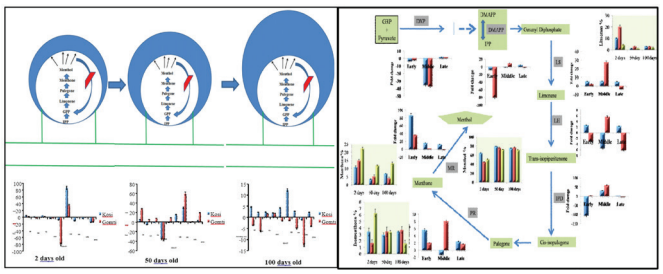


Fig. An overview of biosynthetic ability of trichome for essential oil biosynthesis during development.

DNA Fingerprinting and Genetic Relationships Similarities among the Accessions/Species of Ocimum Using SCoT and ISSR Markers System

Studies on genetic diversity could enhance taxonomic authentication and evolutionary relationship among the species of Ocimum. Therefore, diversity among 36 Ocimum accessions representing species from different regions of world were analyzed using Start Codon-Targeted Polymorphism (SCoT) and inter-simple sequences repeat (ISSR) marker. Marker systems used in this study was potentially targeted the different regions of the genome and included 18 SCoT and 15 ISSR primers, which showed successful amplification profile for Ocimum. The Mantel test indicted a significant correlation (r2 = 0.44) between ISSR and SCoT, which suggested a common genetical background among the accessions. (Molecular Biotechnology (2021)63:446–457).

Fig. Geographical distribution of *Ocimum* accessions from different countries (red colour) and some of the regions of India (yellow colour).

Fig. Morphologically most distinct accessions of *Ocimum* from different parts of the world and some of the regions from India (A to H)

Genotype selection over years using additive main effects and multiplicative interaction (AMMI) model under the ascendancy of genetic diversity in the genus Ocimum

The genetic diversity estimated on the forty-three genotypes belongs to the five Ocimum species. Results revealed significant environmental influence on the essential oil yield and other essential oil yield contributing traits. Genotypes, years, and genotype × year interactions also influenced most of the economic traits. The economic characters alone were not enough to predict essential oil yield. The Additive main effects and multiplicative interaction analysis is used for a further selection of the stable genotypes. (Industrial Crops and Products (2021),161:113198).

Estimation of intra-specific genetic variability and half-sib family selection using AMMI (Additive Main Effects and Multiplicative Interactions) model in menthol mint (*M. arvensis* L.)

The selections namely, Line -1, Line -2, Line -3, Line -5, Line -10, Line -11, Line -15 and two check varieties Kosi and CIM-Kranti were evaluated in multiyear/ environments set up in India. Based on the AMMI model, line15 showed the most extensive adaptability and proved to be the most stable line due to its ability to tolerate broad environmental conditions (temperature/ or abiotic stress) in different years. (JMAPS (2020)42(1-2):102-113).

Dr. Sunita Singh Dhawan & his team

Dr. Sumit Ghosh Mk- lfer ?kk"k

Application of virus-induced gene silencing in kalmegh

Kalmegh [Andrographis paniculata (Burm.f.) Wall. ex Nees] is one of the most studied medicinal plants for pharmaceutical properties and phytochemistry. However, functional genomics studies in kalmegh are so far limited due to the unavailability of a robust tool for gene silencing. We have tested the application of virus-induced gene silencing (VIGS) in kalmegh using the well-known Tobacco rattle virus (TRV)-based vectors and achieved targeted silencing of phytoene desaturase (ApPDS) which is essential in plants for carotenoid biosynthesis that protects chlorophyll from photooxidation. ApPDS silencing in kalmegh leaves developed a typical photobleaching phenotype (Fig 1). The silencing of ApPDS was confirmed by analyzing ApPDS transcript level and determining chlorophyll content in the leaves of VIGS seedlings. The analysis revealed ~30% reduction in chlorophyll content, and 40 to 60% reduction in ApPDS transcript level in the leaves of VIGS seedlings (as shown in Figure below). These findings clearly demonstrated the applicability of VIGS in kalmegh using TRV-based vectors. The VIGS protocol presented in this study might be useful for studying gene function related to medicinal and agricultural traits in kalmegh.

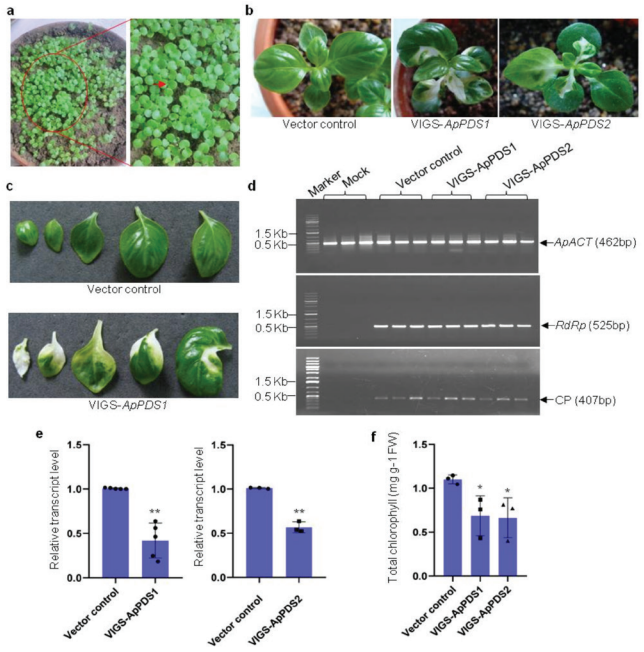


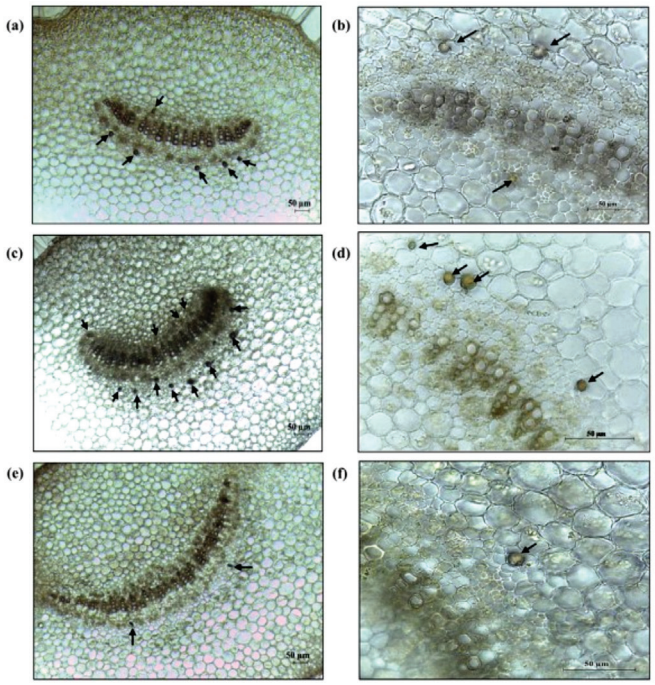
Fig. VIGS in kalmegh (a) Cotyledonary leaf stage (CLS) seedlings were considered for vacuum infiltration of Agrobacterium suspension containing pTRV1 and pTRV2 constructs. Seeds germinated on pre-sterilized soil at 3-4 days after imbibition and reached CLS stage about a week after germination. Red arrow indicates emergence of first pair of true leaf in seedlings. (b) Photobleaching phenotype of the ApPDS-silenced seedlings. Kalmegh seedlings infiltrated with Agrobacterium strains having pTRV1 and pTRV2-ApPDS construct developed photobleaching phenotype. Photobleaching was not observed in the vector control seedlings infiltrated with pTRV1 and pTRV2 empty vectors. Photographs were taken at 35 days post-agroinfiltration. (c) Detached leaves of vector control and VIGS-ApPDS seedlings. (d) RT-PCR detection of TRV2 coat protein (CP) and TRV1 RNA-dependent RNA polymerase (RdRp) transcripts in kalmegh seedlings subjected to VIGS. The amount of cDNA template was normalized based on ApACT amplification. Mock denotes kalmegh seedlings vacuum infiltrated with infiltration buffer only. (e) Decreased level of ApPDS transcript in VIGS-ApPDS seedlings as determined by qRT-PCR analysis. Data are presented as the mean (±SD) of at least three biological replicates each consisting of seven seedlings. ** $P < 0.01$ as compared with vector control. (f) Total chlorophyll content (Chla+b) in VIGS-ApPDS and vector control seedlings. Data are presented as the mean (±SD) of three biological replicates each consisting of seven seedlings. * $P < 0.05$ as compared with vector control.

Dr. Sumits Ghosh & his team

Dr. Ashutosh K Shukla Mk- vk'krk"k d- 'kDyk

Phenotypic, genetic and expression profiling of vindoline-rich *Catharanthus roseus* genotype

Catharanthus roseus is known for its scarce and expensive anticancer bisindole alkaloids, vincristine and vinblastine, which are derived from the coupling of monomeric terpenoid indole alkaloids, catharanthine and vindoline. Vindoline represents the bottleneck in bisindole semi-synthesis as unlike catharanthine, its biosynthesis is restricted to the plant leaves, which are the only commercially-viable source for it. For reducing the exorbitant cost of bisindoles, identification of *C. roseus* genotypes accumulating higher-than-usual amount of vindoline is urgently required. Here, one such vindoline-rich genotype (CIMAP866) was identified and characterized. It was comparatively analysed with elite varieties, Dhawal and Nirmal, for morphology, genetic profile, leaf vindoline content (% dry weight), elemental composition, and expression pattern of alkaloid biosynthetic genes. Its vindoline content (~0.20%) was significantly higher than that of Dhawal (~0.09%) and Nirmal (~0.04%). CIMAP866 possesses dwarf character, spreading/bushy growth, wider canopy, shorter petiole and internodes, more laticifers, higher chlorophyll content, altered content of certain elements and distinct genetic profile, as compared to the other genotypes. Significantly higher *dat* expression in CIMAP866 was a key determinant for its vindoline-rich nature. Vindoline content was a direct function of *dat* expression and laticifer number. (Mall et al., 2021, *South African Journal of Botany* 139: 50-57).



Genotype	Laticifer range per vascular bundle	Maximum frequency
Dhawal	1-9	2
CIMAP866	2-12	4
Nirmal	1-7	1

Fig. Transverse section of the leaf petiole showing the presence of laticifer cells (marked with arrows) in the three genotypes of *Catharanthus roseus*. (a) and (b) Dhawal; (c) and (d) CIMAP866; and (e) and (f) Nirmal. Variation in the number of laticifers in the three genotypes is also denoted in the bottom panel. The scale bars represents 50 μm.

DNA barcoding coupled with secondary structure information for enhanced *Achyranthes* species resolution (Equal Contribution by *Dr.Daya N. Mani, Dr. Ashutosh K. Shukla, Dr. V. Sundaresan*)

Species of the genus *Achyranthes* are known to possess immense medicinal value leading to its inclusion in *Ayurveda*. *A. aspera* has been widely used in all the traditional Indian systems of medicine, while *A. bidentata* is mentioned in Chinese, Japanese and Korean pharmacopoeias. Molecular authentication of any medicinal plant species is a prerequisite for the success of its herbal business. Presently, DNA barcoding provides a successful tool for controlling the quality of medicinal plant materials in the trade. Here, we have evaluated four different barcode loci and their efficiency in delineating the *Achyranthes* species. The

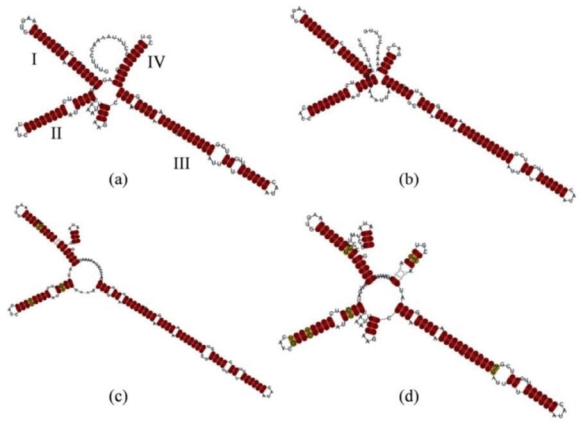


Fig. Secondary structure of ITS2 in *Achyranthes* species. (a) *A. aspera*, (b) *A. coynei*, (c) *A. bidentata*, (d) consensus tree. Roman number (I – IV) in a denotes the helix number.

internal transcribed spacer 2 (*ITS2*) barcode proved to be the best performing marker analysed through barcode gap estimation, BOLD and Bayesian analysis. The inter- and intra-specific genetic divergence observed among and within the *Achyranthes* species was validated through the Wilcoxon signed-rank test. Further secondary structure modeling of the *ITS2* region was performed for better resolution at the species level. The secondary structure was generated based on the lowest free energy state deduced through the mfold web server followed by structure alignment through LocARNA web server. Analysis showed that the helix III and IV possess the maximum variability along with the central ring in differentiating the species. A total of fourteen single-nucleotide polymorphisms (SNPs) identified in the 200 aligned *ITS2* dataset could be useful for the development of species-specific marker(s) in future. Through this study we recommend the use of a combination of secondary structure information with DNA barcoding for significantly improving the species identification resolution. (Singh et al., 2020, *Journal of Applied Research on Medicinal and Aromatic Plants*19: 100269).

Dr. Ashutosh Shukla & his team

Dr. Prema G. Vasudev Mk- itek th- oklpno

Arene interactions in the self-assembly of a pyrazolo[1,5-c] pyrimidine derivative

The fused-ring nitrogen heterocycle of pyrazolopyrimidines are one of the most versatile scaffolds in the high-throughput drug discovery programmes. The potential of pyrazolopyrimidine derivatives as antimicrobial, anticancer, protease inhibitors, tranquilizers, sedatives and analgesics has attracted lot of attention on the synthesis and pharmacological studies on this class of heterocycles. Among the four pyrazolopyrimidine isomers, pyrazolo[1,5-c]pyrimidines are the least studied in terms of synthesis, structure or biological activities. Chemotypes based on pyrazolo [1,5-c] pyrimidines possess antileishmanial and antiviral activities. A survey of the Cambridge Structural Database for crystallographic data on pyrazolo [1,5-c] pyrimidine shows a single example available, indicating the lack of accurate structural data on this class of molecules. A derivative of pyrazolo [1,5-c]pyrimidine, namely, 2-(4-methoxyphenyl)-7-phenylpyrazolo[1,5-c] pyrimidine (Figure a) has been crystallized in our laboratory, for a detailed structure analysis. Apart from the biological activities, the rigid aromatic framework of pyrazolopyrimidines can exhibit distinct molecular arrangements in crystal structures. The flat aromatic rings are considered advantageous in the design of self-assembled nano-materials. In this regard, the aromatic ring scaffold of pyrazolopyrimidines is less explored as a self-assembly promoter. Since the derivative under study does not contain any conventional hydrogen bond donors and acceptors, arene interactions might be guiding the crystal formation in this molecule. The molecular packing arrangement shows extensive π...π interactions between adjacent molecules (Figure b). Aromatic interaction is also an important parameter in the computational drug design approaches and in molecular docking studies of drug molecules with aromatic heterocycles. Therefore, the information of the geometry of aromatic interactions derived in this study will be helpful in understanding the molecular recognition and binding of pyazolopyrimidine-based drug molecules.

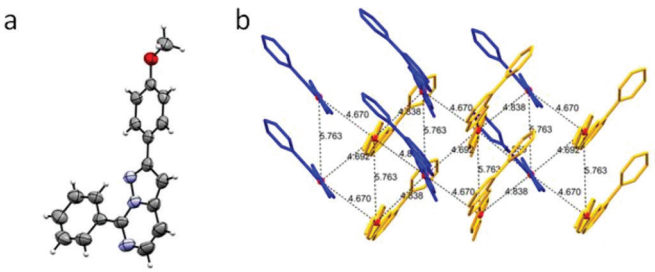


Fig. (a) Molecular conformation of 2-(4-methoxyphenyl)-7-phenylpyrazolo[1,5-c]pyrimidine in crystals (Atom colour code: C-grey, O-red, N-blue). **(b)** Intermolecular aromatic π...π interactions in crystals. Distances between the centroids of aromatic rings are indicated. (*Acta Crystallogr. C,* 2021, communicated

Dr. Prema G Vasudev & her team

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

Role of a global transcription factor, *SuPpressor of Ty10* (*SPT10*), in mevalonate pathway regulation

In the realm of synthetic biology, fine-tuning metabolic flux is accomplished by altering transcription factors activity, which causes global changes in biochemical pathway activities, resulting in the desired metabolic flux. For instance, it has previously been shown that the global transcription factor engineering was utilized to effectively construct a desirable yeast phenotype by modifying the *SPT15* gene, resulting in better glucose and ethanol tolerance. Thus, changing the activity of transcription factors might be a significant metabolic engineering strategy for fine-tuning the metabolic flux that can be redirected to desired compounds. *Saccharomyces cerevisiae* has been widely used in synthetic biology to produce several plant-based triterpenes using various metabolic engineering strategies. A recent study in yeast demonstrated that SuPpressor of Ty10 (*SPT10*) gene deletion increases total phospholipids. Our previous study demonstrated a cross-talk between phospholipid metabolism and the mevalonate/ergosterol (MEV/ERG) pathway. This study further exploited a transcription factor, *SPT10*for improved triterpene production, as *spt10*Δ possesses high endogenous phospholipids. In *spt10*Δ, though MEV/ERG pathway genes were found to be highly expressed, and the key metabolites of MEV/ERG pathway are insignificantly accumulated. Since endoplasmic reticulum (ER) is critical for MEV/ERG pathway activity, our fluorescence microscopy analyses to probe ER revealed massive ER degradation in *spt10*Δ. Thus, we theorized that high lipid droplets (LDs) in *spt10*Δ leads to ER degradation. We then overexpressed *DGK1* in *spt10*Δ as *DGK1* increases phospholipids and also inhibits LDs biogenesis. Further, microscopy results revealed decreased LDs and massive ER structure in *DGK1* overexpressing *spt10*Δ. The mRNA expression data of ER-stress genes suggested that the *DGK1* expressing *spt10*Δ had decreased ER degradation. We then observed that increasing phospholipids for massive ER biogenesis and controlling LDs biogenesis results in elevated MEV/ERG pathway activity. Finally, heterologous expression of β-amyrin synthase showed a significant improvement in β-amyrin, triterpene, production in *DGK1* overexpressing *spt10*Δ. Overall, this study provides a strategic approach to improve triterpene production by increasing ER structure while also limiting ER degradation.

Dr. Venkata Rao & his team

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

Characterization of wound and methyl jasmonate inducible, MYB35 regulated *Geraniol-10-hydroxylase-1* from *Bacopa monnieri*.

During our previous study we have performed the transcriptome analysis of *Bacopa monnieri* in a tissue specific manner to identify the differential transcripts involved biosynthetic pathway of bacosides. The shoot specific analysis of transcripts has identified two enzymes transcripts belonging to the category of geraniol-10-hydroxylase which we named as BmG10-H-1 and BmG10-H-2. It was really interesting for us to identify these enzyme transcripts as G10H1 are one of the most important regulatory cytochrome p-450 involved in monoterpene biosynthetic pathway of *Catharanthus roseus*. The transcript expression of Bm-G10-H1 showed induced expression in response to wounding and methyl jasmonate treatment. We have cloned BmG10-H-1 in yeast expression vector and purified the recombinant protein. The yeast purified recombinant protein was able to convert geraniol into 10-hydroxy geraniol. To further understand the *cis* regulatory elements present in this regulatory enzymes we have walked upstream using genome walking and cloned around 1.Kb of upstream regulatory region of BmG10H-1. The upstream regulatory region of BmG10-H1 was able to drive the GUS-reporter gene suggesting that it is functionally active. We also found that w-box and methyl jamsonate responsive *cis* element present in this regulatory region were able to increase the GUS-activity in response to wounding and methyl jasmonate treatment. To further understand the upstream regulatory factor involved in regulation of this important enzyme we have identified BmMYB35 which specifically interacts with the TGGTTA cis-element present in the promoter region of BmG10H-1 (Jeena et al., 2021). Currently, we are working to understand the regulatory role of BmMYB35 and physiological substrate of these BmG10-H enzyme transcripts in *Bacopa monnieri*. We are also trying to utilize these enzymes for diverting the flux towards tri-terpene biosynthesis for the enhanced production of bacoside in *Bacopa monnieri*.

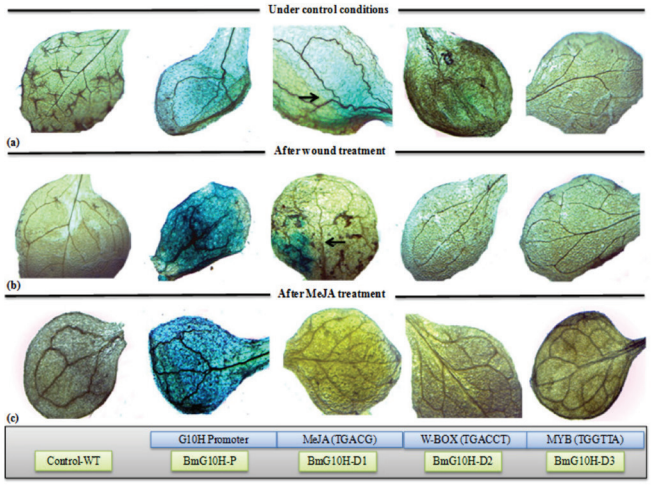


Fig. Histochemical localization of GUS activity in transgenic *Arabidopsis* seedlings (a) Under control conditions **(b)** after wounding and **(c)** after MeJA treatment. The intensity of the blue color represents the activity of the *BmG10H-1* promoter in young leaves. GUS activity was also monitored in different *BmG10H-1* promoter truncations under control, MeJA, and wound treatment. The experiment was performed in two independent biological replicates and all images were taken using a simple light microscope under 10x magnification (S8-APO, Leica). Scale bar = 1mm.

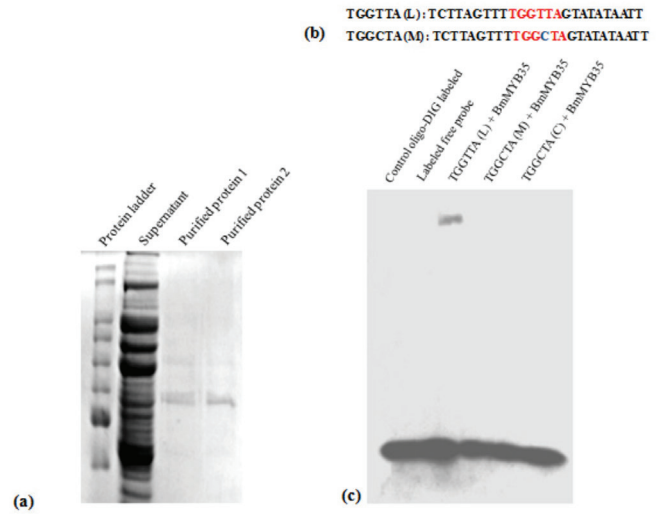


Fig. Recombinant protein purification, EMSA, and transactivation assay. (a) Recombinant Bm-G10H-1 protein was purified from *E.Coli* BL-21 (DE3) strain. The recombinant protein was induced by using 0.3 mM IPTG for 5 hours at 37°C and affinity-purified by using sepharose GST beads. The molecular weight of 61.6 kD along with GST-tagged recombinant protein (GST-BmMYB35) was affinity purified and separated on SDS-PAGE. **(b)** MYB-binding *cis*-element sequence (TGGTTA) used in the study is represented with red color while mutation within the binding site is represented with blue color. **(c)** EMSA of BmMYB35 showed that it specifically interacts with TGGTTA *cis*-element (L-DIG-labelled, M-mutated/substituted, and C-cold/unlabelled probe).

Dr. Rakesh Shukla & his team

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

Targetting NAC transcription factor for improving root phenotype of *W. somnifera*

Withania somnifera, a medicnal plant of high importance for its root. Earlier, we had reported generation of large scale RNAseq data for multiple root growth stages in Nagori and Poshita morphotypes with aim to identify target genes for increasing non-fibrous (texture-related) root biomass and/or decreasing root fibrous texture. Low fibrous content is industrially preferred for significantly better yeild of metabolites. The comparative gene expression analysis across various growth stages and morphotypes revealed several putative transcriptswhich are involved in non-fibrous biomass root formation and secondary cell wall thickening in the root of Nagori and Poshita morphotype of *W. somnifera*. We provided a special focus on NAC transcriptions factor among few others. Our analysis indicated the involvement of various NAC transcription factor during various root growth stages. A few NAC transcription factor belonging to NST subgroup (*NAC SECONDARY WALL THICKNING PROMOTING FACTOR*) showed most significant expression during late stage of development (125 DAS, day after sowing). Their expression in the central core region (inside of cambium) dominated by formation of xylary fibres further indicated their expression correlation to xylary fibre formation. Most of these NSTs maintained a higher level of expression in Poshita roots (having higher texture) compared to those

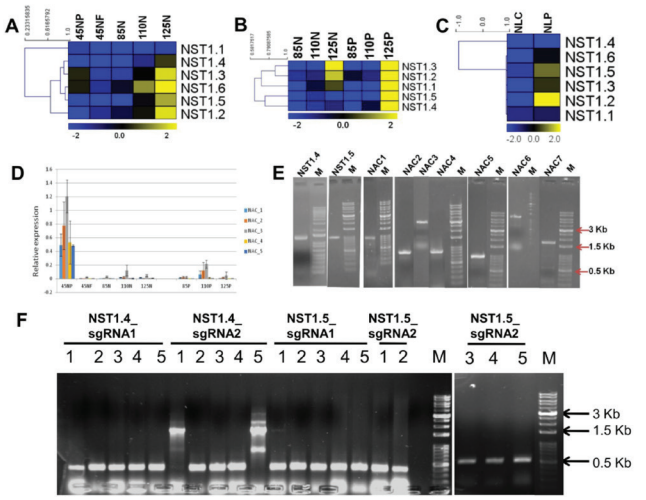


Fig. Expression analysis, cloning and construct preparation of various target root expressed NAC ORF and related sgRNAs. (A) Heatmap showing *NST* gene expression (log2 converted average TPM values) in various root developmental stages of Nagori mophotype. (B) Comparison of NST gene expression log2 fold converted RNA-seq TPM values between Nagori and Poshita morphotype at various root growth stages. (C) Expression analysis NST transcripts at 145 DAS between a radially separated inner core (inside of cambium and outer region (outside of cambium) (D) qRT-PCR analysis of few NAC genes expressed in roots mainly at 45DAS in pot grown plants kept in the green house. (E) Cloning of 9 root expressed NAC genes from *W. somnifera*. (F) Colony PCR indicating formation of sgRNA constructs against two NST genes. **45NP,** 45 DAS (Days after showing) pot grown Nagori morphotype; **45NF,** 45 DAS field grown Nagori morphotype; **85N,** 85 DAS field grown Nagori morphotype; **110N,** 110 DAS field grown Nagori morhphotype; **125N,** 125 DAS field grown Nagori morphotype; **85P,** 85 DAS field grown Poshita morphotype; 110P, 110 DAS field grown Poshita morphotype; **125P,** 125P DAS field grown Poshita morphotype; **145NCL,** 145 DAS field grown Nagori morphotype outer region; **145NLP,** 145 DAS field grown Nagori morphotype.

in Nagori. Als, we Identified few more NAC which are more highly expressed in 45 DAS plants in pots in green house which have more branched than tuberous phenotype compared to plants growing in field. We have cloned nine of these NAC ORFs to establish their functionality and infer if they could be used as target for reduced fibrous texture and/or Further, Under MLP07, pair of sgRNA constructs against two NST gene have also been prepared.

Dr. Pradipto Mukhopadhyay & his team

Dr. Dayanand C. Kalyani Mk- Mh- lh- dY;k.kh

I have recently (March 2021) joined as a Senior Scientist in the Plant Biotechnology DU, CSIR-CIMAP Lucknow. My area of research is focused on to find and understands different carbohydrate-active enzymes in host-pest interactions. Within this scope, I am particularly interested in understanding the mechanisms and pathways of enzymes that synthesize and modify phytopathogenic polysaccharides or flavonoids, as well as enzymes of commensal bacteria involved in natural, health-promoting interactions with the human host.

Crop Production and Protection

Highlights

The division of Crop Production and Protection has been actively involved in several thrust areas of cultivation and promotion of MAPs in India. The major focused areas include the development of agro technologies, management of plant health through soil fertility enhancement and soil nutrient management, reduction of soil erosion by selective cultivation of medicinal and aromatic crops, and eco-friendly technologies for the management of pests and disease of MAPs. At present, the division is focused on the accomplishment of objectives of national projects towards the enhancement of the income of the small and marginal farmers. The faculties of the division have been actively contributed to the Aroma Mission and Namami Gange projects of national importance. During this period, several externally funded projects were obtained from national agencies like the NMPB, DBT, DST, New Delhi, and state agencies like Forest Department, UP.

In this year, an enhancement of productivity of the crops like ashwagandha, lemongrass, aloe vera, and *Mentha arvensis* was examined by the implementation of appropriate agro technologies suitable for different agro

Scientists of Crop Production and Protection Divisional Unit

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

climatic zones. The research on the selective integration of high economic value medicinal and aromatic crops like rose-scented geranium and garlic with vegetable crops like tomato could prove the highest return per hectare to the farmers. The enhanced essential oil content of german chamomile flowers was reported with respect to the temporal variations. A comparative study was initiated to suggest a better solution for the harvesting of aromatic grasses like palmarosa and vetiver roots through the different mechanised harvesting processes.

During the year 2020-21 the degradation pattern of herbicides in the soil as well as atrazine tolerance and reduction in its uptake in *Andrographis paniculata* using endophytic bacterium *Bacillus* sp. strain CIMAP-A7 was also tried. The study on the effect of different rates of organic and inorganic fertilizers and distilled waste mulching on citronella growth, yield and soil health has been conducted. Various combinations were developed to enhance the yield and total Bacoside A content in *Bacopa monnieri* by using four promising endophytic associations.

During the year 2020-21, the plant pathology department has conducted several field surveys to estimate and monitor the emerging fungal pathogens and diseases of MAPs. Recent advancements of the division providing prospective insights into the eco-friendly management of fungal diseases through chemical-free cultivation of MAPs. The organic fungicides formulations were developed in two forms suitable for foliar and soil applications, and seed and planting material treatment. These organic formulations consist of plant product-based components and are environmentally safe. Further, the bioefficacy of the formulations under field conditions is under process. The division has also identified new viral diseases caused by the cucumber mosaic virus isolated from salvia sclares. During prevalent Covid-19 situations, the scientists of the division were in continuous contact with the farmers through smart mobile application tools and developed advisory and crop monitoring services.

During this period, more than 10 students have been joined and registered for the Doctoral programme under AcSIR, and JNU. The division has been published around 25 research articles, and 9 book chapters in various reputed peer-reviewed high impact factor journals like Journal of Hazardous Material, Industrial Crops and Products, Journal of AMB express, Trends Phytochemistry, Journal of Pharmacognosy and Phytochemistry, Journal of Medicinal and Aromatic Plant Sciences, Soil Use and Management, Journal of Environmental Biology, Physiologia Plantarum, Journal of Plant Nutrition, Environmental Process and Sustainable Energy, Environment Conservation, and Journal Acta Ecological Sinica. 3 popular articles.

During this period the DU4 has developed and transferred the promising product of every green tea technology. Five more promising agro technologies were developed for MAPs. Scientists and technical staff of the DU contributed significantly to different skill development outreach programmes through offline as well as online training mode. The demonstration programs of Agro-Technologies developed by CSIR-CIMAP were also conducted at farmers field.

Dr. Abdul Samad Mk- v©ny len

A New viral disease caused by *Cucumber mosaic virus* in *Salvia sclarea*

Salvia sclarea (Clary sage), is a perennial herbaceous plant, distributed throughout the temperate and sub-temperate regions. It is well known for its essential oil used in perfumery and food industries and also has broad spectrum of effects as analgesic, anti-inflammatory, antioxidant, antifungal and antibacterial. Based on morphological, biological and molecular characterization, an isolate of CMV is found to be associated with the present disease on *S. sclarea*. The associated virus, CMV, is among the top ten dangerous viruses. Infected and healthy leaves were taken from the experimental field of CSIR-CIMAP, Lucknow for mechanical inoculation, and RNA isolation. Samples were screened by RT-PCR using CMV specific coat protein gene primers. The amplified PCR products were cloned into pGEM-T Easy vector, recombinant clones were identified by restriction enzyme *Eco-R*1 and sequenced. Virus was purified and morphological studies were done under Transmission electron microscope (TEM). Natural occurrence of green mosaic, curling, deformed leaves and stunted growth was observed on *S. sclarea*. The virus was mechanically transmitted to test plants. Purified virus preparation revealed the presence of spherical particles of ~28 nm in diameter. An amplicon of ~657 bp specific size to coat protein gene of CMV was generated in infected as well mechanically infected plants, whereas no bands were seen in symptomless plants. BLASTn analysis shared the highest similarity of 99% with the CP gene of CMV PV-0005 isolate (KU976469). On the basis of , molecular studies, sequence analysis and TEM, it is concluded an isolate of CMV is associated with the present disease on *S. sclarea* .This study will be helpful for the development of proper diagnostics and management approaches in future.

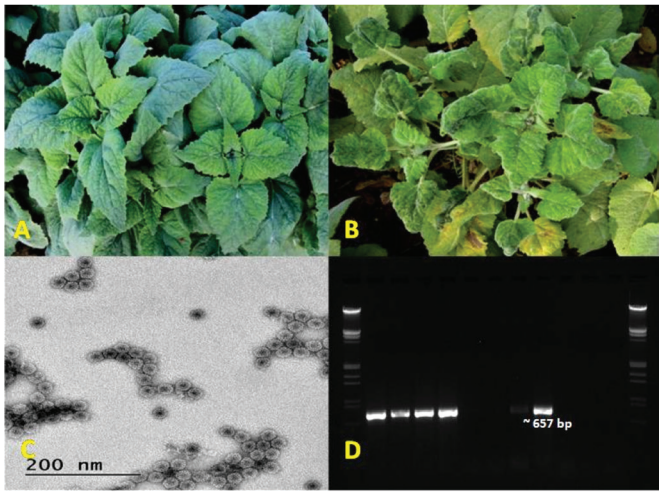


Fig. A. Healthy plants of *S.*sclarea. **B.** Infected plants showing viral symptoms. **C.** Electron micrograph of purified preparation of isolated virus showing the presence of isometric virus particles of ~28 nm (in dia.) (Bar = 200nm). **D.** Gel image presenting RT-PCR product of CP gene (CMV SS2) in 1.2% agarose; M- λ DNA double digested *Eco*RI/*Hind*III marker; Lane 1, 2, 3, 4, 7,8 samples from infected plant; 5, 6, 9, 10, 11-samples from healthy plant.

Enhanced production of phytotoxic polyketides isolated from *Curvularia lunata* by applying chemical stresses

The secondary metabolites produced by the microorganisms have great importance in developing different medications, pesticides, and plant growth regulators. *Curvularia lunata* (Wakker) Boedijn, a plant pathogenic fungus, causes the leaf blight disease in sweet basil (*Ocimum basilicum* L.). In this study we have isolated and identified the fungal secondary metabolites from *C. lunata* and analysed the effect of chemical stresses (NaCl, CaCl2, glycyrrhetinic acid, and NaOH) metabolites production. The influence of chemical stresses

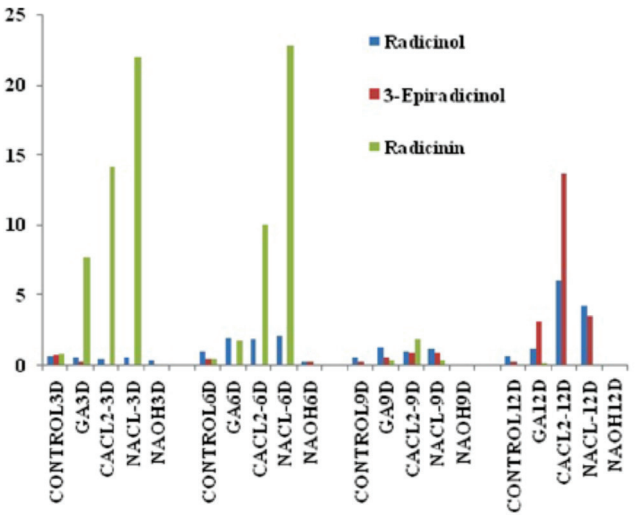


Fig. A time course study for the production of Radicinin, Radicinol, and 3-epiradicinol as determined by HPLC Methods (X axis-Percentage and Y-axis-Days.

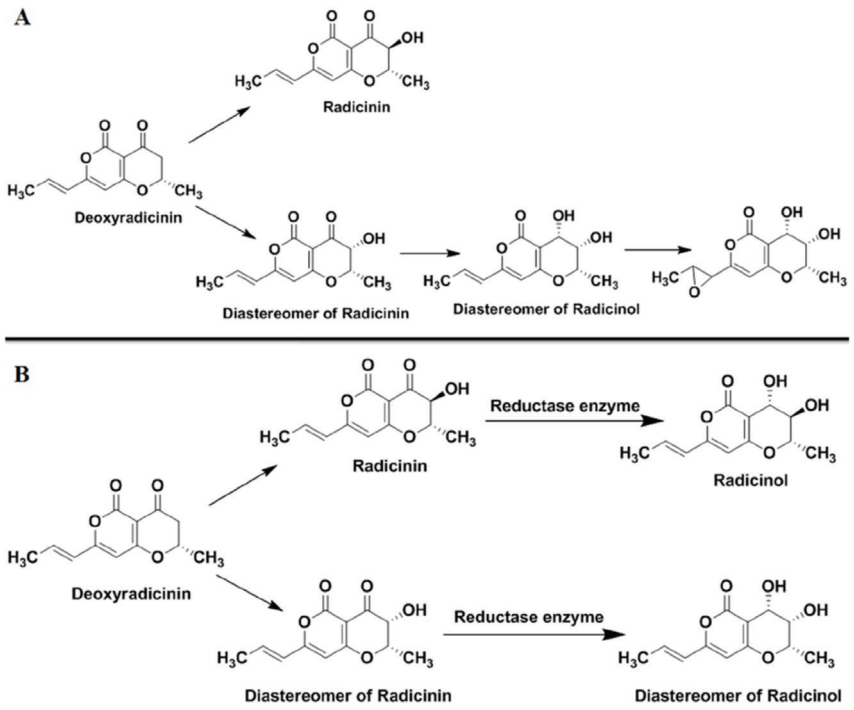


Fig. (A) The proposed biosynthetic relationship among the isolated metabolites from Biporis cocus by (Nakajime et al. 1997), **(B)** Proposed biosynthetic pathway for the production of Radicinin and 3-Epiradicinol (Radicinol diastereomer)

increases the production of isolated secondary metabolites. Additionally, we also check the time-dependent production of identified metabolites. The three secondary metabolites, radicinin (1), radicinol (2) and 3-epiradicinol (radicinol diastereomer) (3) were isolated from the ethyl acetate extract of *C. lunata* and the NMR and HR-ESI -MS spectral analysis confirmed their structure. The influence of chemical stresses increases the production of all three metabolites up to 10–30 times compared to control in all the chemical stresses except NaOH. The time- course study (12 days) showed that in the first three days, radicinin is produced. Later on, the concentration of radicinin is decreased, and the concentration of another two metabolites was increased. The present study establishes a plausible biosynthetic pathway to prepare isolated fungal metabolites inside the fungal cells. *Industrial Crops & Products*. 2021: **160 : 1-9 (I.F: 5.62)**

Dr. A. Samad & his team

Dr. Saudan Singh Mk- lknku flg

Quality assessment of menthofuran rich essential oil of *Mentha piperita* (CIMAP-Patra) stored in different containers and storage temperatures

The storage of the menthofuran rich essential oil of *Mentha piperita* (cv. CIMAP-Patra) is the major problem for its market sustainability. In the present study, the best storage conditions were optimized without degradation in menthofuran content and quality of essential oil. The quality of the essential oil was evaluated in two storage conditions (temperature: 25±2°C and 4±0.5°C), three types of storage containers (transparent glass, amber color glass, and aluminium bottles), and six storage periods (3, 6, 9,12, 15, and 18 months). The results indicated that maximum degradation (52.45%) was reported in the oil sample which was stored in transparent vial at 25°C. At 4°C, degradation in menthofuran content was not pronounced irrespective of different containers; however, lowest degradation was reported in amber color bottle. Apart from the menthofuran, pulegone and isomenthone, minor fluctuations in other chemical constituents were recorded, but not in the proper pattern. The refractive index of the essential oil was not altered with storage condition and time, while optical density was decreased with the storage time. Results suggest that the storage of the menthofuran rich essential oil of *M. piperita* in amber color glass container at 4°C is the best way to reduce the oxidation and degradation/conversion of menthofuran for a longer period of time.

Influence of planting methods on planting material and essential oil yield and quality of menthol mint (*Mentha arvensis* L.)

Menthol mint is a commercially cultivated essential oil-bearing crop belongs to family Lamiaceae. Mint oil is used in aromatherapy, flavor, and pharmaceutical industries. The aims of the present study to optimize planting methods, age of seedlings, and date of harvesting. The experiment was carried out at the research farm of CIMAP, Lucknow. The analysis was consisting of three planting methods, five age of seedlings, and four dates of harvesting. Results were revealed that ridge planting recorded maximum sucker yield (27.50Mg ha^{-1}), essential oil yield (52.97 kg ha^{-1}) with minimum water requirement, and maximum water use efficiency (48.22 ha cm and 0.43 kg ha mm^{-1}) along with net returns ($ 3590.34 ha^{-1}). The 30 days old seedlings produced the highest suckers and essential

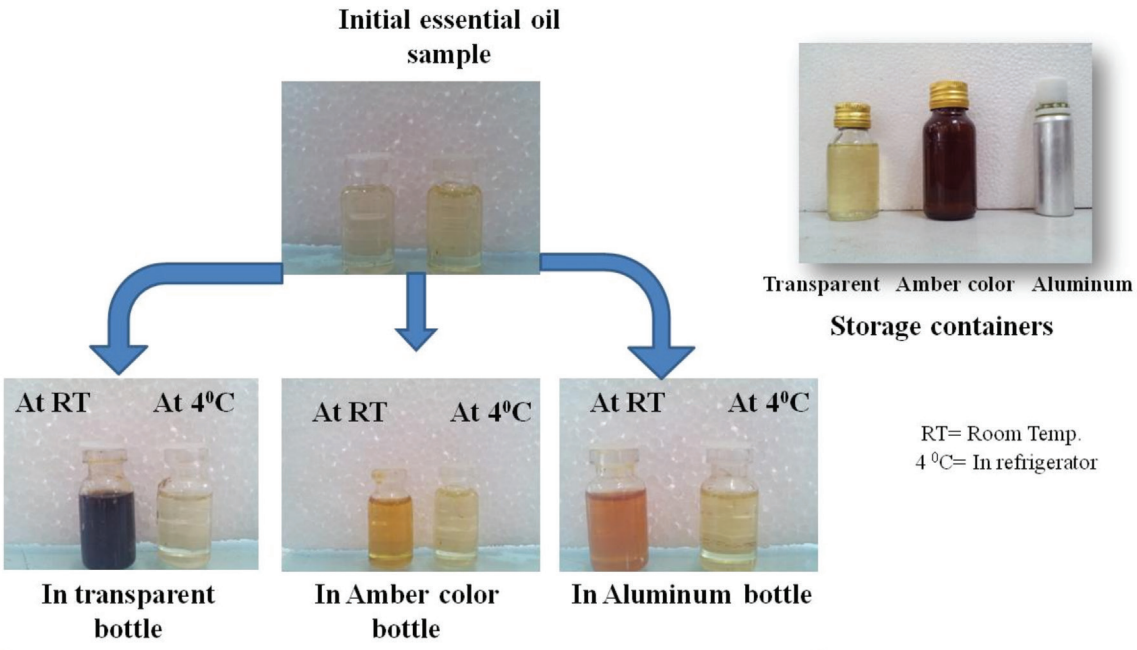
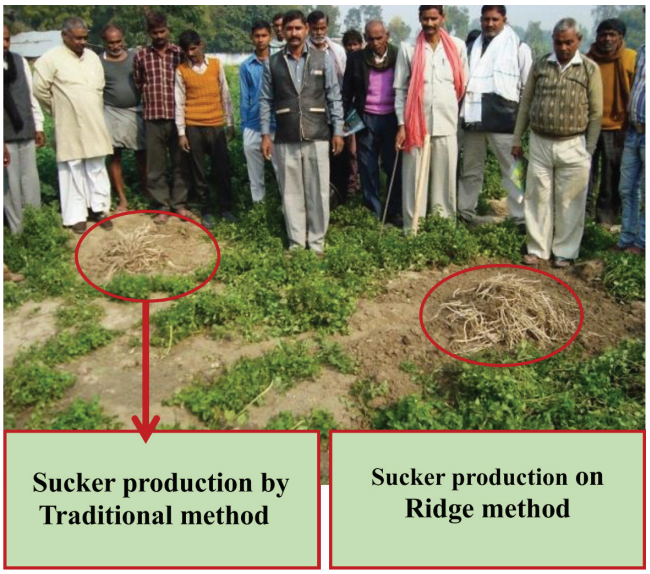


Fig. Essential oil colour after 18 months of storage under different conditions



oil yield (27.43Mg ha^{-1} and 56.62 kg ha^{-1}) along with the maximum net profits ($ 3598.44 ha^{-1}). Maximum suckers and essential oil yield (25.10Mg ha^{-1} and 50.85 kg ha mm^{-1}) with higher net return ($ 3206.22 ha^{-1}) were reported by harvesting (digging) at 31 January. Planting on ridges of 30 days old seedlings along with harvesting on 31 January was a suitable combination to obtain maximum suckers and essential oil yield with higher income.

Optimized agronomic practices for Aloe vera [*Aloe barbadensis* (Miller)] cultivation

Aloe vera is an important medicinal plant that belongs to the family *Asphodelaceae* (Liliaceae) with versatile properties. Cultivation of Aloe vera has accomplished economic significance because of its ever-increasing demand in the cosmetic, nutraceuticals, and pharmaceuticals industries. Field experiments were performed at the research farm of CIMAP, Lucknow, in two consecutive years to optimize the irrigation regimes, planting methods and age of offsets under sub-tropical regions of north India for enhancing yield of Aloe vera leaves and marketable produce for sustainable agriculture and better resource use efficiency. The results revealed that maximum fresh leaves, gel, and juice yield was obtained when crop was irrigated at 20±5% available soil moisture in raised bed planting method for 60 days old offsets.

Field view of Aloe vera

Best monitory returns were also computed in the same treatment combination Thus, planting of 60 day old offsets by ridge bed planting method with irrigation at 20±5% available soil moisture throughout the cropping period is suitable treatment combination for getting higher yield, water productivity, and monetary returns from aloe vera cultivation.

Evaluation of productivity and quality of Ashwagandha under different agro-practices in sub-tropical plain of north-India

The roots of ashwagandha (*Withania Somnifera* L. Dunal) are used to treat various ailments and the demand of quality raw material of ashwagandha is upgrading in the global market. The present studies were planned to optimize the plant density, irrigation regimes and moisture conservation for enhancing roots productivity and quality. Two field experiments were conducted at CSIR-CIMAP, Lucknow, first comprising eight plant densities and second having four irrigation regimes with three moisture conservation, for two consecutive years. Results revealed that plant density (500,000 plants ha^{-1}) provided highest root yield, total withanolide yield and net return. In the second experiment, the irrigation at 20±5% available soil moisture (ASM) with mulch was found to be an appropriate combination for obtaining maximum biomass yield and yield of biological active substances. The maximum net return was also recorded in the same treatment combination.

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Maximizing yields and economics by supplementing additional nutrients for commercially grown menthol mint (*Mentha arvensis* L.) cultivars

Supplementation of nutrients plays a vital role in the growth yields and quality attributes of the crops. An experiment and demo trials were conducted at CIMAP research farm and at farmers' field(s) simultaneously, to study the adequacy of additional nutrients application in menthol mint (*Mentha arvensis* L. cv. Kosi and Kranti) for improving productivity and profitability. Results of both trials clearly indicated that NPK (recommended dose) and micronutrients based fertilizers eventually leads to accrue the net income. Commercially grown menthol mint farmers benefitted by consequently improvising fresh herbage, oil content, oil yield, gross returns, net income and benefit-cost ratio (B:C ratio) (50.86%, 3.45%, 55.04%, 55.04%, 207.80%, and 50.75%, respectively in cv. Kosi) in treatment T4 [NPK (100:60:40 kg ha- 1) + $ZnSO_4.7H_2O$ @ 25 kg ha^{-1})] concerning the recommended dose of NPK fertilizers T1 [NPK (100:60:40 kg ha^{-1})]. Simultaneously, for the second demo trial, conducted in the farmer's fields, forty two farmers were selected for the cultivation of menthol mint. From the results, it was revealed that recommended dose of NPK fertilizers with the addition of zinc sulphate found significantly maximum yield and net returns in the plots; an increase of oil yields, gross returns, net income, and B:C ratio was 37.05%, 37.05%, 111.18%, and 32.88%, respectively in T2 [NPK (100:60:40 kg ha^{-1}) + $ZnSO_4.7H_2O$ @ 25 kg ha^{-1})]. Data attained from soil analysis distinctly showed that moreover increasing the yields and return of menthol mint cultivation, the integration of vermicomposting, macro and micro nutrients, and bio inoculants with the recommended dose of NPK remarkably upgrades the soil fertility status in terms of organic carbon, available N, P, and K.

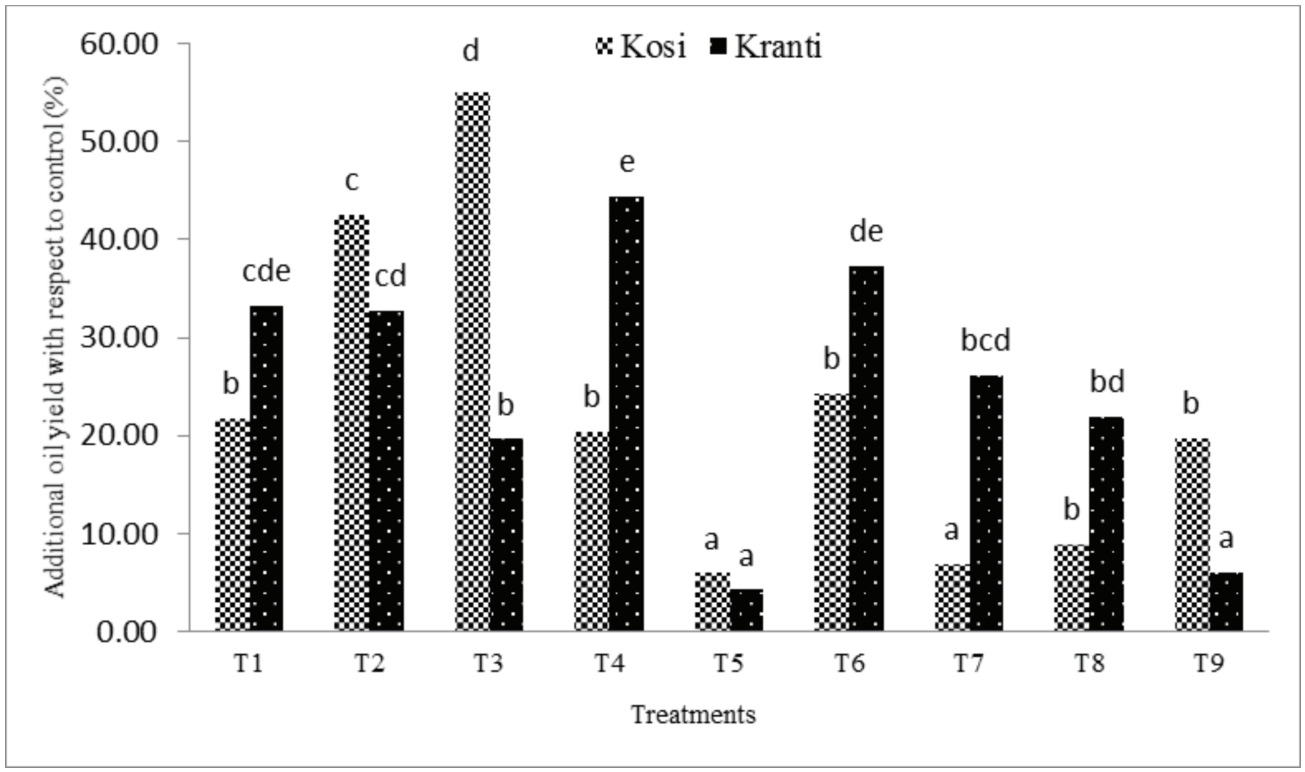

Fig. Response of the different nutrients on oil yield of *Mentha arvensis* L. var. Kosi and Kranti. T_1 - N:P:K (100:60:40) + Vermicompost @ 2.5 t ha^{-1}, T_2 - N:P:K (100:60:40) + $CaSO_4$ @ 25 kg ha^{-1}, T_3 - N:P:K (100:60:40) + $ZnSO_4$ @ 25 kg ha^{-1}, T_4 - N:P:K (100:60:40) + $FeSO_4$ @ 25 kg ha^{-1}, T_5 - N:P:K (100:60:40) + ($ZnSO_4$ + $FeSO_4$) @ 25 kg ha^{-1}, T_6 - N:P:K (100:60:40) + Bioinoculant (*Cedeceadavisae*), T_7 - N:P:K (100:60:40) + $ZnSO_4$ 1% foliar spray, T_8 - N:P:K (100:60:40) + $FeSO_4$ 1% foliar spray, T_9 - N:P:K (100:60:40) + ($ZnSO_4$ + $FeSO_4$ 1% foliar spray).

Essential oil bearing aromatic plants: Their potential for sequestering carbon in marginal soils of India

Continuous rise in the atmospheric CO_2 concentration upshots the genesis of cataclysmic planetary problems such as global warming and climate change. Another critical issue which is environmentally challenging is land degradation. When productive land is poorly managed, it turns to marginal land. And further degradation of marginal land ends up to being unproductive land. On the contrary, considerable part of depleted soil C pool can be restored through the adoption of conservation agricultural practices; unproductive land could be converted to marginal land and by its further restoration, into productive land. Aromatic plants can sustain various adverse conditions prevailing on the marginal lands. Aromatic plants require low input but the output is quite high due to the production of high value essential oil. The pivotal perspective of utilization of marginal lands of India for the production of aromatic plants would explore factors such as land availability, aromatic plants adaptability, C sequestration potential and economic feasibility. India is the largest exporter of essential oils and produces huge amount of aromatic spent residues, which could be converted into several value-added products. Proficient recycle of distillation waste of aromatic plants in marginal lands will aid to sequester C in soil and enhance the biomass yield. Improvement in the livelihood of farmers especially in developing nations through rise in production and income diversification would encourage farmers to reclaim their marginal lands and accelerate their transition to aromatically cultivable lands.

Table. Biomass yield and Carbon sequestration potential of some aromatic plants cultivated on different marginal lands of India

	Area covered (ha)	Biomass yield (Mg)	Biomass-C Sequestered (Mg)
Chrysopogon zizanioides L. (Root)	243.58	608.95	306.20
Chrysopogon zizanioides L. (Shoot)		6089.50	3077.02
Cymbopogon martini L.	565.52	15551.80	8206.69
Cymbopogon flexuosus L.	417.43	11688.04	5195.33
Cymbopogin winterianus Jowitt	47.00	1222.0	611.00

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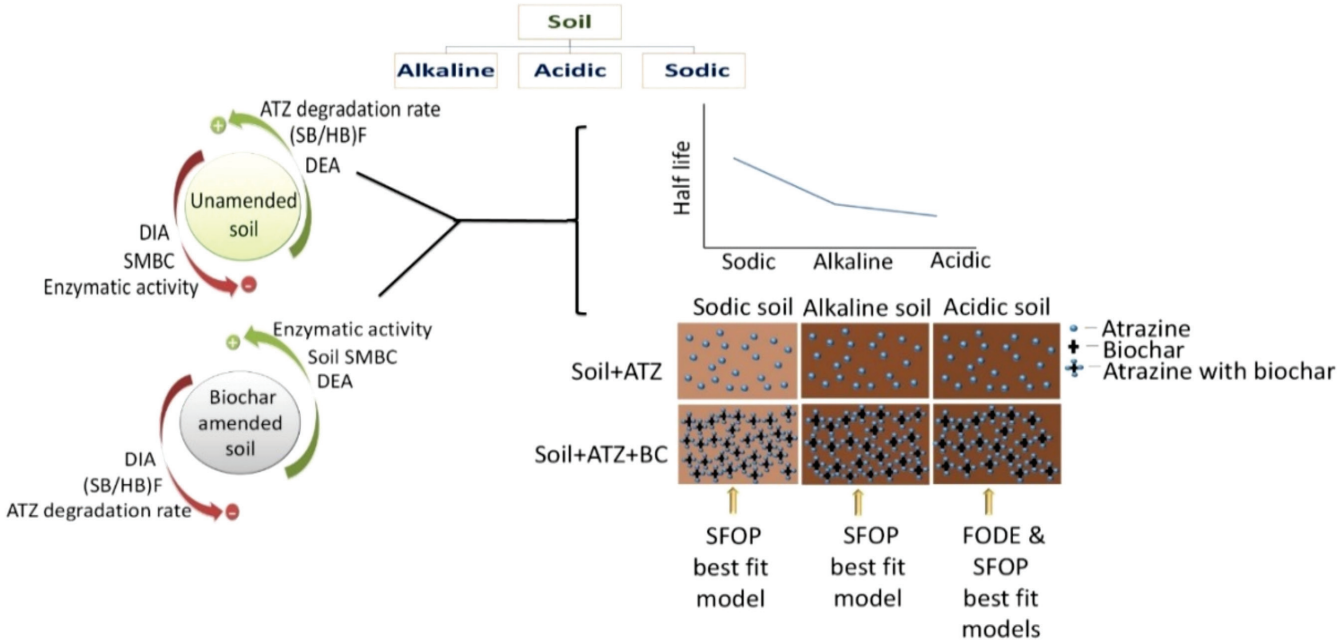
Ameliorative effects of biochar on persistency, dissipation, and toxicity of atrazine in three contrasting soils

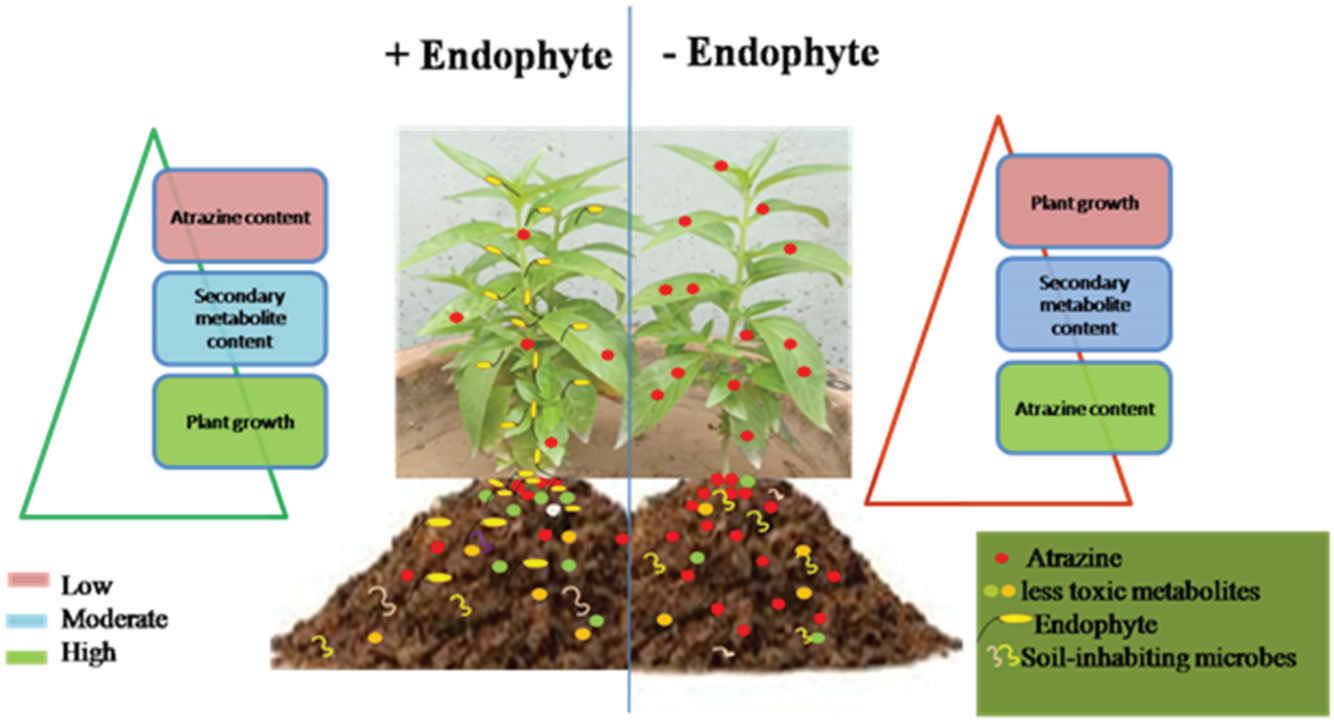
The present study examines the dissipation and toxicity of atrazine in three contrasting soils (silty clay, sandy loam, and sandy clay soils) alone and with biochar amendment. The speciation and degradation of atrazine and its metabolite content, microbial biomass, and enzymatic activities in three soils were determined in this study. Three kinetic models and soil enzyme index were calculated to scrutinize the degradation of atrazine and its toxicity on soil biota, respectively. The goodness of fit statistical indices indicates that the first-order double exponential decay (FODED) model best described the degradation of atrazine in silty clay soil. However, a single first order with plateau (SFOP) was best fitted for atrazine degradation in sandy loam and sandy clay soils. The half-life of atrazine was higher in sandy clay soil (27-106 day^{-1}) than silty clay (28-77 day^{-1}) and sandy loam soil (27-83 day^{-1}). The atrazine partitioning, availability of mineral content (Si, Al, and Fe), and microbial biomass of soil was the reason for variations in the dissipation kinetics and half-life. Biochar amendment significantly reduced the plateau in the kinetic curve and enhanced the microbial activities of soil. Overall, biochar was more effective in sandy clay soil for the restoration of soil microbial activities under atrazine stress due to modulation in the pH and improved soil properties. The results indicate that biochar amendments in all three soil reduced the bioavailability of the atrazine to microbes but enhanced the microbial activities of soil. The enzyme-based index suggests that biochar significantly improves the recovery process of soil biological activities under atrazine stress.

Endophytic bacterium *Bacillus* sp. strain CIMAP-A7 improves atrazine tolerance and reduces its uptake in *Andrographis paniculata*

The presence of atrazine, a triazine herbicide, and its residues in agriculture soil poses a serious threat to human health and environment through accumulation in edible plant parts. Hence, the present study focused on atrazine induced stress amelioration of *Andrographis paniculata*, an important medicinal plant, by a plant growth promoting and atrazine degrading endophytic



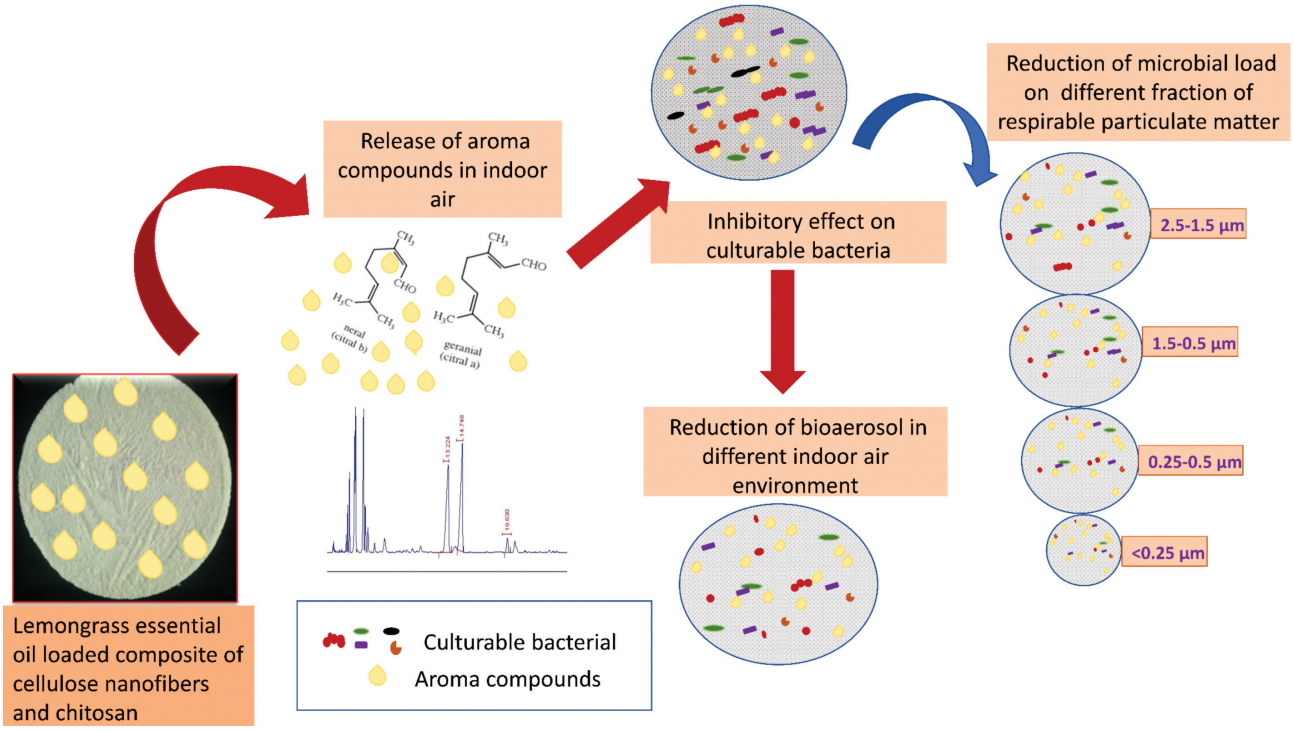
DEA- deethylatrazine, DIA- deisopropylatrazine, ATZ- Atrazine, SMBC- Soil microbial biomass carbon, SB-Soil bound, HB-Humus bound, F- Fraction.



bacterium CIMAP-A7 inoculation. Atrazine has a non-significant effect at a lower dose while at a higher dose (lower: 25 and higher: 50 mg kg^{-1}) 22 and 36% decrease in secondary metabolite content and plant dry weight of *A. paniculata* was recorded, respectively. Endophyte CIMAP-A7 inoculation significantly reduced atrazine soil content, by 78 and 51% at lower and a higher doses respectively, than their respective control treatments. Inoculation of CIMAP-A7 exhibited better plant growth in terms of increased total chlorophyll, carotenoid, protein, and metabolite content with reduced atrazine content under both atrazine contaminated and un-contaminated treatments. Atrazine induced oxidative stress in *A. paniculata* was also ameliorated by CIMAP-A7 by reducing stress enzymes, proline, and malondialdehyde accumulation under contaminated soil conditions than un-inoculated treatments. Furthermore, the presence of atrazine metabolites deisopropylatrazine (DIA) and desethylatrazine (DEA) strongly suggests a role of CIMAP-A7 in mineralization however, the absence of these metabolites in uninoculated soil and all plant samples were recorded. These findings advocate that the amelioration of atrazine induced stress with no/least pesticide content in plant tissues by plant-endophyte co-interactions would be efficient in the remediation of atrazine contaminated soils and ensure safe crop produce.

The incorporation of lemongrass oil into chitosan nanocellulose composite for bioaerosol reduction in indoor air

The bioaerosols present in indoor air play a major role in the transmission of infectious diseases to humans; therefore concern about their exposure is increased recently. In this regard, the present investigation described the preparation of lemongrass essential oil (LGEO) loaded chitosan and cellulose nanofibers composites (CH/CNF) for controlling the indoor air bioaerosol. The evaluation of the inhibitory effect of the composite system on culturable bacteria of the indoor air was done at different sites (air volume from 30 m^3 to 80 m^3) and in different size fractions of aerosol ($<0.25\mu$m to 2.5μm). The composite system had high encapsulation efficiency (88-91%) and citrals content. A significant reduction in culturable bacteria of aerosol (from 6.23 log $CFUm^{-3}$ to 2.33 log $CFUm^{-3}$) was observed in presence of cellulose nanofibers and chitosan composites. The bacterial strains such as *Staphylococcus* sp., *Bacillus cereus*, *Bacillus pseudomycoides* sp., *Pseudomonas otitidis,* and *Pseudomonas* sp. *Cf0-3* in bioaerosols were inhibited dominantly due to the diffusion of aroma molecules in indoor air. The results indicate that the interaction of diffused aroma molecule from the composite system



with bacterial strains enhanced the production of ROS, resulting in loss of membrane integrity of bacterial cells. Among different size fractions of aerosol, the composite system was more effective in finer size fractions ($<0.25\mu$m) of aerosol due to the interaction of smaller aroma compounds with bacterial cells. The study revealed that LGEO loaded chitosan and cellulose nanofibers composites could be a good option for controlling the culturable bacteria even in small-sized respirable bioaerosol.

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Coppicing impact on the essential oil yield and its chemical composition of lemongrass cultivars under the semi-arid region of south-India

A study was carried out at CSIR-CIMAP, RC. Hyderabad (India) to study the impact of coppicing time on the oil percent and its chemical composition of different cultivars of lemongrass using a randomized block design. The freshly harvested herb was used for the hydro-distillation for essential oil, and subsequent chemical analysis. The chemical components identification of the essential oil was performed by GC–MS. In the results coppicing time influenced significant changes in the essential oil content, essential oil yield, and its chemical com- position especially, total citral, and geraniol content. The four superior varieties/cultivars of lemongrass for the essential oil yield were CIM-Shikhar > Krishna > CKP-25 > CIMAP-Suwarna; for the essential oil con- tent CIM–Shikhar > Krishna > CIMAP-Suwarna > Praman; for total citral content Nima > CIM–Shikhar > Krishna > Pragati, and for the total geraniol content Himrosa > CN-5 > Tawirosa > Kalam, respectively. Therefore, we can recommend these varieties/cultivars for commercial cultivation in large areas under the semi-arid region of south India.

The pooled analysis of variance (ANOVA) expressed the highly significant differences in varieties/cultivars, coppicing, and varieties × coppicing for all the four studied traits The variations in the oil percent, yield, and their quality of essential oil including citral and geraniol content percent depending on the coppicing time of the crop that differs between varieties. It appears that coppicing time significantly influences the oil yield and its quality obtained from the herb by the three lemongrass varieties namely, Cauvery (53.2–60.50); Krishna (73.50–81.2), and CIM-Shikhar (75.30–82.20) Kg/ha, respectively. The ten other varieties were not much influenced by coppicing time for the oil yield. On contrary, the essential oil content of five lemongrass varieties namely, Krishna (0.70–1.00), CKP-F2-38-Kalam (0.50–0.75), RRL-CN-5 (0.40–0.75), and CK-10-Himrosa (0.40–0.65) % were highly affected by coppicing time. It is depicted from the results that the variety of Krishna was highly influenced for the coppicing time for all four traits.

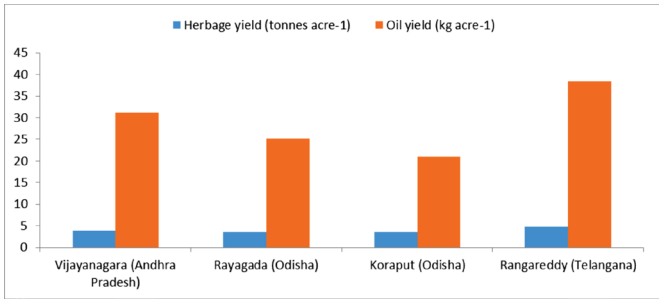

Fig. Variation in the herbage yield and oil yield in different location of southern India

Growth and yield performance of lemongrass under different Agroclimatic conditions of south-India

A trial was conducted to know the variation in growth and yield performance of lemongrass at different agro climatic conditions. From the obtained result it is

Table: Mean performance over four coppicing and four superior varieties of lemongrass under the semi-arid region of south India

Places	Plant Height (cm)	Tillers/ plant	No. of Leaves/ plant	Leaf area (cm^2)	Oil content (in %)	Herbage yield (tonnes $acre^{-1}$)	Oil yield (kg $acre^{-1}$)
Vijayanagara (Andhra Pradesh)	152	29	116	106	0.8	3.9	31.2
Rayagada (Odisha)	142	27	112	101	0.7	3.6	25.2
Koraput (Odisha)	136	24	107	103	0.6	3.5	21.0
Rangareddy (Telangana)	144	32	136	108	0.8	4.8	38.4
SEm±	2.1	0.8	3.3	0.6	0.21	0.1	2.4
CD (P=0.05)	6.3	2.4	9.8	1.8	0.6	0.4	7.2

concluded that among different locations, lemongrass cultivated under Rangareddy district, Telangana state recorded significantly higher oil content, herbage yield and oil yield (0.8%, 4.8 t/acre, 38.4 kg/acre). This attribute is might be due to higher temperature and congenial environment at Rangareddy district favours the higher herbage and oil content compared to other trial locations.

Delineating stability performance for high quality root yield in Withania somnifera (Dunal)

The study was conducted at CSIR-CIMAP, RC, Hyderabad, India in a randomized block design replicated in thrice with plot size = 3.0 m2 in during year late kharif season 2018-2019 and 2019-2020. The *Withania somnifera* (Dunal) cultivars (*var:* CIM-Chetak, CIM-Pratap, NMITLI-101, NMITLI-118 and Poshita seed) were used for the study. Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemicals, phonological and morphological events occurring in the plant. Among the different cultivars of Ashwagandha, NMITIL 118 recorded significantly higher fresh root yield (2746 kg/acre) compared to rest of the cultivar and was on par with NMITILY 101 (2580kg/acre) and Pratap (2586 kg/acre). Significantly lower fresh root yield was noticed in the cultivar Chetak (2186 kg/acre). Similar trend was noticed with regard to dry root yield with NMITILY 101 recorded significantly higher dry root yield (578 kg/acre) and was on par with Pratap (546 kg/acre) and NMITILY 118 (516 kg/acre).

There was significant difference with regard to fresh herbage was noticed among different cultivars of Ashwgandha. NMITIL-118 recorded significantly higher fresh herbage yield (954 kg/acre) compared to rest of the cultivar and was on par with rest of the cultivar except Poshita (653 kg/acre). Similar trend was noticed with regard to total biomass production per plant. This attribute is might be due to inherent characters of varieties.

Table: Mean performance of *Withania somnifera* cultivars in Semi-arid region

Treatment	Cultivar/ variety Name	Plant height (cm)	No. of branch per plant	Leaf length per plant (cm)	Leaf width per plant (cm)	No. of seeds per berry	Root length per plant (cm)	Root diameter per plant (cm)
T_1	CIM-Chetak	72	29	7.8	5.2	42	20.5	2.4
T2	CIM-Pratap	56	26	8.2	4.2	38	18.0	2.0
T3	NMITLI-101	86	32	8.3	4.4	32	23.6	2.7
T4	NMITLI-118	78	30	8.5	4.2	38	22.2	2.8
T5	Poshita	46	24	5.4	2.9	34	19.2	2.4
	SEm±	3.1	1.15	0.8	0.25	0.13	1.2	0.3
	CD (P=0.05)	9.2	3.45	0.24	0.75	0.39	3.6	NS

Table: Yield performance of Indian ginseng cultivars in Semi-arid region

Treatment	Cultivar/variety Name	Fresh Root (kg/acre)	Dry Root (kg/acre)	Fresh herbage (kg/acre)	Total biomass (kg/acre)	Seed production (kg/acre)
T1	CIM-Chetak	2186	347	842	11256	98
T2	CIM-Pratap	2568	546	756	10242	172
T3	NMITLI-101	2580	578	855	13400	137
T4	NMITLI-118	2746	516	954	12133	162
T5	Poshita	2256	429	653	10186	118
	SEm±	98.2	28.5	81.2	514.2	6.2
	CD (P=0.05)	294.6	85.7	243.6	1542.6	18.6

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Integration of high economic value aromatic crops rosescented geranium with garlic to enhance farmers' income in sustainable manner

Among the treatments the T_4 (Rose scented geranium and garlic 1:2 ratio) provided highest return per ha. as compared the others treatments, while lowest was recorded in T_2. Therefore, recommended that farmers should cultivate rose scented geranium as intercropped with garlic in 1:2 ratio as its provided highest return per ha in sustainable manner and also fulfill the aim of more crop per drop.

Effect of nutrient management on yield attributes of Milk thistle (*Silybum marianum*)

The objective of this experiment is to determine the effect of nitrogen fertilizer dosses on the yield attributed and seed yield of silybum during rabi season 2018-19 towards development of new agrotechnology. For this

purpose, different fertilizer dosses were evaluated and their responses were ascertained with respect to yield attributes and economic yield of silybum. The field experiment was conducted to study the effect of four treatments of different nitrogen doses viz., T_1 (control), T_2 (NPK @ 80:80:60/ha), T_3 (NPK @ 100:80:60/ha) and T_4 (NPK @ 120:80:60/ha kg NPK ha^{-1}) with the spacing 50*50cm row to row & plant to plant respectively with three replicates. The result showed significant influence of higher nitrogen doses T_4 (NPK @ 120:80:60/ha kg NPK ha^{-1}) produced higher economic seed yield (9.35 q/ha^{-1}) followed by T_3 (NPK @ 100:80:60/ha) NPK produced (8.50 q/ha^{-1}) and T_2 (NPK @ 80:80:60/ha) produced (6.60 q/ha) seed yield, and lowest seed yield (2.55 q/ha) were recorded in T_1(control) without fertilizer. The observation recorded revealed highest economic yield attribute like; plant height (288.00 cm), canopy (102.1 * 99.2 cm), number of leaf (10) and highest seed yield (9.35 q/ha) were recorded in T_4 application of NPK @ 120:80:60/ha kg NPK ha^{-1} as compared to other treatments. Therefore, recommended application of NPK @ 120:80:60/ha kg NPK ha^{-1} is recommended for quality cultivation of silybum to get higher economic yield and return.

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Development of Organic Fungicide for control of fungal disease of Medicinal plants

The global fungicides market was worth $16.67 billion in 2019 and expected to reach $24.89 billion by 2023. Several developing countries and non-organic farming countries including Brazil, China, and India, are using large number of inorganic fungicides due to their lower prices than organic fungicides. The chemical fungicide use in agriculture can be reduced by practicing the organic farming and use of organic fungicides. However major challenge in the organic cultivation is non-availability of quality bio-resources such as organic fertilizers, biopesticides, and biofertilizers affecting the yield and quality of the produce. A cost effective organic fungicide was developed to control the fungal pathogens causing diseases on medicinal and agricultural crops. The organic fungicides developed in two forms:

A. Water soluble organic fungicide suspension suitable for foliar and soil applications

B. Powder based organic fungicide for seed and planting material treatment

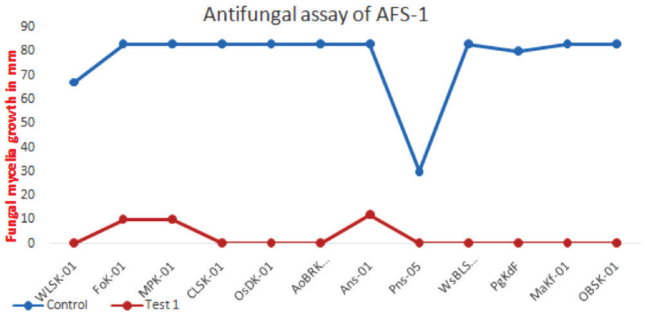

Fig. Antifungal activity of AFS1 (300 ppm): Test 1 represents growth in AFS1 treated PDA plates inoculated with *A. alternata,* WLSK-01; *F. oxysporum,* FoK-01; *M. phaseolina,* MPK-02; *C. lunata,* CLSK-01; *R. solani,* OsDK-01; *Colletotrichum* spp., AoBRK-01; *A. niger,* Ans01; *P. notatum,* Pns05; *P. adansoniae,* WsBLSK-01; *L. theobromae* PgKdF; *F. proliferatum,* MaKf1, and *S. sclerotiorum,* OBSK-01. Control represents growth of above pathogens on untreated PDA plates.

The organic formulations have stable activity at a wide temperature range suitable for field and soil applications. The formulations consist of plant product-based components and are environmentally safe. Further, bio efficacy of the formulations under field conditions is under process.

Stem rot disease on *Catharanthus roseus:*

Sclerotinia sclerotiorum outbreak on *C. roseus* was observed, the symptoms indicating stem rot, watery soft rot. The plants showed fluffy fungal growth at the nodes of the stem, and spreading and covering the whole branch. Dried leaves and defoliation from the infected branch was observed. The fungus infects stem and twigs and upper tip of stem.

Fig. Stem rot symptoms on *C. roseus* caused by *Sclerotinia sclerotiorum*

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Dr. Rakesh Kumar Mk- jkd'k d[ekj

Comparative performance of growth, yield and quality of essential oil of chamomile (*Matricaria chamomila* L.) under different intercropping systems

For enhancing the farmer income, five intercropping treatments were tried chamomile sole (T_1); chamomile + linseed (T_2); chamomile + maize (T_3); chamomile + field pea (T_4); chamomile + spinach (T_5) in additive series in randomized block design with three replications. The varieties were used 'CIM-Samohak' of chamomile; 'Shekhar' of linseed; 'Sulabh-25' of maize; 'Samrat' of field pea; and 'All Green' of spinach. Growth and yield attributes of chamomile and other treatments combinations, chamomile equivalent yield and economics of whole cropping system were compared. The maximum plant height (53.57 cm), plant spread/ width (60.84 cm), number of branches/ plant (22.00), leaf area index (LAI) (2.20) of chamomile were recorded under the treatment T_1 (chamomile sole), which was on par with T_4 (chamomile + field pea) and was also significantly superior to the rest of other treatments (T_2, T_3 and T_5) . The maximum flower yield (70.5 q ha^{-1}) was observed under T_1 (chamomile sole) followed by T_4 (chamomile + field pea; 69.20 q ha^{-1}) and T_2 (chamomile + linseed; 68.58 q ha^{-1}) and was significantly superior over rest of the treatments (T_3 and T_5). The highest oil content was observed under T_4 (chamomile + field pea) (0.16%), T_2 (chamomile + linseed) (0.16%) and T_1 (chamomile sole) (0.16) followed by T_3 (chamomile + maize) (0.15) and T_5 (chamomile + spinach) (0.15) treatments. Maximum oil yield (11.44 kg) was observed under T_1 (chamomile sole) followed by T_4 (chamomile + field pea; 11.07 kg), T_2 (chamomile + linseed ;11.07 kg) and T_3 (chamomile + maize;10.16 kg ha^{-1}) which was significantly superior over T_5 (chamomile + spinach;10.13 kg ha^{-1}) treatment during experimentation. Maximum chamazulene content was observed under T_4 (chamomile + field pea) (5.27%), T_2 (chamomile + linseed) (5.27%) and T_1 (chamomile sole) (5.27%) followed by T_3 (chamomile + maize) (0.5.26) and T_5 (chamomile + spinach) (5.25) treatments. Similar trend was observed for bisabolol oxide B content, however there was marginal variation from 15.63 - 15.64% under different treatments.

Data indicated that maximum chamomile equivalent yield in term of oil (CEY) (16.08 kg/ha) was observed under T_4 (chamomile + field pea) followed by T_2 (14.98 kg/ha), T_3 (14.27 kg/ha), T_5 (13.89 kg/ha) and T_1 (11.44 kg/ha). Similarly, maximum gross return (Rs. 321600) and net return (Rs. 212600) were also obtained under treatment T_4. Although higher cost benefit ratio (2.05) were obtained under treatment T_1 (sole chamomile). In general, intercropping treatments gave more profit in term of money as compared to sole cropping system. Among all the treatments, T_4 (Chamomile + field pea) has been observed superior in term of economic return in chamomile based intercropping treatments.

Table 1: Performance of growth, yield and economics of chamomile under different intercropping system during 2019-20.

Treatments	Plant height (cm)	Plant spread	No. of Branches / plant	Fresh flower yield (q ha^{-1})	Essential Oil yield (kg ha^{-1})	Chamomile equivalent Yield (CEY) (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})
T_1	53.57	59.84	20.67	70.5	11.28	14.14	202800	127800
T_2	48.41	58.33	18.67	68.58	10.97	14.27	285400	180400
T_3	47.85	57.69	18.00	67.75	10.16	14.98	299600	196600
T_4	49.36	57.74	19.33	69.20	11.07	16.08	321600	212600
T_5	46.66	56.93	17.33	67.50	10.13	13.89	277800	177300
SEm ±	1.59	1.28	1.25	1.40	0.68	0.51	-	-
CD @ 5%	3.38	2.71	2.64	2.98	1.44	1.08	-	-

T_1 = Chamomile, T_2 = Chamomile + linseed, T_3 = Chamomile + maize, T_4 = Chamomile + field pea, T_5 = Chamomile + spinach, DAS = Days after sowing.

Dr. Yogendra ND Mk- ;kxUn ,uMh

Application of seaweed liquid extract improves the growth, yield and chemical constituents of lemongrass

The aim of the study was to examine the foliar application of Kappaphycus alvarezii seaweed liquid extracts on growth, herb, essential oil yield and its chemical composition of lemongrass. It was observed that the growth, herb and essential oil yield of lemongrass was significantly enhanced by application of Kappaphycus alvarezii (K extract) at 20% concentration, with herb and oil yield of 35.33 t/ha/year and 442.53 kg/ha/year, respectively when applied with the recommended dose of fertilizer (RDF), compared to RDF which gave yield of 35.2% and 40.7% in herb and oil yields, respectively.

Performance and evaluation of Citronella (*Cymbopogon winterianus*) cultivars under Southern tropical regions of India

The aim of the study was to evaluate the performance of Citronella (*Cymbopogon winterianus*) cultivars for growth, herbage, oil yield and quality under Southern tropical regions of India. The plant height varies from 123.33–139 cm and number of tillers ranged from 37.56-45.67. Significantly higher herb yield was recorded in CIM-Jeeva (217.50 kg/100m^2) > Bio-13 (207.32 kg/100m^2) > C-line (192.33 kg/100m^2). The essential oil recovery varied from 1.13-1.23% (v/w) and essential oil yield varies from 1.93- 2.69 L/100 m^2, respectively in different cultivars. Overall, twenty one constituents, comprising 92.05–98.07% of the total oil compositions, were identified using GC-FID. The varieties arranged according to the citranellal content as follows, CIM-Jeeva (44.60 ± 1.27%) > Jalpallvi (41.35 ± 0.92%) > Manjusha (39.15 ± 1.63%) > Bio-13 (37.65 ± 4.45%) > Medini (21.80 ± 3.11%) > C-line (8.10 ± 2.56%). C-line was superior in geraniol rich (59.35 ± 1.06%) compared to citronellal content among citronella cultivars studied.

Growth and yield parameters of lemongrass influenced by seaweed sap application

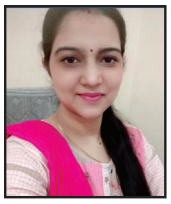
Treatments	Plant height (cm)	Number tillers/ clump	Yield (t/ha) Harvest		Yield (t)/ ha/year	Oil content (%) harvest		Mean oil (%)	Oil yield kg/ha/year harvest		Oil yield/ kg/ha/ year
			1st	2nd		1st	2nd		1st	2nd	
T_1: RDF	128.36 efgh	38.00 abc	11.93 bc	14.21 abc	26.13 bc	1.21 ns	1.22 ns	1.21 ns	143.85 bc	172.93 abc	316.78 bc
T_2: RDF + 2.5% K sap	131.58 def	34.92 de	12.09 bc	15.00 abc	27.09 bc	1.22 ns	1.21 ns	1.21 ns	147.74 bc	181.75 abc	329.48 bc
T_3: RDF + 5% K sap	133.17 de	35.75 cde	12.15 bc	15.16 ab	27.31 bc	1.25 ns	1.23 ns	1.24 ns	151.63 abc	186.46 abc	338.08 bc
T_4: RDF + 7.5% K sap	137.03 cd	36.33 cde	12.72 abc	15.99 ab	28.71 abc	1.25 ns	1.22 ns	1.24 ns	160.08 ab	192.36 ab	352.44 bc
T_5: RDF + 10% K sap	143.58 ab	36.54 bcde	13.53 abc	18.37 ab	31.90 abc	1.23 ns	1.25 ns	1.24 ns	166.76 ab	228.92 ab	395.69 abc
T_6: RDF + 15% K sap	141.62 abc	39.17 ab	14.01 ab	18.66 ab	32.67 ab	1.22 ns	1.23 ns	1.23 ns	170.21 ab	230.80 ab	401.01 ab
T_7: RDF + 20% K sap	146.00 a	39.92 a	16.27 a	19.06 a	35.33 a	1.24 ns	1.26 ns	1.25 ns	202.46 a	240.07 a	442.53 a
T_8: 50%RDF + 7.5% K sap	130.53 efg	37.58 abcd	11.91 bc	13.19 bc	25.10 c	1.22 ns	1.25 ns	1.24 ns	145.25 bc	164.56 bc	309.81 c
T_9: 50%RDF + 10%K sap	123.00 fhij	36.17 cde	10.62 bc	14.78 abc	25.40 c	1.23 ns	1.26 ns	1.24 ns	129.87 bc	184.89 abc	314.75 bc
T_{10}: FYM + 15% K sap	124.50 ghi	34.17 ef	7.97 d	9.32 cd	17.29 d	1.25 ns	1.23 ns	1.24 ns	99.37 cd	114.61 cd	213.98 d

**ns :* *non significant, Values followed by the same lowercase letters in a column are not significantly different at p < 0.05 by DMRT*

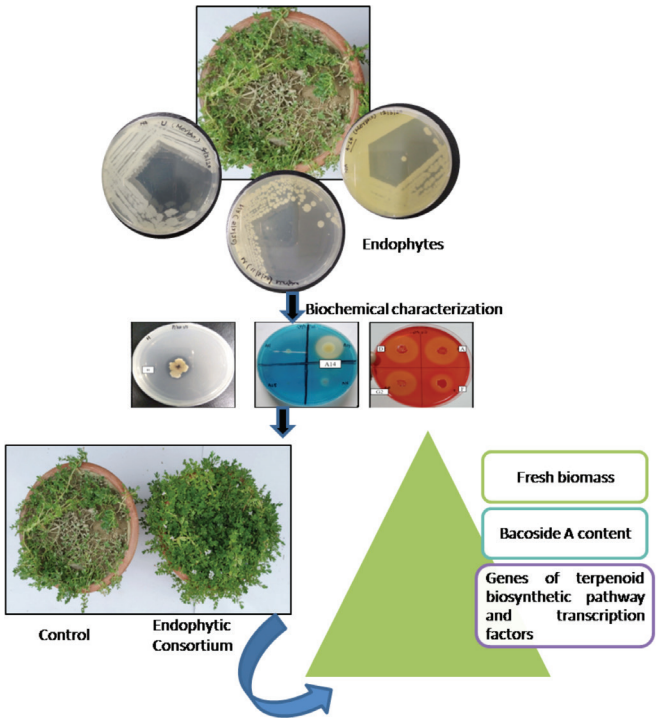
Growth and yield parameters of citronella cultivars under Southern region of Karnataka, Bengaluru

Cultivar	Plant height (cm)	Number tillers	Number of leaves/ tiller	Biomass (kg/100m^2)	Oil recovery (%)	Oil yield (L/100m^2)
Medini	135.55 ab	43.22 ab	5.83 a	192.67 abc	1.13 a	2.16 bc
Jalpallavi	123.33 de	37.56 cd	5.90 a	167.83 cd	1.15 a	1.93 cd
Bio-13	134.67 abc	41.67 abc	5.43 a	207.32 abc	1.20 a	2.49 ab
C-Line	125.00 bcd	42.33 abc	5.74 a	192.33 abc	1.17 a	2.24 abc
CIM-Jeeva	139.00 a	45.67 a	5.45 a	217.50 a	1.23 a	2.69 a
Manjusha	127.00 bcd	40.17 abc	5.77 a	185.00 bc	1.15 a	2.13 bc

Dr. Akanksha Singh Mk- vkdk{kk flag



Synergistic endophytic microbes enhance the yield and total Bacoside A content in *Bacopa monnieri* (L.) by modulating genes of triterpenoid saponin biosynthetic pathway



Bacopa monnieri (L.) Pennell (family Scrophulariaceae), is an important medicinal plant with number of therapeutically important bacosides with Bacoside A being a major active component. In recent years, the attention has been focused on the plant microbiota and its role in the production of secondary metabolites. With this aim the influence of the interaction(s) between the medicinal plant *B. monnieri* and its endophytic communities on the production of bacoside A content and plant yield was studied. Forty seven endophytes obtained from different plant parts (stem, leaves and roots) were subjected for biochemical characterization having role in plant growth promotion. On their performance, 17 isolates were taken up for pot trials amongst which four isolates showed significant increment in Bacoside A as estimated by HPLC. Various combinations were developed using four promising endophytic cultures out of which one combination significantly enhanced total fresh biomass, dry biomass as well as the bacoside A content by modulating the expression of terpenoid biosynthetic pathway genes like *CAD*, *IPP*, *HMGR*, *CHS* and *SQS*. In addition, two transcription factors namely *MYB1* and *MYB3* were upregulated in treatment having combination of endophytes with respect to the control set.

Dr. Akanksha Singh & her team

Dr. Dipender Kumar Mk- nhiUn dqekj

Evaluation of harvesting time and standardization of distillation duration for higher essential oil content and quality in German chamomile (*Chamomilla recutita* L.)

Essential oil yield and composition in aromatic crops might be affected by genetic, agronomical and environmental factors but till date there is no clear information about the harvesting time and distillation for higher essential oil content without affecting quality. The current study was carried out to evaluate harvesting of chamomile flowers without herb and with herb part at three different times (6 A.M., 12 P.M. and 6 P.M.) and four distillation treatments (3 h, 4 h, 5 h & 6 h) for dried chamomile flowers. Results indicated that essential oil content was more in chamomile flowers without herb (0.15-0.18%) as compared to flowers with herb (0.06-0.09%). Essential oil content in chamomile flowers without herb was found statistically at par at harvest time of 12 P.M. (0.18%) and 6 P.M. (0.18%) and significantly higher than harvesting time of 6 A.M. (0.15%). Essential oil of chamomile flowers without herb contained maximum α-bisabolol oxide-B, (Z)-spiroether, and chamazulene at 12 P.M. and 6 P.M. while, α-bisabolone oxide-A and α-bisabolol oxide-A were maximum at 6 A.M. and (E)-β-farnesene was more at 12 P.M. Similarly, in distillation experiment, higher oil content was observed in chamomile dried flowers which were hydro-distilled for 6 h (1.20%) compared to other hydro-distillation durations. Marker compounds i.e. α-bisabolol oxide-A, α-bisabolone oxide-A, α-bisabolol oxide-B, (E)-β-farnesene and chamazulene were more at 5 h and 6 h distillation duration while (Z)-spiroether was more at 3 h distillation duration. The present study showed that in order to obtain higher essential oil, flowers without herb harvested at 12 P.M or 6 P.M. should be subjected to 5-6 h hydro-distillation.

Table 1: Essential oil content (%) in fresh flower with herb and without herb harvested at different time

(Harvesting time)	Essential Oil content (%)	
	Fresh flower without herb	Fresh flower with herb
6 AM	0.15	0.06
12 AM	0.18	0.09
6 PM	0.18	0.09
C.D (P = 0.05)	0.01	0.01

Table 2: Essential oil content (%) in dried flowers at different hydro-distillation duration

Hydro-distillation duration	Essential oil content (%)
3 h	0.600
4 h	0.700
5 h	0.875
6 h	1.200
C.D (P = 0.05)	0.106

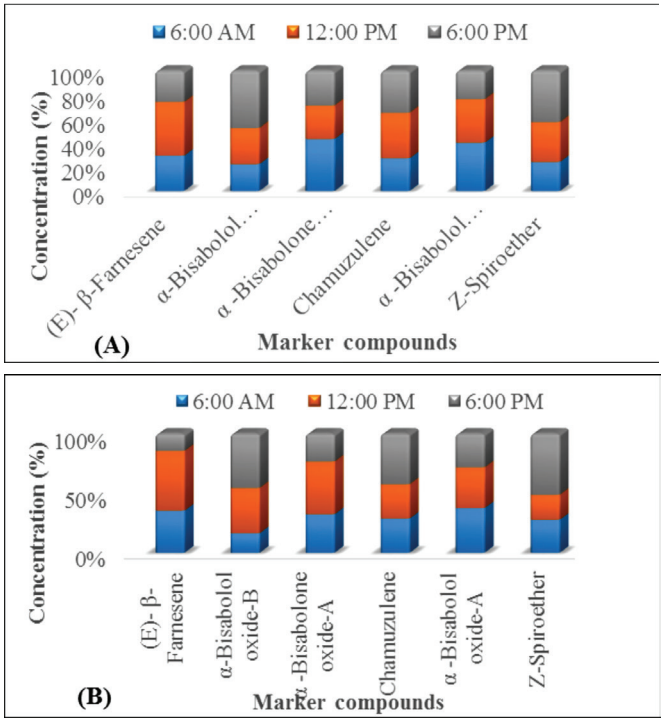


Fig. Marker compounds presence in chamomile fresh flower without herb **(A)** and with herb **(B)** at different harvesting timing

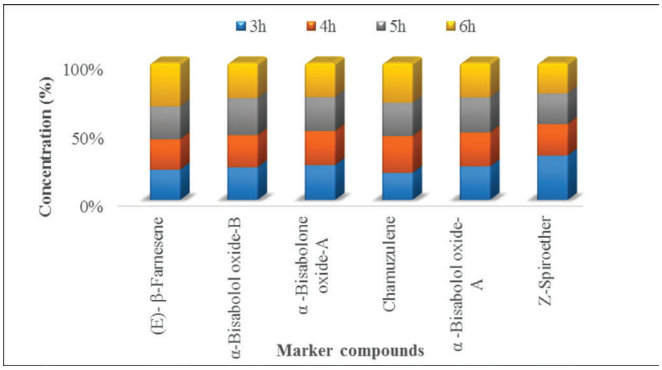


Fig. Marker compounds presence in dried chamomile flowers at varied hydro-distillation duration

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

Identification of insect pest problems of mint (*Mentha arvensis*) in Uttar Pradesh

Roving surveys of major mint growing districts of Uttar Pradesh indicated that major insects attacking mint crop included leaf eating caterpillars, Bihar hairy caterpillar, semilooper, cutworms, tobacco leaf eating caterpillar, leaf webber, aphids, whiteflies, lacebug, mites, and termites. Mint growing farmers were interviewed using semi-structured questionnaire to assess their knowledge and perceptions of insect pests and pest management practices. Studies revealed that farmers were aware of insect pests and considered them the major constraints to mint production, causing significant yield losses. More than 95 percent of farmers relied on chemical insecticides to control insect pests. Insecticides from groups, namely, organophospahtes or their mixtures, avermectins, diamides, and local bio-based pesticides

were used by farmers. An average of five times pesticides was applied during the mint growing season. Most of the farmers' decision to apply the insecticides was mostly on noticing the presence of pest. The study also showed that less than five percent of the farmers had some knowledge of biological control, integrated pest management and other alternative pest control methods. Present findings indicate a need to develop to integrated pest management strategies to reduce the over reliance on pesticides.

Diversity of coccinellid predators in medicinal and aromatic plants agroecosystem

Coccinellid predators are one of the most important group of natural enemies that feed on soft bodied insect pests namely, whitefly, aphids, scales, mealybugs, and other arthropods. Studies on predatory coccinellid beetles diversity in medicinal and aromatic plants agroecosystem is crucial for applied and conservation biological control of pests. Investigations on the identification of different coccinellid predatory beetles in MAPs agroecosystem revealed that seventeen different species belonging to three sub-families Coccinellinae, Chilocorinae, and Scymninae were recorded. All of them had different dynamics of appearance on different sucking pests of medicinal and aromatic plants. These predatory coccinellid beetles were recorded on whiteflies, aphids, mealybugs, scales, and mites damaging medicinal and aromatic plants. Further, there is a need to conserve these coccinellid predatory beetles for enhancing natural biological control of insect pests in MAPs agroecosystem by using organic methods of insect pest control in MAPs.

Aphids diversity in medicinal and aromatic plants agroecosystem

Aphids are the major pests of agricultural and horticultural crops. Information on the different aphid species attacking medicinal and aromatic plants is scanty. Further, the knowledge on the identification of aphid species is a critical component in the development of sound and sustainable integrated pest management strategies. Samples of aphids infesting different medicinal and aromatic plants (MAPs) were collected and preserved for identification. A total of 10 aphids' species infesting different MAPs were identified. The period of occurrence of different aphids varied on different MAPs.

Dr. Santoshkumar C. Kedar & his team

Dr. Priyanka Suryavanshi Mk- fi;dk l;oa'kh

Effect of biostimulants on crop productivity

Effect of medicinal and aromatic plant-based biostimulants on crop growth, soil health and productivity of tomato was evaluated by conducting a preliminary pot experiment. Tomato varieties were Pusa Ruby, Pusa Rohini and Pusa Cherry, Kashi Aman and Kashi Vishesh. Essential oils of *Mentha arvensis*, *Ocimum basilicum*, Palmarosa, Lemongrass and aqueous extract of *kalmegh* were evaluated. Three foliar sprays were provided, first spray at the time of branching, second at anthesis stage and third at early fruit setting stage. Results revealed that MAP based bio stimulants at specified concentrations can possibly enhance growth and productivity of tomato crop.

Fig. Fruits of different varieties of tomato from pot culture experiment

Effect of biofertilizers and foliar applied botanicals on growth, yield and quality of tulsi, geranium, ashwagandha and isabgol were evaluated in pot experiments. Results suggest that crop growth attributes, yield and quality of all these crops were significantly enhanced by combined application of bacterial inoculants and botanicals rather than control. Effect of mychorrhizae inoculation, phosphorus application and organic mulching on yield and quality of geranium was evaluated by conducting a field experiment. Results suggest that this combination can enhance geranium productivity and enhance soil fertility status.

Performance of medicinal and aromatic plants as suitable intercrops in tomato

A field experiment was conducted during *rabi* season 2020. The experiment was laid out in Randomized Block Design (RBD) with three replications along with five treatments namely T1- Control (Sole Tomato), T2- Tomato + Chamomile, T3- Tomato + Tagetes, T4- Tomato + Geranium, T5- Tomato + Withania). Results revealed that intercropping, especially with Tagetus can be a possible measure to enhance system productivity, land equivalent ratio and enhancing farmers income.

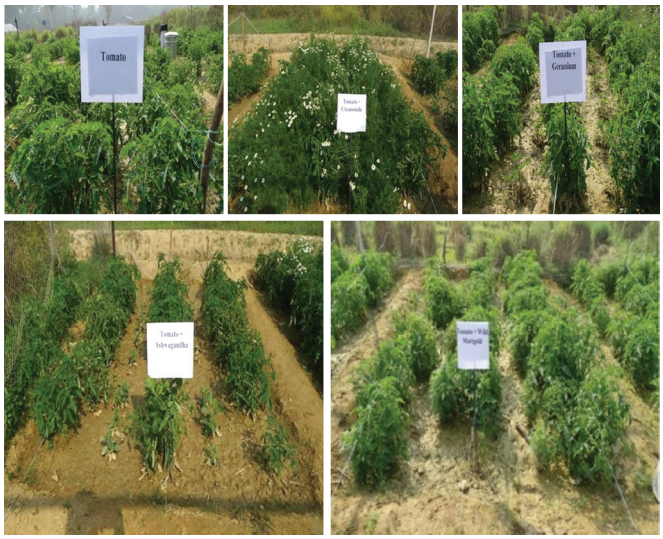


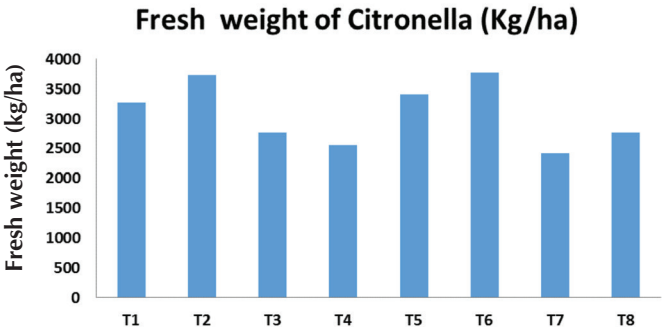
Fig. Field overview of treatment plots in tomato intercropped with MAPs

Dr. Priyanka Suryavanshi and her team

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

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 citronella is common during 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 spit plot design at 3 levels of fertilizers and manures with two levels of mulching in two replications at CIMAP Lucknow to study of effect of mulching and different rates of organic and inorganic fertilizers on growth, yield of Citronella and soil health.



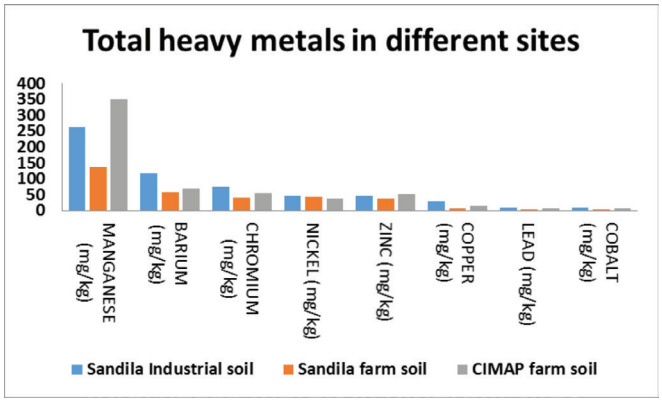
(T1: control ,T2: Compost alone (12 ton/ha), T3: Farmers practice (120:80:60 and 10 ton compost) T4: 125% of fertilizers of Farmers practice +75% of manure in FP, T5: 75% of fertilizers of Farmers practice +125% of manure in FP, T6: 150% of fertilizers of Farmers practice +50% of manure in FP, T7: 50% of fertilizers of Farmers practice +150% of manure in FP, T8: 200% of fertilizers of Farmers practice)

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 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 is very scarce. 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.

The Assessment of soil fertility and soil pollution in the industrial area of Sandila, Uttar Pradesh

Sandila in Uttar Pradesh is known for Industries. Soil fertility and heavy metal content in agricultural land is more concerned due to the many industries surrounding the town. The present study was taken up in 2020-21 to evaluate the impact of industries on soil fertility and heavy metal status in agricultural land. For this, three composite soil samples in triplicates in each soil site of Industrial area , Agricultural land surounding industry and CIMAP farm (control) were collected and analysed for physicochemical properties, micronutrients and heavy metal content. The results indicated that the deterioration of physicochemical propertied like pH, EC and OC in industrial soil compare to others. The presence of sufficient quantity of micronutrients in agricultural land surrounding industries is recorded, however the higher concentration of heavy metals like Nickel (Ni), copper (Cu), Fe and zinc (Zn) pose a serious threat to the human health. Hence remediation of these soils is the need of the hour. The cultivation of non food crops like aromatic crops in these polluted agricultural lands is more suitable as remediation measure.



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

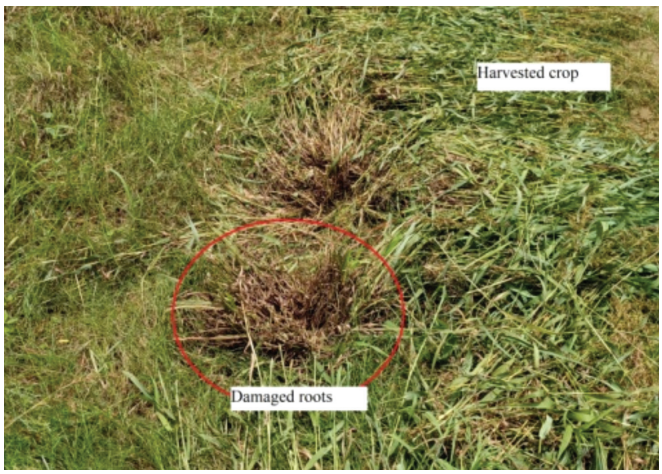
Performance evaluation of tractor drawn Vetiver root digger in the sandy soils

CSIR-CIMAP developed khus digger has been evaluated in the sandy soils. The digger consists main frame to which all other parts are connected, one vertical disc for loosening the soil, one mould board for penetrating, cutting and pulverizing the soils to separate the roots from the soil immediately. Also it includes one standard which connects the main frame and mould boar and three point hitching system. The 60 hp tractor was used for evaluation and it was observed that continues operation of digging is not able to achieve and proper separation of soil from roots was not possible. Only 70% of roots were able to dig out from soil and remaining

30% of roots were left in the soil itself. This is because the vetiver roots were grown upto a depth of 50 cm and digger was not able to reach this much depth. Hence, to overcome these limitations, the modifications of the digger are essential. Therefore to develop improved version of root digger, the calculations for design modifications has been done.

Performance evaluation of tractor drawn vertical conveyor reaper for Palmarosa crop

Generally the Palmarosa grows upto a height of 1.3 to



2.0 m and spreads its canopy upto 0.2 to 0.4 m width. The paddy harvester i.e. vertical conveyor reaper has been evaluated for harvesting Palmarosa crop in the experimental farm. The reaper was operated from the tractor power take off power. The reaper consists of 7 crop dividers, crop conveying belt, cutter bar whose stroke length is 76.4mm, crank to convert rotary motion to reciprocating motion for cutter bar and three point hitch system. The reaper was mounted at the rear of the tractor and operated by moving the tractor in reverse direction. It was observed that the reaper can cut and convey the crop in proper manner without damaging the biomass. The field capacity of the reaper was found as 0.3 ha/h. However, the un-harvested portion left for further growth to get next cutting is getting damaged due to movement of the tractor in the field. Hence, the tractor operated reaper would not suitable harvester for Palmarosa harvesting. So, development of self propelled harvesting equipment for Palmarosa harvesting is going on.

Plant Breeding and Genetic Resource Conservation

HIGHLIGHTS

During 2020-21, Plant breeding and GRC division has been actively involved in development of new varieties and conservation of MAPs. During this period various projects (06) were sanctioned from NMPB, NMMP, Dept of Horticulture, Karnataka, BARC Mumabi and CSIR, New Delhi.

Genetic improvement program in *Ammi Visnaga* led to the identification of genotypes having carotol content of more than 66 percent (AV 45 and AV 7). Predominance of non-additive gene action over the additive gene action in the inheritance of variations for yield and yield attributes was observed in *Papaver somniferum* L.

G x E and stability study conducted in three different soil conditions for rhizome yield among selected superior genotypes of *Curcuma longa* (Turmeric) which has led to the identification of most stable genotype/s across the different soil types genotype suitable for productive soil and genotype/s suitable for poor soil. Highly divergent clusters of genotypes were identified for selection of suitable parents and to use them in hybridization program. High seed yielding genotypes *Abelmoschatus moschatus* were identified (CIM-AM 22, CIM-AM 40, and CIM-AM 49).

Effect of potassium and sodium chloride-induced stress on seed germination percentage, seedling vigor index along with biochemical parameters like carbohydrate, protein, catalase, total phenolic- and proline-content of two *Ocimum tenuiflorum* varieties (CIM-Ayu and CIM-Angana) at different salt concentrations were tested.

Five *Swertia chirayita* genotypes collected from Devvan, Yuksom, Sukhia, Kaddukhal and Kalimpong were tested in lower Himalayan altitude of Uttarakhand. Study

Scientists of Plant breeding and Genetic Resource Conservation Divisional Unit

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

showed that the Gwaldam and Chamoli location was best for the growth and performance of all genotypes followed by Kausani and Purara.

DNA barcode based species-specific marker (designated as CIM-PATH-fwd/CIM-PATH-rev) for *Ocimum tenuiflorum* were developed, which can be successfully employed as a taxonomic marker for *O. tenuiflorum*.

Leaf cell suspension cultures from friable callus were established for conservation of RET species *Decalepissa licifolia*. The light dependent increase in production of vanillin and ferulic acid in suspension cultures was observed with highest production achieved in 40 days. In Magnolia *sirindhorniae* Noot. & Chalermglin, the essential oil secretory cells, oil constituents and its biological activities were first time reported from India.

An advanced breeding line was developed of *Anacyclus pyrethrum* (Akarkara) rich in Pellitorin content with high number of flowers and root yield. Total 14 lines of Kalmegh were selected from M_6 mutant population based on the estimated Andrographolide and Neo-Andrographolide content ranging from 2.00 to 4.20%. Elite lines with high herb yield and high andrographolide content have been selected using half-sib selection scheme. Advanced Varietal Trial and Bench Scale trail of superior clones of selected previously were carried out in lemongrass. The oil content ranges from 2.20-2.8% comapred to check variety 1.2-1.4%.Totally 180 half-sib seed progenies in *Mentha arvensis* were developed and evaluated.

During this period, 29 research articles were published in reputed high impact journals such as Industrial Crops and Products, Innovative Food Science and Engineering Applied Biochemistry & Biotechnology.

Dr. Vedram Singh Mk- onjke flg

Morphological and genotypical variability in *A. visnaga*

Morphological variability was detected for stem and umbel color from center reddish to pink during vegetative growth. In this study, high genetic co-variance (GCV) and high heritability with maximum genetic advance (GA), and high mean percentage were noticed for biological yield and harvest index and seed yield. These auspicious traits would possibly be governed by additive gene effects, which could help select the best genotypes using an appropriate breeding strategy for crop improvement. The highest positive and significant genotypic and phenotypic correlation coefficient was recorded for the number of umbels correlated between biological yields and seed yield. On the other hand, the path coefficient study revealed that the harvest index has the maximum direct contribution followed by biological yield, number of primary branches, and umbels on the seed yield. Results clearly showed variation in important economic traits could facilitate selection for further genetic improvement in *A. visnaga* genotypes. In this study, several unique accessions were identified that might be exciting genotypes for the genetic modification of the different morphometric characters in the hybridization program. The accession no. AV-45 was having the highest carotol (66.1%), followed by AV-7 carotol (66.0%). Therefore, these accessions can be further exploited for commercial production (J. Essential Oil-Bearing Plants 24 (2) 2021 pp 277 - 289).

Fig. Morphological variation in *A. visnaga*

Fig. Non-fringed and fringed petals lines of *Papaver somniferum* L.

Characterization of fourteen economics traits of *Papaver somniferum*

Totally 60 F1s were developed by using line × tester (L x T) mating design from 12 females (lines) and 5 males (tester) diverse parents of *Papaver somniferum* L. collected from different geographical places of India and also some exotic genotypes are therein were characterized for fourteen economical traits. The mean squares due to GCA and SCA were found significant for all the traits indicated the importance of additive as well as non-additive genetic variance playing a significant role in controlling the expression of all the characters. The ratio GCA/SCA was less than unity (<1) and variances due to SCA was higher than variances due to GCA for all the attributes under study indicated predominance of non-additive gene action over the additive gene action in the inheritance and also suggested high potential of the exploitation of variations for yield and yield attributes, useful for genetic improvement of studied characters. Therefore, obtained best parents and cross combinations in this study can be effectively utilized for improving of yield attributes in *Papaver somniferum* L. (Plant Archives Vol. 21, Supplement 1, 2021 pp. 1798-1810).

Dr. Ved Ram Singh & his team

Dr. Birendra Kumar Mk- chjUnz dqekj

Genetic variability and character association among morpho- metric traits and essential oil constituents in eight half-sib seed progenies of peppermint (*Mentha piperita* L.)

Menthol rich with low menthofuran peppermint (*Mentha piperita* L.) genotype MPK-5 and their eight half-sib seed progenies were evaluated for different genetic parameters, namely coefficient of variation, genetic advance, heritability, associations, and path analysis for different economic characters, viz., plant height, leaf length, leaf width, leaf : stem ratio, herb yield, essential oil content (%), and contents of various essential oil constituents (quality traits) such as sabinene, β-myrcene, limonene, α-pinene, β-pinene, 1,8-cineole, menthone, menthofuran, *neo*-menthol, isomenthone, menthyl acetate, menthol and pulegone. The phenotypic coefficient of variations (PCV) were found slightly higher than the genotypic coefficient of variations (GCV) for the characters studied, indicating that the apparent variation was not only due to genetic but also influenced by the growing environment for the expression of studied traits. The highest genotypic coefficients of variation (GCV) was noted for the character pulegone, followed by menthofuran and 1,8-cineole. High heritability coupled with high genetic advance was observed for menthol followed by pulegone demonstrating that these chemical compositions might be under non-additive genetic control. The genotypic correlations were higher than the phenotypic correlations for studied traits. The significant and positive associations of β-pinene with sabinene and 1,8-cineole; α-pinene with β-pinene, sabinene, and 1,8-cineole; menthyl acetate with *neo*-menthol; and sabinene with 1,8-cineole were noted. A high direct positive effect was also recorded between menthofuran and limonene (*Trends in Phytochemical Research*. 2020:4: 143-152).

Gamma irradiation induced variability in morpho-agronomic and oil quality traits of *Mentha piperita* L.

The dormant runner of menthol rich genotype MPK-5 of *Mentha piperita* L. was subjected to different doses of γ- irradiation (10, 20, 30, 50, 70, 90 and 110 Gy) at a dose rate of 55 Gy/ min to induce the genetic variability for morphotype, herb and oil yield of *M. arvensis* as well as oil quality of *M. piperita*. Wide spectrum of variability for herb yield, agro- morphological traits and quality profile was observed among the mutants. The developed and selected mutants namely viz. MPK-5(1) and MPK-5(3) identified as promising mutants, based on mean herb yield: 23.9 and 21.5 Kg/m^2, mean oil yield:92.9 and 80.0 ml/plot and essential oil quality: mean menthol content of 69.01 and 69.16% with mean menthofuran content of 1.55 and 0.53%, respectively. Mutational breeding through γ- irradiation is considered complementary to conventional breeding method, to broaden the spectrum of genetic variability [*International Journal of Radiation Biology*. 2021: 97(5): 1-10. (IF:2.368)]

Influence of potassium and sodium chloride on germination behaviour, biochemical changes, and enzyme activity in two varieties of *Ocimum tenuiflorum* L.

Ocimum species is widely distributed throughout the sub-tropical and tropical regions of the world. The present study was conducted to assess the effect of potassium and sodium chloride-induced stress on germination percentage, seedling vigor index along with biochemical parameters like carbohydrate, protein, catalase, total phenolic content and proline of two *Ocimum tenuiflorum* varieties viz. CIM-Ayu and CIM-Angana at four different salt concentrations (control, 50mM, 100mM, 150mM). The results revealed that CIM-Angana has superior adaptation and tolerance potential (up to 100mM) than CIM-Ayu by depicting a higher percentage of germination and seedling vigor index along with elevated levels of carbohydrate and protein content. The variety CIM-Angana was found to be more salt tolerant than CIM-Ayu. Therefore, it could be suggested to raise the nursery of CIM-Angana under normal conditions of the soil and after that seedling can be transplanted in presence of salinity up to 100 mM of NaCl or/and KCl salts [*Journal of Essential Oil-Bearing Plants*.2021: 24(1): 110-119. (IF:0.824)]

Survival, performance and adaptation of *Swertia chirayita* genotypes at western Himalayan zone of Uttarakhand

Five *Swertia chirayita* genotypes: Devvan (G1), Yuksom (G2), Sukhia (3), Kaddukhal (G4) and Kalimpong (G5)

at three locations: Purara, Gwaldam and Kausani of lower Himalayan altitude of Uttarakhand were studied for the survival, performance and adaptation during October 2018 to Januray, 2020. Gwaldam, Chamoli (Uttarakhand) location was found to be the best for the growth and performance of all genotypes followed by Kausani and Purara. The genotype G5 (Kalimpong) showed higher survival rate, performance and adaptability as compared to other and can be successfully grown to obtain dry herb in Gwaladam. [*Journal of Medicinal and Aromatic Plant Sciences*. 2020: 42(3-4): 220-228].

Identification and characterijastion of elite line/strain in cannabis species

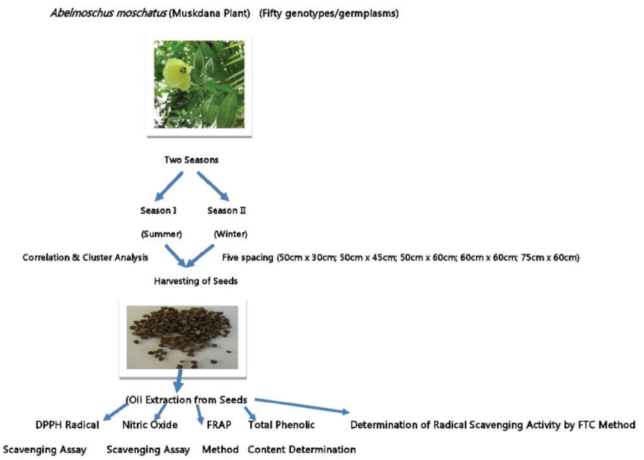
Surveyed 13 major cannabis growing states and collection of about 140 germplasm/accession was made and evaluated at CSIR-CIMAP. In these accessions/collections, THC content was found to be ranging from 0.1-7.27% while CBD content from 0.01-3.89% and THCa from 0.1-4.98% (mean over the plant parts). High CBD with low (less than permissible limit) THC (less than 0.3%) contents (mean over the plant parts) was recorded in two Indian accessions. During screening, few accessions showed low CBD (less than 1.0%) with high THC (more than 2.0%) contents (mean over the plant part) and high CBD (2.0-3.5%) with high THC (1.0-3.0%) contents (mean over the plant part) are also recorded and these accessions were destroyed in the presence of deputed excise officers by Excise Commissioner. Nursery raised under glasshouse (controlled) condition was observed better and nipping at 35 DAT with 120:60:40kg/ha. NPK level was found suitable for the maximum flower yield/plant and yield attribute traits. Oral administration of cannabis extract coded as IVT/CB-1 has shown significant pain-relieving potential.

Dr. Birendra Kumar & his team

Dr. Anil Kumar Gupta Mk- vfuy dekj xIrk

Genotype x environment interaction, stability analysis for yield and quality traits in turmeric (*Curcuma longa* L.)

Genotype x environment interaction and genotype stability were analyzed using Eberhart and Russell model among seventeen accessions/ germplasms of turmeric (*Curcuma longa* L.) over three environments/years. The average rhizome yield (over three environments) ranged from 241.41 q/ha (CIMCH14127) to 579.67 q/ha (CIMCH14229). Six genotypes, namely CIMCH14107, CIMCH14171, CIMCH14165, CIMCH14130, CIMCH14208, and CIMCH14229 had significantly higher mean rhizome yield as compared to the general mean. Among seventeen genotypes, five genotypes had more than 1 regression coefficient (bi), while eight genotypes had less than 1 regression coefficient and four genotypes showed bi = 1. For CIMCH14101, CIMCH14144, CIMCH14159, CIMCH14190, CIMCH14152, CIMCH14123, and CIMCH14164, S2di (deviation from regression) was significant. The stability parameters for rhizome yield revealed that CIMCH14171 and CIMCH14229 providing stable rhizome yield for all three environments. Three genotypes viz., CIMCH14107, CIMCH14130, and CIMCH14208 genotypes were suitable for unfavourable (poor) environment having mean values, bi < 1 and S2di = 0. For rhizome yield, CIMCH14107 showed suitability under only favourable (rich) environment. (Trends in Phytochemical Research)



Effects of season and spacing on growth pattern and seed yield of Muskdana genotypes (*Abelmoschus moschatus* L.) and radical scavenging activity of its seed oil

A study was conducted to evaluate the effects of season and spacing on growth patterns and seed yield performance of muskdana by estimating fixable and non-fixable components of genetic variances for diverse traits of economic significance and identification of highly divergent clusters of genotypes and thereby to exploit them in hybridization program. Radical scavenging activity of oil from muskdana seeds was also studied. The field experiment was conducted in two growing seasons, namely January to June (season I) and July to December (season II) with five different spacing levels at CIMAP. From the results, it was concluded that genotypes CIM-AM 22, CIM-AM 40, and CIM-AM 49 of *A. moschatus* have greater potential in terms of seed yield. Its oil was also effective and exhibits significant radical scavenging activity which was comparable with standard antioxidants such as ascorbic acid, BHA, and BHT (Trends in Phytochemical Research).

Dr. A.K. Gupta & his team

Dr. V. Sunderasan Mk- oh- lnjlu

DNA barcode based species-specific marker for *Ocimum tenuiflorum* and its applicability in quantification of adulteration in herbal formulations using qPCR

Ocimum tenuiflorum L. is a highly traded and extensively used species in Ayurvedic medicine owing to its immense therapeutic potential, which has led to adulteration of both formulations as well as traded raw drugs. To meet the standard international market requirements, quick and efficient techniques for authentication are required which can keep pace with the increasing demand for the herb. In view of this, a species-specific marker (designated as CIM-PATH-fwd/ CIM-PATH-rev) was designed based on the differences in the nucleotide sequence of the *psbA-trnH* intergenic region. A consistent amplicon of 218 bp was generated across all the *O. tenuiflorum* accessions and was absent in other *Ocimum* species studied. Further, developed species-specific primers were assessed for simultaneous authentication as well as quantification of *O. tenuiflorum* in commercially purchased herbal formulations by SYBR green-based quantitative real-time PCR assay. The established qPCR method was determined to be effective for the authentication and relative quantitative assessments of the products. The species-specific marker developed can be successfully employed as a taxonomic marker for *O. tenuiflorum*.

Production of vanillin in cell suspension cultures of *Decalepis salicifolia*

Leaf cell suspension cultures were established from friable callus of *Decalepis salicifolia*. The suspension cultures accumulated vanillin and a light dependent increase in production was observed. Cultures incubated under light and dark did not show significant difference in biomass accumulation, however significant difference in vanillin and ferulic acid production was observed. Accumulation of vanillin and ferulic acid was higher under illumination and highest production was achieved in 40 days. Precursor feeding with ferulic acid was found to increase vanillin accumulation by 4.6-fold as compared to the control cultures in 3 days post elicitation and by 4.3-fold in 6 days.

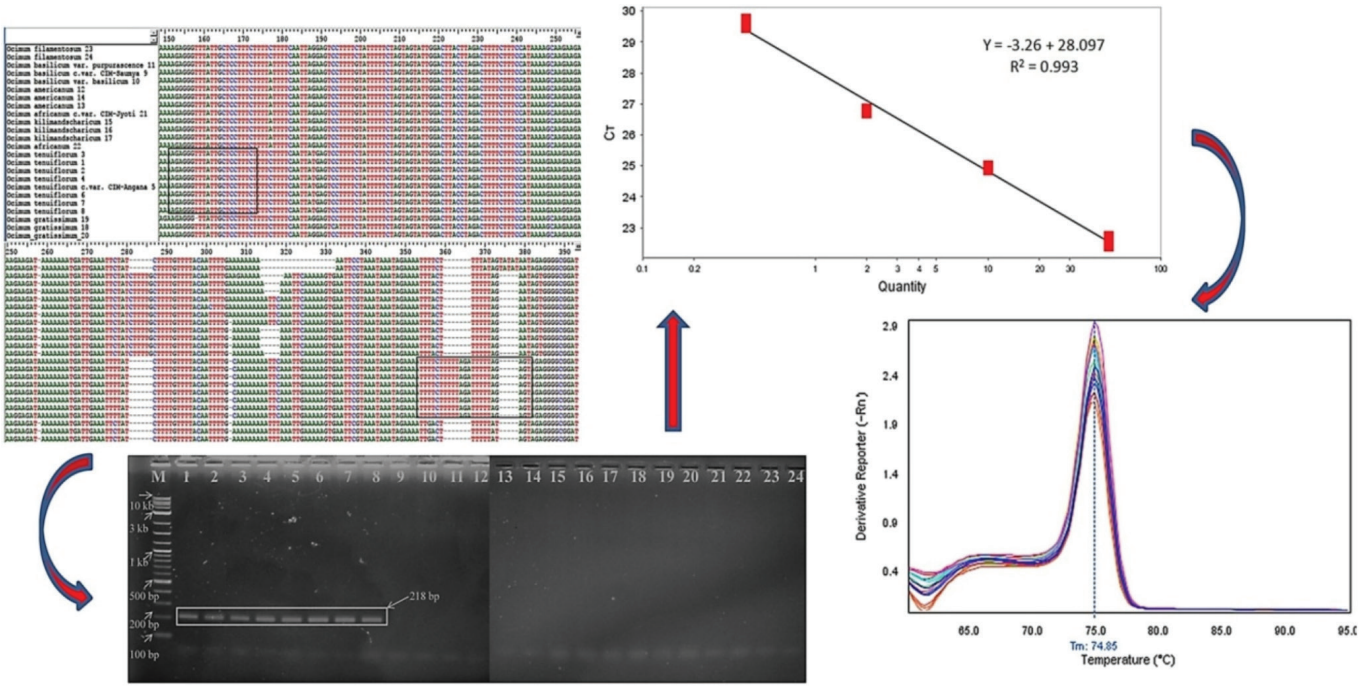


Fig. Design of species-specific marker primer, amplification of different *Ocimum* species with developed species-specific markers, melting curve of real-time PCR.

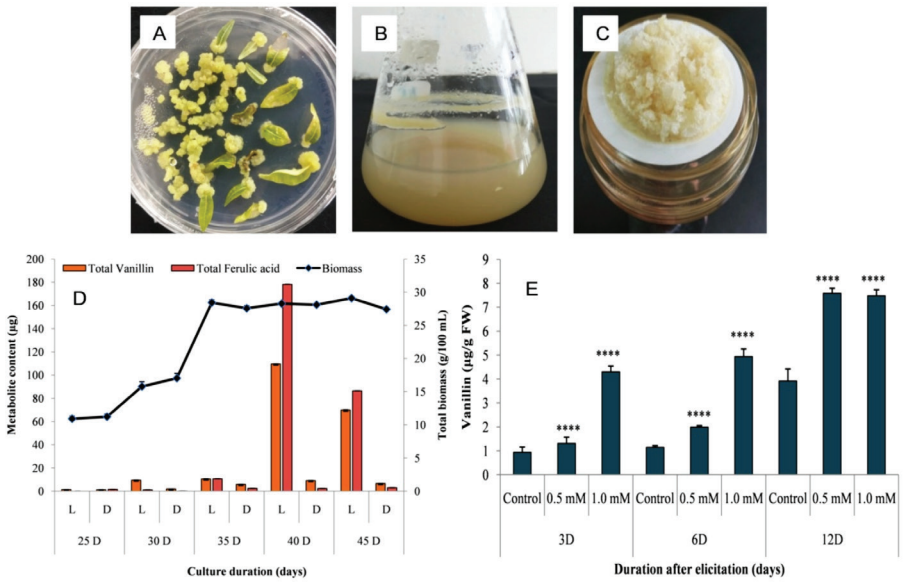


Fig. (A) Induction of leaf callus, (B) cell suspension culture, (C) harvested cell biomass, (D) Effect of culture duration and light on biomass and metabolite production in cell suspension cultures, (E) Effect of ferulic acid feeding on accumulation of vanillin

Effect of salt stress on seed germination, morphology, biochemical parameters, genomic template stability, and bioactive constituents of *Andrographis paniculata* Nees

High level of salinity present in the soil severely affects plant growth and metabolism, eventually reduces crop productivity. In the present study, we have made an effort to obtain detailed insight on the effect salinity on various parameters of *A. paniculata* genotype, CIM-Megha. Maximum seed germination efficiency was observed at 100 mM and with increase in salt concentration, the overall growth of plant was stunted. High salinity had a negative effect on photosynthetic pigments, free cysteine content, non-protein thiol content, and nitrate reductase activity. However, proline accumulation and phenol content were found to increase with the increasing salt concentration. The results from the study demonstrated that activities of CAT and APX antioxidant enzymes increased with the applied salt stress. The accumulation of reactive oxygen species in response to salinity is the most important DNA-damaging factor causing a decrease in the genomic template stability of the plant. Quantification of important bioactive constituents (andrographoloide, neo-andrographolide and 14-DDA) was done through HPLC, and the result showed high variability in constituents. *A. paniculata* may be grown at large scale in saline areas having up to 100 mM salt concentration.

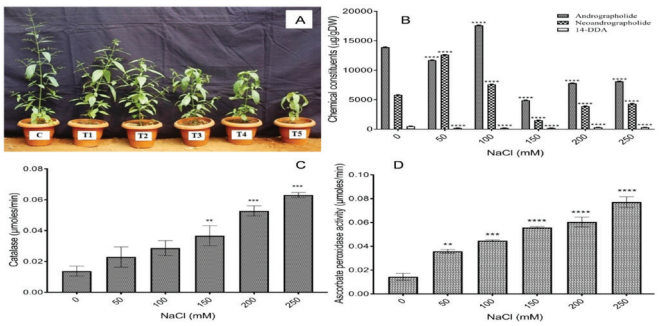


Fig. Effect of different salt concentrations on (A) morphology (B) bioactive constituents quantified through HPLC (C-D) activity of antioxidant enzymes CAT and APX.

Dr. V. Sunderasan & his team

Dr. Tripta Jhang Mk- rfIrk >kx

Citral rich advance breeding line in *Ocimum basilicum x Ocimum africanum*

- *Genesis: O. basilcum* x *O. africanum*---.>3F1 Plants (citral content 31%, EOC 0.2 with high biomass 1200 gm/plant from 2013 were subjected to targeted selection. 12 entries with check CIM Jyoti in three replications has citral content 58-65% (Neral+ Geranial), EOC:0.2-0.3 Fresh Herb Yield: 350-750g /plant(2016-18)

Table: Comparision of yield attributes of H5-2-2-1 with CIM Jyoti

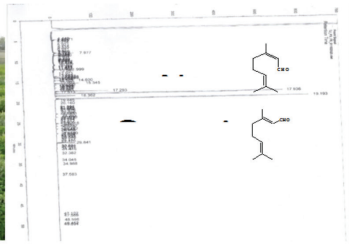
Parameters	H5-2-2-1	CIM- Jyoti
Plant height (cm)	85-110	30-45
Citral content (%)	71	61-75
Oil content (%)	0.37-0.47	0.4-0.67
Fresh herb yield q/ha	388	233
Oil yield (Kg/ha)	166.5	134.8
Days to maturity	165	150
Specific gravity (18 ˚C)	0.9028	0.8913
Optical rotation (20 ˚C)	-5.55	-10.77
Refractive index (20 ˚C)	1.4894	1.4848

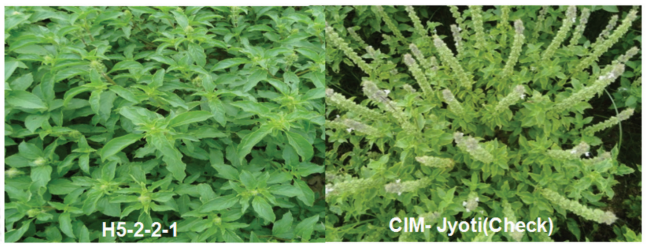
Genetic Enhancement of Pellitorin in *Anacyclus pyrethrum*

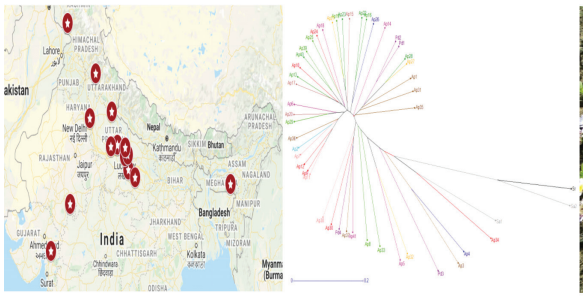
- Mutation Breeding: 4 Mutagens x 5conc x 3time interval
- Pellitorin content increased from 0.08 to 0.12% in roots over four cycles of selection in Accessions
- Pellitorin content inversely correlated with RDW& Herb weight.
- Using NEU and EMS rayless "petal drop mutant were obtained and stabilized at M5.They show normal seed set.

Sodium azide treated subpopulation yielded Multiple whorl flowers

Dr. Tripta Jhang & her team







Dr. Narendra Kumar Mk- ujUn d|ekj

Diversity of Essential Oil-Secretory Cells and Oil Composition in Flowers and Buds of *Magnolia sirindhorniae* and Its Biological Activities

Magnolia sirindhorniae Noot. & Chalermglin produces fragrant flowers. The volatile oil secretary cells, quantity and quality as well as antioxidant and antimicrobial activities of the oils extracted from buds and flowers, have been investigated. The distribution of essential oil secretory cell in bud and flower revealed that the density and size of the oil cells were significantly higher in flowers compared to buds. In different floral parts, carpel has a higher oil cell density followed by gynophore and tepal. The histochemical analysis revealed the essential oil is synthesized in oil secretory cells. The volatile oil yield was 0.25% in the buds and 0.50% in flowers. GC/FID and GC/MS analysis identified 33 compounds contributing 83.2–83.5% of the total essential oil composition. Linalool is the main constituent contributing 58.9% and 51.0% in the buds and flowers oils, respectively. The essential oil extracted from the flowers showed higher antimicrobial efficacy against *Klebsiellapneumoniae* and *Staphylococcus aureus*. Similarly, the essential oil isolated from the flowers depicts higher free radical scavenging, and antioxidant activity compared to buds' oil.*(Chem. Biodiversity* **2021**, *18*, e2000750 DOI: 10.1002/cbdv.202000750)

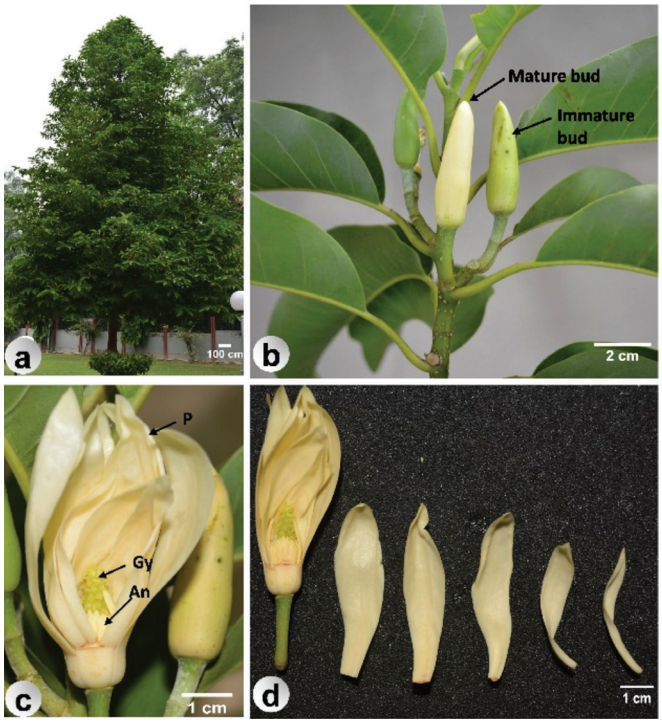


Fig. M. sirindhorniae a) plant habit, b) branch with buds, c) dissected bud showing outer and inner tepals, d) dissected flower showing tepal whorls gynophore, carpels and anthers. c), d) frames are showing sample used for the anatomical and histochemical study.

Table: Essential oil secretory cell size and density in floral parts.

Floral part	Oil cell density (per mm²) (mean ± SEM)				Oil cell size (μm) (mean ± SEM)			
	Flower		Bud		Flower		Bud	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Tepal (Outer whorl)	37.25 ± 0.89	20.85 ± 0.77	26.27 ± 0.88	19.11 ± 1.2	52.87 ± 0.95	56.36 ± 0.67	48.58 ± 0.89	49.62 ± 0.72
Tepal (Inner whorl)	19.41 ± 0.89	8.23 ± 0.58	18.23 ± 0.96	5.29 ± 0.58	49.30 ± 1.3	56.90 ± 0.96	44.74 ± 1.17	47.79 ± 1.35
Gynophore	42.54 ± 0.57		36.96 ± 0.96		56.19 ± 0.84		38.60 ± 0.81	
Carpel	98.24. ± 2.78		86.74 ± 3.61		55.69 ± 1.18		45.95 ± 1.67	

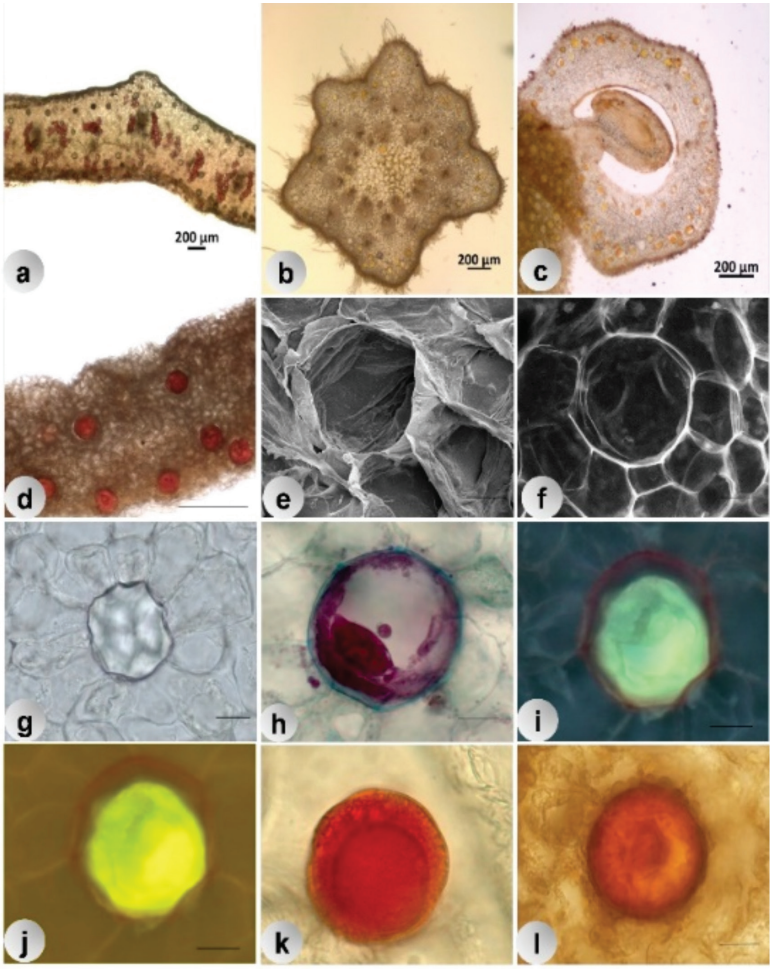


Fig. 2. Histochemistry and fluorescence study. Cross-sections a) tepals, b) gynophore, c) carpel, d stained tissue showing the distribution of oil cells in tepal, e) unstained oil cell (control), f) ESEM micrograph of oil cell, g) essential oil-stained pink with Nile blue, h), i) oil cell stained with Neutral red showing fluorescence at different UV filters, j) terpenes stained blue with Nadi reagent, k) sesquiterpene in the essential oil cell stain reddish-brown with concentrated H2SO4, l) lipophilic substances in oil cell imparts orange color with Sudan IV.

Dr. Narendra Kumar & his team

Dr. Channayya Hiremath Mk- pUu¸;k fgjeV

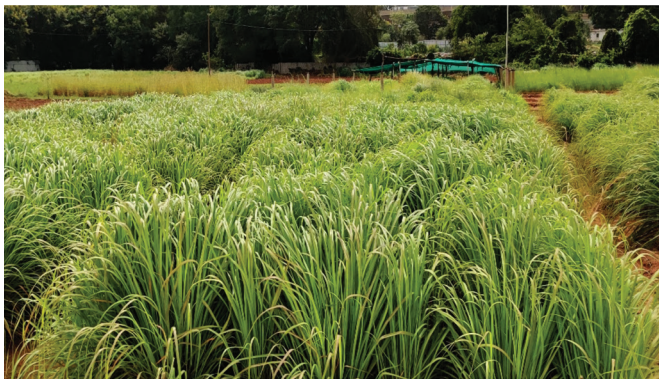
Genetic enhancement of kalmegh through Mutation breeding:

M_6 mutant population of Kalmegh evaluated and selected around 14 best lines based on the estimated Andrographolide and Neo-Andrographolide content. Chemical content ranged from 2.00 to 4.20% in mutant population compared to control check parent CIM-Megha which is having 1.90-2.00%.

Evaluation of lemongrass clones for high oil and citral content

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

Lines	Oil Content (%)	Citral (%)
S-1	2.50-2.80	79.00-83.00
S-2	2.10-2.30	81.00-82.50
S-3	2.20-2.40	82.00-84.00
S-4	2.10-2.20	80.00-82.00
S-5	2.10-2.25	79.00-82.00
Krishna	1.55-1.65	72.00-76.00
CIM-Shikar	1.600-1.80	85.00-87.00



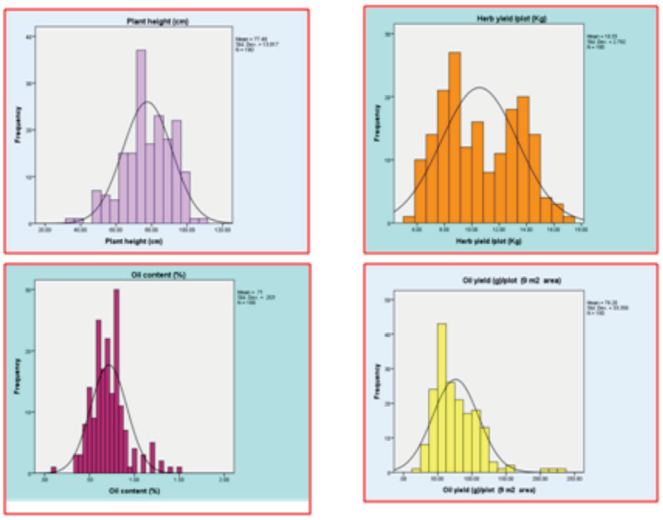
Eucalyptus citriodora

In CSIR-CIMAP, Research Centre, Bengaluru campus around 114 germplasms of eucalyptus trees were planted and maintained. In the year 1986, one of the eucalyptus clone was selected and planted in 1 acre and it gives of about 1.5% oil content with 63.9% citronellal at lab level. In recent years demand for EC oil has been increased, based on increasing demand for EC oil, we have planned for identification of high oil and citronellal rich clone. As a first step, we distilled individual trees conserved in CSIR-CIMAP, Research Center, Bengaluru during the year 2016, the oil content of distilled trees ranged between 0.80% to 3.10% with citronellal content ranging between 46.5 to 88.56% over existing local check having 1.5% oil and 63.9% citronellal content. Further, seeds of high oil and citronellal rich tree were collected individually and sown for next level of evaluation in polycovers.

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

Genetic enhancement of essential oil yield in Menthol mint (*Mentha arvensis* L.)

The essential oil of menthol mint is commercially used in pharmaceuticals, oral care products, tobacco products, confectionaries, chewing gum, perfume and lotions. In India, menthol mint is cultivated in the states of Uttar Pradesh, Punjab, Bihar, Haryana, and Uttarakhand. Presently cultivated menthol mint varieties have moderate essential oil yielding capacity (40-60 kg/acre).Menthol mint growing farmers and essential oil industry required menthe variety with high oil yield and high menthol content. So, an experiment was planned to develop such menthol mint variety, by using population improvement method (Half-sib progeny selection), totally 180 half-



sib seed progenies were developed. These individual half-sib progenies were vegetatively multiplied.All vegetatively multiplied half-sibs were characterized for agro-morphological traits and chemical constituents of essential oil at CSIR-CIMAP, Research Centre, Pantnagar. Among 180 half-sib progenies, plant height was varied from 30cm to 120cm, herb yield/plot (9 m^2 area) was ranged from 5.2 kg/plot (9 m^2 area) to 17.8 kg/plot (9 m^2 area), essential oil content was varied from 0.2% to 1.5%, essential oil yield was varied from 30 ml to 240 ml/plot (9 m^2 area),and Menthol content was varied from 0.02% to 82.09% and menthone content 0.02% to 84.96%.

Development of a high biomass and Rebaudioside–A rich genotype/variety in stevia (*Stevia rebaudiana*) through polyploidy breeding

Stevia rebaudiana (Bertoni) also known as sweet leaf or sugar leaf is a perennial herb (2n = 22) of the Asteraceae family. Leaves of Stevia produce diterpene glycosides (Stevioside and Rebaudioside), which are high-potency sweeteners and substitutes for sugar. The demand for stevia based products is increasing in national and international markets. The stevia varieties available for commercial cultivation at present have lower herb yield (2-4 t/ha of dry herb yeild) and lower Rebaudioside-A content (4-7.34%). So, there is a need to develop a high herb yield with Rebaudioside-A rich stevia variety. It is a hermaphrodite species but highly cross pollinated, photoperiod sensitive, entomophilous crop,which produce self-incompatible tiny white florets. These characteristics affect the success of hybridization and make the improvement of stevia complex. Induction of polyploidy has been observed to improve desirable traits crop plants. Production of larger leaves and other plant parts can be accomplished by induction of polyploidy. So, to develop genotypes with higher herb yield along with high Rebaudioside-A content in stevia an experiment was planned.

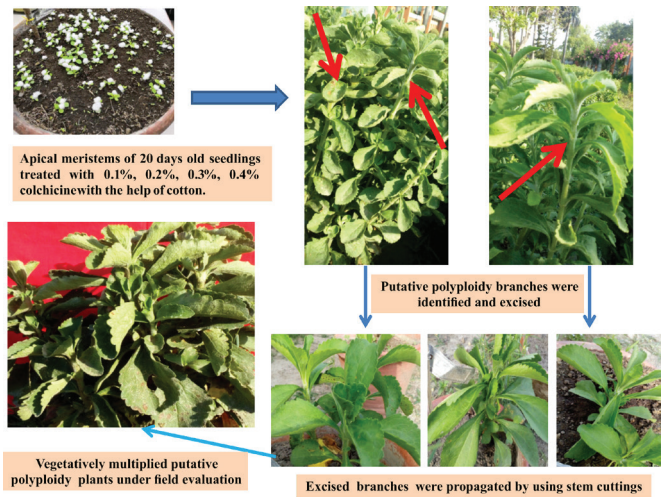


Fig. Induction of polyploidy in stevia *(Stevia rebaudiana)* by using colchicine

Dr. Gunjan Tiwari Mk- xqtu frokjh

Genetic Improvement in an industrially important medicinal herb Kalmegh (*Andrographis paniculata*)

Kalmegh is proved to be very effective in prevention of various infections in the present era of corona virus pandemic. The leaves and extracted juice of this medicinal herb are official and age-old drug in Indian pharmacopoeia and traditional system of medicine. Among various kharif season medicinal plants, kalmegh has a great demand at National and International level. It is a boon for socio-economic uplifting of rural farmers. Thus, the heavy demand of diterpene alkaloid present in this crop motivated Indian farmers to take up its commercial cultivation. Although, few commercial varieties are available for cultivation in the country but still, majority of the collection is from wild sources causing sharp decline in the availability of drug to the industries and escalation in its prices. CSIR-CIMAP has developed only one variety i.e. CIM-Megh with andrographolide content of 2.8% and herb yield of 32t/ha. So far for commercial cultivation and needs further exploitation of breeding in this crop to develop few more improved varieties with high herb yield and andrographolide content as homogeneous raw material for industries. To develop improved varieties over existing ones with respect to herb yield and diterpene alkaloid content, different germplasm lines collected from various agro-climatic zones of India and available at National Gene Bank of CSIR-CIMAP have been

evaluated for high herb yield and high andrographolide content and few elite lines have been selected. These selected lines will be further improved through a half-sib selection scheme and then evaluated in bench-scale and pilot-scale trial for release of commercial variety.

Dr. Gunjan Tiwari & her team

Technology Dissemination & Computational Biology

Highlights

Technology Dissemination: During the year of 2020-21, 17 technologies related to different herbal formulations has been transferred to different industries. An amount of Rs.82 lakhs received as premium and Rs. 21 lakhs received as royalty. During the same period 2 consultancy projects worth Rs. 32 lakhs were also received from industry. 6 online 3 days training and 4 offline training programs have been organized in which 718 farmers and entrepreneurs have been participated from various part of country. About 2509 farmers were made aware on cultivation of medicinal and aromatic plants by organizing various one-day awareness programs. A step towards making self-sustainable to the unemployed and poor women for making incense sticks using offered or used flowers for self-employment activity, CSIR- CIMAP organized 08 training programs attended by 408 women during period. After successfully training and demonstration of making of incense sticks and fragrant cones at KVK, Gorakhpur for utilization of offered flowers into incense sticks and fragrant cones. Shri Yogi Aditya Nath, Hon'ble, Chief Minister of Uttar Pradesh launched Gorakhnath

Scientists of Technology Dissemination & Computational Biology Divisional Units

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

Aashirwad brand incense sticks made from offered flowers on 15.11.2020 at Gorakhpur and another training programme on utilization of offered flowers into various value added products was inaugurated by Dr Shekhar C Mande, DG, CSIR on 29.11.2020 at District Women Jail at Ayodhya for women inmate.

This year 20 days Kisan mela has been organized by institute during January 15th to February 05th, 2021. By considering COVID-19 pandemic situation daily 100 to 200 farmers participated in the programme by following Covid- 19 protocol. The main function of Kisan Mela was celebrated on 31st January, 2021, Dr. Shekhar C. Mande, Director General, CSIR, New Delhi, has addressed the farmers through online mode. More than 4000 farmers, entrepreneurs, representatives of industries, buyers of essential oil hailing from 15 states were participated.

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 Ganga, 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 the year 2020-2021, various studies on discrimination of crop management in menthol mint and citronella crops using portable hyperspectral remote sensing.

Research work of Unmanned Aerial Vehicle (UAV) based high resolution remote sensing for modernized and efficient cultivation practices of commercially important medicinal and aromatic crops were also undertaken with focus on usage of machine learning and Artificial Intelligence tools and techniques for medicinal and aromatic crops. Under the project Indian Bioresource Information Network (IBIN) Geoportal for enhancing bio resource services, institutional linkages and outreach about 700 records of medicinal and aromatic plants were also digitized. The backend frame work design of GR-MAPs database for MAPs genome and transcriptome was developed.

In the research work on the development of bioinformatics pipeline, lncRNA Detector: a bioinformatics pipeline for long non-coding RNA identification and MAPslnc: a repository of medicinal and aromatic plant lncRNAs were developed. The lncRNADetector has been utilized to analyse and identify more than 88,459 lncRNAs from 21 species of MAPs.

Seven days' online skill development training program entitled "Genetic algorithm & receptor-ligand binding mode detection through molecular docking", March 1-7, 2021 under NWP-100 project was also organised by the division.

During this period, the Computational Biology Unit published 04 publications in high impact journals such as Industrial Crops and Products, RNA Biology, Current Topics in Medicinal Chemistry and Journal of the Indian Society of Remote Sensing.

Human Resource Development: A total of 23 students of CSIR-CIMAP were awarded their doctorate degrees during the year 2020-21. Among them, 10 students were registered under the Academy of Scientific and Innovative Research (AcSIR) and 13 students were registered under the CIMAP-JNU PhD Programme. Intake of students at CSIR-CIMAP during this period was 44, with 30 students enrolled under the AcSIR and the remaining students under CIMAP-JNU PhD programme. Currently, CSIR-CIMAP has 115 students in AcSIR and 83 students in the CIMAP-JNU PhD Programmes. As a part of CSIR-Summer Research Training Programme (CSIR-SRTP), CSIR-CIMAP offered online training to about 55 M.Sc. students during July-September, 2020. In addition, the institute also offered internship to about 45 students from various colleges and universities, during 2020-21.

Patent Cell: CIMAP Patent Cell works in cooperation with CSIR-Innovation Protection Unit, New Delhi to protect and manage intellectual property generated through research in the area of medicinal and aromatic plant varieties, agro-technology, bioactivities, chemical processes and product formulations. During 2020-21 CSIR–CIMAP filled 4 patents in India in the area of chemical process and product formulations simultaneously 3 Indian patents granted in herbal formulation and chemical process.

PME: PME Cell manages and coordinates the research and development activities of CSIR-CIMAP. PME Cell also coordinates between the CSIR-CIMAP and CSIR-HQ. PME unit assisted several scientists to submit various projects to external funding agencies during the period. During 2020-21, 26 new project received in the institute from various agencies like DST, NMPB, various state governments and CSIR New Delhi.

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

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

A. Technology transfer

Sl. no.	Name of the technology	Date of transfer of technology	Name of industry
1	An agreement was signed for making of Hand Sanitizer gel	21.04.2020	RakoAgrochem Pvt. Ltd. Khasra No. 1261, Goyla Industrial Area, Chinhat Deva Raod Lucknow-226019
2	An agreement was signed for making Hand Sanitizer gel	27.04.2020	M/s. Innovative Concepts Ground floor, C-1215, Rajajipuram, P.O. Rajajipuram, Tah. Lucknow -226017
3	An agreement was signed for making Hand Sanitizer gel/liquid	19.05.2020	Hapi Key 44/1/6, Phase-1,I.D.A., Jeedimetla, Hyderabad-500055
4	An agreement was signed for making Hand Sanitizer gel/liquid	26.05.2020	Shri Vinay Shukla M/s. Sai International Shop No.-11, Shanti Complex, Faizabd Road, Indira Nagar Lucknow
5	An agreement was signed for making Hand Sanitizer gel/liquid	15.6.2020	Shri Pankaj Sinha, M.D. M/s. Asear Medicare, 68/2B, Wazir Hasan Road, Lucknow-226001 U.P., India
6	An agreement was signed for making Hand Sanitizer gel/liquid	26.09.2020	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
7	An agreement was signed for making of Mospray	26.09.2020	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
8	An agreement was signed for making of Clean Germ (Floor Cleaner)	26.09.2020	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
9	An agreement was signed for making of Mospray-Mosquito repellent spray	15.10.2020	M/s. MAA DURGA MARKETING , F-36,37 Industrial Area RamnagarChandauli, UP
10	An agreement was signed for making of Relaxomap	10.11.2020	M/s. Hapi Key 44/1/6, Phase-1,I.D.A., Jeedimetla, Hyderabad-500055
11	An agreement was signed for making flower based incense sticks and fragrant cone	18.12.2020	M/s. Green Dream Bharat, 83 B, MahebaPurab Patti, Naini, Prayagraj
12	An agreement was signed for making of Evergreen Tea	31.01.2021	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
13	An agreement was signed for making of Herby soft	31.01.2021	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.

14	An agreement was signed for making of Geranium Active Shampoo	31.01.2021	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
15	An agreement was signed for making of Kleenzie	31.01.2021	M/s. Vyom India Organics Private Limited, B- 346 Rajendra Nagar, Bareilly-243122, U.P.
16	An agreement was signed for making of Immune Booster CIM-Megh	12.02.2021	Meghdoot GramodyogSevaSansthan, A 1/18, Sector-H, Purania, Aliganj Lucknow-226024
17	An agreement was signed for making of incense sticks	08.03.2021	AadarshShikshaEvamSevaSamiti, Gonda

A view of agreement exchange between industry and CSIR-CIMAP

A view of agreement exchange between industry and CSIR-CIMAP

B. Skill Development Programmes

i. Online training Programmes on Medicinal and Aromatic Plants Production Technology

Sl. no.	Date	Place	No. of parti.	Sponsored by
1	13-17 July, 2020	CIMAP Lucknow (Online Training)	179	HCL Foundation (CNP-416)
2	22-23 July, 2020	CIMAP Lucknow (Online Training)	35	DBT Sponsored project for Bundelkhand region
3	17-19 August, 2020	CIMAP Lucknow (Online Training)	73	SIDBI
4	22-24 September, 2020	CIMAP Lucknow (Online Training)	69	SIDBI
5	13-15 October, 2020	CIMAP Lucknow (Online Training)	95	SIDBI
6	25-27 November, 2020	CIMAP Lucknow (Online Training)	55	SIDBI
7	01-05 March, 2021	CIMAP Lucknow	37	BAMETI, Bihar
8	09-10 March, 2021	CIMAP Lucknow	52	HCL Foundation, Hardoi
9	12-13 March, 2021	CIMAP Lucknow	56	HCL Foundation, Hardoi
10	22-23 July 2020	CIMAP Lucknow	67	CIMAP Lucknow
		Total	**718**	

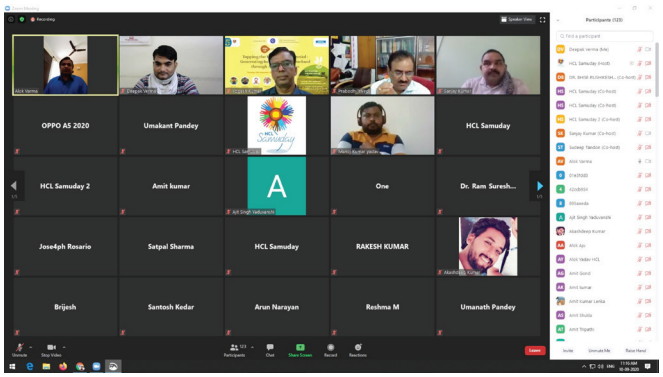
ii) Awareness Programmes were conducted under different projects

Sr. No.	Date	Place	No. of Participants		Sponsored by
			Total	Women	
1	22.05.2020	CIMAP Lucknow (Online webinar)	235	15	CSIR-CIMAP
2	29.07.2020	CIMAP Lucknow (Online webinar)	250	65	
3	10.09.2020	CIMAP Lucknow (Online webinar)	150	35	HCL Foundation (CNP-416)
4	06.10.2020	CIMAP Lucknow (Online aromatic oil buyers producer meet)	160	40	CSIR-CIMAP
5	19.02.2021	Dhuskiya, Chandanchwoki Dudhwa	60	12	HCP-0007
6	20.02.2021	Pipraula, Sunda, Dudhwa	59	10	
7	22.02.2021	Belhari, Purelal Shah, Sultanpur(UP)	94	78	
8	23.02.2021	CIMAP, Lucknow	39	09	BBA University
9	23.02.2021	Awareness Programme, Majuli, Assam	98	55	HCP-0007
10	24.02.2021	Awareness Programme, RiBhoy	51	38	
11	25.02.2021	CIMAP, Lucknow	42	0	ATMA, Azamgarh

A view of online training programme

12	02.03.2021	Balakothi, Siwan, Bihar	42	02	HCP-0007
13	04.03.2021	Madhepura	25	0	
14	05.03.2021	Parsiya, Dudhwa, Kheri	84	19	
15	06.03.2021	Bandar Bharari, Kheri	101	45	
16	06.03.2021	Pipraula, Sunda, Dudhwa, Kheri	90	40	
17	07.08.2020	Jalaun, Aata , U.P.	28	0	NAFCC (Forest Department)
18	29.09.2020	Jalaun, Tandhva U.P.	45	0	
19	29.09.2020	Hamirpur, Rath U.P.	49	0	
20	30.09.2020	Banda, Khanpur U.P.	44	08	
21	30.09.2020	Chitrakoot, Bharatpur U.P	39	0	
22	01.10.2020	Chitrakoot, Manikpur U.P.	67	15	
23	07.01.2021	Dimapur Nagaland	41	38	NASI 436
24	09.01.2021	KVK, Hengburg, Senapati Manipur	71	61	
25	12.01.2021	Jengraimukh, Majuli Assam	40	35	
26	14.01.2021	Nongshilong, West Khasi Hills	**44**	**39**	
27	04.03.2021	Jalaun Ragauli	32	0	GAP-408
28	05.03.2021	Jalaun Tandwa	61	20	
29	06.03.2021	Hamirpur Devkhari	55	12	
30	07.03.2021	Banda Bhagelawari	42	0	
31	07.03.2021	Chitrakoot NadinKumariya	49	5	
32	08.03.2021	Chitrakoot Ameempur Chhivlaha	40	8	
33	08.03.2021	Chhatarpur ToriyaTek	50	7	
34	08.03.2021	Chhatarpur Mankari	30	0	
35	09.03.2021	Panna Tara	39	8	
36	10.03.2021	Damoh Bhaurasa	63	0	
		Total	**2509**	**719**	

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



A view of training and awareness programme

A view of training and awareness programme

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 8 training programmes attended by 408 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.

C. Visitors:

More than two thousands visitors including students, teachers' farmers, government officials and

Training Programme on Making of Incense sticks from Floral Wastes

Sl. No.	Date	Place	No. of Participants (F)	Sponsored by
1	27.10.2020	Gorakhpur Mandir, KVK Gorakhpur	50	GAP-440
2	29.11.2020	District Jail, Ayodhya	45	
3	16.12.2020	KashiVishvanathMandir, Varanasi	50	SSP-370
4	15.01.2021 to 05.02.2021	Kissan Mela CSIR-CIMAP	109	SSP-370
5	10.02.2021	Training Programme CSIR-CIMAP, Lucknow	21	HCP-0007
6	09.03.2021	Traning Programmes &Innagration, Ayodhya Jail	46	HCP-0007
7	09.03.2021	Trainning&Innaugration, AdarshSikshaSevaSamithi, Ayodhya	25	HCP-0007
8	13.03.2021	Training Programme, SemraiKathari, Barabanki	62	HCP-0007
Total Participants			**408**	

A view of training programme on making incense sticks and fragrant cones.

others common people from society visited CSIR-CIMAP and were apprised about different activities of the institute.

D. Major events organized

i) National Technology Day

On the occasion of National Technology Day on 11 May, 2021, the programme was organized through virtual basis and students, farmers and entrepreneurs were participated in this event.

Views of visitors visiting different spot in CIMAP

ii) CSIR-CIMAP, Kisan Mela- 2021

CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow has been organizing Kisan Mela every year on 31st January. Kisan Mela is being organized for the last 17 years. The increasing number of farmers attending this Kisan Mela every year shows that the popularity of CSIR-CIMAP Kisan Mela among the farmers.This year Kisan mela were organized in between January 15th to February 05th, 2021 (excluding 17, 24, 26 Jan 2021).

Shri Brijesh Pathak, Honorable Law Minister, Government of Uttar Pradesh and special guest Dr. G. N. Singh, Former Drug Controller General, Government of India and Adviser Mr. Chief Minister of Uttar Pradesh and Director of CIMAP Dr. Prabodh Kumar Trivedi and scientist releasing Aus Gyanya on the occasion of kisan Mela-2021.

Due to COVID-19 pandemic situation, Kisan mela were organized with the help of science and technical cooperation, plans for the safety management in mind, CIMAP arranged this Kisan Mela. The following points were the center of attraction for the farmers in this Kisan Mela-2021:

- Market of medicinal and aromatic plants - from the point of view of industry
- Sale of improved plant material and publications
- Display of improved varieties and CIMAP products
- Live demonstration of distillation units/ processing
- Training in making incense sticks and rose water
- Demonstration of early farming techniques of Geranium cultivation and Mentha in the plains of North India
- Incorporation of medicinal and aromatic (MAPs) crops into the traditional cropping system

This year about 4000 farmers from different states of the country like Uttar Pradesh, Madhya Pradesh, Bihar, Uttarakhand, Chhattisgarh, Gujarat, Rajasthan, West Bengal, Orissa, Haryana, Punjab, Delhi, Karnataka, and Maharashtra etc. participated in the Kisan Mela. 500 students from different universities also participated in the Kisan Mela.Scientists, officers and students under the leadership of Dr. Prabodh Kumar Trivedi, Director of CIMAP, contributed to this farmers' fair of 2021 and set an example of farmer's interest in front of the world. Farmers from all over the country participated in this Kisan Mela through daily pre-registration process. Industries associated with the aroma industry such as Ultra International Pvt. Ltd., Expo Essential Oil, Ghaziabad, Multi Commodity Exchange, Mumbai, Essential Association of India, Mumbai, BKK Specialist, Mumbai,representatives of Ajmal Biotech, Mumbai, Ultradox, Bangalore, Ashri Menthol, Barabanki, Yathavat Aromatic, Agra, Aromed Herbals, Lucknow, Aromatic & Allied, Bareilly, Sona Mint, Badaun etc. also participated in the Kisan Mela with great enthusiasm and farmers. Participation of these industries were really noticeable and all shared information related to national and international market demand and quality of essential oils produced by and assured to buy oil.

Views of the participating farmers on the occasion of Kisan Mela-2021

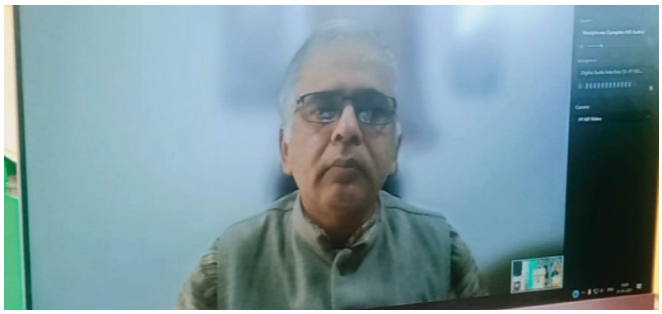
Efforts were made to make women self-reliant and strengthen their economic status by training more than 100 urban and rural women on the technology of making incense sticks from flowers by CSIR-CIMAP. CIMAP has been continuously developing agricultural technologies to increase the income of farmers and

On the occasion of Kisan Mela-2021, women receiving training in making incense sticks

improve their economic status. By the team of CIMAP scientists, detailed information about improved farming, improved varieties and processing and marketing was made available to the farmers daily in the Kisan Goshti.

Plant material of advanced species of medicinal and aromatic plants like Mentha, Geranium, lemongrass, Citronella, Khus, Tulsi, Satwar, Ashwagandha, Sarpagandha, Kalmegh etc. were distributed in this Kisan Mela. Mainly, about 400 quintals of improved varieties of Mentha were distributed to the farmers.

On January 15, 2021, the chief guest, Dr. Alok Kalra, former Executive Director, CSIR-CIMAP, Lucknow, visited the Kisan Mela and Dr. Anil Kumar Singh, former Chief Scientist and Dr. V.K.S. Tomar, Former Chief Scientist, CSIR-CIMAP and Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP addressed the Kisan Mela participants.



On the occasion of the main function of Kisan Mela-2021, Chief Guest Dr. Shekhar C. Mande, Director General, CSIR, New Delhi addressing the farmers through virtual mode.

Director, CSIR-CIMAP, Lucknow addressing the farmers on the occasion of the main function of Kisan Mela-2021.

The main function of Kisan Mela was celebrated on 31st January, 2021. On this occasion the chief guest Dr. Shekhar C. Mande, Director General, CSIR, New Delhi, was associated with the Kisan Mela through online medium. Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, addressing the farmers in the Kisan Mela. He said that CIMAP has been working for almost 6 decades to provide economic benefits to the farmers by developing new species of economically important medicinal and aromatic plants been doing. CIMAP has been creating public awareness among farmers through its research and extension works. The main objective of organizing this Kisan Mela is to make the new research

happening in the institute aware of the farmers and the general public.

Chief Guest Dr. Shekhar C. Mande, Director General, CSIR said that the events of such Kisan Mela have a special place in bringing the new experiments being done by CSIR to the general public and he said that CSIR-CIMAP should continuously provide high quality plant material to the farmers. The income is increasing from their produce.

On this occasion, 'Souvenir publication' and CIMAP official logo was launched. The herbal products Ever Green Tea, Herbie Soft Shampoo, Geranium Active Shampoo, and Cleansing Technology, developed by CSIR-CIMAP, have also been shared with M/s Vyom India Organic Pvt. Ltd. On this occasion, progressive farmers shared their success stories with the participants, which would inspire other farmers to move forward. The main objective of CIMAP Kisan Mela is to make the farmers self-reliant.

On this occasion, special guest Mr. Brijesh Pathak, Hon'ble Law Minister, Government of Uttar Pradesh welcomed the farmers and he told that many efforts are being made by the state government for the benefit of the farmers,so that the country can become self-reliant and special guest Dr. GN. Singh, Former Drug Controller General, Government of India and Advisor to the Hon'ble Chief Minister, Government of Uttar Pradesh informed that the way India has achieved self-sufficiency in the field of medicine, in the same way, with the efforts of CSIR-CIMAP, the cultivation of medicinal and aromatic plants has not stopped. Not only the income of farmers will be doubled, but at the same time India will also become self-sufficient in the production of many essential oils.

On the occasion of the main function of Kisan Mela-2021, special guest Shri Brijesh Pathak, Hon'ble Law Minister, Government of Uttar Pradesh addressing the farmers

On the occasion of the main function of Kisan Mela-2021, special guest Dr. G. N. Singh, Former Drug Controller General, Government of India and Adviser, Chief Minister, Uttar Pradesh addressing the farmers

On the occasion of closing ceremony of Kisan Mela -2021, Chief guest Smt. Swati Singh, Hon'ble Minister of state (Independent Charge) Women's Welfare, Child Development and Nutrition, Government of Uttar Pradesh in its address praised the contribution of CSIR-CIMAP in the production of medicinal and aromatic plants and said thatthere is a need to promote the cultivation of medicinal and aromatic plants and the contribution of this institute is important in this work.

Chief guest Smt. Swati Singh, Hon'ble Minister of State (Independent Charge) Women Welfare, Child Development and Nutrition, Government of Uttar Pradesh addressing the farmers on the occasion of closing ceremony of Kisan Mela-2021

The Hon'ble Minister of State further informed that the improved varieties of Mentha and other medicinal and aromatic plants developed by CIMAP are very popular among the farmers and have proved to be helpful in increasing their yield.

Former Director of CSIR-CIMAP, Dr. Suman Preet Singh Khanuja, who came as a special guest on the occasion of closing ceremony of Kisan Mela, welcomed all the participants and said that this Kisan Mela was started by CSIR-CIMAP in the year 2003. Through this Kisan Mela, farmers interact directly with scientists and buyers

associated with the medicinal and aromatic plants industry. Through this, it also shows that the demand for which crop is increasing at present so that farmers can get more profit by growing the same crop. Through Kisan Mela, farmers get information about new species and techniques developed by the institute.

Former Director of CSIR-CIMAP, Dr. Suman Preet Singh Khanuja addressing the farmers on the occasion of closing ceremony of Kisan Mela-2021

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP while addressing the guests, farmers and entrepreneurs who came to the Kisan Mela said that this Kisan Mela provides a unique opportunity for direct interaction between farmers, entrepreneurs and scientists. Today, the pressure on our unproductive land is increasing, due to which the holding of farmers is continuously getting smaller.Medicinal and aromatic crops are being promoted by CSIR-CIMAP so that farmers can increase their income and earn their livelihood by growing these crops on their land. He further said that CSIR-CIMAP is also providing technologies based on medicinal and aromatic plants for setting up small and cottage industries to make unemployed youth and rural women self-reliant. In addition, incubation facility is also being provided for startups.

Dr. Abdul Samad President, Kisan Mela Organizing Committee proposed vote of thanks. Dr. Sanjay Kumar, Convener, Kisan Mela conducted various programs of Kisan Mela for 20 days. For successful organization of 20-day Kisan Mela, Dr. R. K. Srivastava, Dr. R. S. Sharma, Dr. Rushikesh, Mr. R P. Yadav, Shri Deepak Kumar Verma, Shri Manoj Yadav, technical officers and students role has been remarkable.

E. Study on economics and marketing of Vetiver:

The study was conducted in Madhepura district of Bihar to understand the socio-economic status of vetiver growers, profile of inputs used, relationship between cost and return, influence of input's cost on yield and

Director, CSIR-CIMAP, Lucknow addressing the farmers on the occasion of closing ceremony of Kisan Mela-2021

Dr. Sanjay Kumar, Convener, Kisan Mela addressing the farmers on the occasion of closing ceremony of Kisan Mela-2021

returns of vetiver. The study is absolutely based on primary information, collected from 70 farmers those who are benefited by CSIR-CIMAP Aroma Mission. The data were collected through field visit and adopted the personal interview method. The statistical tools like, descriptive analysis, CACP cost concept and multiple regression function were used to attain the objectives of the study. The results revealed that literacy rate of

Mr. Brijesh Pathak, Hon'ble Law Minister, Government of Uttar Pradesh and Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP presenting the newly developed variety of Mentha to the women farmer.

Farmers carrying new variety of Mentha

Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP presenting the newly developed variety of Mentha to the farmers

farmers in the study area was 82.42 percent, occupation structure was concerned 96.80 percent of overall sample farmers were dependent on agriculture and 3.20 percent on Non-farm sources. The majority of sampled farmers (94.29%) were belonging to general category. The average land holding size was found to be 2.60 hectare. In total land holding of farmers about 70.79 percent acreage devoted under cultivation of traditional crops and 29.21 percent under medicinal and aromatic crops like Satavari, Vetiver, Lemongrass, Mint, etc. The total cost of cultivation and gross return of vetiver were found to be Rs. 121475/ha and 289920/ha. The net return over Cost C_3 was found to be highest with Rs. 168445/ha followed by Cost B_2, Cost C_2, Cost C_1, Cost B_1 and Cost A_1. The benefit-cost ratio is observed to be highest (1: 3.05) at Cost A_1 it is implies that the farmers obtained Rs.3.05 as profit by investing Rs. 1 in vetiver cultivation. The lowest benefit-cost ratio was found at Cost C_3 (1:1.39) farmers obtained Rs. 1.39 profit. Total seven explanatory variables were considered in this study. Out of these variables, the regression coefficient of planting material, manures and fertilizer, number of irrigation, distillation method have positive influence the yield and returns of vetiver. It was also observed that out of these two identified channels, Channel-II was dominated in the study area as 80.00 percent of vetiver growers were selling their vetiver oil through this channel and remaining 20.00 percent growers were selling vetiver oil through Channel- I. Thus, enhance income and employment through cultivation of vetiver may attract large number of farmers in the study area with integrated and traditional crops farming.

F. Natural Menthol Mint Oil Production in India: Role of CSIR-CIMAP, Opportunities and challenges

India is the largest producer of menthol mint oil in the world with over 29.50 million tons of production and 25.75 million tons of export in maximum in last twenty years. The remarkable growth in production and export of mint oil in recent years and this trend is almost certain to continue in future. The existing of wide range of natural endowment, favourable climatic condition and support of CSIR-CIMAP in development and dissemination of improved plant varieties, agro-production and processing technologies offers vast potential for cultivation of natural mentha oil and employment generation for millions of farming families throughout the country. However, there is a need to tape this potential so that production and household employment will expand and mentha growers will get more benefit.

G. New Initiatives:

1. After successful training and demonstration of making of incense sticks and fragrant cones at KVK, Gorakhpur for utilization of offered flowers into incense sticks and fragrant cones. Shri Yogi Aditya Nath, Hon'ble, Chief Minister of Uttar Pradesh launched Gorakhnath Aashirwad brand incense sticks made from offered flowers on 15.11.2020 at Gorakhpur. The event was presided by Dr Prabodh Kumar Trivedi, Director, CSIR-CIMAP and Dr GN Singh, Advisor, Hob'ble Chief Minister of Uttar Pradesh. Hon'ble Chief Minister has appreciated the efforts made by CSIR-CIMAP on utilization of offered flowers and providing job opportunities to rural women. He also assured to utilize all the offered flowers in each and every places of worship in UP for making incense sticks and fragrant cones.
2. Training programme on utilization of offered flowers into various value added products was inaugurated by Dr Shekhar C Mande, DG, CSIR on 29.11.2020 at District Women Jail at Ayodhya for women inmate.

3. Established a CSIR-CIMAP Window at Shillong, Meghalaya was inaugurated by Director, CSIR-CIMAP and Director CSIR-NEIST with the presence of Principal Secretary Govt. of Meghalaya on 25.02.2021 in collaboration with MBDA.

4. Organized National Conference on Challenges and recent innovation in herbal drug standardization, quality evaluation and new drug development from 26-27 February, 2021 jointly organized with DRI, NMPB and NASI.

A view of launch of Incense sticks and fragrant cones by Shri Yogi Aditya Nath, Hon'ble Chief Minister, UP on 15.11.2020

Dr Shekhar C Mande, DG, CSIR is discussing with the women inmates during training programme at At Ayodhya on 29.11.2020

A view of inauguration of pulveriser for making powder from offered flowers by Shri Yogi Aditya Nath, Hon'ble Chief Minister, UP on 15.11.2020

A view of inauguration of CSIR-CIMAP Technology CIMAP Window at Shillong with MBDA

A view of training programme inaugurated by Dr Shekhar C Mande, DG, CSIR at Women Jail At Ayodhya on 29.11.2020

A view of inauguration of CSIR-CIMAP Window at Shillong

Input: Manoj Semwal eukt leoky

High throughput imaging system in *Mentha arvensis* for determining economically optimal time of harvest using machine learning algorithms

Proximal hyperspectral remote sensing holds great potential in measuring canopy reflectance throughout crop growth period as the derived hyperspectral indices are capable of characterizing the crop phenotypic traits efficiently. Remote sensing image based phenotyping for mint crop has not been attempted yet. Continual crop monitoring and harvesting at optimum time to ensure maximum economic returns is a huge challenge. The present study was undertaken to evaluate different hyperspectral indices for phenotyping the canopy of *Mentha arvensis* (Cv Kranti). Our study was successful in development of a method for maximizing yield of mint essential oil without losing on the yield of suckers. Numerous hyperspectral vegetation indices derived from spectral reflectance images acquired at several dates near to crop maturity period were evaluated and hyperspectral indices showing strong correlation yield related traits were identified. Our results showed promise for development of non-destructive methods of crop monitoring and better detection of optimum harvest time. This study utilizes automated image analysis using open source R language in which increased the speed of analysis for the multidimensional hyperspectral image data.

Biochemical, Physiological and Imaging studies in Menthol Mint (*Mentha arvensis*) under moisture stress

Menthol mint (*Mentha arvensis*) is a rich source of essential oil that is used in pharmaceutical, flavoring and cosmetic industries. The present study was undertaken to investigate the biochemical, physiological and imaging traits in different cultivars of Menthol Mint (Mentha arvensis) i.e., cv(s): Kosi, Kranti, Unnati under moisture stress. The experiment was conducted to investigate the biochemical composition, physiological and imaging traits in different cultivars of Menthol Mint (*Mentha arvensis*). It was observed that there were substantial variations in the growth, chlorophyll and its pigment content, essential oil yield, and biochemical composition of essential oils under moisture stress. In this experiment, the stresses were monitored during the last 15 days to see the effect of moisture stress on menthol mint crop physiological parameters, biochemical composition and imaging traits and to test the adaptability of menthol mint toward those stresses.

Fig. Imagery captured by Parrot Sequoia Sensor of *M. arvensis* in glasshouse

Fig. Lateral RGB Image of *M. arvensis*

Fig. Top RGB Image of *M. arvensis*

Non-imaging hyper spectral leaf reflectance studies for the characterization of nutrient in *Mentha arvensis*

The study was undertaken to investigate a non-destructive method of monitoring plant stresses in *Mentha arvensis* using the handheld leaf spectrometer (CID CI-710, Bio-Science, Camas, WA, USA) to acquire reflectance from *M. arvensis* crop and calculate vegetative pigment indices such as Plant Senescence Reflectance Index (PRSI), Normalized Difference Vegetation Index (NDVI), Water Band Index (WBI), etc which are used to monitor the crop over its entire growth cycle. During this study, it was found that the original reflectance or first-order derivative spectra were able to quantify leaf macro-nutrients nitrogen (N), phosphorus (P), potassium (K)] using the training datasets. The proposed hyper-spectral indices were shown to effectively quantify leaf N, P, and K content ($R2 > 0.5$, $p < 0.05$), confirming that non-imaging hyper-spectral data is potentially useful for micro scale monitoring of vegetation.

Menthol mint (*Mentha arvensis* L.) crop acreage estimation using multi-temporal satellite imagery

Crop acreage estimation is an essential component for forecasting crop production. Menthol mint acreage estimation is a necessity as the crop production data changes every year due to fluctuations in the market prices of menthol mint oil, hence the rate available to farmers also change every year. This study focuses on

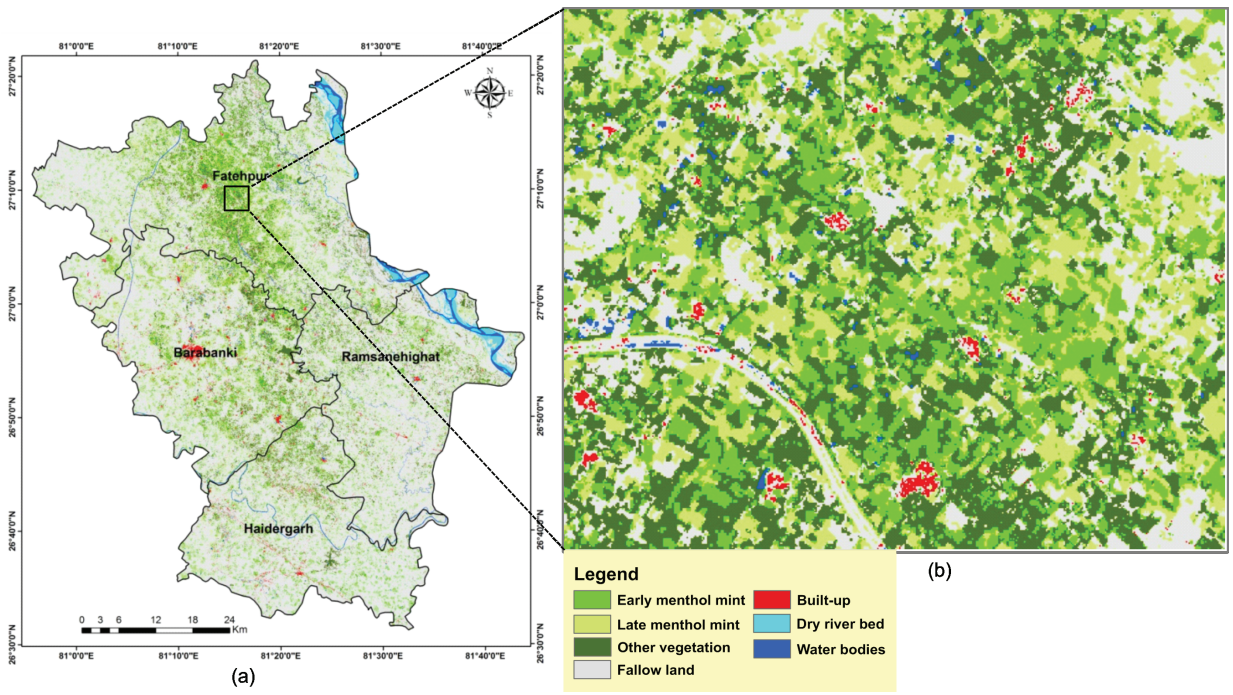


Fig. Early and late transplanted menthol mint acreage map of Barabanki district
(a). Study area classified map, (b). Snap-shot wherein, early and late menthol mint crop field are clearly distinguishable.

menthol mint crop acreage estimation in the Barabanki district of Uttar Pradesh, India using 2017 Sentinel-2Asatellite data. Adaptive Maximum Likelihood Classification algorithm was applied after intensive ground survey to obtain reliable menthol mint crop acreage estimation for taluk wise statistics. Results have shown that menthol mint was extensively cultivated in the Fatehpur and Barabanki taluks as compared to the Haidergarh and Ramsanehighat taluks of Barabanki district. Menthol mint crop acreage estimation in the study area was estimated to be about 58284.70 hectares with(89.13%and 87.23%; users and producer's accuracy) with overall accuracy(90.67%) and Kappa value (0.844). In this study early and late menthol mint crop acreage estimation was also attempted and it was found that about 26123.50 hectares and 29911.40 hectares was the area of early and late menthol mint respectively. This method can be useful for localised level crop acreage estimation from early to mature stage of menthol mint during its growing season.

Discrimination of crop management in Chamomile (*Chamomila recutita*) using portable hyperspectral remote sensing

Various studies have focused on evaluating the Vegetation Indices (VIs) in order to quantify the biophysical variability of vegetation. The present investigation was inspired to extract and explore the potential of optimized hyperspectral vegetation indices to discriminate different management practices (chemical fertilizers, micronutrients and microbial inoculants) in Chamomile crop especially in the context of precision farming. VIs are suitable for crop monitoring and management, which are mainly influenced by the biochemical and structural properties

Fig. Experiment field view

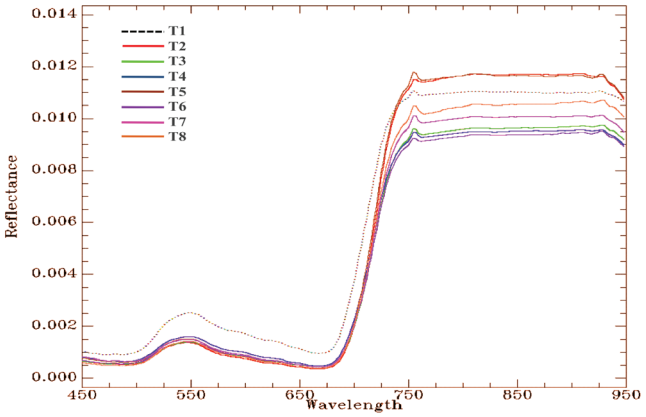


Fig. Spectral reflectance curve of Chamomile crop of all treatment at full flowering stage.

of vegetation. The spectral observations were collected from experimental field at CSIR-CIMAP, Lucknow, using portable hyperspectral camera at full flowering stage of the crop. The study has clearly derived optimum bandwidths that can be utilized for various vegetation indices, which can help in crop monitoring and management practices.

High resolution Unmanned Aerial Vehicle (UAV) multispectral imaging for menthol mint crop monitoring

Unmanned Aerial Vehicle (UAV) technologies have nowadays become an emerging tool for the agricultural field monitoring. In this study we demonstrated the UAV remote sensing technology for menthol mint crop monitoring. UAV fitted with multispectral and thermal camera was flown over the study area during the crop growing period. The high resolution multispectral images were orthomosaicked and thematic maps of popular vegetation indices (VIs) viz., NDVI (Normalized Difference Vegetation Index), GNDVI (Green Normalized Difference Vegetation Index) and NDRE (Normalized Difference Red Edge) were generated to assess the health status of menthol mint crop. Results show that the highest value for NDVI, GNDVI, and NDRE were obtained during crop maturity period and GNDVI index was found to be the most suitable indicator for menthol mint crop health assessment. Furthermore, all the indices values were increasing with crop growth stages, clearly indicating the presence of high biomass and chlorophyll in the maturity stage as compared to the early growth stages.

Fig. Unmanned Aerial Vehicle (UAV) studies at CIMAP Research Center and Farmers field

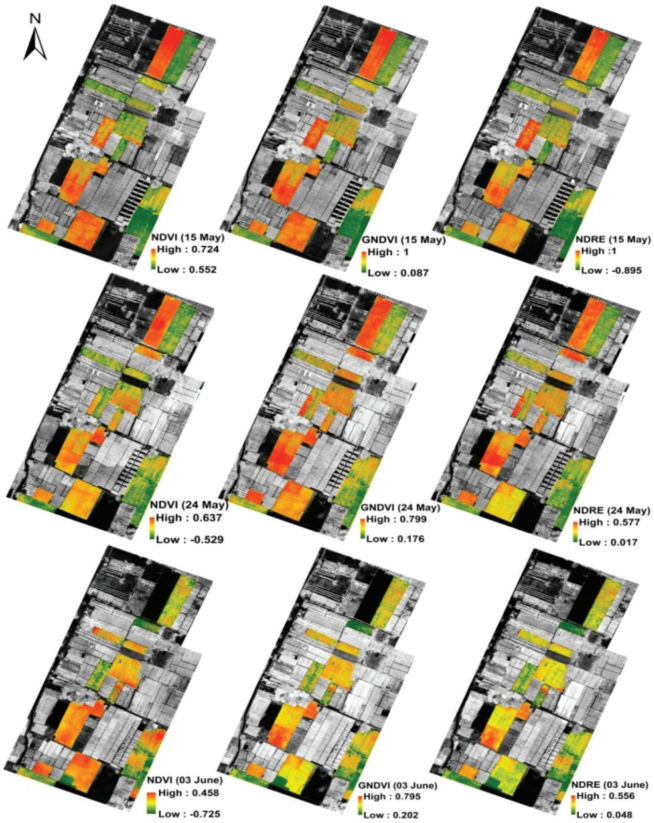


Fig. Indices derived from the drone data for crop monitoring

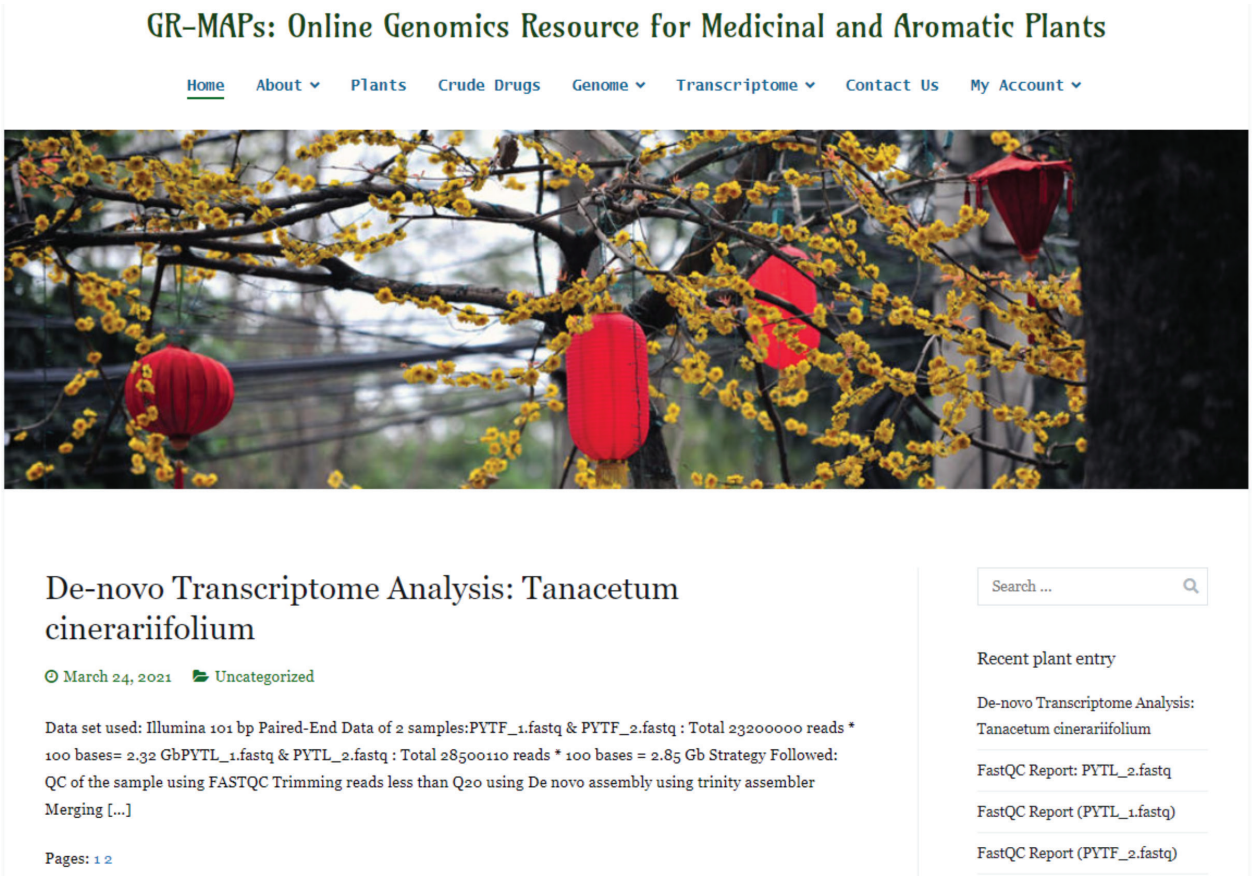
Indian Bioresource Information Network (IBIN) Geoportal Phase III: Enhancing Bioresource Services, Institutional Linkages and Outreach

In this research 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 being undertaken. In the medicinal and aromatic plants web information database, about 651 records of medicinal and aromatic plants 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.

Er. Manoj Semwal & his team

Input: Dr Feroz Khan Mk- fQjkt [kku

1. Identified natural inhibitors against human liver cancer cell lines predicted through Quantitative Structure-Activity Relationship (QSAR), Molecular Docking simulation for target binding assessment, and in-silico pharmacokinetics screening studies such as Absorption, Distribution, Metabolism, Excretion and Toxicity (ADMET) filters for bioavailability.
2. QSAR, ADMET & molecular docking simulation on 4-hydroxy-α-tetralone analogs for anti-inflammatory activity.
3. Molecular docking simulation studies on Brevifoliol and its analogs for Anti-tubercular activity.
4. Molecular docking studies on amide derivatives of stilbene for osteogenic activity.
5. Molecular modeling studies of 2, 3-diaryl benzofuran derivatives for antitubercular activity and *in vitro* evaluation.
6. Molecular docking simulation study on glabridin derivatives and in-silico target identification for *in-vitro* antiproliferative activity.
7. Molecular docking simulation study on Silymarin, a polyphenolic flavonoid impede *Plasmodium falciparum* growth through interaction with heme
8. Molecular docking and ADMET studies on *Lavandula angustifolia* essential oil major components linalool and linalyl acetate for Anti-psoriatic effect.
9. Molecular docking simulation studies on Fluorinated benzylidene indanone for antiproliferative activity.
10. Molecular docking simulation studies on Phytol derivatives for Antihyperglycemic activity.
11. Molecular docking simulation studies on Swertiamarin from *Enicostemma littorale*, counteracts PD associated neurotoxicity via enhancement of α-synuclein suppressive genes and SKN-1/NRF-2 activation through MAPK pathway.
12. Molecular docking simulation studies on Angiotensin II Receptor Blocker Fluorophenyl Benzimidazole for Antihypertensive Effect: Contribution of cGMP, Voltage-dependent Calcium



Channels, and BKCa Channels to Vasorelaxant Mechanisms.

13. Molecular docking studies of indanocine and 2-benzyl-indanocine for antiproliferative activity through microtubule destabilization.

Developed the backend frame work design of GR-MAPs database for MAPs genome and transcriptome.

- Any other relevant information:
    1. Organized 7 days online skill development training program entitled "Genetic algorithm & receptor-ligand binding mode detection through molecular docking", March 1-7, 2021 under NWP-100 project.
    2. Expert member, Environmental Science, Project review committee, Council of Science & Technology, Uttar Pradesh Govt. (UPCST), Lucknow.
    3. Executive Council Member, Bioinformatics & Drug Discovery Society (BIDDS), Alagappa University, Karaikudi, Tamil Nadu, India (Feb.2020-Feb.2023)
- Member, Board of Studies (BOS), M.Tech. Biotechnology Program, Institute of Engg. & Technology (under AKTU), Lucknow.
- Member, Evaluation Committee, Faculty funding under Visvesvaraya Research Promotion Scheme, Dr. APJ Abdul Kalam Technical University (AKTU), Lucknow.

Dr. Feroz Khan & his team

Input: Bhaskar Shukla HkkLdj 'kDyk

lncRNADetector: a bioinformatics pipeline for long non-coding RNA identification and MAPslnc: a repository of medicinal and aromatic plant lncRNAs

Long non-coding RNAs (lncRNAs) are an emerging class of non-coding RNAs and potent regulatory elements in the living cells. High throughput RNA sequencing analyses have generated a tremendous amount of transcript sequence data. A large proportion of these transcript sequences does not code for proteins and are known as non-coding RNAs. Among them, lncRNAs are a unique class of transcripts longer than 200 nucleotides with diverse biological functions and regulatory mechanisms. Recent emerging studies and next-generation sequencing technologies show a substantial amount of lncRNAs within the plant genome, which are yet to be identified. The computational identification of lncRNAs from these transcripts is a challenging task due to the involvement of a series of filtering steps. We have developed lncRNADetector, a bioinformatics pipeline for the identification of novel lncRNAs, especially from medicinal and aromatic plant (MAP) species. The lncRNADetector has been utilized to analyse and identify more than 88,459 lncRNAs from 21 species of MAPs. To provide a knowledge resource for the plant research community towards elucidating the diversity of biological roles of lncRNAs, the information generated about MAP lncRNAs (post-filtering steps) through lncRNADetector has been stored and organized in MAPslnc database (MAPslnc, https://lncrnapipe.cimap.res.in). The lncRNADetector web server and MAPslnc database have been developed in order to facilitate researchers for accurate identification of lncRNAs from the next-generation sequencing data of different organisms for downstream studies. To the best of our knowledge no such MAPslnc database is available till date. (Shukla et al., 2021, *RNA Biology* https://doi.org/10.1080/15476286.2021.1899673). (Fig.).

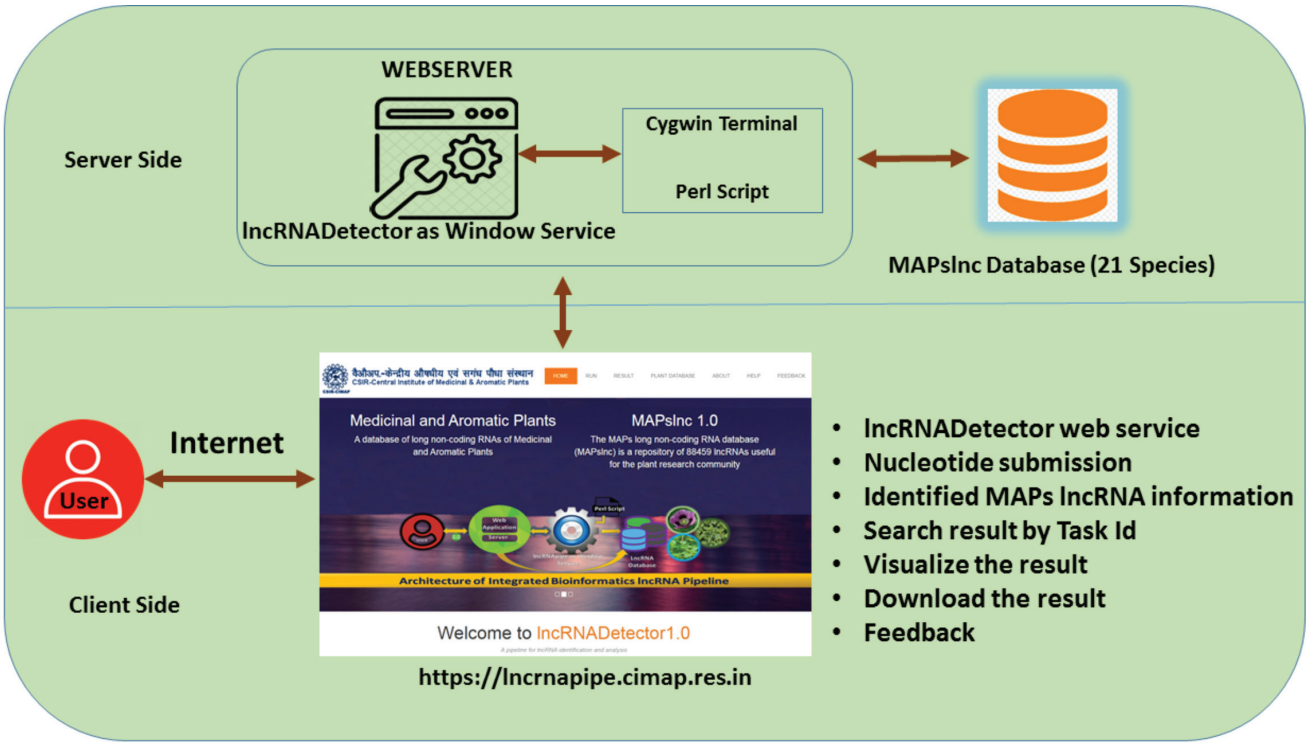


Fig. Architecture of lncRNADetector

CSIR-AROMA MISSION PHASE II PROGRESS AT A GLANCE

Total Area Covered (ha)	700
Total Manpower Trained (number)	6525
Total Awareness Programs (number)	61
Distillation Units Installed	09

CSIR Aroma Mission Phase II, which started in the year 2020 endeavors 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, in the first year of the project has covered an area of around 700 ha with various aromatic crops contributing immensely in improving income of farmers and nurturing essential oil-based aroma industry in the country. About 09 improved distillation units were installed in the aroma clusters during this period of time. 01 high oil-yielding *Eucalyptus citriodora* clone was identified along with development of 04 improved agro & processing technologies during this period. 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. 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.

To make farmers aware about the benefits of aromatic crops 56 one-day awareness programs were organized

Transportation of Planting Material

Plantation of Vetiver

Distribution of Planting Material

Planting of Menthol Mint

High oil-yielding *Eucalyptus citriodora* clone identified

Modified harvesting management in Palmarosa for enhancing yield and productivity

Nursery raising technique in Vetiver for water stress prone areas.

across the country benefiting about 6371 farmers. Also, three skill development (2-3 days) programs were organized wherein training was imparted to more than 100 farmers and entrepreneurs on cultivation and processing of aromatic crops. Further, two advanced (five days) skill development programs were also conducted in which more than 50 farmers were imparted training.

It is hoped that CSIR Aroma Mission Phase II will pave the way for achieving self-sufficiency as well as global leadership in the production essential oils like vetiver, palmarosa and lemongrass.

1000 kg FDU at Datia, M.P

500 kg FDU at Baripada, Odisha

Awareness Programme at Majholi, Assam

Training Programme at CIMAP, Hyderabad

Awareness Programme at Meerut, UP

Kisan Mela 2021, Lucknow

Kisan Mela 2021, Pantnagar

Inputs: Dr. Rajesh Kumar Verma

Establishment of Aarogya Vatika in Lucknow

Aarogya Vatika programme was jointly started by CSIR-CIMAP and Nav Bharat Times (NBT), Lucknow with the help of Lucknow municipal board, Lucknow. In this plantation drive mission programme, several important medicinal and aromatic plants of authentic variety were planted in various parks, government offices, academic institutions and police commissionerate office including 40 police stations of the Lucknow city. In this programme Director CSIR-CIMAP, ministers, Mayer of the Lucknow, scientific & academic dignitaries, social workers, News & TV reporters, NBT reporters & their team and residents participated actively.

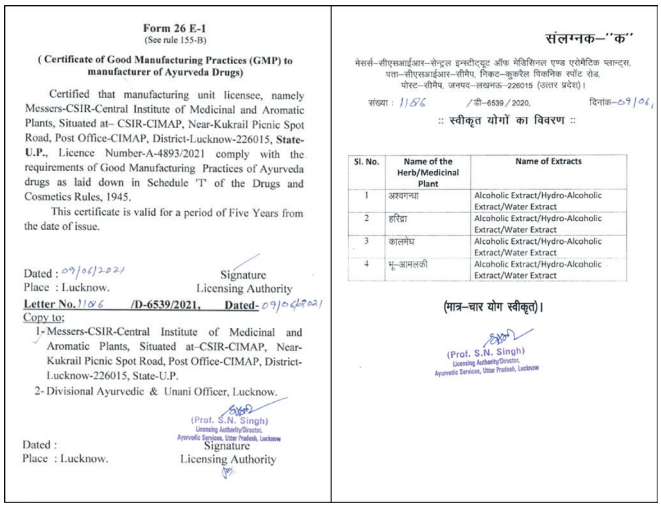
These Arogya Vatikas has fulfilled the Prime Minister desires to Medicinal plants represent each human organs denoting benefits of each plant for each organ. CSIR-CIMAP is encouraging people and academic institutions to develop a **Manav Herbal Park** where medicinal plants are organized in such a way that it gives a shape of human body and specific plant is placed as per the use of that plant to the specific parts of the human body. This concept will help visitors to be aware of the therapeutic value of the plant.

In this Arogya vatika, people can get information about the herbs for their medicinal values, health and environmental benefits. More than 100 Arogya Vatikas were established in vicinity of the Lucknow city with the aims to create awareness about the pivotal role of the plant in the wellness of the human body.

Inputs: Dr. Sudeep Tandon

GMP Certification of CIMAP Extraction Facility for Manufacturing of Ayurvedic Drugs

Medicinal and Aromatic Plants have played a key role in human health since time immemorial. Plants and their parts have been in use since ancient times as medicines for the treatment of a range of diseases. In spite of the great advances observed in modern medicine in recent decades, plants still make an important contribution to global healthcare. Although the use of herbal extracts and medicines have enhanced, the validation of the extraction and processing techniques to ensure the quality, safety and efficacy of the herbal products is yet to be fully standardised. Starting from the source & quality of the raw materials, processing techniques / solvents, extraction unit design, storage conditions of products, etc. all parameters directly influence the end quality and efficacy of herbal medicine. The application of Good Manufacturing Practices (GMP) in the manufacture of herbal extracts is thus becoming an essential requirement to assure the safety, quality and efficacy of the herbal products.



Form 26 E-1
(See rule 155-B)

(Certificate of Good Manufacturing Practices (GMP) to manufacturer of Ayurveda Drugs)

Certified that manufacturing unit licensee, namely Messers-CSIR-Central Institute of Medicinal and Aromatic Plants, Situated at– CSIR-CIMAP, Near-Kukrail Picnic Spot Road, Post Office-CIMAP, District-Lucknow-226015, State-U.P., Licence Number-A-4893/2021 comply with the requirements of Good Manufacturing Practices of Ayurveda drugs as laid down in Schedule 'I' of the Drugs and Cosmetics Rules, 1945.

This certificate is valid for a period of Five Years from the date of issue.

Dated : 07/01/2021
Place : Lucknow.
Signature
Licensing Authority
Letter No.1186 /D-6539/2021, Dated- 07/01/2021
Copy to:
1- Messers-CSIR-Central Institute of Medicinal and Aromatic Plants, Situated at–CSIR-CIMAP, Near-Kukrail Picnic Spot Road, Post Office-CIMAP, District-Lucknow-226015, State-U.P.
2- Divisional Ayurvedic & Unani Officer, Lucknow.

(Prof. S.N. Singh)
Licensing Authority/Director,
Ayurvedic Services, Uttar Pradesh, Lucknow

Dated :
Place : Lucknow.
Signature
Licensing Authority

संलग्नक–"क"

मेसर्स–सीएसआईआर–सेन्ट्रल इन्स्टीट्यूट ऑफ मेडिसिनल एण्ड एरोमेटिक प्लान्ट्स,
पता–सीएसआईआर–सीमैप, निकट–कुकरैल पिकनिक स्पॉट रोड,
पोस्ट–सीमैप, जनपद–लखनऊ–226015 (उत्तर प्रदेश)।

संख्या : 1186 /डी-6539/2020. दिनांक–07/01/

:: स्वीकृत योगों का विवरण ::

Sl. No.	Name of the Herb/Medicinal Plant	Name of Extracts
1	अश्वगन्धा	Alcoholic Extract/Hydro-Alcoholic Extract/Water Extract
2	हरिद्रा	Alcoholic Extract/Hydro-Alcoholic Extract/Water Extract
3	कालमेघ	Alcoholic Extract/Hydro-Alcoholic Extract/Water Extract
4	भू–आमलकी	Alcoholic Extract/Hydro-Alcoholic Extract/Water Extract

(मात्र–चार योग स्वीकृत)।

(Prof. S.N. Singh)
Licensing Authority/Director,
Ayurvedic Services, Uttar Pradesh, Lucknow

In this direction, the Extraction Facility of the Chemical Engineering unit of Phyto Chemistry Division was

GMP Extraction Unit at CSIR-CIMAP, Lucknow

certified as a GMP facility by the State Ayurvedic Department for production of herbal extracts (License No A -4893/ 2021). The GMP license has been taken initially for production of herbal extracts of four plants namely *Withania somnifera, Andographis paniculata, Phyllanthus amarus* and *Curcuma longa* whose CMC (Chemistry, Manufacturing and Control) data has already been generated by CIMAP. The CMC data requirement for adding new / other plants presently being used in CIMAP formulations is also being defined and will be applied for GMP certification as an addendum at later stages.

Inauguration of New Dual Distillation Unit

A new stainless steel 500 kg capacity directly fired type dual field distillation unit with double condenser and cohobation column suitable for all types of essential oils including water miscible oils was inaugurated by our honourable Director General CSIR Dr Shekhar C Mande during his visit to CSIR-CIMAP Lucknow on 30th November 2020.

Installation of New Pilot Scale SCFE Unit: Super critical fluid extraction (SCFE) technology has come as a revolutionary development in the field of processing of natural products as a green extraction technology. SCFE is nowadays being explored as an alternative modern technology for extracting natural plant products such as essential oils, extracts, oleoresins, phytomolecules, dyes etc. SCFE extraction using CO_2 has multiple advantage such as being non-toxic, non-flammable, having high diffusivity, low viscosity, highly selective and faster extraction with no solvent residues.

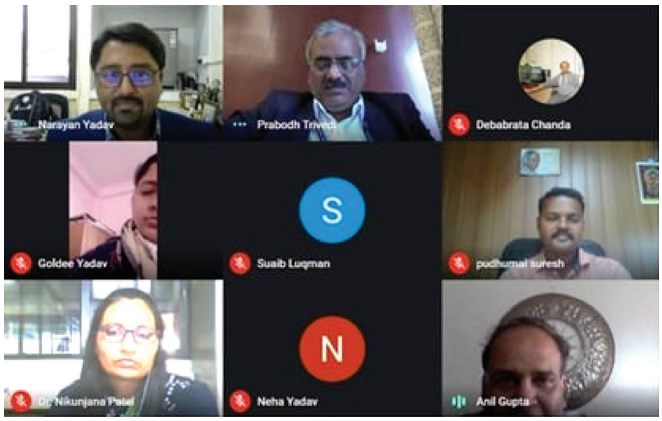
A new Pilot scale SCFE facility having dual extractors of 5lt and 2lt has been installed and commissioned in the Chemical Engineering central facilities under Phytochemistry Division. The GMP compatible SS-316 unit is fully microprocessor graphic based with user interface coupled with PLC & HMI controlled system. The unit is having automated back pressure regulators with operating pressure rating of 400 bar

and proof testing pressure of 500 bar along with co solvent and CO_2 recycling system The unit shall be used for development of improved green processing technologies for targeted extraction of high value medicinal plants, lead therapeutic bio molecules. essential oilss, aroma chemicals, concretes / absolutes / extracts etc.

Inputs: Dr. L. Rahman

CSIR- Integrated Skill Initiative

CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow has undertaken skill/training programmes under CSIR Integrated Skill Initiative. During 2020-21,



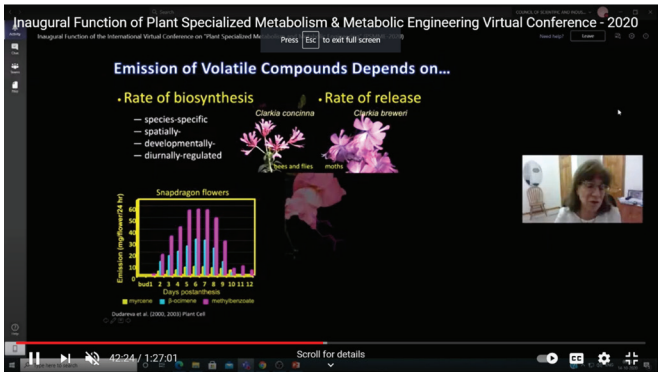
a total of 122 candidates have been trained on different topics of medicinal and aromatic plants cultivation, processing, analysis and herbal product development as well as on pre-clinical development of MAP based leads. A total amount of Rs.795000.00 ECF has been generated from fee of participating candidates.

Inputs: Dr. Dinesh A. Nagegowda

Conference at CSIR-CIMAP

CSIR-CIMAP successfully conducted a virtual International Conference on "Plant Specialized Metabolism and Metabolic Engineering (PSMME-2020)" during October 14-16, 2020. This virtual event was conceptualized and conducted as physical attendance was not possible due to Covid-19 pandemic. The main aim of the event was to bring together the global scientific community to discuss the latest happenings in various aspects of plant secondary metabolism, its engineering, and application of secondary metabolites in human health.

The conference was attended by 35 eminent invited speakers from 10 different countries. Among them 21 were from India, 3 from USA, 2 speakers each from Germany and Singapore, and one speaker each from Canada, France, Australia, New Zealand, Israel and Hong Kong. Besides invited speakers, the conference was attended by more than 450 registered participants



which included 70 submitted abstracts. Among the abstracts, 17 were selected for oral talks to encourage young researchers. Complimentary to the live event, there was a poster session conducted via Conference Twitter account through which the participants displayed their posters.

The conference was inaugurated by Dr. Shekhar C. Mande, Director General of Council of Scientific and Industrial Research, and Secretary, Department of Scientific and Industrial Research, Govt of India. In his inaugural address, Dr. Mande appreciated the initiative taken by CSIR-CIMAP to conduct the event in this unusual situation of COVID-19 pandemic. The inaugural talk was given by Prof. Natalia Dudareva, a Distinguished Professor of Biochemistry from Purdue University, USA, who is an authority on the biosynthesis and emission of aromatic compounds in plants.

Followed by the inaugural session, various researchers from academia and industry presented their latest findings in different topics that were distributed among 3 days. The topics broadly included all the aspects of plant small and/or specialized metabolites such as their biosynthesis, their roles in plant growth and development, how their formation is regulated, different strategies for their overproduction by metabolic engineering or synthetic biology for applications in drug, fragrance, flavor, cosmetic, and biofuel industries. In addition, the scientists also presented their research and deliberated the importance small/specialized molecules in ecological aspects, their applications to plant trait improvement, and their use in human health including COVID-19 mitigation.

Finally, the virtual conference ended with a valedictory session involving feedback from the participating scientists and students. The attendees both in the valedictory session as well as via emails expressed that they were lucky to have such great platform where they could listen and learn from world-renowned researchers and further told that such events could be organized in a regular interval. Besides, many of the invited speakers have expressed their appreciation through e-mails and twitter for hosting such an event and providing an opportunity to share their research findings and to listen to other speakers. Post-conference, the student awards for best oral talks and posters were given based on the evaluation of expert committee.

After having successfully conducted this event, CSIR-CIMAP can proudly state that the conference was unique and one of a kind in the area of plant secondary metabolism and its engineering in the world.

Inputs: Dr. R.K. Srivastava

CSIR-CIMAP opened a CSIR-Technology Window at Shillong, Meghalaya

With the approval of DG CSIR, CSIR-CIMAP opened a Technology Window at Shillong, Meghalaya on 25.02.2021. The CSIR-Window was inaugurated by Dr. Shakil P. Ahmad, IAS, Principal secretary, Agriculture, Fishries, Water Resources, Food Civil Supplies and CA Department, Govt. of Meghalaya along with Dr G.N. Sastry, Director, CSIR-NEIST, Jorhat and Dr Prabodh Kumar Trivedi, CSIR-CIMAP, Lucknow. The CSIR Technology Window is working as a show-case of the activities and technologies of CSIR-CIMAP to people of NER especially state of Meghalaya.

The main objectives of the Technology window are as under:

1. To facilitate agro- technical know-how of different MAPs suited for Meghalaya, explore possibility of promoting locally available crops of medicinal and aromatic value, provide guidance along with quality planting materials to the local farmers and herbal formulations for the MSME and startup in North East region particularly Meghalaya.
2. Provide technical help in establishment of laboratory of Govt. of Meghalaya for quality and quantity analysis of essential oils and herbal products.
3. The rural technology of all CSIR laboratory may be demonstrated through this Technology Window.

Inputs: Dr. Anil Kumar Maurya

The new logo of CSIR-CIMAP

सी.एस.आई.आर.–सीमैप की नवचेतना को प्रदर्षित करता, पारंपरिक ज्ञान को संजोए हुए एवं आधुनिक विज्ञान की सा. र्थकता का द्योतक और हरित पथ पर मानवहित में आगे बढ़ने की प्रेरणा देता हुआ सी.एस.आई.आर.–सीमैप का नवसृजित प्रतीक चिन्ह

The new logo of CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP) was launched at Kisan Mela 2021. It represents the amalgamation of India's traditional knowledge with modern scientific discoveries and highlights the quality research work and major achievements.

Director CSIR-CIMAP, Dr PK Trivedi described it as the new aspiration of the institute. It begins with supporting hands attached to two leaves that denote CIMAP scientists and technical officers holding leaves of medicinal plant Mentha. It shows how CIMAP's efforts have made India a leading exporter for Mentha".

The logo tagline is "**Towards better health and life**"

The logo was adopted after a national logo design competition with many entries across the country. The logo designed by CIMAP's Senior Technical Officer Dr Anil Kumar Maurya was finally selected with some modifications.

Honours and awards 2020-21

1. DBT- Ramalingaswami Fellowship awarded to Dr. Ratnasekhar in Life Sciences, Department of Biotechnology, India 2020

Inputs: Er. G.D. Kiran Babu

One-day awareness program for B. Pharm. students

Organized an awareness program for the final year B Pharma students from two colleges, i.e. Bharat Institute of Technology and Bharat School of Pharmacy, Ibrahimpatnam, Hyderabad on February 10, 2021, at CRC, Hyderabad.

Fig. The B Pharma students visited the processing facilities employed in the extraction of MAPs.

One-day awareness program conducted at Tyda village, Visakhapatnam

One-day awareness program on 'Cultivation, Processing and Quality Evaluation of Medicinal and Aromatic Plants' was conducted with the help of Green Connexion (an NGO) at Tyda, Anantagiri Mandal, Visakhapatnam District, Andhra Pradesh on 25-03-2021 under CSIR-Aroma Mission, Phase-II (HCP-0007). Fifty-two tribal farmers including 2 woman participants from Agency areas of Mediparthi, and Singarbha clusters participated in the said awareness program. Five thousand Lemongrass slips and 2.5 kg Palmarosa seeds were distributed to five prospective farmers to initiate their cultivation.

Fig. Distributed Palmarosa seeds and Lemongrass slips to the farmers of Mediparthi, and Singarbha clustersinAnanthagiri Mandal, Visakhapatnam District (AP).

One-day awareness program conducted at Utla village, East Godavari District

Organized one-day awareness program on the occasion of CSIR-CIMAP Foundation Day on 26-03-2021 on Cultivation of aromatic crops at Utla village (a remote tribal area), Rampachodavaram Mandal, East Godavari District under CSIR-Aroma Mission, Phase-II (HCP-0007) and distributed 3000 Lemongrass slips and 2.5 kg Palmarosa seeds to seven interested farmers (Fig.). Lemongrass plantation was also initiated in the fields in Utla village in one of the potential farmers (Fig.).

Fig. Distributing Palmarosa seeds and Lemongrass slips to the farmers of Utla village (a remote tribal area), Rampachodavaram Mandal, East Godavari District (AP).

Fig. Initiation of lemongrass plantation at Utla village, Rampachodavaram Mandal, East Godavari District, Andhra Pradesh during field visit of Scientists from CSIR-CIMAP, Research Centre, Hyderabad

Skill Development-cum-Training Program

A 3-day Skill Development-cum-Training Program on "Cultivation, Primary Processing, and Quality Aspects of Aromatic and Medicinal Plants" was conducted at CRCH from 15 to 17th March 2021 under CSIR-Aroma Mission, Phase-II. A practical demonstration on the production of essential oils was imparted to the trainees during the trainingon 16th March 2021 (Fig.). Forty-one participants including farmers, students, entrepreneurs,

Fig. A practical demonstration on distillation, purification, and storage of essential oils has been imparted to the trainees on 16th March 2021 at CRC, Hyderabad.

Fig. A group photograph with the participants, faculty members, and staff during the training program conducted during 15-17 March 2021.

from Maharashtra, Telangana, and Andhra Pradesh attended the said program.

Visit by distinguished guests

Sri G Jagadish Reddy, Honorable Minister for Energy along with Sri G Kishore Kumar, Honorable MLA, Thungathurthi (Nalgonda District), Telangana visited CSIR-CIMAP, Research Centre, Hyderabad on 8th August 2020 to know the activities being carried out. He was taken to the fields where MAPs are being cultivated and to the distillation unit facility. He was briefed about the CIMAP's R&D efforts and extension

Fig. The visit of the Honorable Minister to the experimental fields and the distillation facility at CRCHon 8th August 2020.

work being done in the states of Telangana and Andhra Pradesh (Fig.).

Commissioning of solvent extraction unit

A pilot-scale solvent extraction unit having the capacity to extract 20-25kg/batch was designed and got fabricated and erected at CRC, Hyderabad to extract herbal plant materials.The pilot plant was commissioned by Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, Lucknow on 08/01/2021 (Fig.). Thispilot plant contains (i) extractor with agitation, heating with steam & hot water, reflux provision, heat exchanger, solvent recycling facility, (ii) filtration with centrifuge for solid-liquid separation, (iii) extract storage tank, (iv) circulation pumps, (v) reboiler with hot water/steam jacket, condenser and (vi) vacuum pump, (vii) skid, (viii) piping, etc. All contact parts are made up of SS-304 and mandated medicinal crops such as Ashwagandha, Kalmegh, etc.will be extracted to produce the active ingredients from the said plants.

Fig. Inauguration of pilot-scale solvent extraction plant for the extraction of medicinal plants

Inauguration of herbal processing facility

Primary and secondary leaf grading machines for sorting the dry leaves of Senna based on their size and the micropulverizer for making the powder from the dry medicinal plant parts were commissioned (Fig.).These leaf grading machines and the micro pulverizer were housed in a newly constructed herbal processing shed which was inaugurated by Dr. Prabodh Kumar Trivedi, Director during his visit to this Research Centre on 08/01/2021 (Fig.). During the visit, he also inspected the 500kg/batch capacity field distillation unit commissioned at the Centre under CSIR-Aroma Mission, Phase-I (Fig.). Director also inspected the Aloe vera processing facility commissioned at this Centre along with Mr. Sudhakar Rao, Dy. CEO, Telangana State Medicinal Plant Board, Hyderabad (Fig.).

Fig. Inspection of pilot-scale primary and secondaryleaf grading machines and SS-316 Pulverizer.

Fig. Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, inaugurated the newly constructed herbal processing unit at CSIR-CIMAP Research Centre, Hyderabad on 08/01/2021

Fig. Inspection of the Aloe vera processing facility by the CIMAP Director along with Mr. Sudhakar Rao, Dy. CEO, Telangana State Medicinal Plant Board who sponsored the project.

Construction of new polyhouse and shade net

The newly constructed polyhouse and shade net were inaugurated by Dr. Prabodh Kumar Trivedi, Director, CSIR-CIMAP, Lucknow on 08th January 2021 (Fig.). The project was sponsored by the National Medicinal Plant Board, New Delhi for the establishment of a model nursery got production and supply of quality planting material.

Fig. Inaugurated new polyhouse and shade net constructed under the sponsored project for the establishment of model nursery and production of quality planting material.

Inputs: Dr. R.C. Padalia

'Kisan Gosthi' at CSIR-CIMAP, Research Center, Pantnagar

One-day '**Kisan Gosthi'** was organized at CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP) Research Center, Pantnagar on 08/02/2021 and 09/02/2021 with 121 and 126 participants, respectively. Total 247 farmers participated in these Gosthi. Dr. Prabodh Kumar Trivedi, Director CSIR-CIMAP inaugurated and presided over the program. Prof. Tej Pratap, honorable Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar was the Chief Guest of the Kisan Gosthi. Dr. Saudan Singh-Co-coordinator of CIMAP Research Centers, Dr. Sanjay Kumar-Convenor of the Kisan Gosthi, Dr. V R Singh, Dr. R. C. Padalia-Scientist-in-chagre CRC Panat Nagar, Dr. R.S. Verma, Dr. R.K. Upadhyay, Dr. Venkatesh KT, Dr. Rushikesh, Dr. Deependra Kumar, Dr. Amit Chauhan and all staff of CRC Pantnagar interacted with farmers and disseminated CSIR-CIMAP technologies. Demonstration of agrotechnologies of medicinal and aromatic crops, distillations processes, rose-water technology, and early mint technology, training for Agarbatti/Incense sticks production were carried out during the Kisan Mela. Various stalls displayed different activities pertaining to MAPs technologies, herbal products, agro-advisory, and CIMAP publications. The quality planting material of menthol mint 'CIM-Unnati'

was sold to the farmers during Kisan Gosthi. Tulsi and Ashwagandha plants were distributed to progressive farmers and visitors under the CSIR-CIMAP extension and social outreach program.

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

CSIR-Central Institute of Medicinal & Aromatic Plants (CIMAP) Research Center, Pantnagar participated in the Kisan Kumbh: 109th All India Farmers' Fair and Agro-Industrial Exhibitions held at G.B. Pant University of Agriculture and Technology, Pantnagar on 22-25th March 2021. CSIR-CIMAP received a special prize for its outstanding exhibition of various activities on MAPs technologies, agro-advisory, herbal products, and CIMAP publications on MAPs.

Training program conducted in CSIR-Aroma mission at Uttarakhand

Three one-day training and demonstration programs were conducted at Sitarganj (District: Udham Singh Nagar), Ramgarh, (District: Nainital), and CRC, Purara, (District: Bageshwar) on 24/02/2021, 03/03/2021, and 04/03/2021 for promotion of different aromatic crops in CSIR-Aroma Mission to enhance farmers income and utilize wasteland / fallow land / hilly areas in Uttarakhand.

Inputs: Dr. Sudeep Tandon

Dissemination of distillation units & agro-technology

In the second phase of the project, 9 different types of directly fired type, cohobation, boiler operated and mobile type improved distillation units of varying capacities & designs have been successfully designed, fabricated, installed and commissioned at different aroma clusters throughout India including two at Meghalaya, one in Orissa, one in Datia, MP and one unit is under installation in Haveli, Karnataka. CSIR-CIMAP Resource Centers at Bangalore and Pantnagar have also been equipped with Tractor trolley mounted Mobile Distillation Units to cater to the distillation of the farmers of nearby areas.

200 kg Cohobation FDU at Umkrem West Khasi Hills, Meghalaya

A consultancy project was undertaken for providing technical guidance for planning and setting up of the processing facilities for the distillation of Aromatic Crops at Mirzapur. The units fabricated as per CSIR-CIMAP designs were installed in September 2020. A team of CSIR-CIMAP technical staff visited the site and commissioned the units. Several trials using Palmarosa, lemongrass were carried out. Another visit of the team was undertaken in January 2021 for distillation trials of Vetiver. The project has been successfully completed.

Dissemination of Vetiver (*Chrysopogon zizanioides*) agro-technology in flood prone and contaminated area of Ganga river of Uttar Pradesh (GAP 369): Dissemination of Vetiver (*Chrysopogon zizanioides)* agro-technology in flood prone and contaminated area of Ganga river of Uttar Pradesh Designing, fabrication and installation of improved directly fired type field distillation units in Kanpur and Varanasi districts for the distillation of Vetiver being cultivated in flood prone and contaminated area of Ganga river of Uttar Pradesh. The units have been successfully commissioned and demonstrated by technical team of CIMAP to the farmers of the region.

Skill Upgradation Training Workshop on Essential oil processing (EOPT-2021)

Skill Upgradation Training Workshop on Essential oil processing (EOPT-2021) was conducted from 22-26 March 2021 under the Skill India Mission and CSIR Aroma Mission for the farmers and entrepreneurs interested in setting up of units for processing and value addition of essential oils. Sixteen candidates representing over 06 states of India participated in the workshop. The workshop was specially designed to give the participants a systematic knowledge on the processing & value addition technologies for aromatic plants Particular emphasis was laid on the quality analysis procedures for the essential oils as the export market demands only high quality products.

CIM-RespCool

CSIR-Central Institute of Medicinal and Aromatic Plants has been prospecting Medicinal and Aromatic Plants for few decades. Collating the traditional knowledge, text mining and the scientific observations, the institution has come up with a formulation for use in diffusers in hospital wards, hotels or even homes for sanitized air.

CSIR-CIMAP has developed diffuser formulation, which incorporates 5 essential oils from traditionally used herbs and spices, however, the selection is based on the text mining of the anti-viral activity possessed by the molecules present in these essential oils. These plants and (or) essential oils are in daily use in one way or other for food, cosmetics, flavour and fragrance. As per literature, these molecules are very effective against different viruses such as Infectious Bronchitis virus (IBV), Herpes Simplex Type 1 (HSV-1), influenza A and B, avian influenza (H5N1), adenovirus, hepatitis B virus, coxsackie virus, enterovirus 71, feline calicivirus (FCV), tomato leaf curl virus, rhino virus etc.

The formulation has been found to be helpful in bronchospasms and also it is free of any mucous membrane or skin irritation as observed in Swiss Albino Mice. In addition, it was also being tested for cardiovascular toxicity and trachea-bronchial tissue reactivity. CIM-RespCool showed 99% viral (SARS-CoV2) reduction from 10% to 100% concentration in culture. The viral particles reduced from 106.8 to 102.9 as per the test report by CSIR-CCMB. Observational studies on human volunteers have expressed a feeling of decongestion of the respiratory tract.

Hand Sanitizing Gel

Utilizing hand sanitizer either in the form of liquid, gel or semi gel are most effective way to make your hand and other body part to sanitize and make microbe free. In general alcohol-based sanitizers are more liked by the health workers and other mass to sanitize the hand. It is well known that products contain about > 60% of alcohol and isopropyl alcohol or combination of both are most effective to kill the micro-organisms and better tolerated than soap and other products. Since alcohol and isopropyl alcohol-based sanitizers are effective against variety of micro-organisms but not much effective against spores.

CSIR-CIMAP has scientifically developed a very effective, safe, broad spectrum anti-bacterial and anti-fungal formulation of hand sanitizing gel, which contains plant, based active molecule and essential oils.

Hand sanitizing gel was found effective against following bacteria and fungi:

Bacteria: *Staphylococcus epidermidis, Enterococcus faecalis, Escherichia coli, Klebsiella pneumonia, Streptococcus mutans, Mycobacterium smegmatis, Salmonella typhimurium, Salmonella typhi,*

Staphylococcus aureus resistant and *Staphylococcus aureus*

Fungi: *Malassezia furfur, Candida albicans* (ATCC-2), *Candida albicans* (K4-1), *Candida albicans* (AI) and *Sporothrix schenckii*

Safety / Toxicity data:

- Acute Dermal Irritation Test
- Acute Oral Toxicity Study

CIM-EVERGREEN

Healthy Ageing Tea

CSIR-Central Institute of Medicinal and Aromatic Plants has been prospecting Medicinal and Aromatic Plants for few decades. Collating the traditional knowledge, text mining and the scientific observations, the institution has come up with a formulation for healthy ageing life. The formulation incorporates plants from traditionally used herbs, however, the selection is based on the text mining of the anti oxidant, anti-ageing and cognitive boosting activities present in these plant materials. The selection of the ratio of the plant is based on their different health promoting activities. Observational studies upon giving tea to mice did not result in any abnormal behaviour even after 28 days. The formulation has the remarkable action on strengthening the function of brain, anti-aging and anti-inflammatory and cognitive boosting activities especially against Alzheimer's and parkinson disease.

Directions for use: Dip 1g formulation sachet in 100 ml of boiled water and remove the sachet from the tea cup.

CIM-Megh[CIMAP]

Kalmegh based immune booster [CIM-Megh[CIMAP]]: Inspired from *Ayurvedic* knowledge as well as available pharmacological evidence, the Kalmegh (*Andrographis paniculata*) was selected to develop a standardized Ayurvedic product that can support in combating the severity of COVID-19 infection through immune-boosting and anti-inflammatory actions. The developed product is intended for human clinical studies to come up as an effective phytopharmaceutical product for alternate therapy.

Salient Feature/ USP of the product

- Ensured sustainability of quality raw material
- Environmental friendly process.
- Defined CMC (Chemistry, manufacturing, and Controls)
- Standardization based on (04) marker for quality assurance
- SOPs for batch-to-batch process monitoring
- Scientific evidence for **h**epatoprotection, antipyretic, analgesic, anti-inflammatory, and immunity enhancing potential.
- Defined stability
- Pre-clinical proven safety (Acute & sub-acute animal toxicity & Ame's test)
- Can be converted into the tablet dosage form
- Ready for pilot clinical studies

Team member: Dr. Prabodh K Trivedi, Dr.Karuna Shanker, Dr. DU Bawankule, Dr. Anirban Pal, Dr. Puja Khare, Dr. D. Chanda, Dr. Abha Meena, Dr. DN Mani, Dr. NP Yadav, Dr. Sudeep Tandon, Dr. Rajesh K. Verma, Dr. Narendra Kumar, Dr. Ramesh K Srivastava, Mrs. Namita Gupta, Dr. Manju Singh, Dr. Neerja Tiwari, Dr. Pooja Singh, Dr. Sonali Mishra, Ms. Pooja Gaur, Mr. Ramdas, Ms. Iti Gaur, Ms. Vijaya Shukla

Product Technology CIM-Megh[CIMAP]: Kalmegh based immune booster [CIM-Megh[CIMAP]] was transferred to M/s Meghdoot Gramoudyog Sewa Sansthan, Lucknow.

Technology Transfer for Commercialization

Sl. No	Title	Period during which developed	Date of transfer	Organization/Industry
1.	Hand Sanitizer liquid/gel	2020-21	21.04.2020	M/s Rako Agrochem Pvt. Ltd., Lucknow
2.	Hand Sanitizer gel/liquid	2020-21	27.04.2020	M/s Innovative Concepts Lucknow, UP
3.	Hand Sanitizer gel/liquid	2020-21	19.05.2020	M/s. Hapi Key Hyderabad (Telangana)
4.	Hand Sanitizer gel/liquid	2020-21	26.05.2020	M/s. Sai International Lucknow, UP
5.	Hand Sanitizer gel/liquid	2020-21	15.6.2020	M/s. Asear Medicare, Lucknow, U.P.
6.	Hand Sanitizer gel/liquid	2020-21	26.09.2020	M/s. Vyom India Organics Private Limited, Bareilly
7.	Mosquito repellent spray (Mospray)	1997-98	26.09.2020	M/s. Vyom India Organics Private Limited, Bareilly
8.	Clean Germ (Floor Cleaner)	2018-19	26.09.2020	M/s. Vyom India Organics Private Limited, Bareilly
9.	Mospray-Mosquito repellent spray	1997-98	15.10.2020	M/s. Maa Durga Marketing, Chandauli, UP
10.	Relaxo-map (Pain reliving oil)	2013-14	10.11.2020	M/s. Hapi Key Hyderabad
11.	Flower based incense sticks and fragrant cone from offered flowers	2011-12 (Modified in 2017-18)	18.12.2020	M/s. Green Dream Bharat, Naini, Prayagraj
12.	Immunity booster Tea (Evergreen Tea)	26.9.2021	31.01.2021	M/s. Vyom India Organics Private Limited, Bareilly
13.	Herby soft Shampoo	2005-06	31.01.2021	M/s. Vyom India Organics (P) Ltd.
14.	Geranium Active (Anti-dandruff Shampoo)	2005-06	31.01.2021	M/s Vyom India Organics Private Limited, Bareilly
15.	Kleenzie (Aloe vera based face wash)	2005-06	31.01.2021	M/s Vyom India Organics Private Limited, Bareilly (UP)
16.	Immunity Booster based on Kalmegh CIM-Megh	28.1.2021	12.02.2021	M/s Meghdoot Gramodyog Seva Sansthan, Lucknow
17.	Incense sticks from offered flowers	2011-12 (Modified in 2017-18)	08.03.2021	Aadarsh Shiksha Evam Seva Samiti, Gonda

Agreement signed for Market seeding of CSIR-CIMAP formulations by the start-up/MSMEs

S. N.	Date of agreement	Company Name	Product Name
1.	13/05/2020	M/s Rako Agrochems Pvt. Ltd, Lucknow	Hankool Plus
2.	26/05/2020	M/s Sai International, Lucknow	Hankool Plus
3.	9/6/2020	M/s Innovative Concepts, Lucknow	Hankool Plus
4.	15/6/2020	M/s B Care Sure Life Cure LLP, Lucknow	Hankool Plus
5.	15/07/2020	M/s Being Arogyam Herbals Private Limited, Lucknow	CIM-Paushak, CIM-Phalse, Clean germ Hankool Plus
6.	16/06/2020	M/s Vadic biocare Pvt.Ltd, Lucknow	Clean germ
7.	19/09/2020	M/s Nains Herbal & Organics Pvt. Ltd, Sonipat, Haryana	CIM-Phalse, Clean germ, Hair oil, Relaxomap, Cracknil
8.	23/09/2020	M/s VYOM INDIA ORGANICS PVT. LTD. Bareilly	Hankool Plus Hand Sanitizer, Mospray-Mosquito Repellent Spray and Cleangerm –Floor cleaner
9.	28/09/2020	M/s Meesa International Concept Pvt.Ltd	Mospray
10.	3/01/2021	M/s Mirjapur Jaiv Urja Farmers Producer Company Limited	Painchhoo, Relaxomp, Cleangerm

ECF generated from Pilot Plant Facility (TBIC) towards providing manufacturing facilities of CSIR-CIMAP formulations for the start-up/MSMEs/industries for a period of one year

S. No	Date	Name of MSME	Name of the CSIR-CIMAP formulation
1.	20/05/2020	M/s Rako Agichem (P) Ltd	Hankool Plus
2.	15/06/2020	Sai International	Hankool Plus
3.	5/06/2020	M/s Hapi Key	Geranium active, Kleenzie lime & fruit, herby soft
4.	15/06/2020	M/S Hapi Key, Hyderabad	Hankool Plus
5.	18/06/2020	M/S Vadic Biocare Private Limited	Clean germ
6.	16/07/2020	Being Arogyam Herbals(P)Ltd.	CIM-Phalse, Cleangerm, CIM-Poshak
7.	18/8/2020	Being Arogyam Herbals(P)Ltd.	CIM Phal-se, Cleangerm,
8.	27/8/2020	M/S Hapi Key Hyderabad	Herby Soft
9.	16/09/2020	M/s Sai International	Hankool Plus

10.	21/09/2020	M/S Kings herbal research laboratories	Relaxomap
11.	24/09/2020	M/s Vyom India organics Pvt. Ltd. Bareilly	Mospray, Clean germ, Geranium active, Herby soft, Kleenzie lime, Kleenzie fruit, Acne wash, Hankool plus
12	25/09/2020	M/s Hapi key, Hyderabad	Lip balm, Relaxomap, Hair oil
13	28/10/2020	Sai International	Hankool plus
14	18/09/2020	M/s Nains herbals and organics (poc) Private Limited	Clean germ, Hair oil, CIM-Phal-se
15.	29/09/2020	M/s Nains herbals and Organics Private Limited	Relaxomap
16.	09/11/2020	M/s Vyom India organics Pvt. Ltd. Bareilly	Hankool Plus
17.	10/11/2020	M/s Maa Durga Marketing	Mospray
18.	17/12/2020	M/s Hapi key, Hyderabad	Relaxomap, Hair oil, Herby Soft, Kleenzie lime & fruit
19.	06/02/2021	M/S Being Arogyam Herbals Pvt. Ltd, Lucknow	Acne wash, Relaxomap, Geranium active, Poly herbal toothpaste
20.	25/02/2021	M/s Vyom India organics Pvt. Ltd. Bareilly	Mospray, Clean germ, Geranium active, Herby soft, Kleenzie lime, Kleenzie fruit, Acne wash, Hankool plus
21.	18/03/2021	M/s Maa Durga Marketing	Mospray

CSIR–CIMAP released CIM–RespCool–a scientific knowledge based essential oil vaporiser concentrate formulation helpful in management of respiratory distress caused by environmental containments including viruses on 2nd May 2020

CSIR-CIMAP Director, Dr Prabodh K. Trivedi provided 500 bottles of herbal sanitizers for the prevention of COVID-19 among police personnel of Lucknow city on 18th April 2020.

The technology of the hand sanitizing gel was transferred to Lucknow based company Rako Group Private Limited on 21st April 2020

Transfer of Hand Sanitizer 'Hankool' Technology to M/s Sai International Pvt. Ltd., Lucknow 26-05-2020

CSIR-CIMAP distributed hand sanitizers and surface disinfectants to Lucknow Development Authority to combat COVID-19

Massive awareness programme was organized by CIMAP Staff club to make all staff members aware about preventive measures to combat COVID-19

Dr Prabodh K. Trivedi, Director, CSIR-CIMAP and Shri Ashutosh Tandon, Hon'ble Minister of Urban Development, Uttar Pradesh inaugurated the 'Arogya Vatika' a joint initiative of CSIR CIMAP and Navbharat Times at Thakurganj, Lucknow on 11th October 2020

Celebration of Republic day on 26th January 2021

Plantation drive for planting medicinal and aromatic trees was organized in CSIR-CIMAP on the occasion of world environment day

Transfer of hand sanitizer technology-Mesars B Care Sure Life Cure LLP, Lucknow

A MoU was signed between CISR-CIMAP and Lucknow University for academic and research programmes

Kisan Mela 2021

CSIR-CIMAP organized Kisan Mela 2021 from 15th January – 5th February 2021

Dr. J.L.N Sastry, CEO, National Medicinal Plant Board, New Delhi, Ministry of AYUSH visited CSIR-CIMAP and met Dr. Prabodh K. Trivedi, Director, CSIR-CIMAP and team of scientists.

CSIR Cimap, FICCI FLO Lucknow and Kshitij, Sultanpur signed a tripart agreement for upliftment of women farmers in Sultanpur district of UP.

A view of plantation of Geranium at West Khasi Hills under Aroma Mission

A view of IISF 2020 at CSIR-CIMAP

A view of training programme at Ayodhya Jail

DG CSIR inaugurated a training-cum demonstration programme on making of incense sticks from offered flowers at Ayodhya Jail for Women inmates

A view of Training programme of agarbatti making by jail inmates at Ayodhya Jail

DG CSIR visited Ram Jamn Bhumi Nyash and discussing about Surya Kiran Project in with Shri Champat Rai, General Secretary, RJB, Ayodhya

DG CSIR discussing with women training at Ayodhya Jail

A view of training programme at Majuli under Aroma Mission

DG CSIR visited Pilot Plant Facilities at CSIR-CIMAP

Director CIMAP visited in Geranium Nursery field at WKH, Meghalaya under Aroma Mission

Inauguration of Mobile distillation Units by DG CSIR

Visit of CSIR-NEIST Jorhat and discussion with Dr Narhari Shashtry Director NEIST

Inauguration ceremony of training programme at Ayodhya Jail

Hon'ble CM UP inaugurated grinding machine for offered flowers at Gorakhpur

Hon'ble CM UP discussing with the tranees of Agarbatti making from offered flowers at Gorakhpur

Director CSIR-CIMAP presenting Vetiver shawl to Hon'ble CM UP

Field visit and discussion with the tribal farmers at West Khasi Hills at Meghalaya

Discussion with CIMAP's start-ups and DG CSIR

Hon'ble CM UP launching Gorakhnath Ashirwad Agarbatti at Gorakhpur

Distribution of lemongrass slips at Majuli, Assam under Aroma Mission

Sponsored Projects

SN	Funding Agency	Project No.	Project title	PI	Start date	Total cost (Rs.)	End date
1	BASF, Mumbai	SSP-450	Evaluation of bio-efficacy and phytotoxicity of Bentazone 48% SL against sedges and broad-leaved weeds in Menthol mint (Mentha arvensis) and its residual effect on succeeding crop	Dr. Priyanka Suryavashi	13.05.2020	27,12,000	12.05.2022
2	Biotechnology Industry Research Assistance Council, New Delhi	GAP-454	Development of Indigenous yeast system through pathway engineering for sustainable production of high-value sandalwood sesquiterpenes	Dr. Dinesh A. Nagegowda	30.06.2020	40,71,000	29.12.2021
3	NMMP Dept. of Horticulture, State Dept. of Karnataka, BLR	GAP-455	Model nursery for propagation of important medicinal plants	Dr. Channayya Hiremath	10.08.2020	25,00,000	09.08.2021
4	DAE, BARC, Mumbai	GAP-456	Genetic improvement of Damask Rose (Rose damascene Mill) for higher flower and oil yield through induced mutagenesis	Dr. Venkatesha KT	07.08.2020	26,09,850	06.08.2023
5	Chief Conservator of Forest Bundelkhand Zone, Jhansi, UP	SSP-457	Organization of awareness programme on cultivation and processing of suitable aromatic crop in four districts of Bundelkhand region, UP.	Dr. RK Srivastava	01.09.2020	6,00,000	30.08.2021
6	Protection of Plant Varieties & Farmers' Rights Authority, New Delhi	GAP-458	Development of Guidelines for Conduct of Test for Distinctiveness, Uniformity and Stability on Ashwagandha (Withania somnifera (L.) Dunal).	Dr. Tripta Jhang	23.10.2020	27,00,000	22.10.2023
7	Office of Deputy Director Horticulture, Sawai Madhopur, Govt. of Rajasthan	CNP-459	Providing consultancy for designing, fabrication and setting up of Rose oil & Rose water distillation units	Dr. Sudeep Tandon	25.11.2020	7,12,400	24.11.2021
8	National Medicinal Plants Board	GAP-460	Chemometric assisted chromatographic fingerprinting/ marker based method to distinguish sida complex	Dr. Karuna Shanker	02.02.2021	25,54,000	01.02.2024

9	DST-SERB	GAP-461	Elucidating micronutrient dependency of vindoline accumulation and relevant gene prospecting in Cathranthus roseus	Dr Ashutosh Kumar Shukla	09.02.2021	34,23,859	08.02.2024
10	DST-SERB	GAP-462	Assessment of selected transcripts for their functional role in development of specific cell types enriched in withanolides in roots of *Withania somnifera*.	Dr. Pradipto Mukhopadhyay	10.03.2021	38,17,264	09.03.2024
11	DST-SERB	GAP-463	Exploring alternate yeast system, Yarrowia lipolytica, for the bioproduction of pharmacologically important triterpene ursolic acid from castor oil.	Dr. Venkata Rao, D.K.	10.03.2021	39,29,428	09.03.2024
12	CSIR, New Delhi	FC2020-23 / MLP-01	Development of Functional food : *Ocimum basilicum* derived line (Tukmaria) to be released as plant variety yielding "functional food" for weight management (FBR)	Dr. Tripta Jhang	09.07.2020	75,89,000	31.03.2023
13	CSIR, New Delhi	FC2020-23 / MLP-02	Utilization of *Ocimum* Genome for production of industrially important medicinal and aromatic compounds (FBR)	Dr. AK Shasany/ Dr. Ashutosh K Shukla	09.07.2020	98,85,000	31.03.2023
14	CSIR, New Delhi	FC2020-23 / MLP-03	Understanding essential oil biosynthesis in commercially important aromatic grasses (*Cymbopogon* sp.) and Davana (*Artemisia pallens*) for crop improvement (FBR)	Dr. Dinesh Nagegawda	09.07.2020	66,66,000	31.03.2023
15	CSIR, New Delhi	FC2020-23 / MLP-04	Induction, identification, characterization and selection of polyploidy in *Stevia rebaudiana* to increase biomass, stevioside, and rebaudioside-A yield (FBR)	Dr. Venkatesha KT	09.07.2020	70,50,000	31.03.2023
16	CSIR, New Delhi	FC2020-23 / MLP-05	Metabolic engineering of *Bacopa monnieri* by redirecting the flux towards triterpenoid biosynthesis for enhanced bacosides production (FBR)	Dr. Rakesh Kumar Shukla	09.07.2020	42,20,000	31.03.2023
17	CSIR, New Delhi	FC2020-23 / MLP-06	Small RNAs and associated factors for enhanced post-harvest life (sRNA-life) Phase II (FBR)	Dr. Prabodh Kumar Trivedi/ Dr. Prema G. Vasudev	17.07.2020	1,49,50,000	31.03.2023

18	CSIR, New Delhi	FC2020-23 / MLP-07	Genome-editing for crop improvement (GE-Crop) (FBR Network)	Dr. Pradipto Mukhopadhyay	22.07.2020	5,10,00,000	31.03.2023
19	CSIR, New Delhi	FC2020-23 / MLP-08	Commercialization of 'CIM-Pushti': Withanolide-A rich, Leaf Blight tolerant high yielding variety of Ashwagandha (*Withania somnifera*) with good root textural quality (FTC)	Dr. Tripta Jhang	24.07.2020	43,94,500	31.03.2022
20	CSIR, New Delhi	FC2020-23 / MLP-09	Scale-up process for isolation of ricinoleic acid from castor oil and its biotransformation to food-flavor perspective (*)-ɣ-decalactone using Candida strain (FTT)	Dr. PK Rout	24.07.2020	73,33,000	31.03.2022
21	CSIR, New Delhi	NBRI / MLP0048	Deciphering the mechanism(s) of host-endophytes co-evolution, enhanced secondary metabolite production and crop productivity (FBR Network)	Dr. Akanksha Singh	15.07.2020	3,16,50,000	31.03.2023
22	CSIR, New Delhi	NBRI / MLP0049	Bio-stimulants for stress amelioration, enhanced plant productivity and soil health (FBR Network)	Dr. Priyanka Suryavanshi	22.07.2020	2,93,54,000	31.03.2023
23	CSIR, New Delhi	FC2020-23/ NMITLI/ TLP0001	Development of novel anti stroke phytopharmaceutical formulation from the roots of a Aswagandha variety (NMITLI-118)	Dr. Prabodh Kumar Trivedi	05.10.2020	45,00,000	04.10.2023
24	CSIR, New Delhi	FC2020-23/HNP-Cov-19/ MLP-10	Andrographis based therapy to suppress the severity of the COVID-19 infection by targeting host pathogenic mechanisms	Dr. Karuna Shanker	24.12.2020	68,08,000	31.12.2021
25	CSIR, New Delhi	NWP100	CSIR-Integrated Skill Initiative Phase II	Dr. Laiq-ur-Rahman	08.12.2020	1,59,55,000	31.03.2021
26	CSIR, New Delhi	HCP0101	Pilot implementation of CSIR-Virtual Laboratory (for School Student)	Er. Manoj Semwal	11.11.2020	17,70,000	31.03.2021
27	CSIR, New Delhi	HCP0007 (Phase II)	CSIR Aroma Mission – Phase II: Catalyzing Rural Empowerment through Cultivation, Processing, Value Addition and Marketing of Aromatic Plants	Dr. Saudan Singh	31.12.2020	96,82,34,000	31.03.2023

DBT-Department of Biotechnology, DST-Department of Science and Technology, UPCST-Council of Science and Technology, UP, NMPB- National Medicinal Plants Board, DHR-Department of Health Research, SERB-Science and Engineering Research Board, IORA-Indian Ocean Rim Association

Dr. Abdul Samad

DR. ABDUL SAMAD, an eminent plant virologist, superannuated as Chief Scientist on 31 January 2021. He has served as a Professor (Biological Science) of the Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, and Adjunct Professor of the Jawaharlal Nehru University (JNU), New Delhi (for the CIMAP-JNU Ph.D. program). During his illustrious career, he also served CSIR-CIMAP as its Acting Director from 01 May 2019 to 13 February 2020.

Born on 6 January 1961 in district Fatehpur, Uttar Pradesh, after completing his schooling in his native place, he joined Aligarh Muslim University (AMU), Aligarh in 1976 for his graduation. He was awarded Ph.D. in Plant Virology by AMU in 1988. Thereafter he joined the French Virus laboratory ORSTOM/IIRSDA as a Post-Doctoral Fellow in the laboratory of Prof. Jean Claude Thouvenel. Upon his return to India, he joined CSIR-CIMAP as a scientist on 28 February 1992. He was instrumental in laying the foundation of a state-of-the-art plant virology laboratory in the institute, which played a key role in the identification and characterization of viruses associated with medicinal and aromatic plants (MAPs) as well as creating diagnostics for plant pathogenic viruses and phytoplasmas using biological, serological and molecular approaches.

His research focused on understanding the host-pathogen interactions that play significant roles in the synthesis of secondary metabolites. His major contribution was the development of a very simple and cheap dip-stick for the diagnosis of the economically devastating begomovirus infecting the mint crop in India. Dr. Samad was associated with numerous projects in the institute. As a Principal Investigator, he was able to attract major funding support for his research from the Department of Biotechnology (DBT), New Delhi. He received the CIES-Post Doc, award during his post-doctoral studies in France. He was also a member of the team that received the prestigious CSIR-Biological Award-1999. He represented India as an application and translation expert in the Joint Forum for Traditional Medicine under the New Southbound Traditional Medicine Resources at National Research Institute of Chinese Medicine (NRICM) Taipei, Taiwan in September 2019**.** During 2019, Dr. Samad was the Editor-in-Chief of the Journal of Medicinal and Aromatic Plant Sciences (JMAPS).

Dr. Samad contributed to the development of 05 new MAP varieties, published over 90 research papers in reputed journals, contributed in 03 US patents, 03 chapters in books, and also co-authored a book. He is a life member of many professional societies, a reviewer for several national/international journals, and served on various technical committees in CSIR and other organizations. He has delivered over 45 invited lectures, supervised 6 Ph.D. and 40 graduate/ post-graduate students.

Dr. Rakesh Pandey

DR. RAKESH PANDEY has more than 37 years of research experience in the field of Phytopathology and Nematology with special reference to development of agro technologies for some of the important medicinal and aromatic plants viz. Mints, Aromatic grasses, Henbane, Basil, Opium poppy, Patchouli, Scented Geranium, Serpagandha, Brahmi, Ashwangandha, Safed Musli and Pyrethrum. Some of his path-breaking research contributions are (a) strategic utilization of *Caenorhabditis elegans,* a multicellular model system as biosensor for monitoring environmental and heavy metal toxicities in soil, and (b) identification of several novel phytomolecule from medicinal and aromatic plants for their anti-ageing, neuroprotective and cognitive booster activities especially anti-Alzheimer and anti-Parkinson activities

Dr. Rakesh Pandey has published more than 160 Research Papers, 18 Review Articles, 32 Book Chapters, 03 Edited Books, 04 US Patent (Granted).

He has received many awards and recognition viz., DAAD Fellow (1990-1993) & Senior DAAD Fellow (1999) Bonn Univ., Germany), Visiting Scientist (2003-2005) University of Pittsburgh, U.S.A., Golden Peacock Award (2008) by WEF, Prof. V.P. Bhide Memorial Award (2008)-SIMPP Udaipur, CSIR Technology Award -1999 & 2015, Outstanding Scientist Award-2010, Dr. S.L. Mishra Medal 2011, Young Achiever Award-2014-Asian PGPR Soc., Prof. R.K. Srivastava Memorial Oration Award 2015 by NASI , Prof. H. S. Srivastava Memorial Award - 2015 for Social Contribution, Prof. J.F. Dastur Memorial Award-2017 by IPS, Prof. H. M. Shah Memorial Award-2017-by NSI, Dr. Manmohan Attavar Gold Medal in Floriculture-2017 by Indian Academy of Horticulture Sciences, Plant Pathology Leadership Award-2017 by GBPUA&T , Pantnagar, Dr. M.R. Siddiqui Memorial Award-2018 by AMU, Aligarh, Dr. Umakant Sinha Memorial Award -2021 by IBS, President- Indian Phytopathological Society, IARI New Delhi 2021-23 and many more.

Dr. Pandey was elected as fellow of National Academy of Agriculture Sciences (FNAAS-2015), Phytopathological Society of India (FPSI -1999), Nematological Society of India (FNSI -1998), Indian Botanical Society (FIBS -2006), Indian Society of Mycology and Plant pathology (FISMPP-2007) and Indian Academy of Horticulture Sciences (FIAHSc -2019).

He also served as Editor of many peer-reviewed Journal.

Dr. Rakesh Pandey superannuated as Senior Principal Scientist on 31st October, 2020 from CSIR-CIMAP.

Staff Members (As on 31 March 2021)

Dr. Prabodh Kumar Trivedi
Director

Chief Scientist

Shri PV Ajaya Kumar
Dr. AK Shasany
Dr. Saudan Singh
Dr. Alok Kumar Krishna

Senior Principal Scientist

Dr. Ved Ram Singh
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. Vikrant Gupta
Dr. Anirban Pal
Dr. Dinesh A. Nagegowda
Dr. J Kotesh Kumar
Dr. (Mrs) Sunita Singh Dhawan

Principal Scientist

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
Dr. V. Sunderesan
Mr. Ram Swaroop Verma
Mr. KVN. Satya Srinivas
Dr. Chandan Singh Chanotiya
Dr. Debabrata Chanda
Dr. Prasanta Kumar Rout
Dr. (Mrs) Prema G. Vasudev
Dr. Rakesh K. Shukla
Dr. Venkata Rao D.K
Dr. (Smt) Puja Khare

Sr. Scientist

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

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 Dependra 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
Dr. Ananda Kumar T.M.
Dr. Ratnashekhar C.H.

Group-III

Medical Officer
Dr VK Agarwal

Sr. Superintending Engineer

Shri A M Khan

Principal Technical Officer

Shri Prem Singh
Dr. Sukhmal Chand

Sr. Technical Officer (3)

Shri K Bhaskaran

Mrs. Sudha Agarwal

Sr. Technical Officer (2)

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

Sr. Technical Officer (1)

Dr. Rajendra Prasad Patel
Dr. Rakshpal Singh
Shri Ram Pravesh
Dr. Amit Chauhan
Dr. Anil Kumar Maurya
Shri A.K. Tiwari
Shri Amit Mohan
Smt Namita Gupta

Technical Officer

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

Technical Assistant

Shri Manish Arya
Shri Sanjeet Kumar Verma
Shri Deepak Kumar Verma
Miss Pooja Singh
Shri Sonveer Singh
Shri Abhishek Kushwaha
Shri Rohit Kumar
Shri Ranjith Kumar Sunkari
Shri Abhishek Singh
Dr(Mrs) Sujata Singh Yadav
Shri Gyanesh Pandey
Shri Mohd Danish Hussain

Group-II

Sr. Technician (3)

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
Shri Kundan Narayan Wasnik

Technician (2)

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
Shri Sateesh Kumar

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
Shri Hare Ram Kushwaha
Smt. B. Mallikamba

Finance & Account Officer
Shri Bhaskar Kumar Ravi
Shri H. Chongloi

Sec. Officer [F&A]
Shri Shailendra Pratap Singh

Sec. Officer [S&P]
Shri Vikash Chand Mishra

Group-B (Gazetted)
Sec. Officer [Gen.]
Shri Sanjay Kumar Ram
Shri Vivek Bajpayee

Sec. Officer[F&A]
Shri R K Sonkar

Sec. Officer [S&P]
Sri Pratap Singh Chauhan

Private Secretary
Smt Kanchan Lata Thomas
Miss Gaitry Sharda

Group-B (Non-Gazetted)
Asstt. Section Officer(Gen)
Smt Sufia Kirmani
Shri Sant Lal
Shri P Srinivas
Shri Kaushal Kishore
Shri Siddharth Shukla
Shri Ravi Prakash
Shri KG Thomas
Ms. Sanyogita Sainger
Shri PK Chaturvedi
Shri Manoj Swaroop Shukla
Mrs. Sheela Yadav

Asstt. Section Officer(F&A)
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
Smt P Sabitha
Shri Srikar Ji Sinha
Ms. Suchita Gupta

Isolated Posts (Group-B)
Shri Yograj Singh
Shri Rohit Khanna

Group-C Posts
Sr. Secretariat Asstt(Gen)
Shri Vijay Kumar Bhartey
Mrs. Preeti Gangwar
Sri Ravi Prakash Mishra
Ms Pratibha Maurya

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 Mohd. Shameem
Shri Mohd. Mohseen
Smt. Pushpa

CIMAP Welcomes New Staff Members

S.No	Name	Designation	Date of Joining	Posting
1.	Dr Ananda Kumar T.M.	Scientist	05.06.2020	CSIR-CIMAP, Lucknow
2.	Dr. Ratnashekhar C.H.	Scientist	07.09.2020	CSIR-CIMAP, Lucknow
3.	Dr. Dayanand Chandrahas Kalyani	Sr. Scientist	05.03.2021	CSIR-CIMAP, Lucknow

Staff Superannuated

S.No.	Name	Designation	Date of Retirement
1.	Shri S K Sharma	Senior Technician	30.06.2020
2.	Shri D K Rajput	Senior Technical Officer(3)	31.07.2020
3.	Dr. Ateeque Ahmad	Principal Technical Officer	31.07.2020
4.	Shri Munneshewaar Prasad	Assistant Section Officer (G)	31.07.2020
5.	Shri Kripa Ram	Group D (NT)	31.07.2020
6.	Dr. Rakesh Pandey	Senior Principal Scientist	31.10.2020
7.	Smt Sangeeta Tanwar	Receptionist	31.12.2020
8.	Dr. Abdul Samad	Chief Scientist	31.01.2021
9.	Shri Haripal Balmiki	JSG	31.01.2021
10.	Shri Kishan Lal	JSG	31.03.2021

Publications (2020- 2021)

1. Agarwal P, Pathak S, Kumar RS, Dhar YB, Shukla S, Asif MH, Trivedi PK. (2020) Short-chain dehydrogenase/reductase, PsDeHase, from opium poppy: putative involvement in papaverine biosynthesis. Plant Cell, Tissue and Organ Culture 143 : 431–440 (IF 2.711).
2. Alam S, Nasreen S, Ahmad A, Darokar MP, Khan F. (2021) Detection of Natural Inhibitors against Human Liver Cancer Cell Lines through QSAR, Molecular Docking, and ADMET Studies. *Current Topics in Medicinal Chemistry*, 21(8):686-695. (IF: 3.295).
3. Babu V, Binwal M, Kumari R, Sen S, Kumar A, Mugale MN, Shanker K, Kumar N, Bawankule DU. (2021) Hesperidin rich ethanol extract from waste peels of *Citrus limetta* mitigates rheumatoid arthritis and related complications. *Phytotherapy Research*. 35(6):3325-3336. (IF: 5.878)
4. Bandamaravuri KB, Nayak AK, Bandamaravuri AS, Samad A. (2020) Simultaneous detection of downy mildew and powdery mildew pathogens on *Cucumis sativus* and other cucurbits using duplex-qPCR and HRM analysis. *AMB Express*.10(1):1-1. (IF: 3.298).
5. Bhatia C, Reddy S, Pandey A, Trivedi PK. (2021) COP1 mediates light-dependent regulation of flavonol biosynthesis through HY5 in Arabidopsis. Plant Science 303, 110760 (IF 4.729).
6. Bhatt G, Tiwari AK, Venkatesha KT, Upadhyay RK, Chauhan A, Verma RS, Singh VR, Padalia RC. (2020) Harvest and post-harvest studies on *Mentha arvensis* var. CIM-Kranti for quality essential oil production in winter and summer season. *J. Med. Arom. Plant Sci.*;42 (1-2), 114-120.
7. Bhukya B, Alam S, Chaturvedi V, Trivedi P, Kumar S, Khan F, Negi AS, Srivastava SK. (2021) Brevifoliol and its Analogs: A New Class of Anti-tubercular Agents. *Current Topics in Medicinal Chemistry,* 21(9):767-776. (IF: 3.295).
8. Bhukya B, Fatima K, Nagar A, Lakshmi V, Dubey P, Kumar S, Kumar Y, Luqman S, Chanda D, Tandon S, Shanker K. (2020) Brevifoliol ester induces apoptosis in prostate cancer cells by activation of caspase pathway. *Chemical biology & drug design*. 95(1):150-61. (IF: 2.817).
9. Bhukya B, Shukla A, Chaturvedi V, Trivedi P, Kumar S, Khan F, Negi AS, Srivastava SK. Design, synthesis, *in vitro* and *in silico* studies of 2, 3-diaryl benzofuran derivatives as antitubercular agents. *Bioorganic chemistry*.1;99:103784. (IF: 5.275)
10. Bisht D, Saroj A, Durgapal A, Chanotiya C, Samad A. (2021) Inhibitory effect of cinnamon (*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.) essential oil and its aldehyde constituents on growth and spore germination of phytopathogenic fungi. *Trends in Phytochemical Research*; 5(2): 62-70.
11. Borgohain A, Konwar K, Buragohain D, Varghese S, Dutta AK, Paul RK, Khare P, Karak T. (2020) Temperature effect on biochar produced from tea (*Camellia sinensis* L.) pruning litters: A comprehensive treatise on physico-chemical and statistical approaches. *Bioresource Technology*.1;318:124023 (IF: 9.642)
12. Chanotiya CS, Pragadheesh VS, Yadav A, Gupta P and Lal RK. Cyclodextrin-based Gas Chromatography and GC/MS methods for determination of chiral pair constituents in mint essential oils, J Essent. Oil Res, 2021, 33 (1), 23-31 (IF: 1.96).
13. Chaudhary P, Mishra M, Singh SP, Verma DK, Sharma RS, Srivastava R.K. and Kumar S. (2020). Green Economics towards Rural Development: A Study of Ashwagandha Cultivation in Deccan Plateau. *Agricultural Situation in India, LXXVII (9) pp 17-23.*
14. Das P, Khare P, Singh RP, Yadav V, Tripathi P, Kumar A, Pandey V, Gaur P, Singh A, Das R, Hiremath C, Verma AK, Shukla AK, Shanker K. (2021) Arsenic-induced differential expression of oxidative stress and secondary metabolite content in two genotypes of Andrographis paniculata. *Journal of Hazardous Materials*. 406:124302. (IF: 10.588)
15. Garg A, Sharma S, Srivastava P, Ghosh S. (2021) Application of virus-induced gene silencing in Andrographis paniculata, an economically important medicinal plant. *Protoplasma*.11:1-8. (IF: 3.356)
16. Gaur I, Gaur P, Gautam P, Tiwari N, Khare P, Tripathi S, Shanker K. (2021) Simplified process of candidate certified reference material development for the analysis of Andrographis

paniculata derived therapeutics. *Microchemical Journal*.1;165:106140. (IF:4.821)

17. Gehlot PS, Gupta H, Rathore MS, Khatri K, Kumar A. (2020) Intrinsic MRI contrast from amino acid-based paramagnetic ionic liquids. *Materials Advances*; 1(6):1980-7.
18. Ghosh D, Chaudhary N, Uma Kumari K, Singh J, Tripathi P, Meena A, Luqman S, Yadav A, Chanotiya CS, Pandey G, Kumar N. (2021) Diversity of Essential Oil Secretory Cells and Oil Composition in Flowers and Buds of *Magnolia sirindhorniae* and Its Biological Activities. *Chemistry & Biodiversity*;18(1):e2000750. (IF: 2.408)
19. Gupta A, Singh V, Prasad P, Kumar M, Srivastava A, Singh V, Luqman S, Birendra Kumar. (2021) Influence of potassium and sodium chloride on germination behavior, biochemical changes and enzyme activity in two varieties of *Ocimum tenuiflorum* L. *Journal of Essential Oil-Bearing Plants* 24(1): 110-119.(IF: 1.699).
20. Gupta AK, Shukla AK, Singh P, Mall M, Yadav S, Shasany AK, Shanker K, Baskaran K, Sundaresan V, Talha M, Srivastava A, Gupta S, Khare P, Mani DN, Samad A. (2020) CIM-Sushil: A high vindoline yielding variety of *Catharanthus roseus* (L.) G. Don. *J. Med. Arom. Plant Sci*.; 42(1-2):51-63.
21. Gupta P, Dhawan SS, Lal RK, Chanotiya CS, Mishra A. (2021) Genotype selection over years using additive main effects and multiplicative interaction (AMMI) model under the ascendancy of genetic diversity in the genus *Ocimum*. *Industrial Crops and Products*.;161:113198. (IF: 5.645)
22. Gupta P, Mishra A, Lal RK, Dhawan SS. (2021) DNA fingerprinting and genetic relationships similarities among the accessions/species of *Ocimum* using SCoT and ISSR markers system. *Molecular Biotechnology*;63(5):446-57. (IF: 2.695)
23. Hiremath C, Greeshma M, Gupta N, Kuppusamy B, Shanker K, Sundaresan V. (2020) Morphometric, chemotypic, and molecular diversity studies in *Andrographis paniculata*. *Journal of Herbs, Spices & Medicinal Plants*; 1-14 (IF: 0.909).
24. Hiremath C, Sundaresan V, Baskaran K, Kumar A, Yogendra ND, Yadav MK, Verma RS, Srinivas Satya KV, Kumar JK, Kumar N, Kalra A, Tripathi AK. (2020) A linalool rich variety - CIM-Sukhda of *Ocimum basilicum*. *J. Med. Arom. Plant Sci*.;42(1-2), 68-72.
25. Hiremath C, Yadav MK, Swamy Gowda MR, Kumar AN, Srinivas KV. (2020) Influence of growth stage on essential oil content and major chemical constituents of Artemisia pallens Bess. *Trends in Phytochemical Research*;4(2):85-92.
26. Hiremath C, Yogendra N, Vadatti R, Baskaran K, Verma MK, Sundaresan V. (2020) Evaluation of *Mentha arvensis* L. cultivars for essential oil yield in Southern tropical regions of India. *J. Med. Arom. Plant Sci*.; 42(1-2):127-31.
27. Jain A, Dasgupta N, Ranjan S, Singh V, Singh H, Purohit SD, Mishra NC, Yadav NP, Haque S, Mishra BN, Samanta SK. (2021) Whey protein based electrosprayed nanospheres for encapsulation and controlled release of bioactive compounds from *Tinospora cordifolia* extract. *Innovative Food Science & Emerging Technologies*; 69:102671. (IF:5.916)
28. Jeena GS, Kumar S, Shukla RK. (2021) Characterization of MYB35 regulated methyl jasmonate and wound responsive Geraniol 10-hydroxylase-1 gene from *Bacopa monnieri*. *Planta*. 253(5):1-3. (IF:4.116)
29. Khan MS, Singh S, Pandey P, Semwal M, Kalra A. (2021) Menthol Mint (*Mentha arvensis* L.) crop acreage estimation using multi-temporal satellite imagery. *Journal of the Indian Society of Remote Sensing*; 49(4):987-96. (IF: 1.563)
30. Khare P, Deshmukh Y, Yadav V, Pandey V, Singh A, Verma K. (2021) Biochar production: A sustainable solution for crop residue burning and related environmental issues. *Environmental Progress & Sustainable Energy*.40(2):e13529. (IF:2.431).
31. Kulkarni RN, Baskaran K, Sundaresan V, Hiremath C, Yogendra ND, Yadav MK, Satya Srinivas KVN, Kumar JK, Kumar N, Padalia RC, Kumar A, Kalra A, Tripathi AK. (2020). A geraniol rich variety of lemongrass (*Cymbopogon flexuosus* (Steud.) Wats.): CIM-Atal. *J. Med. Arom. Plant Sci*.;42(1-2), 2020; 64-67.
32. Kumar A, Rodrigues V, Baskaran K, Shukla AK, Sundaresan V. (2020) DNA barcode based species-specific marker for *Ocimum tenuiflorum* and its applicability in quantification of adulteration in herbal formulations using qPCR. *Journal of Herbal Medicine* 23: 100376. DOI: 10.1016/j.hermed.2020.100376. (IF: 3.032).

33. Kumar A, Rodrigues V, Verma S, Singh M, Hiremath C, Shanker K, Shukla AK, Sundaresan V. (2021) Effect of salt stress on seed germination, morphology, biochemical parameters, genomic template stability, and bioactive constituents of *Andrographis paniculata* Nees. *Acta Physiologiae Plantarum*. 43(4): 68. (IF:2.354)

34. Kumar D, Kumar R, Singh AK, Verma K, Singh KP, Nilofer AK, Kaur P, Singh A, Pandey J, Khare P, Singh S. (2020) Influence of Planting Methods on Production of Suckers (Rhizome or Propagative Material), Essential Oil Yield, and Quality of Menthol Mint (*Mentha arvensis* L.). *Int. J. Curr. Microbiol.* App. Sci; 9(7):3675-89.

35. Kumar D, Kumar R, Singh AK, Verma K, Singh KP, Nilofer, Kumar A, Singh V, Kaur P, Singh A, Anandakumar TM, Khare P, Singh S. (2021) A novel and economically viable agro-technique for enhancing productivity and resource use efficiency in menthol mint (*Mentha arvensis* L.). *Industrial Crops and Products;*162:113233. (IF:5.645)

36. Kumar D, Padalia RC, Suryavanshi P, Chauhan A, Pratap P, Verma KT, Kumar R, Singh S, Tiwari AK. (2021) Essential oil yield, composition and quality at different harvesting times in three prevalent cultivars of rose-scented geranium. *Journal of Applied Horticulture*;23(1):19-23.

37. Kumar D, Suryavanshi P, Padalia RC, Chauhan A, Venkatesha KT, Tiwari AK, Singh VR, Singh S, Upadhyay RK. (2020) Evaluation of harvesting time and standardization of distillation duration for higher essential oil content and quality in German chamomile (*Chamomilla recutita* L.). *Journal of Spices & Aromatic Crops*.;29(2) 140-147.

38. Kumar P, Sahoo D, Chanotiya CS, Nannaware AD, Mohapatra P, Pradhan B, Rout PK. (2020) Valorization of undesired pulegone in *Mentha* essential oil by selective catalytic reduction: An overview, *J. Med. Arom. Plant Sci*.;42, 86-92.

39. Kumar V, Singh N, Singh V, Kumar M, Srivastava RK. (2020). Introduction of improved cultivar of menthol mint (Mentha arvensis L.) in district Chhatarpur of Madhya Pradesh for better yield and quality of essential oils. *Journal of lipid science and technology,* 52(1) pp: 23-27.

40. Kumar V, Singh VR, Singh N, Yadav R, Singh MK, Verma RS, Padalia RC, Lal RK. (2021) Quantification of variability, character associations, and contribution in Indian landraces of Bishop's weed *(Ammi visnaga* (L.) Lam). *Journal of Essential Oil Bearing Plants*; 24(2):277-89. (IF:1.699)

41. Kumari P, Meena A. (2020) Green synthesis of gold nanoparticles from *Lawsonia inermis* and its catalytic activities following the Langmuir-Hinshelwood mechanism. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 606. 125447. (IF: 4.539)

42. Lakhwani D, Sanchita, Pandey P, Sharma D, Asif MH, Trivedi PK. (2020) Novel microRNAs regulating ripening-associated processes in banana fruit. Plant Growth Regulation 90, 223–235 (IF 3.412).

43. Lal RK, Chanotiya CS, Dhawan SS, Gupta P, Mishra A, Srivastava S, Shukla S, Maurya R. (2020) Estimation of intra-specific genetic variability and half-sib family selection using AMMI (Additive Main Effects and Multiplicative Interactions) model in menthol mint (*Mentha arvensis* L.). *J. Med. Arom. Plant Sci*.;42(1-2):102-13.

44. Lothe NB, Mazeed A, Pandey J, Patairiya V, Verma K, Semwal M, Verma RS, Verma RK. (2021). Maximizing yields and economics by supplementing additional nutrients for commercially grown menthol mint (*Mentha arvensis* L.) cultivars, *Industrial Crops and Products*, 160, 113110. (IF: 5.645)

45. Mahendran G, Deepak K, Sanjeet KV, Ashish C, Zafar IW, Zakir H, Shama A, Rout PK, Laiq Ur Rahman (2021). Sodium nitroprusside enhances biomass and gymnemic acids production in cell suspension of *Gymnema sylvestre* (Retz.) R.Br. ex. Sm. *Plant Cell, Tissue and Organ Culture (PCTOC)* 146:161–170. (IF: 2.711)

46. Mahendran G, Rahman LU. (2020) Ethnomedicinal, phytochemical and pharmacological updates on Peppermint *(Mentha×piperita* L.)-A review. *Phytotherapy Research*; 34(9):2088-139. (IF: 5.878)

47. Mahendran G, Zafar I, Deepak K, Sanjeet KV, Rout PK, Laiq ur Rahman (2021). *Enhanced gymnemic acids production in cell suspension cultures of Gymnema sylvestre (Retz.) R.Br. ex Sm. through elicitation. Industrial Crops & Products* 162, 113234. (IF: 5.645)

48. Mall M, Singh P, Kumar R, Shanker K, Gupta AK, Khare P, Shasany AK, Khatoon S, Sundaresan V, Baskaran K, Yadav S, Shukla AK. (2021) Phenotypic, genetic and expression profiling of a vindoline-rich genotype of *Catharanthus roseus*. *South African Journal of Botany*.139: 50-57.. (IF: 2.315)

49. Mani DN, Shukla S, Shukla YN. (2020) Medicinal plant-derived therapeutics for treatment of neoplasms in modern and traditional systems of medicine. *J. Med. Arom. Plant Sci.*;42: 1-29.

50. Masood N, Dubey V, Luqman S. (2020) Activation of caspase-3 by terpenoids and flavonoids in different types of cancer cells. *Current Topics in Medicinal Chemistry* 20: 1876-1887. (IF: 3.295)

51. Maurya R, Gupta P, Chanotiya CS, Dhawan SS, Srivastava S, Yadav A, Kumar A, Swamy Y, Lal RK. (2020) Investigation of monoterpenoids rich essential oils of two *Ocimum basilicum* L. varieties at different agro-climatic conditions in India. *Acta Ecologica Sinica*. 2020 Nov 20. (IF: 1.414)

52. Maurya Ranjana, Gupta Pankhuri, Chanotiya CS, Dhawan SS, Srivastava Shubham, Yadav Anju, Kumar A, Swamy Yvvs, Lal RK, Investigation of Monoterpenoids rich Essential Oils of two *Ocimum basilicum* L. Varieties at different agro-climatic conditions in India, Acta Ecologica Sinica, 2020 (IF: 0.935).

53. Michael R, Ranjan A, Kumar RS, Pathak PK, Trivedi PK (2020) Light-regulated expression of terpene synthase gene, AtTPS03, is controlled by the bZIP transcription factor, HY5, in *Arabidopsis thaliana*. Biochemical and Biophysical Research Communications 529: 437-443 (IF 3.575).

54. Mishra A, Gupta P, Lal RK, Dhawan SS. (2021) Assessing and integrating the transcriptome analysis with plant development, trichomes, and secondary metabolites yield potential in *Mentha arvensis* L. *Plant Physiology and Biochemistry*; 162:517-30. (IF: 4.270)

55. Mishra A, Gupta P, Lal SS. (2020) Adaptability and stability pattern of a genetic character-trichome diversity in menthol mint (*Mentha arvensis* L.). *J. Med. Arom. Plant Sci.*;42(1-2):121-6.

56. Mishra A, Gupta S, Gupta P, Dhawan SS, Lal RK. (2020) In silico identification of miRNA and targets from *Chrysopogon zizanioides* (L.) Roberty with functional validation from leaf and root tissues. *Applied Biochemistry and Biotechnology*; 192 (3):1076-92. (IF: 2.926)

57. Mishra R, Gupta AK, Lal RK. (2020) Genotype x environment interaction, stability analysis for yield and quality traits in turmeric (*Curcuma longa* L.). *Trends in Phytochemical Research*;4(4):219-34.

58. Mishra R, Gupta AK. (2021) Biological Activities of Curcuminoids. In *The Chemistry and Bioactive Components of Turmeric*. 172-195.

59. Mishra R, Kumar A, Gupta AK, Saikia D, Lal RK. (2020) Effects of season and spacing on growth pattern and seed yield of Muskdana genotypes (*Abelmoschus moschatus* L.) and radical scavenging activity of its seed oil. *Trends in Phytochemical Research*;4(3):165-76.

60. Mishra S, Gupta N, Shanker K. (2020) HPTLC method for the simultaneous determination of six bioactive terpenoids in *Putranjiva roxburghii* Wall. *JPC–Journal of Planar Chromatography–Modern TLC*.;33(4):353-64. (IF: 0.856)

61. Mohanty CS, Syed N, Kumar D, Khare S, Nayak SP, Sarvendra K, Pattanayak R, Pal A, Chanotiya CS, Rout PK. (2021) Chemical characterization of winged bean (*Psophocarpus tetragonolobus* (L.) DC. seeds and safety evaluation of its fatty oil. *Journal of Food Measurement and Characterization*;15(1):807-16. (IF: 2.431)

62. Nigam N, Khare P, Ahsan M, Yadav V, Shanker K, Singh RP, Pandey V, Das P, Anupama, Yadav R, Tripathi P, Sinam GG, Shukla AK, Karak T. (2021) Biochar amendment reduced the risk associated with metal uptake and improved metabolite content in medicinal herbs. *Physiologia Plantarum*, 173: 321-329, https://doi.org/10.1111/ppl.13393. (IF:4.500)

63. Nilofer, Singh AK, Singh N, Kumar B, Singh S. (2020) Effect of seed heteromorphism and seed collection time on germination of the medicinal plant *Centella asiatica* (L.) Urban in sub-tropical plains of north India. *J. Med. Arom. Plant Sci.*;42 (3-4): 229-233.

64. Nilofer, Singh KP, Verma K, Kumar D, Kumar A, Singh PK, Chanotiya CS, Singh S. (2020) Quality assessment of menthofuran rich essential oil of *Mentha piperita* (CIMAP-Patra) stored at different temperatures and containers. *Journal of Pharmacognosy and Phytochemistry*; 9(5):1603-10.

65. Padalia RC, Upadhyay RK, Chauhan A, Singh VR, Verma RS, Chanotiya CS. (2020) Influence of Harvesting Frequency on Essential Oil Yield and Composition of Geraniol-Rich Cultivar of *Cymbopogon flexuosus* L. *National Academy Science Letters*. 8:1-6. (IF:0.788)

66. Pandey H, Pandey P, Singh S, Negi AS, Banerjee S. (2020) Unveiling the future reservoir of anti-cancer molecule—Combretastatin A4 from callus and cell aggregate suspension culture of flame creeper (*Combretum microphyllum*): growth, exudation and elicitation studies. *Plant Cell, Tissue and Organ Culture* (PCTOC);143(3):681-91. (IF: 2.711).

67. Prakash P, Srivastava RK. (2020). Production and trade of menthol mint in India: Problem and prospects. *J. Med. Arom. Plant Sci.*;42 (3-4)200-204.

68. Prasad P, Kishor R, Gupta A, Saxena V, Zaidi S, Kushwaha H, Singh V, Verma RS, Kumar B. (2020) Genetic variability and character association among morpho-metric traits and essential oil constituents in eight half-sib seed progenies of peppermint (*Mentha piperita* L.). *Trends in Phytochemical Research*;4(3):143-52.

69. Prasad P, Singh V, Aftab N, Gupta A, Kishor R, Kushwaha HK, Singh V, Verma RS, Kumar B. (2021) Gamma irradiation-induced variability in morpho-agronomic and oil quality traits of *Mentha piperita* L. *International Journal of Radiation Biology*; 97(5):737-45. (IF: 2.694)

70. Rai VK, Sinha P, Yadav KS, Shukla A, Saxena A, Bawankule DU, Tandon S, Khan F, Chanotiya CS, Yadav NP. (2020) Anti-psoriatic effect of *Lavandula angustifolia* essential oil and its major components linalool and linalyl acetate. *Journal of Ethnopharmacology*; 261:113127. (IF:4.360)

71. Rajakani R, Prakash P, Ghosliya D, Soni R, Singh A, Gupta V. (2021) *Azadirachta indica* MicroRNAs: Genome-Wide Identification, Target Transcript Prediction, and Expression Analyses. *Applied Biochemistry and Biotechnology*;193(6):1924-44. (IF: 2.926)

72. Raza W, Luqman S, Meena A. (2020) Prospects of tangeretin as a modulator of cancer targets/ pathways. *Pharmacological Research*. 161. 1052020. (IF: 7.658)

73. Seth R, Kushwaha S, Luqman S, Meena A. (2021) Flavonoids as prospective aromatase inhibitors in breast cancer prevention/therapy. *Current molecular pharmacology*. (IF: 3.339)

74. Shannon M, Ratnasekhar CH, McGrath TF, Kapil AP, Elliott CT. (2021) A two-tiered system of analysis to tackle rice fraud: The Indian Basmati study. *Talanta*, 225, 22038. (IF: 6.057)

75. Sharma A, Badola P, Bhatia C, Sharma D, Trivedi PK (2020) Primary transcript of miR858 encodes regulatory peptide and controls flavonoid biosynthesis and development in Arabidopsis. Nature Plants 6:1262-1274 (IF 15.793).

76. Sharma PP, Yadav V, Rajput A, Gupta H, Saravaia H, Kulshrestha V. (2020) Sulfonated poly (ether ether ketone) composite cation exchange membrane for selective recovery of lithium by electrodialysis. *Desalination*. 15;496:114755. (IF: 9.501)

77. Sharma RS, Kumar S, Kumar D, Srivastava RK. (2020). Economic analysis of mint cultivation in Madhepura district of Bihar, *International Research Journal of Agricultural Economics and Statistics,* 11(2), pp: 127-131. (IF: 1.90)

78. Shukla B, Gupta S, Srivastava G, Sharma A, Shukla AK, Shasany AK. (2021): lncRNADetector: a bioinformatics pipeline for long non-coding RNA identification and MAPslnc: a repository of medicinal and aromatic plant lncRNAs, RNA Biology. 18: 2290-2295 (IF:4.652)

79. Singh A, Srivastava N, Yadav KS, Sinha P, Yadav NP. (2020) Preparation, optimization, characterization and bioevaluation of rosmarinic acid loaded phytovesicles for anti-inflammatory activity, *Journal of Drug Delivery Science and Technology*, 59: 101888 (IF:3.981)

80. Singh A, Verma K, Kumar D, Lothe NB, Kumar A, Chaudhary A, Kaur P, Singh KP, Singh AK, Kumar R, Anandakumar TM. (2021). Optimized irrigation regime and planting technique improve yields and economics in *aloe vera* [*Aloe barbadensis* (Miller)]. *Industrial Crops and Products*. 167: 113539. (IF: 5.645)

81. Singh DP, Kumar A, Rodrigues V, Prabhu KN, Kaushik A, Mani DN, Shukla AK, Sundaresan V. (2020) DNA barcoding coupled with secondary structure information enhances *Achyranthes* species resolution. *Journal of Applied Research on Medicinal and Aromatic Plants* 19: 100269. (IF:3.400)

82. Singh J, Hussain Y, Luqman S, Meena A. (2021) Purpurin: A natural anthraquinone with multifaceted pharmacological activities. *Phytotherapy Research*; 35(5):2418-28. (IF: 5.878)

83. Singh J, Luqman S, Meena A. (2020) Emerging role of phytochemicals in targeting predictive, prognostic, and diagnostic biomarkers of lung cancer. *Food and Chemical Toxicology*. 144. 111592. 2020. (IF: 6.023)

84. Singh P, Dasgupta N, Singh V, Mishra NC, Singh H, Purohit SD, Srivastava N, Ranjan S, Yadav NP, Mishra BN. (2020) Inhibitory effect of clove oil nanoemulsion on fumonisin isolated from maize kernels, *LWT - Food Science and Technology*, 134:110237. (IF:4.952)

85. Singh S, Agarwal K, Iqbal H, Yadav P, Yadav D, Chanda D, Tandon S, Khan F, Gupta AK, Gupta A. (2020) Synthesis and evaluation of substituted 8,8-dimethyl-8H-pyrano[2,3-f]chromen-2-one derivatives as vasorelaxing agents. *Bioorganic & medicinal chemistry letters*;30(1):126759. (IF: 3.641)

86. Singh S, Bisht M, Kashyap PK, Chauhan A, Tandon S, Padalia RC, Gupta A, Verma RS. (2020) Essential oil composition of wild-mint (*Mentha longifolia* (L.) harvested at different stages of plant growth. *J. Med. Arom. Plant Sci.*;42(1-2), 168-174.

87. Singh S, Gupta P, Meena A, Luqman S. (2020) Acacetin, a flavone with diverse therapeutic potential in cancer, inflammation, infections and other metabolic disorders. *Food and Chemical Toxicology*; 145: 111708. (IF: 6.023)

88. Singh S, Meena A, Luqman S, Meena A. (2021) Acacetin and pinostrobin as a promising inhibitor of cancer-associated protein kinases. *Food and Chemical Toxicology*. 151. 112091. 2021. (IF: 6.023)

89. Srivastava A, Fatima K, Fatima E, Singh A, Singh A, Shukla A, Luqman S, Shanker K, Chanda D, Khan F, Negi AS. (2020) Fluorinated benzylidene indanone exhibits antiproliferative activity through modulation of microtubule dynamics and antiangiogenic activity. *European Journal of Pharmaceutical Sciences*.1;154:105513. (IF:4.384)

90. Srivastava A, Gupta S, Shanker K, Gupta N, Gupta AK, Lal RK. (2020) Genetic diversity in Indian poppy (*P. somniferum* L.) germplasm using multivariate and SCoT marker analyses. *Industrial Crops and Products*. 144:112050. (IF: 5.645)

91. Srivastava AK, Kapkoti DS, Gupta M, Rout PK, Bhakuni RS, Samad A. (2021) Enhanced production of phytotoxic polyketides isolated from *Curvularia lunata* by applying chemical stresses. *Industrial Crops and Products*.;160:113156. (IF: 5.645)

92. Syed N, Chaturvedi S, Rout PK, Nannaware AD, Naik SN. (2021) Thermal properties of Castor oil for the production of chemicals, *J. Lipid Sci Technol*., 52, 99-105.

93. Tiwari A, Kumar D, Venkatesha KT, Suryavanshi P, Chauhan A, Singh S, Verma PP, Kumar R, Singh VR. (2020) Performance of stem cuttings in different propagating media in Patchouli (*Pogostemon patchouli* Benth.) *Plant archives* 20(2): 4880-4884.

94. Tiwari AK, Verma PP, Kumar D, Singh S, Kumar R, Padalia RC, Upadhyay RK. (2021) Germination behavior of *Rauvolfia serpentine* (L.) seeds with the use of different seed treatments. *Indian J. Agl. Res*. DOI. 10.18805/IJARe.A-5624.

95. Tripathi P, Singh RP, Srivastava S, Shivanna B, Singh AK, Singh S, Khare P. (2021) Quantifying the boron demand of Pelargonium graveolens for optimum biomass yield and quality of essential oil under field conditions. *Journal of Plant Nutrition*.16:1-4. (IF:1.707)

96. Upadhyay HC, Singh M, Prakash O, Khan F, Srivastava SK, Bawankule DU. (2020) QSAR, ADME and docking guided semi-synthesis and in vitro evaluation of 4-hydroxy-á-tetralone analogs for anti-inflammatory activity. *SN Applied Sciences*; 2(12):1-1.

97. Venkatesha KT, Singh VR, Padalia RC, Upadyay RK, Chauhan A, Tiwari AK, Singh S, Divya, Bhatt G, Pandey P, Verma RS, Mall M, Shukla AK, Chanotiya CS, Kumar S, Kumar B, Gupta AK, Verma RK, Samad A, Kumar P, Rawat MC. (2020). CIM-Unnati: An essential oil rich variety of menthol mint (*Mentha arvensis* L.). *J. Med. Arom. Plant Sci.*;42(1-2):73-79.

98. Venkatesha KT, Singh VR, Padalia RC, Upadyay RK, Di D, Bhatt G, Chauhan A.(2020) Correlation and path-analysis for morpho-economic traits and chemical constituents of essential oil in Corn mint *(Mentha arvensis* L.) accessions. *Arabian Journal of Medicinal and Aromatic Plants*;6(2):1-6.

99. Verma AK, Fatima K, Dudi RK, Tabassum M, Iqbal H, Kumar Y, Luqman S, Mondhe DM, Chanda D, Khan F, Shanker K, Negi AS. (2020) Antiproliferative activity of diarylnaphthylpyrrolidine derivative via dual target inhibition. *European journal of medicinal chemistry*;188:111986. (IF:6.514)

100. Verma K, Singh KP, Singh A, Lothe NB, Kumar D, Singh AK, Kumar R, Khare P, Singh S. (2021) Co-cultivation of a medicinal plant kalmegh [*Andrographis paniculata* (Burm. F.) Wall ex. Nees] with food crops for enhancing field productivity and resource use efficiency. *Industrial Crops and Products*. 1;159:113076. (IF: 5.645)

101. Verma PPS, Aftab N, Singh V, Shanker K, Birendra Kumar. (2020) Survival, performance and adaptation of *Swertia chirayita* genotypes at western Himalayan zone of Uttarakhand. *J. Med. Arom. Plant Sci.*;42(3-4): 220-228.

102. Verma RS, Verma SK, Tandon S, Padalia RC, Darokar MP. (2020) Chemical composition and antimicrobial activity of Java citronella (*Cymbopogon winterianus* Jowitt ex Bor) essential oil extracted by different methods. *Journal of Essential Oil Research*, 32(5), 449-455. (IF: 1.148).

Popular Articles:

1. Singh N, Kumar V, Patel S, Srivastava RK. (2020). Commercial cultivation and economic importance of scented rose. *Morden Kheti, 43-45*.
2. Patel S, Kumar V, and Srivastava RK.,(2020) Advanced commercial cultivation of medicinal and aromatic crops and its benefits, 2020. *Souvenir of Rajkiye Shak Bhaji, phal and Pushp Pradarshni, Baranasi,* PP: 27-29.
3. Singh SP, Kumar S. (2020). Natural Menthol Mint Oil Production in India: Role of CSIR-CIMAP, Opportunities and challenges. *Just Agriculture,* (1)5.

Books and Book Chapters

1. Singh, A. and Pandey, R. (2020). Management of Diseases of Medicinal and Aromatic Plants Using High Shelf Life Formulation of Trichoderma. In *Trichoderma: Agricultural Applications and Beyond* (pp. 181-194). Springer, Cham.
2. Singh, A., Chaubey, R., Srivastava, S., Kushwaha, S. and Pandey, R. (2021). Beneficial Root Microbiota: Transmogrifiers of Secondary Metabolism in Plants. In *Emerging Trends in Plant Pathology* (pp. 343-365). Springer, Singapore.
3. Tripathi, P. and Singh, A. (2021). Biofertilizers: "An ace in the hole" in medicinal and aromatic plants cultivation. In *Biofertilizers* (pp. 253-263). Elsevier, Woodhead Publishing.
4. Arvind Singh Negi (2021) *"Anti-breast cancer terpenoids from nature origin" pp.29-68,. In* NATURAL PRODUCT DRUG DISCOVERY': Volume-5 (2021): Discovery and Development of Anti-Breast Cancer Agents from Natural Products. ISBN: 978-0-12-821277; Elsevier, USA.
5. Mani DN, Kaushik A, Khanna H, Singh DP, Kumar A, Patel MK, Mall M, Pandey P, Sundaresan V, Shanker K, Shukla AK and Sachdev K. (2020). Anti-allergic property-based screening and validation of medicinal plants described in *Ayurveda*. In: Madhunapantula SV (Ed.) *Drug Development from Natural Resources: Scope and Challenges*, A Publication from the Centre for Science & Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre), Allied Publishers Pvt. Ltd., New Delhi, pp 46-57. [ISBN: 978-93-89934-15-1].
6. C.S. Mathela and R.C. Padalia (2020). Chemical Composition, Bioactivity and Commercial Potential of Some Himalayan Lamiaceae Species, In: The Lamiaceae Family: An Overview. Ed. A. Adler, Nova Science Publishers, Inc., New York, pp. 1-98.
7. Sunita Singh Dhawan (2021). Ocimum species: A model medicinal industrial crop enriched with array of bioactive chemicals with improved tolerance. In Medicinal Plants: Bioprospecting and Pharmacognosy (USA and Canada), 9781774638453 AAP-CRC Press: A Taylor and Francis Group
8. Sunita Singh Dhawan (2021). Biogenesis and Chemoecology of Essential Oil, Aromatherapy and Conservation in Vetiver In: Aromatic Plants: The Technology, Human Welfare and Beyond (USA), Nova Science Publishers.
9. Mahendran. G and Laiq ur Rahman (2021). Biosynthesis and Biotechnological Production of Anticancer Drug Camptothecin in Genus *Ophiorrhiza*. Reference Series in Phytochemistry. Plant Cell and Tissue Differentiation and Secondary Metabolites. Springer Springer Nature, Switzerland pp-903-920.

Patents Filed / Granted

1. Negi AS, Tyagi R, Pathak N, Fatima K, Luqman S, Chanda D, Kode J, Shanker K, Gupta S, Bawankule DU, Gupta AK A synergistic polyherbal formulation exhibiting potential anticancer activity. Application No. 202111001172.
2. PK Rout, A Kalra, CS Chanotiya, AD Nannaware, AK Tripathi, R. Singh, A Jain, P Kumar, N Syed, Process for isolation of ricinoleic acid / ester from castor oil and its biotransformation to (+)-?-decalactone, 147 NF2019, India & US patent (Filed).
3. Atul Gupta, Ram Swaroop Verma, Sarita Singh, Swati Singh, Arvind Singh Negi, Karuna Shanker, Sudeep Tandon, Alok Kalra A PROCESS FOR THE PREPARATION OF VANILLIN AND ITS DERIVATIVES (India : 202011028345).
4. Atul Gupta, Ram Swaroop Verma, Sarita Singh, Swati Singh, Arvind Singh Negi, Karuna Shanker, Sudeep Tandon, Alok Kalra A PROCESS FOR THE PREPARATION OF VANILLIN AND ITS DERIVATIVES (PCT :PCT/IN2021/050495).
5. Arvind Singh Negi, A Singh, S Luqman, D Chanda, DM Mondhe, AK Saxena, K Fatima, A Singh. "2-Benzyl-indanone compounds as anticancer agents and the process of preparing the same" India 3322687, 26 Feb 2020, PCT 356367, 21 Jan 2021.

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Finance & Account Officer

Member Secretary

Controller of Administration /
Administrative Officer

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The summary of the cases during 01 Apr 2020- 31 March 2021 is:

Year 2021 (01 Jan 2020 - 31 Mar 2021)					
Application Received	**Rejected**	**Information provided**	**1st Appeal**	**Decision where 1st appeal replied**	**Referred to CIC, New Delhi**
105 including Transfer cases	NIL	105	03	03	NIL

Input: Bhaskar Shukla/D.Saikia

Budget at Glance (As on 31 March 2021)

	Allocation (₹ in lakhs)	Expenditure (₹ in lakhs)
Pay and Allowance	2992.513	2992.513
Contingency	278.832	278.832
HRD		
Lab Maintenance	238.392	238.392
Staff Qtr. Maintenance	41.514	41.514
Chemicals / Consumables	329.549	329.549
Works and Services	165.855	165.855
Apparatus and Equipment	220.807	220.807
Office Equipment		
Furniture and Fitting	7.306	7.306
Library (Books& Journal) P50	131.363	131.363
Staff Qtrs. (Construction)	8.265	8.265
CSIR Network Projects	679.555	679.555
Total	5093.951	5093.951
Pension	2585.531	2585.531
External Budgetary Resources		
Lab Reserve Fund (LRF)		6.323
External Cash Flow (ECF)		762.737

Input: Finance & Accounts

List of the PhD Degree Awarded

List of the students whose Ph.D award during 1st April 2020 to 31st March 2021					
S.No.	**Name of the Students**	**Thesis Title**	**Supervisor / Co-supervisor**	**Date of Viva**	**University**
1	Sudeep Tandon	Extraction, Isolation and chemical characterization of aroma molecules for their bioactive and anti-aging activities	Dr. Rakesh Pandey	12-May-20	AcSIR
2	Archana	Structural investigation of insecticidal plant polypeptides and designed peptides with Non natural Amino Acids	Dr. Prema G Vasudev	8-Jun-20	JNU
3	Harshita Pandey	Pathway engineering in Stevia rebaudiana for enhanced secondary metabolite production	Dr. Laiq Ur Rahman	11-Jun-20	AcSIR
4	Janhvi Pandey	Studies on phytoremediation potential of aromatic grasses with special emphasis on Lemongrass (Cymbopogon species) in tannery sludge polluted soil	Dr Rajesh Verma	24-Jun-20	AcSIR
5	Pooja Mishra	Studies on microbial diversity of rhizospheric soils of selected MAPs through Culture Dependent and Culture Independent approaches	Alok Klara	17-Jul-20	AcSIR
6	Pooja Rani Meena	Studies on anti-plasmodial plant derived products, their mechanism and potential in combination therapy	Dr. M P Darokar	5-Aug-20	JNU
7	Sachi Shuchismita	Studies of Asparagus racemosus Willd. for its antiaging and neuromodulatory potential using Caenorhabditis elegans	Dr. Rakesh Pandey	20-Oct-20	JNU
8	Anchal Garg	Molecular and Biochemical Studies of the Diterpene Biosynthesis in Kalmegh [Andrographis paniculata (Burm.f.) Wall. ex Nees]	Dr. Sumit Ghosh	1-Nov-20	JNU
9	Saumya Sinha	Genomic characterization of cucumber mosaic virus (es) infecting selected medicinal and aromatic plants: Pathogenic effects and management strategies	Dr. Abdul Samad	15-Dec-20	AcSIR
10	Sonali Mishra	Chemico-biological studies to repurpose the therapeutic potential of Putranjiva roxburghii	Dr. Karuna Shankar	16-Dec-20	JNU

11	Nilofer	Enhancing productivity and quality of Senna (*Cassia augustifolia Vahl*) through agrotechnological interventions under sub-tropical plains of North India	Dr. Saudan Singh	17-Dec-20	AcSIR
12	Nupur Srivastava	Nutritional and Chemico-Biological Assessment of Selected Medicinal Plants as Functional Supplement	Dr. Karuna Shankar	4-Jan--21	JNU
13	Taruna Pandey	Studies of swertiamarin for its anti-ageing and neuromodulatory potential using Caenorhabditis elegans	Dr. Rakesh Pandey	13-Jan-21	JNU
14	Ankita Srivastava	Development of Podophyllotoxin congeners as cancer chemotherapeutics through fragment based drug discovery approach	Dr. A S Negi	5-Feb-21	AcSIR
15	Madhumita Srivastava	Chemical and biological investigation of Clerodendrum and Duranta species from family Verbenaceae	Dr. Karuna Shankar	17-Feb-21	AcSIR
16	Dolly Ghosliya	Cloning of protein kinase gene homolog(s) from Catharanthus roseus andstudies on their roles in stress-responses and secondary metabolism	Dr. Vikrant Gupta	19-Feb-21	JNU
17	Arpita Tripathi	Identifying endophytes enhancing growth and content of artemisinin and reducing stress induced damage in Artemisia annua	Dr. Alok Klara	23-Feb-21	AcSIR
18	Amit Kumar Verma	Studies on design and synthesis of microtubule destabilizers as anticancer agents	Dr. A S Negi	24-Feb-21	JNU
19	Mamta Kumari	Biotechnological Interventions in Ocimum species for High value/ Value-Added Products	Dr. Laiq Ur Rahman	25-Feb-21	JNU
20	Divya Vashisht	Effect of abiotic stresses on Artemisia annua transcriptome	Dr A.K. Shasany	26-Feb-21	JNU
21	Gajendra	Identification and characterization of transcripts involved in triterpenoid biosynthesis in *Bacopa monnieri*	Dr Rakesh Shukla	4-Mar-21	JNU
22	Shama Shukla	Genetics of quantitative and qualitative traits in opium poppy (Papaver somniferum L.)	Dr. V R Singh	9-Mar-21	JNU
23	Sadiya Khwaja	Nature inspired microtubule destabilizers as possible cancer chemotherapeutics	Dr. A S Negi	26-Mar-21	AcSIR

*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-locational 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 MAPs 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 the establishment of the Central Indian Medicinal Plants Organization (CIMPO) in 1957 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.

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.

शोध केन्द्र, बैंगलुरू Research Center, Bengaluru

मुख्यालय, लखनऊ Head Quarter Lucknow

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